City of Santa Fe

SANTA FE, NEW MEXICO

Paseo Real Wastewater Treatment Plant Anaerobic Digesters

Client Project Number: CIP #950

Volume II

Construction Documents
Technical Specifications

December 2017 - Rev

Issued for Construction

HDR Project No. 10029382

Table of Contents

VOLUME I

DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

VOLUME II

DIVISION 26 - ELECTRICAL

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

DIVISION 31 - EARTHWORK

DIVISION 32 - EXTERIOR IMPROVEMENTS

DIVISION 40 - PROCESS INTERCONNECTIONS

DIVISION 43 - PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

DIVISION 46 - WATER AND WASTEWATER EQUIPMENT

SECTION 26 05 00

ELECTRICAL: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for electrical systems.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 05 50 00 - Metal Fabrications.
   5. Section 10 14 00 - Identification Devices.
   6. Section 26 05 19 - Wire and Cable: 600 Volt and Below.
   7. Section 26 05 33 - Raceways and Boxes.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Aluminum Association (AA).
   2. American Iron and Steel Institute (AISI).
   3. ASTM International (ASTM):
      a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   4. ETL Testing Laboratories (ETL).
   5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C2, National Electrical Safety Code (NESC).
   6. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   7. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   8. Underwriters Laboratories, Inc. (UL).

B. Where UL test procedures have been established for the product type, use UL or ETL approved electrical equipment and provide with the UL or ETL label.

1.3 DEFINITIONS

A. For the purposes of providing materials and installing electrical work the following definitions shall be used.
   1. Outdoor area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.
   2. Architecturally finished interior area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.
   3. Non-architecturally finished interior area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.
   4. Corrosive areas: Areas identified on the Drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or acidic agents, chemicals, chemical fumes or chemical mixtures.
   5. Hazardous areas: Class I, II or III areas as defined in NFPA 70.

6. Shop fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of submittal process.
   2. See Specification Section 40 05 05 and individual specification sections for submittal requirements for products defined as equipment.
   3. General requirements:
      a. Provide manufacturer's technical information on products to be used, including product descriptive bulletin.
      b. Include data sheets that include manufacturer's name and product model number.
         1) Clearly identify all optional accessories.
      c. Acknowledgement that products are UL or ETL listed or are constructed utilizing UL or ETL recognized components.
      d. Manufacturer's delivery, storage, handling and installation instructions.
      e. Product installation details.
      f. See individual specification sections for any additional requirements.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content process of Operation and Maintenance Manuals.

C. When a Specification Section includes products specified in another Specification Section, each Specification Section shall have the required Shop Drawing transmittal form per Specification Section 01 33 00 and all Specification Sections shall be submitted simultaneously.

1.5 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 01 65 50.

B. Protect nameplates on electrical equipment to prevent defacing.

1.6 AREA DESIGNATIONS

A. Designation of an area will determine the NEMA rating of the electrical equipment enclosures, types of conduits and installation methods to be used in that area.
   1. Outdoor areas:
      a. Wet.
      b. Also, corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.
   2. Indoor areas:
      a. Dry.
      b. Also, wet, corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, refer to specific Electrical Specification Sections and specific material paragraphs below for acceptable manufacturers.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

C. Provide all components of a similar type by one (1) manufacturer.

2.2 MATERIALS

A. Electrical Equipment Support Pedestals and/or Racks:
   1. Approved manufacturers:
      a. Modular strut:
         1) Unistrut Building Systems.
         2) Eaton B-Line.
         3) Globe Strut.
         4) Thomas & Betts Superstrut.
   2. Material requirements:
      a. Modular strut:
         1) Galvanized steel: ASTM A123/123M or ASTM A153/A153M.
         2) Stainless steel: AISI Type 316.
         3) Aluminum: AA Type 6063-T6.
      b. Structural members (e.g., I beams, L and C channels):
         1) Galvanized steel: ASTM A123/A123M.
         2) Aluminum: AA Type 6063-T6.
      c. Mounting plates:
         1) Galvanized steel: ASTM A123/A123M.
         2) Aluminum: AA Type 6063-T6.
      d. Mounting hardware:
         1) Galvanized steel.
         2) Stainless steel.
      e. Anchorage per Specification Section 05 50 00.

B. Field touch-up of galvanized surfaces.
   1. Zinc-rich primer.
      a. One (1) coat, 3.0 mils, ZRC by ZRC Products.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and wire all equipment, including prepurchased equipment, and perform all tests necessary to assure conformance to the Drawings and Specification Sections and ensure that equipment is ready and safe for energization.

B. Install equipment in accordance with the requirements of:
   1. NFPA 70.
   2. IEEE C2.
   3. The manufacturer's instructions.

C. In general, conduit routing is not shown on the Drawings.
   1. The Contractor is responsible for routing all conduits including those shown on one-line and control block diagrams and home runs shown on floor plans.
   2. Conduit routings and stub-up locations that are shown are approximate; exact routing to be as required for equipment furnished and field conditions.

D. When complete branch circuiting is not shown on the Drawings:
   1. A homerun indicating panelboard name and circuit number will be shown and the circuit number will be shown adjacent to the additional devices (e.g., light fixture and receptacles) on the same circuit.
   2. The Contractor is to furnish and install all conduit and conductors required for proper operation of the circuit.
   3. The indicated home run conduit and conductor size shall be used for the entire branch circuit.
   4. See Specification Section 26 05 19 for combining multiple branch circuits in a common conduit.

E. Do not use equipment that exceed dimensions or reduce clearances indicated on the Drawings or as required by the NFPA 70.

F. Install equipment plumb, square and true with construction features and securely fastened.

G. Install electrical equipment, including pull and junction boxes, minimum of 6 IN from process, gas, air and water piping and equipment.

H. Install equipment so it is readily accessible for operation and maintenance, is not blocked or concealed and does not interfere with normal operation and maintenance requirements of other equipment.

I. Avoid interference of electrical equipment operation and maintenance with structural members, building features and equipment of other trades.
   1. When it is necessary to adjust the intended location of electrical equipment, unless specifically dimensioned or detailed, the Contractor may make adjustments in equipment locations in accordance with the following without obtaining the Engineer's approval:
      a. 1 FT at grade, floor and roof level in any direction in the horizontal plane.
      b. 1 FT for equipment other than lighting at ceiling level in any direction in the horizontal plane.
      c. 1 FT for lighting fixtures at ceiling level in any direction in the horizontal plane.
      d. 1 FT on walls in a horizontal direction within the vertical plane.
      e. Changes in equipment location exceeding those defined above require the Engineer's approval.

J. Provide electrical equipment support system per the following area designations unless specifically indicated on the Drawings or noted otherwise in these specifications:
   1. Dry areas, including areas that are also designated as hazardous:
      a. Galvanized system consisting of galvanized steel channels and fittings, nuts and hardware.
      b. Field touch-up cut ends and scratches of galvanized components with the specified primer during the installation, before rust appears.
   2. Corrosive and/or wet areas, including areas that are also designated as hazardous:
      a. Aluminum system consisting of aluminum channels and fittings with stainless steel nuts and hardware.
      b. Stainless steel system consisting of stainless steel channels and fittings, nuts and hardware.

K. Provide all necessary anchoring devices and supports rated for the equipment load based on dimensions and weights verified from approved submittals, or as recommended by the manufacturer.
   1. See Specification Section 05 50 00.
   2. Do not cut, or weld to, building structural members.
   3. Do not mount safety switches or other equipment to equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.

L. Provide corrosion resistant spacers to maintain 1/4 IN separation between metallic equipment and/or metallic equipment supports and mounting surface in wet areas, on below grade walls and on walls of liquid containment or processing areas such as Basins, Clarifiers, Digesters, Storage Tanks, etc.

M. Do not place equipment fabricated from aluminum in direct contact with earth or concrete.

N. Screen or seal all openings into equipment mounted outdoors to prevent the entrance of rodents and insects.

O. Do not use materials that may cause the walls or roof of a building to discolor or rust.

P. Identify electrical equipment and components in accordance with Specification Section 10 14 00.

3.2 FIELD QUALITY CONTROL

A. Verify exact rough-in location and dimensions for connection to electrified equipment, provided by others.
   1. See Specification Section 01 73 20 for openings and penetrations in structures.

B. Replace equipment and systems found inoperative or defective and re-test.

C. Cleaning:
   1. See Specification Section 01 74 13.

D. The protective coating integrity of support structures and equipment enclosures shall be maintained.
   1. Repair galvanized components utilizing a zinc rich paint.
   2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
   3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the component.
   4. Repair surfaces which will be inaccessible after installation prior to installation.
   5. See Specification Section 26 05 33 for requirements for conduits and associated accessories.

E. Replace nameplates damaged during installation.

3.3 DEMONSTRATION

A. Demonstrate equipment in accordance with Specification Section 01 75 00.

END OF SECTION

SECTION 26 05 19

WIRE AND CABLE: 600 VOLT AND BELOW

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Building wire.
      b. Shielded VFD cable.
      c. Instrumentation cable.
      d. Wire connectors.
      e. Insulating tape.
      f. Pulling lubricant.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 – Identification Devices.
   4. Section 26 05 00 - Electrical: Basic Requirements.
   5. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Insulated Cable Engineers Association (ICEA):
      a. S-58-679, Standard for Control Cable Conductor Identification.
   2. National Electrical Manufacturers Association (NEMA):
      a. ICS 4, Industrial Control and Systems: Terminal Blocks.
   3. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
      a. WC 57/S-73-532, Standard for Control Cables.
      b. WC 70/S-95-658, Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   5. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
      a. 568, Commercial Building Telecommunications Cabling Standard.
   6. Underwriters Laboratories, Inc. (UL):
      a. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
      b. 83, Standard for Safety Thermoplastic-Insulated Wires and Cables.
      c. 467, Standard for Safety Grounding and Bonding Equipment.
      d. 486A, Standard for Safety Wire Connectors and Soldering Lugs for use with Copper Conductors.
      e. 486C, Standard for Safety Splicing Wire Connections.
      f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
      g. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
      h. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.
      i. 2250, Standard for Safety Instrumentation Tray Cable.

1.3 DEFINITIONS

A. Instrumentation Cable:

1. Multiple conductor, insulated, twisted or untwisted, with outer sheath.
2. The following are specific types of instrumentation cables:
    a. Analog signal cable:
        1) Used for the transmission of low current (e.g., 4-20mA DC) or low voltage (e.g., 0-10 Vdc) signals, using No. 16 AWG and smaller conductors.
        2) Commonly used types are defined in the following:
            a) TSP: Twisted shielded pair.
            b) TST: Twisted shielded triad.
    b. Digital signal cable: Used for the transmission of digital signals between computers, PLC's, RTU's, etc.

B. VFD Cable: Multi-conductor, insulated, with shield, drain wire and building wires, No. 12 AWG and larger.

C. Building Wire: Single conductor, insulated, with or without outer jacket depending upon type.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data:
    a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
        1) Wire connectors.
        2) Insulating tape.
        3) Cable lubricant.
    b. See Specification Section 26 05 00 for additional requirements.

B. Samples:
1. Provide sample of largest size of each type of wire or cable for review prior to installation.
    a. Sample shall have a legible and complete surface printing of identification.

1.5 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Building wire:
    a. Aetna Insulated Wire.
    b. Alphawire.
    c. Cerrowire.
    d. Encore Wire Corporation.
    e. General Cable.
    f. Okonite Company.
    g. Southwire Company.
2. Instrumentation cable:
    a. Analog cable:
        1) Alphawire.
        2) Belden Inc.
        3) General Cable.
3. Wire connectors:
    a. Burndy Corporation.
    b. Buchanan.

c. Ideal.
d. Ilsco.
e. 3M Co.
f. Teledyne Penn Union.
g. Thomas and Betts.
h. Phoenix Contact.

4. Insulating and color coding tape:
   a. 3M Co.
   b. Plymouth Bishop Tapes.
   c. Red Seal Electric Co.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MANUFACTURED UNITS

A. Building Wire:
1. Conductor shall be copper with 600 V rated insulation.
2. Conductors shall be stranded.
   a. Conductors, sized #12 AWG used only in lighting and receptacle circuits, may be stranded or solid.
3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
4. When direct buried, UL listed and marked as suitable for direct bury.
5. When exposed to sunlight, UL listed and marked as sunlight resistant.
6. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 for type THHN/THWN and THHN/THWN-2 insulation.
7. Conform to NEMA/ICEA WC 70/S-95-658 and UL 44 for type XHHW-2 insulation.

B. Electrical Equipment Control Wire:
1. Conductor shall be copper with 600 V rated insulation.
2. Conductors shall be stranded.
3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
4. Conform to UL 44 for Type SIS insulation.
5. Conform to UL 83 for Type MTW insulation.

C. Instrumentation Cable:
1. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
2. Analog cable:
   a. Tinned copper conductors.
   b. 600 V PVC insulation with PVC jacket.
   c. Twisted pair(s) or triad(s) with 100 percent aluminum-polyester foil shield coverage with stranded drain wire.
   d. Six (6) twists per foot minimum.
   e. When direct buried, UL listed and marked as suitable for direct bury.
   f. When exposed to sunlight, UL listed and marked as sunlight resistant.
   g. Individual conductor color coding: ICEA S-58-679, Method 1, Table E-2.
   h. Conform to UL 2250, UL 1581 and NFPA 70 Type ITC.
3. Digital cable:
   a. As recommended by equipment (e.g., PLC, RTU) manufacturer.
   b. Horizontal voice and data cable:
      1) Category 6 per TIA/EIA/ANSI 568.
      2) Cable shall be label-verified.
      3) Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level.
      4) Conductors: No. 24 AWG solid untinned copper.
      5) Rated CMP per NFPA 70.

c. Conform to NFPA 262 and NFPA 70 Type ITC.

D. Wire Connectors:
1. Twist/screw on type:
a. Insulated pressure or spring type solderless connector.
b. 600 V rated.
c. Ground conductors: Conform to UL 486C and/or UL 467 when required by local codes.
d. Phase and neutral conductors: Conform to UL 486C.
2. Compression and mechanical screw type:
a. 600 V rated.
b. Ground conductors: Conform to UL 467.
c. Phase and neutral conductors: Conform to UL 486A.
3. Terminal block type:
a. High density, screw-post barrier-type with white center marker strip.
b. 600 V and ampere rating as required, for power circuits.
c. 600 V, 20 ampere rated for control circuits.
d. 300 V, 15 ampere rated for instrumentation circuits.
e. Conform to NEMA ICS 4 and UL 486A.

E. Insulating and Color Coding Tape:
1. Pressure sensitive vinyl.
2. Premium grade.
3. Heat, cold, moisture, and sunlight resistant.
4. Thickness, depending on use conditions: 7, 8.5, or 10 mil.
5. For cold weather or outdoor location, tape must also be all-weather.
6. Color:
a. Insulating tape: Black.
b. Color coding tape: Fade-resistant color as specified herein.
7. Comply with UL 510.

F. Pulling Lubricant: Cable manufacturer's standard containing no petroleum or other products which will deteriorate insulation.

G. Wire Markers: See Section 10 14 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. When complete branch circuiting is not indicated on the Drawings:
1. A homerun indicating panelboard name and circuit number will be indicated and the circuit number will be indicated adjacent to the additional devices (e.g., light fixture and receptacles) on the same circuit.
2. The Contractor is to furnish and install all conduit and conductors required for proper operation of the circuit.
3. The indicated homerun conduit and conductor size shall be used for the entire branch circuit.

B. Permitted Usage of Insulation Types:
1. Type XHHW-2:
a. Building wire No. 6 AWG and larger.
2. Type THHN/THWN and THHN/THWN-2:
a. Building wire No. 8 AWG and smaller.
3. Type SIS and MTW:
a. For the wiring of control equipment within control panels and field wiring of control equipment within switchgear, switchboards, motor control centers.

C. Conductor Size Limitations:

1. Feeder and branch power conductors shall not be smaller than No. 12 AWG unless otherwise indicated on the Drawings.
2. Control conductors shall not be smaller than No. 14 AWG unless otherwise indicated on the Drawings.
3. Instrumentation conductors shall not be smaller than No. 18 AWG unless otherwise indicated on the Drawings.

D. Color Code All Wiring as Follows:
   1. Building wire:

	240 V, 208 V, 240/120 V, 208/120 V	480 V, 480/277 V
Phase 1	Black	Brown
Phase 2	Red *	Orange
Phase 3	Blue	Yellow
Neutral	White	White or Gray
Ground	Green	Green

* Orange when it is a high leg of a 120/240 V Delta system.

      a. Conductors No. 6 AWG and smaller: Insulated phase, neutral and ground conductors shall be identified by a continuous colored outer finish along its entire length.
      b. Conductors larger than No. 6 AWG:
         1) Insulated phase and neutral conductors shall be identified by one (1) of the following methods:
            a) Continuous colored outer finish along its entire length.
            b) 3 IN of colored tape applied at the termination.
         2) Insulated grounding conductor shall be identified by one (1) of the following methods:
            a) Continuous green outer finish along its entire length.
            b) Stripping the insulation from the entire exposed length.
            c) Using green tape to cover the entire exposed length.
         3) The color coding shall be applied at all accessible locations, including but not limited to: Junction and pull boxes, wireways, manholes and handholes.

E. Install all wiring in raceway unless otherwise indicated on the Drawings.

F. Feeder, branch, control and instrumentation circuits shall not be combined in a raceway, cable tray, junction or pull box, except as permitted in the following:
   1. Where specifically indicated on the Drawings.
   2. Where field conditions dictate and written permission is obtained from the Engineer.
   3. AC control circuits shall be isolated from all DC circuits.
   4. Instrumentation circuits shall be isolated from feeder and branch power and AC control circuits but combining of instrumentation circuits is permitted.
      a. The combinations shall comply with the following:
         1) Analog signal circuits may be combined.
         2) Digital signal circuits may be combined but isolated from analog signal circuits.
   5. Multiple branch circuits for lighting, receptacle and other 120 Vac circuits are allowed to be combined into a common raceway.
      a. Contractor is responsible for making the required adjustments in conductor and raceway size, in accordance with all requirements of the NFPA 70, including but not limited to:
         1) Up sizing conductor size for required ampacity de-ratings for the number of current carrying conductors in the raceway.
         2) The neutral conductor may be shared on sequential 277V lighting circuits (e.g., circuit numbers 1,3,5) if multiple circuit breakers are provided.
         3) Up sizing raceway size for the size and quantity of conductors.

G. Ground the drain wire of shielded instrumentation cables at one (1) end only.
   1. The preferred grounding location is at the load (e.g., control panel), not at the source (e.g., field mounted instrument).

H. Splices and terminations for the following circuit types shall be made in the indicated enclosure type using the indicated method.
   1. Feeder and branch power circuits:
      a. Device outlet boxes:
         1) Twist/screw on type connectors.
      b. Junction and pull boxes and wireways:
         1) Twist/screw on type connectors for use on No. 8 and smaller wire.
         2) Compression, mechanical screw or terminal block or terminal strip type connectors for use on No. 6 AWG and larger wire.
      c. Motor terminal boxes:
         1) Twist/screw on type connectors for use on No. 10 AWG and smaller wire.
         2) Insulated mechanical screw type connectors for use on No. 8 AWG and larger wire.
      d. Manholes or handholes:
         1) Twist/screw on type connectors pre-filled with epoxy for use on No. 8 AWG and smaller wire.
         2) Watertight compression or mechanical screw type connectors for use on No. 6 AWG and larger wire.
   2. Control circuits:
      a. Junction and pull boxes: Terminal block type connector.
      b. Manholes or handholes: Twist/screw on type connectors pre-filled with epoxy.
      c. Control panels and motor control centers: Terminal block or strips provided within the equipment or field installed within the equipment by the Contractor.
   3. Instrumentation circuits can be spliced where field conditions dictate and written permission is obtained from the Engineer.
      a. Maintain electrical continuity of the shield when splicing twisted shielded conductors.
      b. Junction and pull boxes: Terminal block type connector.
      c. Control panels and motor control centers: Terminal block or strip provided within the equipment or field installed within the equipment by the Contractor.
   4. Non-insulated compression and mechanical screw type connectors shall be insulated with tape or hot or cold shrink type insulation to the insulation level of the conductors.

I. Insulating Tape Usage:
   1. For insulating connections of No. 8 AWG wire and smaller: 7 mil vinyl tape.
   2. For insulating splices and taps of No. 6 AWG wire or larger: 10 mil vinyl tape.
   3. For insulating connections made in cold weather or in outdoor locations: 8.5 mil, all-weather vinyl tape.

J. Color Coding Tape Usage: For color coding of conductors.

K. Kellums, or equal, woven grips shall support wire and cable in vertical risers where necessary to prevent heavy loading on wire or cable connections.

L. Wire and cable shall not be pulled tight against bushings nor pressed heavily against enclosures.

M. After wire and cable have been installed and connected, conduit ends shall be sealed with a non-hardening sealing compound (Duxseal or equal), forced into conduits to a minimum depth equal to the conduit diameter. This shall apply for all conduits, including spares, entering any structures or electrical enclosures from underground, or from wet/corrosive areas.

N. Tag wires with wire markers in control panels, electrical gear, terminal boxes: See Section 10 14 00.

O. Tag wires with wire markers in cable vaults, cable trays, manholes and handholes: See Section 10 14 00.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing:
   1. See Specification Section 26 08 13.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for grounding and bonding system(s).

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 - Identification Devices.
   4. Section 26 05 00 - Electrical: Basic Requirements.
   5. Section 26 05 19 - Wire and Cable: 600 Volt and Below.
   6. Section 26 05 33 - Raceways and Boxes.
   7. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL):
      a. 467, Grounding and Bonding Equipment.

B. Assure ground continuity is continuous throughout the entire Project.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data.
      a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
         1) Grounding clamps, terminals and connectors.
         2) Exothermic welding system.
      b. See Specification Section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Ground rods and bars and grounding clamps, connectors and terminals:
      a. Erico Products, Inc.
      b. Harger Lightning & Grounding.
      c. Heary Brothers.
      d. Hubbell - Burndy.
      e. Robbins Lightning Protection.

f. Thomas & Betts - Blackburn.
g. Thompson Lightning Protection.
2. Exothermic weld connections:
a. Erico Products Inc., Cadweld.
b. Harger Lightning & Grounding - Ultraweld.
c. Hubbell - Burndy (Thermoweld).
d. Thomas & Betts - Furseweld.

2.2 COMPONENTS

A. Wire and Cable:
1. Bare conductors: Soft drawn stranded copper meeting ASTM B8.
2. Insulated conductors: Color coded green, per Specification Section 26 05 19.

B. Conduit: As specified in Specification Section 26 05 33.

C. Ground Rods:
1. 3/4 IN x 10 FT.
2. Copper-clad:
a. 10 mil minimum uniform coating of electrolytic copper molecularly bonded to a rigid steel core.
b. Corrosion resistant bond between the copper and steel.
c. Hard drawn for a scar-resistant surface.

D. Grounding Clamps, Connectors and Terminals:
1. Mechanical type:
a. Standards: UL 467.
b. High copper alloy content.
2. Compression type for interior locations:
a. Standards: UL 467.
b. High copper alloy content.
c. Non-reversible.
d. Terminals for connection to bus bars shall have two bolt holes.
3. Compression type suitable for direct burial in earth or concrete:
a. Standards: UL 467, IEEE 837.
b. High copper alloy content.
c. Non-reversible.
d. Factory filled with oxide inhibiting compound.

E. Exothermic Weld Connections:
1. Copper oxide reduction by aluminum process.
2. Molds properly sized for each application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
1. Install products in accordance with manufacturer's instructions.
2. Size grounding conductors and bonding jumpers in accordance with NFPA 70, Article 250, except where larger sizes are indicated on the Drawings.
3. Remove paint, rust, or other non-conducting material from contact surfaces before making ground connections.
4. Where ground conductors pass through floor slabs or building walls provide nonmetallic sleeves and install per Specification Section 01 73 20.
5. Do not splice grounding conductors except at ground rods.
6. Install ground rods and grounding conductors in undisturbed, firm soil.
a. Provide excavation required for installation of ground rods and ground conductors.

b. Use driving studs or other suitable means to prevent damage to threaded ends of sectional rods.
c. Unless otherwise specified, connect conductors to ground rods with compressor type connectors or exothermic weld.
d. Provide sufficient slack in grounding conductor to prevent conductor breakage during backfill or due to ground movement.
e. Backfill excavation completely, thoroughly tamping to provide good contact between backfill materials and ground rods and conductors.

7. Do not use exothermic welding if it will damage the structure the grounding conductor is being welded to.

B. Grounding Electrode System:
1. Provide a grounding electrode system in accordance with NFPA 70, Article 250 and as indicated on the Drawings.
2. Grounding conductor terminations:
a. Ground bars in electrical equipment, use compression type terminal and bolt it to the ground bar.
b. Piping systems use mechanical type connections.
c. Building steel, below grade and encased in concrete, use compression type connector or exothermic weld.
d. At all above grade terminations, the conductors shall be labeled per Specification Section 10 14 00.
3. Ground ring grounding system:
a. Ground ring consists of ground rods and a grounding conductor looped around the structure.
b. Placed at a minimum of 5 FT from the structure foundation and 2 FT-6 IN below grade.
c. Provide a minimum of four (4) ground rods placed at the corners of the structure and additional rods so that the maximum distance between ground rods does not exceed 50 FT.
d. Building/Structure grounding:
1) Bond building/structure metal support columns to the ground ring at all corners of the structure.
e. Grounding conductor: Bare conductor, size as indicated on the Drawings.

C. Supplemental Grounding Electrode:
1. Provide the following grounding in addition to the equipment ground conductor supplied with the feeder conductors whether or not shown on the Drawings.
2. Metal light poles:
a. Connect metal pole to a ground rod.
b. Grounding conductor: Bare #6 AWG minimum.
3. Equipment support rack and pedestals mounted outdoors:
a. Connect metallic structure to a ground rod.
b. Grounding conductor: #6 AWG minimum.

D. Low Voltage Transformer Separately Derived Grounding System:
1. Ground separately mounted step-down transformers XO terminal to one of the following:
a. Closest building steel using mechanical type terminal bolted to the steel, compression type connection or exothermic weld.
b. Closest water pipe using a mechanical type connection.
2. Ground step-down transformer integrally mounted in motor control center to motor control center ground bus.

E. Raceway Bonding/Grounding:
1. All metallic conduit shall be installed so that it is electrically continuous.
2. All conduits to contain a grounding conductor with insulation identical to the phase conductors, unless otherwise indicated on the Drawings.
3. NFPA 70 required grounding bushings shall be of the insulating type.
4. Provide double locknuts at all panels.

5. Bond all conduit, at entrance and exit of equipment, to the equipment ground bus or lug.
6. Provide bonding jumpers if conduits are installed in concentric knockouts.
7. Make all metallic raceway fittings and grounding clamps tight to ensure equipment grounding system will operate continuously at ground potential to provide low impedance current path for proper operation of overcurrent devices during possible ground fault conditions.

F. Equipment Grounding:
1. All utilization equipment shall be grounded with an equipment ground conductor.

G. Manhole and Handhole Grounding:
1. Provide a ground rod and ground bar, when indicated or as needed, in each manhole and handhole with exposed metal parts.
   a. Expose a minimum of 4 IN of the rod above the floor for field connections to the rod.
2. Connect all exposed metal parts (e.g., conduits and cable racks) to the ground rod.
3. Connect any separate bare grounding conductors run underneath or within ductbank encasement to the ground rod.

3.2 FIELD QUALITY CONTROL

A. Leave grounding system uncovered until observed by Owner.

B. Acceptance testing:
1. See Specification Section 26 08 13.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Conduits.
      b. Conduit fittings.
      c. Conduit supports.
      d. Wireways.
      e. Outlet boxes.
      f. Pull and junction boxes.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 05 19 - Wire and Cable: 600 Volt and Below.
   5. Section 26 05 43 - Electrical: Exterior Underground.
   6. Section 26 27 26 - Wiring Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Iron and Steel Institute (AISI).
   2. ASTM International (ASTM):
      a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
      c. D2564, Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit (IMC).
      c. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
      d. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   4. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. C80.1, Electric Rigid Steel Conduit (ERSC).
      b. C80.5, Electrical Aluminum Rigid Conduit.
      c. OS 1, Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   6. Underwriters Laboratories, Inc. (UL):
      a. 1, Standard for Flexible Metal Conduit.
      b. 6, Standard for Electrical Rigid Metal Conduit - Steel.
      c. 50, Enclosures for Electrical Equipment, Non-Environmental Considerations.
      d. 360, Standard for Liquid-Tight Flexible Steel Conduit.
      e. 467, Grounding and Bonding Equipment.
      f. 514A, Metallic Outlet Boxes.
      g. 514B, Conduit, Tubing, and Cable Fittings.

h. 651, Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
i. 797, Electrical Metallic Tubing - Steel.
j. 870, Standard for Wireways, Auxiliary Gutters, and Associated Fittings.
k. 886, Standard for Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

1.3 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data:
a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
1) Conduit fittings.
2) Support systems.
b. See Specification Section 26 05 00 for additional requirements.
3. Fabrication and/or layout drawings:
a. Identify dimensional size of pull and junction boxes to be used.

1.4 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Rigid metallic conduits:
a. Allied Tube and Conduit Corporation.
b. Triangle PWC Inc.
c. Western Tube and Conduit Corporation.
d. Wheatland Tube Company.
e. LTV Steel Company.
f. EASCO Aluminum.
g. Indalex.
h. VAW of American, Inc.
2. PVC coated rigid metallic conduits:
a. Thomas & Betts Ocal.
b. Rob-Roy Ind.
3. Rigid nonmetallic conduit:
a. Prime Conduit (Carlon).
b. Cantex.
c. Osburn Associates.
4. Flexible conduit:
a. AFC Cable Systems.
b. Anamet, Inc.
c. Electri-Flex.
d. Flexible Metal Hose Company.
e. International Metal Hose Company.
f. Triangle PWC Inc.
g. LTV Steel Company.
5. Wireway:
a. Hoffman Engineering Company.
b. Wiegmann.
c. Square D.

6. Conduit fittings and accessories:
    a. Appleton Electric Co.
    b. Carlon.
    c. Cantex.
    d. Crouse-Hinds.
    e. Killark.
    f. Osburn Associates.
    g. OZ Gedney Company.
    h. RACO.
    i. Steel City.
    j. Thomas & Betts.
7. Support systems:
    a. Unistrut Building Systems.
    b. Eaton B-Line.
    c. Kindorf.
    d. Minerallac Fastening Systems.
    e. Caddy.
    f. Thomas & Betts Superstrut.
8. Outlet, pull and junction boxes:
    a. Appleton Electric Co.
    b. Eaton Crouse-Hinds.
    c. Killark.
    d. O-Z/Gedney.
    e. Thomas & Betts Steel City.
    f. Raco.
    g. Bell.
    h. Hoffman Engineering Co.
    i. Wiegmann.
    j. Eaton B-Line.
    k. Adalet.
    l. Rittal.
    m. Stahlin.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 RIGID METALLIC CONDUITS

A. Rigid Galvanized Steel Conduit (RGS):
1. Mild steel with continuous welded seam.
2. Metallic zinc applied by hot-dip galvanizing or electro-galvanizing.
3. Threads galvanized after cutting.
4. Internal coating: Baked lacquer, varnish or enamel for a smooth surface.
5. Standards: NEMA/ANSI C80.1, UL 6.

B. PVC-Coated Rigid Steel Conduit (PVC-RGS):
1. Nominal 40 mil Polyvinyl Chloride Exterior Coating:
    a. Coating: Bonded to hot-dipped galvanized rigid steel conduit conforming to NEMA/ANSI C80.1.
    b. The bond between the PVC coating and the conduit surface: Greater than the tensile strength of the coating.
2. Nominal 2 mil, minimum, urethane interior coating.
3. Urethane coating on threads.
4. Conduit: Epoxy prime coated prior to application of PVC and urethane coatings.
5. Female Ends:
    a. Have a plastic sleeve extending a minimum of 1 pipe diameter or 2 IN, whichever is less beyond the opening.
    b. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used with it.

6. Standards: NEMA/ANSI C80.1, UL 6, NEMA RN 1.

C. Rigid Aluminum Conduit (RAC):
   1. AA Type 6063 aluminum alloy, T-1 temper.
   2. Maximum copper content of 0.10 percent.
   3. Extruded, seamless.
   4. Standards: NEMA/ANSI C80.5, UL 6.

2.3 RIGID NONMETALLIC CONDUIT

A. Schedules 40 (PVC-40) and 80 (PVC-80):
   1. Polyvinyl-chloride (PVC) plastic compound which includes inert modifiers to improve weatherability and heat distribution.
   2. Rated for direct sunlight exposure.
   3. Fire retardant and low smoke emission.
   4. Shall be suitable for use with 90 DegC wire and shall be marked "maximum 90 DegC".
   5. Standards: NEMA TC 2, UL 651.

2.4 FLEXIBLE CONDUIT

A. Flexible Galvanized Steel Conduit (FLEX):
   1. Formed of continuous, spiral wound, hot-dip galvanized steel strip with successive convolutions securely interlocked.
   2. Standard: UL 1.

B. PVC-Coated Flexible Galvanized Steel (liquid-tight) Conduit (FLEX-LT):
   1. Core formed of continuous, spiral wound, hot-dip galvanized steel strip with successive convolutions securely interlocked.
   2. Extruded PVC outer jacket positively locked to the steel core.
   3. Liquid and vaportight.
   4. Standard: UL 360.

2.5 WIREWAY

A. General:
   1. Suitable for lay-in conductors.
   2. Designed for continuous grounding.
   3. Covers:
      a. Hinged or removable in accessible areas.
      b. Non-removable when passing through partitions.
   4. Finish: Rust inhibiting primer and manufacturers standard paint inside and out except for stainless steel type.
   5. Standards: UL 870, NEMA 250.

B. General Purpose (NEMA 1 rated) Wireway:
   1. 14 or 16 gage steel without knockouts.
   2. Cover: Solid, non-gasketed and held in place by captive screws.

C. Watertight (NEMA 4X rated) Wireway:
   1. 14 GA Type 304 or 316 stainless steel bodies and covers without knockouts and 10 GA stainless steel flanges.
   2. Cover: Fully gasketed and held in place with captive clamp type latches.
   3. Flanges: Fully gasketed and bolted.

D. Dusttight (NEMA 12 rated) Wireway:
   1. 14 GA steel bodies and covers without knockouts and 10 GA steel flanges.
   2. Cover: Fully gasketed and held in place with captive clamp type latches.
   3. Flanges: Fully gasketed and bolted.

2.6 CONDUIT FITTINGS AND ACCESSORIES

A. Fittings for Use with RGS and RAC:

1. General:
   a. In hazardous locations listed for use in Class I, Groups C and D locations.
2. Locknuts:
   a. RGS: Threaded steel or malleable iron.
   b. RAC: Threaded stainless steel.
   c. Gasketed or non-gasketed.
   d. Grounding or non-grounding type.
3. Bushings:
   a. Threaded, insulated metallic.
   b. Grounding or non-grounding type.
4. Hubs: Threaded, insulated and gasketed metallic for raintight connection.
5. Couplings:
   a. Threaded straight type: Same material and finish as the conduit with which they are used on.
6. Unions:
   a. RGS: Threaded galvanized steel or zinc plated malleable iron.
   b. RAC: Threaded copper-free cast aluminum.
7. Conduit bodies (ells and tees):
   a. Body: Zinc plated cast iron (RGS) or cast copper free aluminum (RAC) with threaded hubs.
   b. Standard and mogul size.
   c. Cover:
      1) Clip-on type with stainless steel screws.
      2) Gasketed or non-gasketed galvanized steel or zinc plated cast iron (RGS); cast copper free aluminum (RAC).
8. Conduit bodies (round):
   a. Body: Zinc plated cast iron (RGS) or cast copper free aluminum (RAC) with threaded hubs.
   b. Cover: Threaded screw on type, gasketed, galvanized steel or zinc plated cast iron (RGS); cast copper free aluminum(RAC).
9. Sealing fittings:
   a. Body: Zinc plated cast iron (RGS) or cast copper free aluminum (RAC) with threaded hubs.
   b. Standard and mogul size.
   c. With or without drain and breather.
   d. Fiber and sealing compound: UL listed for use with the sealing fitting.
10. Hazardous location flexible coupling (HAZ-FLEX):
   a. Liquid tight and arc resistant.
   b. Electrically conductive so no bonding jumper is required.
   c. Dry areas:
      1) Bronze braided covering over flexible brass core.
      2) Bronze end fittings.
      3) Zinc-plated steel or malleable iron unions and nipples.
   d. Wet and/or corrosive areas:
      1) Stainless steel braided covering over flexible stainless steel core.
      2) Stainless steel end fittings.
      3) Aluminum unions and nipples.
11. Service entrance head:
   a. Malleable iron, galvanized steel (RGS) or copper free aluminum (RAC).
   b. Insulated knockout cover for use with a variety of sizes and number of conductors.
12. Expansion couplings:
   a. 2 IN nominal straight-line conduit movement in either direction.
   b. RGS: Galvanized steel with insulated bushing.
   c. RAC: Cast copper-free aluminum with insulated bushing.
   d. Gasketed for wet locations.
   e. Internally or externally grounded.

13. Expansion/deflection couplings:
    a. 3/4 IN nominal straight-line conduit movement in either direction.
    b. 30-degree nominal deflection from the normal in all directions.
    c. Metallic hubs, neoprene outer jacket and stainless steel jacket clamps.
    d. Internally or externally grounded.
    e. Watertight, raintight and concrete tight.
14. Standards: UL 467, UL 514B, UL 886.

B. Fittings for Use with PVC-RGS:
1. The same material and construction as those fittings listed under paragraph "Fittings for Use with RGS and RAC" and coated as defined under paragraph "PVC Coated Rigid Steel Conduit (PVC-RGS)."

C. Fittings for Use with FLEX:
1. Connector:
    a. Zinc plated malleable iron.
    b. Squeeze or clamp-type.
2. Standard: UL 514B.

D. Fittings for Use with FLEX-LT:
1. Connector:
    a. Straight or angle type.
    b. Metal construction, insulated and gasketed.
    c. Composed of locknut, grounding ferrule and gland compression nut.
    d. Liquid tight.
2. Standards: UL 467, UL 514B.

E. Fittings for Use with Rigid Nonmetallic PVC Conduit:
1. Coupling, adapters and conduit bodies:
    a. Same material, thickness, and construction as the conduits with which they are used.
    b. Homogeneous plastic free from visible cracks, holes or foreign inclusions.
    c. Bore smooth and free of blisters, nicks or other imperfections which could damage the conductor.
2. Solvent cement for welding fittings shall be supplied by the same manufacturer as the conduit and fittings.
3. Standards: ASTM D2564, NEMA TC 3, UL 651, UL 514B.

F. Weather and Corrosion Protection Tape:
1. PVC based tape, 10 mils thick.
2. Protection against moisture, acids, alkalis, salts and sewage and suitable for direct bury.
3. Used with appropriate pipe primer.

2.7 ALL RACEWAY AND FITTINGS

A. Mark Products:
1. Identify the nominal trade size on the product.
2. Stamp with the name or trademark of the manufacturer.

2.8 OUTLET BOXES

A. Metallic Outlet Boxes:
1. Hot-dip galvanized steel.
2. Conduit knockouts and grounding pigtail.
3. Styles:
    a. 2 IN x 3 IN rectangle.
    b. 4 IN square.
    c. 4 IN octagon.
    d. Masonry/tile.
4. Accessories:
    a. Flat blank cover plates.

b. Barriers.
c. Extension, plaster or tile rings.
d. Box supporting brackets in stud walls.
e. Adjustable bar hangers.

5. Standards: NEMA/ANSI OS 1, UL 514A.

B. Cast Outlet Boxes:

1. Zinc plated cast iron or die-cast copper free aluminum with manufacturer's standard finish.
2. Threaded hubs and grounding screw.
3. Styles:
   a. "FS" or "FD".
   b. "Bell".
   c. Single or multiple gang and tandem.
   d. "EDS" or "EFS" for hazardous locations.
4. Accessories: 40 mil PVC exterior coating and 2 mil urethane interior coating.
5. Standards: UL 514A, UL 886.

C. Nonmetallic Outlet Boxes:

1. Polyvinyl-chloride (PVC) plastic compound.
2. Rated for direct sunlight exposure.
3. Fire retardant and low smoke emission.
4. Suitable for use with 90 DegC wire.
5. Styles:
   a. "FS" or "FD".
   b. Single or multiple gang.
6. Standards: UL 514A, NEMA TC 3.

D. See Specification Section 26 27 26 for wiring devices, wallplates and coverplates.

2.9 PULL AND JUNCTION BOXES

A. NEMA 1 Rated:

1. Body and cover: 14 GA minimum, galvanized steel or 14 GA minimum, steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
2. With or without concentric knockouts on four (4) sides.
3. Flat cover fastened with screws.

B. NEMA 4X Rated (metallic):

1. Body and cover: 14 GA Type 304 or 316 stainless steel.
2. Seams continuously welded and ground smooth.
3. No knockouts.
4. External mounting flanges.
5. Hinged door and stainless steel screws and clamps.
6. Door with oil-resistant gasket.

C. NEMA 4X Rated (Nonmetallic):

1. Body and cover: Ultraviolet light protected fiberglass-reinforced polyester boxes.
2. No knockouts.
3. External mounting flanges.
4. Hinged door with quick release latches and padlocking hasp.
5. Door with oil resistant gasket.

D. NEMA 7 Rated:

1. Cast gray iron alloy or copper-free aluminum with manufacturer's standard finish.
2. Drilled and tapped openings or tapered threaded hub.
3. Cover bolted-down with stainless steel bolts or threaded cover with neoprene gasket.
4. External mounting flanges.
5. Grounding lug.
6. Accessories: 40 mil PVC exterior coating and 2 mil urethane interior coating.

E. NEMA 12 Rated:
   1. Body and cover:
      a. 14 GA steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
      b. Type 5052 H-32 aluminum, unpainted.
   2. Seams continuously welded and ground smooth.
   3. No knockouts.
   4. External mounting flanges.
   5. Non-hinged cover held closed with captivated cover screws threaded into sealed wells or hinged cover held closed with stainless steel screws and clamps.
   6. Flat door with oil resistant gasket.

F. Miscellaneous Accessories:
   1. Rigid handles for covers larger than 9 SF or heavier than 25 LBS.
   2. Split covers when heavier than 25 LBS.
   3. Weldnuts for mounting optional panels and terminal kits.
   4. Terminal blocks: Screw-post barrier-type, rated 600 volt and 20 ampere minimum.

G. Standards: NEMA 250, UL 50.

2.10 SUPPORT SYSTEMS

A. Multi-conduit Surface or Trapeze Type Support and Pull or Junction Box Supports:
   1. Material requirements.
      a. Galvanized steel: ASTM A123/A123M or ASTM A153/A153M.
      b. Stainless steel: AISI Type 316.
      c. Aluminum: AA Type 6063-T6.

B. Single Conduit and Outlet Box Support Fasteners:
   1. Material requirements:
      a. Zinc plated steel.
      b. Stainless steel.
      c. Malleable iron.
      d. Steel protected with zinc phosphate and oil finish.

2.11 OPENINGS AND PENETRATIONS IN WALLS AND FLOORS

A. Sleeves, smoke and fire stop fitting through walls and floors:
   1. See Specification Section 01 73 20.

PART 3 - EXECUTION

3.1 RACEWAY INSTALLATION - GENERAL

A. Shall be in accordance with the requirements of:
   1. NFPA 70.
   2. Manufacturer instructions.

B. Size of Raceways:
   1. Raceway sizes are shown on the Drawings, if not shown on the Drawings, then size in accordance with NFPA 70.
   2. Unless specifically indicated otherwise, the minimum raceway size shall be:
      a. Conduit: 3/4 IN.
      b. Wireway: 2-1/2 IN x 2-1/2 IN.

C. Field Bending and Cutting of Conduits:
   1. Utilize tools and equipment recommended by the manufacturer of the conduit, designed for the purpose and the conduit material to make all field bends and cuts.
   2. Do not reduce the internal diameter of the conduit when making conduit bends.
   3. Prepare tools and equipment to prevent damage to the PVC coating.

4. Degrease threads after threading and apply a zinc rich paint.
5. Debur interior and exterior after cutting.

D. Male threads of conduit systems shall be coated with an electrically conductive anti-seize compound.

E. The protective coating integrity of conduits, fittings, outlet, pull and junction boxes and accessories shall be maintained.
1. Repair galvanized components utilizing a zinc rich paint.
2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the conduit; or a self-adhesive, highly conformable, cross-linked silicone composition strip, followed by a protective coating of vinyl tape.
    a. Total nominal thickness: 40 mil.
4. Repair surfaces which will be inaccessible after installation prior to installation.

F. Remove moisture and debris from conduit before wire is pulled into place.
1. Pull mandrel with diameter nominally 1/4 IN smaller than the interior of the conduit, to remove obstructions.
2. Swab conduit by pulling a clean, tight-fitting rag through the conduit.
3. Tightly plug ends of conduit with tapered wood plugs or plastic inserts until wire is pulled.

G. Only nylon or polyethylene rope shall be used to pull wire and cable in conduit systems.

H. Where portions of a raceway are subject to different temperatures and where condensation is known to be a problem, as in cold storage areas of buildings or where passing from the interior to the exterior of a building, the raceway shall be sealed to prevent circulation of warm air to colder section of the raceway.

I. Fill openings in walls, floors, and ceilings and finish flush with surface.
1. See Specification Section 01 73 20.

3.2 RACEWAY ROUTING

A. Raceways shall be routed in the field unless otherwise indicated.
1. In general, conduit routing is not indicated on the Drawings:
    a. The Contractor is responsible for routing all conduits including those indicated on one-line and control block diagrams and homeruns indicated on floor plans.
    b. Conduit routings and stub-up locations that are indicated are approximate; exact routing to be as required for equipment furnished and field conditions.
2. Conduit and fittings shall be installed, as required, for a complete system that has a neat appearance and is in compliance with all applicable codes.
3. Run in straight lines parallel to or at right angles to building lines.
4. Do not route conduits:
    a. Through areas of high ambient temperature or radiant heat.
    b. In suspended concrete slabs.
5. Conduit shall not interfere with, or prevent access to, piping, valves, ductwork, or other equipment for operation, maintenance and repair.
6. Provide pull boxes or conduit bodies as needed so that there is a maximum of 360 degrees of bends in the conduit run or in long straight runs to limit pulling tensions.

B. All rigid conduits within a structure shall be installed exposed except as follows:
1. As indicated on the Drawings.
2. Concealed above gypsum wall board or acoustical tile suspended ceilings.
3. Concealed within stud frame, poured concrete, concrete block and brick walls of an architecturally finished area.
4. Embedded in floor slabs or buried under floor slabs where shown on the Contract Drawings or with the Engineer's permission.

C. Maintain minimum spacing between parallel conduit and piping runs in accordance with the following when the runs are greater than 30 FT:
   1. Between instrumentation and telecommunication: 1 IN.
   2. Between instrumentation and 600 V and less AC power or control: 6 IN.
   3. Between telecommunication and 600 V and less AC power or control: 6 IN.
   4. Between 24 Vdc and 600 V and less AC power or control: 2 IN.
   5. Between process, gas, air and water pipes: 6 IN.

D. Conduits shall be installed to eliminate moisture pockets.
   1. Where water cannot drain to openings, provide drain fittings in the low spots of the conduit run.

E. Conduit shall not be routed on the exterior of structures except as specifically indicated on the Drawings.

F. Where sufficient room exists within the housing of roof-mounted equipment, the conduit shall be stubbed up inside the housing.

G. Provide all required openings in walls, floors, and ceilings for conduit penetration.
   1. See Specification Section 01 73 20.

H. Conduit embedded in columns and floor slabs or buried under slab-on-grade:
   1. Run in the most direct, practical route.
   2. Not to be installed under equipment pads unless approved by Engineer.
   3. No crossovers unless approved by the Engineer.
   4. To be backfilled with concrete during the installation of the slab-on-grade. or to be placed, backfilled and compacted in the slab subgrade.
   5. Secured in place to prevent movement during the backfill and pour.

I. Conduits and accessories embedded in concrete where shown on the Contract Drawings:
   1. Shall not be considered to replace structurally the displaced concrete except as indicated in the following:
      a. Conduit and fittings shall not displace more than 4 percent of the area of the cross-section of a column on which stress is calculated or which is required for fire protection.
      b. Size and locate sleeves or conduits passing through floors, walls, or beams so as not to significantly impair the strength of the construction.
      c. Sleeves or conduits passing through floors, walls or beams may be considered as replacing the displaced concrete structurally in compression.
         1) Shall not be exposed to rusting or other deterioration.
         2) Nominal inside diameter shall not exceed 2 IN.
         3) Minimum spacing: 3 DIA OC.
   2. Shall not be larger in outside diameter than one-third the thickness of the slab, column or beam.
   3. Shall have a minimum spacing of 3 DIA OC.
   4. In reinforced concrete construction:
      a. Conduit shall not be run in beams.
      b. Place conduit after reinforcing steel has been laid.
      c. The reinforcement steel shall not be displaced by the conduit.
      d. Provide a minimum of 1-1/2 IN of cover over conduit, excluding surface finish.
      e. Conduits parallel to main reinforcement shall be run near the center of the wall.
      f. Conduits perpendicular to main reinforcement shall be run midway between wall or slab supports.

3.3 RACEWAY APPLICATIONS

A. Permitted Raceway Types Per Wire or Cable Types:
   1. Power wire or cables: All raceway types.
   2. Control wire or cables: All raceway types.
   3. Instrumentation cables: Metallic raceway except nonmetallic may be used underground.

4. Telecommunication cables: All raceway types.

B. Permitted Raceway Types Per Area Designations:
   1. Dry areas:
      a. RGS.
      b. RAC.
   2. Wet areas:
      a. RAC.
   3. Corrosive areas, unless specifically required by the Drawings:
      a. PVC-RGS.
      b. RAC.
   4. NFPA 70 hazardous areas:
      a. Dry areas: RGS, RAC.
      b. Wet and/or corrosive areas, or as required by the Drawings:
         1) PVC-RGS.
         2) RAC.

C. Permitted Raceway Types Per Routing Locations:
   1. In concrete block or brick walls:
      a. PVC-40.
      b. NEMA 1 rated wireway.
   2. Embedded in poured concrete walls and floors:
      a. PVC-40.
      b. RGS wrapped with factory applied weather and corrosion protection tape when emerging from concrete into areas designated as dry, wet, or corrosive .
      c. PVC-RGS when emerging from concrete into areas designated as wet or corrosive.
   3. Beneath floor slab-on-grade:
      a. PVC-40.
   4. Through floor penetrations, see Specification Section 01 73 20:
      a. RGS wrapped with factory applied weather and corrosion protection tape when emerging from concrete into areas designated as dry, wet, or corrosive.
      b. PVC-RGS in areas designated as wet or corrosive.
   5. Direct buried conduits and ductbanks:
      a. PVC-80.
      b. 90 degree elbows for transitions to above grade:
         1) RGS wrapped with factory applied weather and corrosion protection tape.
         2) PVC-RGS.
      c. Long sweeping bends greater than 15 degrees:
         1) RGS wrapped with factory applied weather and corrosion protection tape.
         2) PVC-RGS.
   6. Concrete encased ductbanks:
      a. PVC-40.
      b. 90 degree elbows for transitions to above grade:
         1) RGS wrapped with factory applied weather and corrosion protection tape.
         2) PVC-RGS.
      c. Long sweeping bends greater than 15 degrees:
         1) RGS for sizes 2 IN and larger.

D. FLEX conduits shall be installed for connections to light fixtures, HVAC equipment and other similar devices above the ceilings.
   1. The maximum length shall not exceed:
      a. 6 FT to light fixtures.
      b. 3 FT to all other equipment.

E. FLEX-LT conduits shall be install as the final conduit connection to light fixtures, dry type transformers, motors, electrically operated valves, instrumentation primary elements, and other electrical equipment that is liable to vibrate.
   1. The maximum length shall not exceed:

a. 6 FT to light fixtures.
b. 3 FT to motors.
c. 2 FT to all other equipment.

F. HAZ-FLEX coupling shall be installed as the final conduit to motors, electrically operated valves, instrumentation primary elements and electrical equipment that is liable to vibrate.
1. The maximum length shall not exceed:
a. 3 FT to motors.
b. 2 FT to all other equipment.

G. NEMA 1 Rated Wireway:
1. Surface mounted in electrical rooms.
2. Surface mounted above removable ceilings tiles of an architecturally finished area.

H. NEMA 4X Rated Wireway:
1. Surface mounted in areas designated as wet and or corrosive.

I. NEMA 12 Rated Wireway:
1. Surface mounted in areas designated as dry in architecturally and non-architecturally finished areas.

J. Underground Conduit: See Specification Section 26 05 43.

3.4 CONDUIT FITTINGS AND ACCESSORIES

A. Conduit Seals:
1. Installed in conduit systems located in hazardous areas as required by the NFPA 70.
2. Filler plug and drain shall be accessible.
3. Pour the conduit seals in a two-step process.
a. Pour the seal and leave cover off.
b. After seal is dry, inspect for proper sealng, install cover and mark (for example, paint or permanent marker) as complete.

B. Rigid nonmetallic conduit and fittings shall be joined utilizing solvent cement.
1. Immediately after installation of conduit and fitting, the fitting or conduit shall be rotated 1/4 turn to provide uniform contact.

C. Install Expansion Fittings:
1. Where conduits are exposed to the sun and conduit run is greater than 100 FT.
2. Elsewhere as identified on the Drawings.

D. Install Expansion/Deflection Fittings:
1. Where conduits enter a structure.
a. Except electrical manholes and handholes.
b. Except where the ductbank is tied to the structure with rebar.
2. Where conduits span structural expansions joints.
3. Elsewhere as identified on the Drawings.

E. Threaded connections shall be made wrench-tight.

F. Conduit joints shall be watertight:
1. Where subjected to possible submersion.
2. In areas classified as wet.
3. Underground.

G. Terminate Conduits:
1. In metallic outlet boxes:
a. RGS and RAC:
1) Conduit hub and locknut.
2) Insulated bushing and two (2) locknuts.
3) Use grounding type locknut or bushing when required by NFPA 70.
2. In NEMA 1 rated enclosures:

a. RGS and RAC:
   1) Conduit hub and locknut.
   2) Insulated bushing and two (2) locknuts.
   3) Use grounding type locknut or bushing when required by NFPA 70.
3. In NEMA 12 rated enclosures:
   a. Watertight, insulated and gasketed hub and locknut.
   b. Use grounding type locknut or bushing when required by NFPA 70.
4. In NEMA 4X rated enclosures:
   a. Watertight, insulated and gasketed hub and locknut.
5. In NEMA 7 rated enclosures:
   a. Into an integral threaded hub.
6. When stubbed up through the floor into floor mount equipment:
   a. With an insulated grounding bushing on metallic conduits.
   b. With end bells on nonmetallic conduits.

3.5 CONDUIT SUPPORT

A. Permitted multi-conduit surface or trapeze type support system per area designations and conduit types:
   1. Dry areas, including those areas designated as hazardous:
      a. Galvanized system consisting of: Galvanized steel channels and fittings, nuts and hardware and conduit clamps.
      b. Aluminum system consisting of: Aluminum channels, fittings and conduit clamps with stainless steel nuts and hardware.
   2. Wet and corrosive areas, including those areas designated as hazardous:
      a. Aluminum system consisting of: Aluminum channels, fittings and conduit clamps with stainless steel nuts and hardware.
      b. Stainless steel system consisting of: Stainless steel channels and fittings, nuts and hardware and conduit clamps.
   3. Conduit type shall be compatible with the support system material.
      a. Galvanized steel system may be used with RGS.
      b. Stainless steel system may be used with RGS and PVC-RGS and RAC.
      c. Aluminum system may be used with RAC and PVC-RGS.

B. Permitted single conduit support fasteners per area designations and conduit types:
   1. Architecturally finished areas:
      a. Material: Zinc plated steel, or steel protected with zinc phosphate and oil finish.
      b. Types of fasteners: Spring type hangers and clips, straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
      c. Provide anti-rattle conduit supports when conduits are routed through metal studs.
   2. Dry areas, including those areas designated as hazardous :
      a. Material: Zinc plated steel, stainless steel and malleable iron.
      b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
   3. Wet and corrosive areas, including those areas designated as hazardous:
      a. Material: Stainless steel and PVC coated malleable iron or steel.
      b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
   4. Conduit type shall be compatible with the support fastener material.
      a. Zinc plated steel, steel protected with zinc phosphate and oil finish and malleable iron fasteners may be used with RGS.
      b. Stainless steel system may be used with RGS and PVC-RGS and RAC.
      c. Nonmetallic fasteners may be used with PVC-40, and PVC-80.

C. Conduit Support General Requirements:
   1. Maximum spacing between conduit supports per NFPA 70.
   2. Support conduit from the building structure.
   3. Do not support conduit from process, gas, air or water piping; or from other conduits.

4. Provide hangers and brackets to limit the maximum uniform load on a single support to 25 LBS or to the maximum uniform load recommended by the manufacturer if the support is rated less than 25 LBS.
    a. Do not exceed maximum concentrated load recommended by the manufacturer on any support.
    b. Conduit hangers:
        1) Continuous threaded rods combined with struts or conduit clamps: Do not use perforated strap hangers and iron bailing wire.
    c. Do not use suspended ceiling support systems to support raceways.
    d. Hangers in metal roof decks:
        1) Utilize fender washers.
        2) Not extend above top of ribs.
        3) Not interfere with vapor barrier, insulation, or roofing.
5. Conduit support system fasteners:
    a. Use sleeve-type expansion anchors as fasteners in masonry wall construction.
    b. Do not use concrete nails and powder-driven fasteners.

3.6 OUTLET, PULL AND JUNCTION BOX INSTALLATION

A. General:
1. Install products in accordance with manufacturer's instructions.
2. See Specification Section 26 05 00 and the Drawings for area classifications.
3. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
4. Size boxes to accommodate quantity of conductors enclosed and quantity of conduits connected to the box.

B. Outlet Boxes:
1. Permitted uses of metallic outlet boxes:
    a. Housing of wiring devices:
        1) Recessed in all stud framed walls and ceilings.
        2) Recessed in poured concrete, concrete block and brick walls of architecturally finished areas and exterior building walls.
    b. Pull or junction box:
        1) Above gypsum wall board or acoustical tile ceilings.
        2) Above 10 FT in an architecturally finished area where there is no ceiling.
2. Permitted uses of cast outlet boxes:
    a. Housing of wiring devices surface mounted in non-architecturally finished dry, wet, corrosive, and hazardous areas.
    b. Pull and junction box surface mounted in non-architecturally finished dry, wet, and corrosive areas.
3. Permitted uses of non-metallic outlet boxes:
    a. Housing of wiring devices surface mounted in corrosive areas where PVC conduit is required by the Drawings.
4. Mount device outlet boxes where indicated on the Drawings and at heights as scheduled in Specification Section 26 27 26.
5. Set device outlet boxes plumb and vertical to the floor.
6. Outlet boxes recessed in walls:
    a. Install with appropriate stud wall support brackets or adjustable bar hangers so that they are flush with the face of the wall.
    b. Locate in ungrouted cell of concrete block with bottom edge of box flush with bottom edge of block and flush with the face of the block.
7. Place barriers between switches in boxes with 277 V switches on opposite phases.
8. Back-to-back are not permitted.
9. When an outlet box is connected to a PVC coated conduit, the box shall also be PVC coated.

C. Pull and Junction Boxes:
1. Install pull or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.

a. Make covers of boxes accessible.

2. Permitted uses of NEMA 1 enclosure:
   a. Pull or junction box surface mounted above removable ceiling tiles of an architecturally finished area.
3. Permitted uses of NEMA 4X metallic enclosure:
   a. Pull or junction box surface mounted in areas designated as wet and/or corrosive.
4. Permitted uses of NEMA 7 enclosure:
   a. Pull or junction box surface mounted in areas designated as Class I hazardous.
      1) Provide PVC coating in corrosive and highly corrosive areas when PVC coated conduit is used.
5. Permitted uses of NEMA 12 enclosure:
   a. Pull or junction box surface mounted in areas designated as dry.

END OF SECTION

SECTION 26 05 43

ELECTRICAL: EXTERIOR UNDERGROUND

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Manholes.
      b. Handhole.
      c. Underground conduits and ductbanks.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 31 21 33 - Trenching, Backfilling and Compacting for Utilities.
   4. Division 03 - Concrete.
   5. Section 10 14 00 - Identification Devices.
   6. Section 26 05 26 – Grounding and Bonding.
   7. Section 26 05 33 - Raceways and Boxes.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. HB, Standard Specifications for Highway Bridges.
   2. ASTM International (ASTM):
      a. A536, Standard Specification for Ductile Iron Castings.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Society of Cable Telecommunications Engineers (SCTE):
      a. 77, Specification for Underground Enclosure Integrity.

1.3 DEFINITIONS

A. Direct-buried conduit(s):
   1. Individual (single) underground conduit.
   2. Multiple underground conduits, arranged in one or more planes, in a common trench.

B. Concrete encased ductbank: An individual (single) or multiple conduit(s), arranged in one or more planes, encased in a common concrete envelope.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
   3. Fabrication and/or layout drawings:
      a. Provide dimensional drawings of each manhole indicating all specified accessories and conduit entry locations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Precast manholes and handholes:
      a. Utility Vault Co.
      b. Oldcastle Precast, Inc.
      c. Lister Industries.
   2. Manhole and handhole and ductbank accessories:
      a. Neenah.
      b. Unistrut.
      c. Condux International, Inc.
      d. Underground Devices, Inc.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MANHOLES AND HANDHOLES

A. Precast Manholes and Handholes:
   1. Fiberglass reinforced polymer concrete or steel reinforced cement concrete structures:
   2. AASHTO live load rating: H-20 for full deliberate vehicle traffic.
   3. Mating edges: Tongue and groove type.
   4. Solid bottom with an 18 IN DIA, 18 IN deep sump with aluminum grate in the bottom of each manhole. Sump shall be located directly beneath manhole opening. Handholes not required to be equipped with a sump.
   5. Gasketed removable top slab with lifting eyes and cast in frame for cover.
   6. Cover extension rings as required.
   7. Cable pulling eyes opposite all conduit entrances.
      a. Coordinate exact location with installation contractor.

2.3 CONCRETE MANHOLE AND HANDHOLE ACCESSORIES

A. Cover and Frame:
   1. Cast gray iron: ASTM A48/A48M-03, Class 35B.
   2. Cast ductile iron: ASTM A536.
   3. AASHTO live load rating: H-20.
   4. Diameter: 30 IN.
   5. Cast the legend "ELECTRICAL-HIGH VOLTAGE" (above 600 volts), “ELECTRICAL-LOW VOLTAGE” (600 volts and below), or "CONTROL" into manhole and handhole covers to correspond to the type of conductors contained within.

B. Cable Racks and Hooks:
   1. Material: Heavy-duty nonmetallic (glass reinforced nylon).
   2. Hook loading capacity: 400 LBS minimum.
   3. Rack loading capacity: Four (4) hooks maximum.
   4. Hook deflection: 0.25 IN maximum.
   5. Hooks: Length, as required, with positive locking device to prevent upward movement.
   6. Mounding hardware: Stainless steel.

C. Cable Pulling Irons:
   1. 7/8 IN DIA hot-dipped galvanized steel.
   2. 6000 LB minimum pulling load.

D. Ground Rods and Grounding Equipment: See Specification Section 26 05 26.

2.4 UNDERGROUND CONDUIT AND ACCESSORIES

A. Concrete: Comply with applicable sections of Division 03 Specifications.

B. Conduit: See Specification Section 26 05 33.

C. Duct Spacers/Supports:
   1. High density polyethylene or high impact polystyrene.
   2. Interlocking.
   3. Provide 2 IN minimum spacing between conduits.
   4. Accessories, as required:
      a. Hold down bars.
      b. Ductbank strapping.

PART 3 - EXECUTION

3.1 GENERAL

A. Drawings indicate the intended location of manholes and handholes and routing of ductbanks and direct buried conduit.
   1. Field conditions may affect actual routing.

B. Manhole and Handhole Locations:
   1. Approximately where shown on the Drawings.
   2. As required for pulling distances.
   3. As required to keep pulling tensions under allowable cable tensions.
   4. As required for number of bends in ductbank routing.
   5. Shall not be installed in a swale or ditch.
   6. Determine the exact locations after careful consideration has been given to the location of other utilities, grading, and paving.
   7. Locations are to be approved by the Engineer prior to excavation and placement or construction of manholes and handholes.

C. Install products in accordance with manufacturer's instructions.

D. Install manholes and handholes in conduit runs where indicated or as required to facilitate pulling of wires or making connections.

E. Comply with Specification Section 31 21 33 for trenching, backfilling and compacting.

3.2 MANHOLES AND HANDHOLES

A. Precast Manholes and Handholes:
   1. For use in vehicular and non-vehicular traffic areas.
   2. Construction:
      a. Grout or seal all joints, per manufacturer's instructions.
      b. Support cables on walls by cable racks:
         1) Provide a minimum of two (2) racks, install symmetrically on each wall of manholes and handholes.
            a) Provide additional cable racks, as required, so that both ends of cable splices will be supported horizontally.
         2) Equip cable racks with adjustable hooks: Quantity of cable hooks as required by the number of conductors to be supported.
      c. In each manhole and handhole, drive 3/4 IN x 10 FT long copper clad ground rod into the earth with approximately 6 IN exposed above finished floor.
         1) Drill opening in floor for ground rod.
         2) Connect all metallic components to ground rod by means of #8 AWG minimum copper wire and approved grounding clamps.
         3) Utilize a ground bar in the manhole or handhole if the quantity of ground wires exceeds three (3).
            a) Connect ground bar to ground rod with a #2/0 AWG minimum copper wire.
   3. Place manhole or handhole on a foundation of compacted 1/4 to 1/2 IN crushed rock or gravel a minimum of 8 IN thick and 6 IN larger than manholes or handholes footprint on all sides.
   4. In unpaved areas install so that the top of cover is 1 IN above finished grade.

a. Where existing grades are higher than finished grades, install sufficient number of courses of curved segmented concrete block between top of handhole and manhole frame to temporarily elevate manhole cover to existing grade level.

5. In paved areas install so that cover is flush with finished pavement.
6. After installation is complete, backfill and compact soil around manholes and handholes. Slope away from manholes and handholes.
7. Handhole size:
    a. As indicated on the Drawings or as required for the number and size of conduits entering.
        1) Minimum floor dimension of 4 FT x 4 FT and minimum depth of 4 FT.
8. Manhole size:
    a. As indicated on the Drawings or as required for the number and size of conduits entering.
        1) Minimum floor dimension of 6 FT x 6 FT and a minimum depth of 6 FT.

3.3 UNDERGROUND CONDUITS

A. General Installation Requirements:
1. Unless otherwise noted on the Drawings, all underground conduits shall be concrete-encased.
    a. Steel reinforcement is required for the following:
        1) Under traffic areas, (roadways, parking lots, etc.) and for a distance 10 FT either side of the traffic area.
        2) At structures (including manholes and handholes) where the ductbank enters below grade beginning 10 FT away from the structure.
        3) Elsewhere as identified or indicated on the Drawings.
    b. The reinforcement shall be as detailed on the Drawings.
2. Do not place concrete or soil until conduits have been observed by the Engineer.
3. Ductbanks shall be sloped a minimum of 4 IN per 100 FT or as detailed on the Drawings.
    a. Low points shall be at manholes or handholes.
4. During construction and after conduit installation is complete, plug the ends of all conduits using approved conduit caps or plugs.
5. Provide conduit supports and spacers.
    a. Place supports and spacers for rigid nonmetallic conduit on maximum centers as indicated for the following trade sizes:
        1) 1 IN and less: 3 FT.
        2) 1-1/4 to 3 IN: 5 FT.
        3) 3-1/2 to 6 IN: 7 FT.
    b. Place supports and spacers for rigid steel conduit on maximum centers as indicated for the following trade sizes:
        1) 1 IN and less: 10 FT.
        2) 1-1/4 to 2-1/2 IN: 14 FT.
        3) 3 IN and larger: 20 FT.
    c. Securely anchor conduits to supports and spacers to prevent movement during placement of concrete or soil.
6. Stagger conduit joints at intervals of 6 IN vertically.
7. Make conduit joints watertight and in accordance with manufacturer's recommendations.
8. Accomplish changes in direction of runs exceeding a total of 15 degrees by long sweep bends having a minimum radius of 25 FT.
    a. Sweep bends may be made up of one or more curved or straight sections or combinations thereof.
9. Furnish manufactured bends at end of runs.
    a. Minimum radius of 18 IN for conduits less than 3 IN trade size and 36 IN for conduits 3 IN trade size and larger.
10. Field cuts requiring tapers shall be made with the proper tools and shall match factory tapers.
11. After the conduit run has been completed:

a. Prove joint integrity and test for out-of-round duct by pulling a test mandrel through each conduit.
    1) Test mandrel:
        a) Length: Not less than 12 IN
        b) Diameter: Approximately 1/4 IN less than the inside diameter of the conduit.
b. Clean the conduit by pulling a heavy duty wire brush mandrel followed by a rubber duct swab through each conduit.

12. Pneumatic rodding may be used to draw in lead wire.
    a. Install a heavy nylon cord free of kinks and splices in all unused new ducts.
    b. Extend cord 3 FT beyond ends of conduit.
13. Transition from rigid nonmetallic conduit to rigid metallic conduit, per Specification Section 26 05 33, prior to entering a structure or going above ground.
    a. Except rigid nonmetallic conduit may be extended directly to manholes, handholes, pad mounted transformer boxes and other exterior pad mounted electrical equipment where the conduit is concealed within the enclosure.
    b. Terminate rigid PVC conduits with end bells.
    c. Terminate steel conduits with insulated bushings.
14. Place warning tape in trench directly over ductbanks, direct-buried conduit, and direct-buried wire and cable in accordance with Specification Section 10 14 00.
15. Placement of conduits stubbing into handholes and manholes shall be located to allow for proper bending radiuses of the cables.

B. Concrete Encased Ductbank:
1. Ductbank system consists of conduits completely encased in minimum 2 IN of concrete and with separations between different cabling types as required in Specification Section 26 05 33 or as detailed on the Drawings.
2. Install so that top of concrete encased duct, at any point:
    a. Is not less than 24 IN below grade.
    b. Is below pavement sub-grading.
3. Conduit supports shall provide a uniform minimum clearance of 2 IN between the bottom of the trench and the bottom row of conduit.
4. Conduit separators shall provide a uniform minimum clearance of 2 IN between conduits or as required in Specification Section 26 05 33 for different cabling types.

C. Direct-Buried Conduit(s):
1. Install so that the top of the uppermost conduit, at any point:
    a. Is not less than 30 IN below grade.
    b. Is below pavement sub-grading.
2. Provide a uniform minimum clearance of 2 IN between conduits or as required in Specification Section 26 05 33 for different cabling types.
    a. Maintain the separation of multiple planes of conduits by one of the following methods:
        1) Install multilevel conduits with the use of conduit supports and separators to maintain the required separations, and backfill with flowable fill (100 PSI) or concrete per Specification Section 31 21 33.
        2) Install the multilevel conduits one level at a time.
            a) Each level is backfilled with the appropriate amount of soil and compaction, per Specification Section 31 21 33, to maintain the required separations.

END OF SECTION

SECTION 26 05 74

SHORT CIRCUIT AND COORDINATION STUDY, AND ARC FLASH REPORT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies the short circuit and protective-device coordination study, and arc flash study and report, for the electrical power system for the City of Santa Fe, New Mexico Wastewater Treatment Plant.
   1. The "electrical power system" starts at each utility transformer and includes the main switchboard and VFDs associated with this Contract.
   2. Arc flash study shall include the method and recommendation in determining proper Personal Protective Equipment (PPE) and proper labeling of equipment as specified in this Section.
   3. Provide equipment labeling.

B. Reports shall include the utility transformer, switchboard, and motor control equipment (VFDs).
   1. Field data as needed shall be determined and gathered by the Contractor after Notice to Proceed to accomplish the Arc Flash Report.
   2. The report shall include electrical equipment being installed in this Construction Contract.

1.2 RELATED SECTIONS

A. Related Sections include but are not necessarily limited to:
   1. Section 26 05 00 - Electrical: Basic Requirements.

1.3 QUALITY ASSURANCE

A. Referenced Standards:
   1. This Section incorporates by reference the latest revision of the following documents.
   2. These references are a part of this Section as specified and modified.
   3. In case of conflict between the requirements of this Section and those of a listed document, the requirements of this Section shall prevail.

REFERENCE	TITLE
IEEE 1584	IEEE Guide for Performing Arc-Flash Hazard Calculations
NFPA 70	National Electrical Code
NFPA 70E	Standard for Electrical Safety Requirements for Employee Workplaces
OSHA 29-CFR	Occupational Safety and Health Standards: Electrical Part 1910 Subpart S

B. Qualifications:
   1. Prepared by the manufacturer of the electrical equipment or by an electrical testing service or an Engineering Company which is regularly engaged in power system studies.
   2. All calculations shall be prepared by or prepared under direct supervision of a New Mexico State Licensed Professional Electrical Engineer.

C. Certification:
   1. Short circuit and coordination study and arc flash report to be stamped and signed by a New Mexico State Licensed Professional Electrical Engineer.

1.4 SUBMITTALS

A. Short circuit and coordination study report.

B. Arc flash report.

C. Arc flash warning labels for the electrical equipment being installed in this construction contract.

1.5 SHORT CIRCUIT AND COORDINATION STUDY

A. Coordinated Power System Protection:
   1. A study shall be prepared to demonstrate that the equipment and system constructed within the scope of these Contract Documents meet the specified requirements for equipment ratings, coordination and protection.
      a. The studies shall be performed in accordance with IEEE 242 and IEEE 399.
   2. Computer generated studies shall include the information about the software: name of the developer and software package and version number.
   3. System short circuit study report:
      a. The study shall begin at each main service electrical switchboard and extend down the system through all buses.
         1) The study for Switchboard SWBD-101 shall include the switchboard and MCC-401 only.
      b. A balanced three-phase fault, bolted line-to-line fault and line-to-ground fault study shall be performed.
      c. A one-line diagram shall be prepared to show the electrical system buses, transformers and all sources of fault current including generators and motors.
      d. Manufacturer's data for the actual proposed equipment shall be utilized (e.g., transformer impedance).
      e. The available utility fault current shall be coordinated with the power utility company.
      f. Input data shall be shown in tabular form in the report and/or on the one-line diagram.
         1) Input data shall include but is not limited to:
            a) Utility fault current or MVA and X/R ratio.
            b) Bus voltages.
            c) Conductor sizes and type of conduit.
            d) Motor sizes and contributions.
            e) Transformer sizes and impedances.
      g. Available fault current at each bus shall be shown in tabular form in the report and/or on the one-line diagram.
      h. Perform studies for both normal power and emergency/standby power scenarios.
   4. System protective coordination study report:
      a. The study shall begin at each main service electrical switchboard and extend down the system through all buses as required to ensure a coordinated power system.
         1) The study for Switchboard SWBD-101 shall include the switchboard and MCC-401 only.
      b. The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified for the protection of equipment and conductors from damage from overloads and fault conditions.
         1) Where necessary an appropriate compromise shall be made between system protection and service continuity.
         2) System protection and service continuity shall be considered to be of equal importance.
      c. A one-line diagram shall be prepared to show the electrical system buses, transformers and protective devices.
      d. Manufacturer's data for the actual proposed protective devices shall be utilized.
      e. Summarize the coordination study, conclusions and recommendations.
         1) As a minimum, include the following:
            a) The manufacturer's information used to prepare the study.
            b) Assumptions made during the study.
            c) Recommended taps and settings of all adjustable devices in tabulated form.
            d) Composite coordination time-current curves on log-log paper showing:
               (1) That the settings for each protective device will provide protection and selectivity.
               (2) Identify each curve.
               (3) Cable and equipment damage points.

(4) Circuit interrupting device operating and interrupting times.

e) One-line sketch of the part of the system being investigated.

f) Include as many curves as possible on a graph while maintaining readability.

f. Position time-current curves for each device to provide for maximum selectivity to minimize system disturbances during fault clearing.

g. Advise the Engineer of potential coordination problems discovered during the study and include recommendations to resolve the problem.

B. Submit the reports for approval 90 days prior to equipment energization.

1.6 ARC FLASH STUDY

A. Perform arc flash hazard studies after the short circuit and protective device coordination studies have been completed.

B. For each major part of the electrical power system, determine the following:

1. Flash hazard protection boundary.
2. Limited approach boundary.
3. Restricted approach boundary.
4. Prohibited approach boundary.
5. Incident energy level.
6. PPE hazard/risk category.
7. Type of PPE required.

C. Produce arc flash warning labels listing items B 1-7 from above.

1. Also include the bus name and voltage.

D. Produce bus detail sheets that list the items B 1-7 from above and the following additional items:

1. Bus name.
2. Upstream protective device name, and type.
3. Bus line to line voltage.

E. Produce an arc flash evaluation summary sheet listing the following additional items:

1. Bus name matching existing and contract document identification numbers.
2. Upstream protective device name, and type.
   a. Numbering shall match existing and contract document identification numbers.
3. Bus line to line voltage.
4. Bus bolted fault.
5. Protective device bolted fault current.
6. Arcing fault current.
7. Protective device trip/delay time.
8. Breaker opening time.
9. Solidly grounded column.
10. Equipment type.
11. Gap.
12. Arc flash boundary.
13. Working distance.
14. Incident energy.
15. Required protective fire rated clothing type and class.

F. Analyze the short circuit, protective device coordination and arc flash calculations and highlight any equipment that is determined to be underrated or causes an abnormally high incident energy calculation.

1. Propose approaches to reduce the energy levels. Where possible the hazard/risk category shall be reduced to Category 2 and still maintain proper coordination through the means of resetting of breakers and relays.

1.7 ARC FLASH REPORT

A. Prepare a report summarizing the arc flash study and conclusions or recommendations which may affect the integrity of the electric power distribution system.

B. A qualified engineer must perform arc flash calculations to determine the incident energy, arc flash boundary, and minimum PPE requirements for locations throughout the power system.
   1. Arc flash warning labels shall be produced and attached to the electrical equipment by the Contractor.
   2. These labels must indicate approach boundaries, incident energy level, and the minimum PPE that is required when servicing the equipment within the arc flash boundary.

C. As a minimum, include the following in the report:
   1. Equipment manufacturer's information for the equipment installed.
   2. Assumptions made during the study.
   3. Reduced copy of the one line drawing.
   4. Arc flash evaluations summary spreadsheet.
   5. Bus detail sheets.
   6. Arc flash warning labels printed in color on adhesive backed labels.

D. Submit report 30 days before energizing electrical equipment.
   1. Labels shall be affixed on all new equipment prior to the new equipment being energized.

PART 2 - PRODUCTS

2.1 LABELS

A. Provide weatherproof labels for equipment mounted outdoors.

PART 3 - EXECUTION

3.1 GENERAL

A. Perform each arc flash study in accordance with NFPA 70E, OSHA 29-CFR, Part 1910 Subpart S, and IEEE 1584 Standards.

B. Perform the studies using actual equipment data for the equipment provided.
   1. Provide data from the manufacturer of the protective relays, circuit breakers, fuses, devices, etc. provided by the contractor's subcontractors and vendors.

C. Provide arc flash warning labels on equipment as specified in this Section.
   1. Labels shall be printed in color on adhesive backed labels.

D. Set all low voltage circuit breakers settings/ratings as determined by the coordination study. Fuse ratings on equipment shall be based on the coordination study.

END OF SECTION

SECTION 26 08 13
ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for acceptance testing.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 26 32 14 - Engine Generator - Diesel.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
      b. 400.3, Guide for Partial Discharge Testing of Power Cable Systems in a Field Environment.
   2. InterNational Electrical Testing Association (NETA):
      a. ATS, Standard for Acceptance Testing Specifications for Electric Power Equipment and Systems.
   3. Nationally Recognized Testing Laboratory (NRTL).
   4. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
      a. 455-78-B, Optical Fibres - PART 1-40: Measurement Methods and Test Procedures - Attenuation.

B. Qualifications:
   1. Testing firm qualifications: See Specification Section 40 05 05.
   2. Field personnel:
      a. See Specification Section 40 05 05.
      b. As an alternative, supervising technician may be certified by the equipment manufacturer.
   3. Analysis personnel:
      a. See Specification Section 40 05 05
      As an alternative, supervising technician may be certified by the equipment manufacturer.

C. Phasing Diagram:
   1. Coordinate with Utility Company for phase rotations and Phase A, B and C markings.
      a. Create a phasing diagram showing the coordinated phase rotations with generators and motors through the transformers.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 05 05 and 26 05 00 for electrical equipment and connection testing plan submittal requirements.

B. Informational Submittals:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Prior to energizing equipment:
    a. Coordinated phasing diagram.
3. Within two (2) weeks after successful completion of Demonstration Period (Commissioning Period):
    a. Single report containing information including:
        1) Summary of Project.
        2) Information from pre-energization testing.
        3) See testing and monitoring reporting requirements in Specification Section 40 05 05.

PART 2 - PRODUCTS

2.1 FACTORY QUALITY CONTROL

A. Provide Electrical equipment with all factory tests required by the applicable industry standards or NRTL.

B. Factory testing will not be accepted in lieu of field acceptance testing requirements specified in this Specification Section and Specification Section 40 05 05.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. General:
1. See Specification Section 40 05 05.
2. Complete electrical testing in three (3) phases:
    a. Pre-energization testing phase.
    b. Equipment energized with no load.
    c. Equipment energized under load.
3. Perform testing in accordance with this Specification Section and NETA ATS.
4. Provide field setting and programming of all adjustable protective devices and meters to settings as determined by the approved coordination study.

B. Equipment Monitoring and Testing Plan: See Specification Section 40 05 05.

C. Instruments Used in Equipment and Connections Quality Control Testing: See Specification Section 40 05 05.

D. Testing and Monitoring Program Documentation: See Specification Section 40 05 05.

E. Electrical Equipment and Connections Testing Program:
1. See Specification Section 40 05 05.
2. See individual Division 26 Specification Sections for equipment specific testing requirements.
3. Test all electrical equipment.
    a. Perform all required NETA testing.
    b. Perform all required NETA testing plus the optional testing identified with each specific type of equipment in Article 3.2 of this Specification Section.

3.2 SPECIFIC EQUIPMENT TESTING REQUIREMENTS

A. Switchboards:
1. Perform inspections and tests per NETA ATS 7.1.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

B. Transformers - Small Dry Type:

1. Perform inspections and tests per NETA ATS 7.2.1.1.
2. Perform the following additional tests:
   a. Record phase-to-phase, phase-to-neutral, and neutral-to-ground voltages at no load after energizing, and at operating load after startup.
3. Adjust tap connections as required to provide secondary voltage within 2-1/2 percent of nominal under normal load after approval of Engineer.
4. Record as-left tap connections.

C. Cable - Low Voltage:
   1. Perform inspections and tests per NETA ATS 7.3.2.

D. Low Voltage Molded Case Circuit Breakers:
   1. Perform inspections and tests per NETA ATS 7.6.1.1.
   2. Components:
      a. Test all components per applicable paragraphs of this Specification Section and NETA ATS.
      b. Thermal magnetic breakers: Visual and mechanical inspection per NETA ATS only.
      c. Solid state trip type: Visual and mechanical inspection and electrical tests per NETA ATS.
   3. Record as-left settings.

E. Protective Relays:
   1. Perform inspections and tests per NETA ATS 7.9.
      a. Tests to be performed using secondary injection of 3 PH current and potential at final settings.
      b. Test at manufacturer's recommended test points and critical timing points identified on relay setting sheet.
   2. Perform all tests identified as optional per NETA ATS.
   3. Perform the following additional tests:
      a. Verification of direct trip of associated lockout relay or circuit breaker(s) by using relay test function or shorting trip contact at relay case.
      b. Microprocessor-based relays:
         1) Complete commissioning procedure per manufacturer's instructions, followed by tests of each relay element at final settings.
         2) Verification of all internally-programmed logic.
      c. Verification of all auxiliary input and output signals.
      d. Verification of power supply/self-diagnostic alarm contact and remote annunciation.
   4. Record as-left settings.

F. Metering:
   1. Perform inspections and tests per NETA ATS 7.11.
   2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

G. Grounding:
   1. Perform inspections and tests per NETA ATS 7.13.
   2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

H. Ground Fault Protection:
   1. Perform inspections and tests per NETA ATS 7.14.
   2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
   3. Perform the following optional tests per NETA ATS:
      a. Control wiring insulation resistance.
   4. Perform the following additional tests for four-wire systems:
      a. Primary current injection into switchgear bus with test set configured to simulate transformer source and high current jumper used to simulate unbalanced load and ground fault conditions.

b. Verify no tripping for unbalanced load on each feeder and each main breaker.
c. Verify no tripping for unbalanced load across tie breaker for dual-source schemes.
d. Verify tripping for ground fault on load side of feeder each feeder and on each main bus.
e. Verify tripping for ground fault on a single feeder and on each main bus through tie breaker(s) for multiple-source schemes.

I. Motors:
1. Perform inspections and tests per NETA ATS 7.15.
2. See Specification Section 40 05 05.

J. Motor Controllers:
1. Perform inspections and tests per NETA ATS 7.16.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

K. Generators:
1. Perform inspections and tests per NETA ATS 7.15.2.
2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.
3. Perform the following additional tests:
a. Load and cycle crank test per Specification Section 26 32 13

END OF SECTION

SECTION 26 09 13

ELECTRICAL METERING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Digital metering equipment.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. C12.20, For Electricity Meter - 0.2 and 0.5 Accuracy Classes.
   3. Underwriters Laboratories, Inc. (UL):
      a. 508, Standard for Safety Industrial Control Equipment.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Provide submittal data for all products specified in PART 2 of this Specification:
      b. See Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings.
      a. Electrical wiring/connection diagrams.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
      b. Content of Operation and Maintenance Manual:
         1) Data sheet of the meters electrical parameters, configuration and characteristics including a complete model number and associated equipment connected too.
         2) Operating instructions of the meter(s) supplied.
         3) Maintenance instructions.
         4) As-constructed electrical wiring/connection diagrams.
         5) Acceptance testing data.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Allen-Bradley.
   2. Eaton.

3. Electro Industries.
4. General Electric Company.
5. Power Measurement.
6. Square D Company.
7. Siemens.

2.2 DIGITAL METERING DEVICES

A. General:
   1. Direct reading metered or calculated values.
   2. Microprocessor based.
   3. Integral LED or LCD display.
   4. Current and potential transformers as required.
   5. Integral fusing.
   6. Operating temperature: 0 DegF to 150 DegF.
   7. Standards:
      a. NEMA/ANSI C12.20.
      b. UL 508.

B. Type 'B' Midrange Meter:
   1. Display the following minimum electrical parameters (accuracy):
      a. RMS current per phase (+0.3 percent full scale).
      b. RMS voltage line-to-line and line-to-neutral (+0.3 percent full scale).
      c. Real power (W): 3 PH total (+0.6 percent full scale).
      d. Apparent power (VA): 3 PH total (+0.6 percent full scale).
      e. Reactive power (VAR): 3 PH total (+0.6 percent full scale).
      f. Power factor (+1.0 percent).
      g. Frequency (+0.17 percent).
      h. Percent current total harmonic distortion (31st).
      i. Percent voltage total harmonic distortion (31st).
   2. Data logging:
      a. 128 KB.
      b. Selectable for parameters listed above for display.
      c. Software for configuration, retrieval, and trending.
   3. Communication ports and protocols: Ethernet TCP/IP.
   4. Supply voltage: 120 Vac.

2.3 ACCESSORIES

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.
   1. Provide all equipment as necessary to provide a complete and functioning system.

B. Meter Type Application:
   1. Type B meters: Integral to equipment as indicated on the Drawings.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: See Section 26 08 13.

3.3 TRAINING

A. A qualified factory-trained manufacturer's representative shall provide the Owner with 2 HRS of on-site training in the operation and maintenance of the metering system and its components.

END OF SECTION

SECTION 26 09 16

CONTROL EQUIPMENT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Operator control devices (selector switches, pushbuttons, indicator lights, etc.).
   2. Control devices (timers, relays, contactors, etc.).
   3. Industrial Control Panels.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ICS 2, Industrial Control and System Controllers, Contactors and Overload Relays Rated 600 Volts.
   2. Underwriters Laboratories, Inc. (UL):
      a. 508, Standard for Safety Industrial Control Equipment.
      b. 508A, Standard for Safety Industrial Control Panels.

1.3 SYSTEM DESCRIPTION

A. This Specification specifies components used within other equipment as referenced in other technical specifications.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification:
         1) When components are used within equipment specified in another Section, submittal data for components specified herein shall be included with the submittal for the equipment the components are used in.
      b. Industrial Control Panel bill of material.
      c. Control Station bill of material.
      d. See Specification Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings.
      a. Industrial Control Panel:
         1) Interior and exterior layout.
         2) Wiring/connection diagrams.
         3) Short circuit rating.
         4) Copy of the UL 508A label.
      b. Operator Control Station:
         1) Interior (if applicable) and exterior layout.
         2) Wiring/connection diagrams.
      c. Associate Industrial Control Panel and Operator Control Stations with associated equipment name and tagging.

B. Informational Submittals:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Functional Test Plan.

C. Contract Closeout Information:
1. Operation and Maintenance Data:
   a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
   b. Content of Operation and Maintenance Manual:
      1) Product technical data of components used within Industrial Control Panels and Operator Control Stations.
      2) As-constructed wiring/connection diagrams for Industrial Control Panels and Operator Control Stations.
      3) Functional Test Report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Pilot devices:
   a. Allen Bradley.
   b. Eaton.
   c. General Electric Company.
   d. Schneider Electric.
2. Timers and relays:
   a. ATC Diversified Electronics.
   b. Idec.
   c. Phoenix Contact.
   d. Potter & Brumsfield.
3. Contactors:
   a. Automatic Switch Company (ASCO).
   b. Eaton.
   c. General Electric Company.
   d. Schneider Electric.
   e. Siemens.
   f. Allen Bradley.
4. Photocells and time clocks:
   a. Grasslin.
   b. Tork.
   c. Intermatic.
   d. Paragon.
5. Alarm devices:
   a. Edwards Signaling.
   b. Federal Signal Corp.
6. Enclosures:
   a. Hoffman Engineering Co.
   b. Wiegmann.
   c. Eaton B-Line.
   d. Adalet.
   e. Stahlin.
7. Terminal blocks:
   a. Phoenix Contact.
   b. Allen-Bradley.

2.2 PILOT DEVICES

A. General Requirements:
   1. Standards: NEMA ICS 2, UL 508.
   2. Heavy-duty NEMA 4/13 watertight/oiltight.
   3. Heavy-duty NEMA 4/4X corrosion resistant.
   4. Heavy-duty factory sealed, explosion-proof and dust ignition-proof (Class I and II).
   5. Mounting hole: 30.5 mm.
   6. Contact blocks: 10 amp, NEMA A600 rated, number as required to fulfill functions shown or specified.
   7. Legend plate marked as indicated on Drawings or specified.

B. Selector Switches:
   1. Two, three- or four-position rotary switch as required to fulfill functions shown or specified.
   2. Maintained contact type.
   3. Knob or lever type operators.

C. Pushbuttons:
   1. Non-illuminated type:
      a. Protective boot.
      b. Momentary contact.
      c. Standard flush and mushroom operators.
      d. Black colored button for START or ON and black color for STOP or OFF.
      e. Emergency stop pushbuttons: Red mushroom head operator and maintained contact.

D. Indicating Lights:
   1. Allowing replacement of bulb without removal from control panel.
   2. Lamp: LED, 120 V or 24 V as required.
   3. Full voltage type.
   4. Push-to-test indicating lights.
   5. Glass lens.
   6. Color code lights as follows:
      a. Green: OFF or stopped; valve closed.
      b. Amber: FAIL.
      c. Red: ON or running; valve open

2.3 RELAYS

A. General Requirements:
   1. Standards: NEMA ICS 2, UL 508.

B. Control Relays:
   1. General purpose (ice cube) type:
      a. Plug-in housing.
      b. Clear polycarbonate dust cover with clip fastener.
      c. Coil voltage: 120 Vac or as required.
      d. Contacts:
         1) 10 amp continuous.
         2) Silver cadmium oxide.
         3) Minimum of 3 SPDT contacts.
      e. Sockets: DIN rail mounted.
      f. Internal neon or LED indicator is lit when coil is energized.
      g. Manual operator switch.
   2. Industrial type:
      a. Coil voltage: 120 Vac or as required.
      b. Contacts:
         1) 10 amp, NEMA A600 rated.
         2) Double break, silver alloy.

3) Convertible from normally open to normally closed or vice versa, without removing any wiring.
4) Expandable from 2 poles to 12 poles.
c. Provide contacts for all required control plus two spares.

C. Time Delay Relays:
1. General purpose type:
a. Timing modes: On and Off delay, interval, one shot and repeat cycle.
b. Plug-in housing.
c. Polycarbonate dust cover with clip fastener.
d. Coil voltage: 120 Vac or as required.
e. Contacts:
1) 10 amp continuous.
2) Silver cadmium oxide.
3) Two normally open and two normally closed DPDT contacts.
f. Sockets: DIN rail mounted.
g. External timing adjustment knob.
h. Timing ranges: 0.05 seconds to 16.65 HRS.
i. Repeat accuracy: +1 percent.
2. Solid State industrial type:
a. Timing modes: On and Off delay and repeat cycle.
b. Industrial housing.
c. Coil voltage: 120 Vac or as required.
d. Contacts:
1) 5 amp, NEMA B150 rated.
2) Silver alloy.
3) Convertible On Delay and Off Delay contacts.
4) One normally open and one normally closed timed contacts.
5) One normally open and one normally closed instantaneous contacts.
e. Furnish with "on" and "timing out" indicators.
f. External timing adjustment knob.
g. Timing ranges: 0.05 seconds to 10 HRS.
h. Repeat accuracy: +1 percent.
3. Mechanical industrial type:
a. Timing modes: On and Off delay.
b. Coil voltage: 120 Vac or as required.
c. Contacts:
1) 10 amp, NEMA A600 rated.
2) Double break, silver alloy.
3) Convertible On Delay and Off Delay contacts.
4) Convertible normally open and normally closed timed contacts.
5) Convertible normally open instantaneous contacts.
d. External timing adjustment knob.
e. Timing ranges: 0.2 - 60 sec or 5 - 180 sec.
f. Repeat accuracy: Greater than +10 percent.

2.4 CONTACTORS

A. General Requirements:
1. Standards: NEMA ICS 2, UL 508.

B. Lighting and Remote Control Switches:
1. Electrically operated, electrically held.
2. Coil voltage: 120 Vac or as required.
3. Contacts: Totally enclosed, double-break silver-cadmium-oxide.
4. Rated for ballasted lighting, tungsten and general use loads.
5. Number of poles, continuous ampere rating and voltage, as indicated on Drawings or as specified.

6. Auxiliary control relays, as indicated on Drawings or as specified.
7. Auxiliary contacts, as indicated on Drawings or as specified.

2.5 PHOTOCELLS

A. Photocells:
1. Weatherproof enclosure.
2. Adjustable turn-on range, initially set at 1.0 footcandles.
    a. Turn-off level approximately three times turn-on.
3. Provide time delay device to eliminate nuisance switching.
4. Voltage, amperage and/or wattage ratings as required for the application.

2.6 MISCELLANEOUS DEVICES

A. Run Time Meters:
1. Six-digit wheels including a 1/10 digit.
2. Non-reset type.
3. Time range in hours.
4. Automatic recycle at zero.
5. Accuracy: 1 percent.
6. Sealed against dirt and moisture.
7. Tamperproof.

2.7 TERMINATION EQUIPMENT

A. General Requirements:
1. Modular type with screw compression clamp.
2. Screws: Stainless steel.
3. Current bar: Nickel-plated copper alloy.
4. Thermoplastic insulation rated for -40 to +90 DegC.
5. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
6. End sections and end stops at each end of terminal strip.
7. Machine-printed terminal markers on both sides of block.
8. Spacing: 6 mm.
9. Wire size: 22-12 AWG.
10. Rated voltage: 600 V.
11. DIN rail mounting.

B. Standard-type block:
1. Rated current: 30 A.
2. Color: Gray body.

C. Bladed-type disconnect block:
1. Terminal block with knife blade disconnect which connects or isolated the two sides of the block.
2. Rated current: 10 A.
3. Color:
    a. Panel control voltage leaves enclosure - normal: Gray body, orange switch.
    b. Foreign voltage entering enclosure: Orange body, orange switch.

D. Grounded-type block:
1. Electrically grounded to mounting rail.
2. Terminal ground wires and analog cable shields.
3. Color: Green and yellow body.

E. Fuse Holders:
1. Blocks can be ganged for multi-pole operation.
2. Spacing: 9.1 mm.
3. Wire size: 30-12 AWG.
4. Rated voltage: 300 V.
5. Rated current: 12 A.

6. Fuse size: 1/4 x 1-1/4.
7. Blown fuse indication.
8. DIN rail mounting.

2.8 ENCLOSURES

A. Industrial Control Panels:
  1. NEMA 4X rated:
     a. Body and cover: 14 GA Type 304 or 316 stainless steel.
     b. Seams continuously welded and ground smooth.
     c. No knockouts.
     d. External mounting flanges.
     e. Hinged door and stainless steel screws and clamps.
     f. Door with oil-resistant gasket.
  2. NEMA 7 rated:
     a. Cast gray iron alloy or copper-free aluminum.
     b. Drilled and tapped openings or tapered threaded hub.
     c. Cover bolted-down with stainless steel bolts or threaded cover with neoprene gasket.
     d. External mounting flanges.
     e. Grounding lug.
     f. Accessories: 40 mil PVC exterior coating and 2 mil urethane interior coating.
  3. NEMA 12 enclosure:
     a. Body and cover: 14 GA steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
     b. No knockouts.
     c. External mounting flanges.
     d. Non-hinged stainless steel cover held closed with captivated cover screws threaded into sealed wells or hinged cover held closed with stainless steel screws and clamps.
     e. Flat door with oil resistant gasket.
  4. Control panel miscellaneous accessories:
     a. Back plane mounting panels: Steel with white enamel finish or Type 304 stainless steel.
     b. Interiors shall be white or light gray in color.
     c. Wire management duct:
        1) Bodies: PVC with side holes.
        2) Cover: PVC snap-on.
        3) Size as required.
     d. Rigid handles for covers larger than 9 SF or heavier than 25 LBS.
     e. Split covers when heavier than 25 LBS.
     f. Floor stand kits made of same material as the enclosure.
     g. Weldnuts for mounting optional panels and terminal kits.
     h. Ground bonding jumper from door, across hinge, to enclosure body.
  5. Standards: NEMA 250, UL 508.

B. Operator Control Stations:
  1. NEMA 4/13 rated:
     a. Die cast aluminum body with manufacturers standard finish.
     b. Gasketed die cast aluminum cover with manufacturers standard finish.
     c. Number of device mounting holes as required.
  2. NEMA 4X rated:
     a. Type 304 or 316 stainless steel body.
     b. Gasketed Type 304 or 316 stainless steel cover.
     c. Number of device mounting holes as required.
  3. NEMA 7 rated:
     a. Zinc plated cast iron or die-cast copper free aluminum, with threaded hubs, grounding screw and with manufacturer’s standard finish.
     b. "EDS" or "EFS" style.

c. Single or multiple gang or tandem.
d. Accessories: 40 mil PVC exterior coating and two (2) mil urethane interior coating where used with PVC coated conduit system.

2.9 FABRICATION

A. Supplier of Industrial Control Panels shall build control panel under the provisions of UL 508A.
1. Entire assembly shall be affixed with a UL 508A label "Listed Enclosed Industrial Control Panel" prior to shipment to the jobsite.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Unless indicated otherwise on the Drawings, mounting heights are as indicated below:
a. Pushbutton or selector switch control station (to center): 48 IN.

C. Control Panels:
1. Size as required to mount the equipment.
2. Permitted uses of NEMA 4X enclosure:
a. Surface mounted in areas designated as wet and/or corrosive or highly corrosive.
3. Permitted uses of NEMA 7 enclosure:
a. Surface mounted in areas designated as Class I hazardous.
4. Permitted uses of NEMA 12 enclosure:
a. Surface mounted in areas designated as dry and/or dusty architecturally or non-architecturally finished areas.

D. Operator Control Stations:
1. Permitted uses of NEMA 4/13 enclosure:
a. Surface mounted in areas designated as dry and/or dusty architecturally or non-architecturally finished areas and wet.
2. Permitted uses of NEMA 4X enclosure:
a. Surface mounted in areas designated as wet and/or corrosive or highly corrosive.
3. Permitted uses of NEMA 7 enclosure:
a. Surface mounted in areas designated as Class I hazardous with PVC coating in corrosive areas when PVC coated conduit is used.

3.2 FIELD QUALITY CONTROL

A. See Section 26 05 00.

B. Industrial Control Panel(s) and Operator Control Station Functional Test:
1. The test is to prove the correct interaction of all sensing, processing and action devices.
2. Develop a test plan and parameters for the purpose of evaluating the performance of the system.
a. Plan shall have witness signature lines for the contractor and owner and submitted when system pass the test.
3. Perform the following tests:
a. Verify functionality of all control states.
b. Verify the correct operation of all interlock safety devices for fail-safe functions
c. Verify the correct operation of all sensing devices, alarms and indicating devices.

3.3 TRAINING

END OF SECTION

SECTION 26 22 13

DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Dry-type transformers, 1000 kVA and less.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 05 26 – Grounding and Bonding.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C57.96, Guide for Loading Dry-Type Distribution and Power Transformers.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ST 20, Dry-Type Transformers for General Applications.
      c. TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.
   3. Underwriters Laboratories, Inc. (UL):
      a. 506, Standard for Safety Specialty Transformers.
      b. 1561, Standard for Safety Dry-Type General Purpose and Power Transformers.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings.
      a. Nameplate drawing.
   4. Certifications:
      a. Sound level certifications.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Eaton.
   2. General Electric Company.
   3. Square D Company.
   4. Siemens.

5. Sola/Hevi-Duty.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 GENERAL PURPOSE DRY-TYPE TRANSFORMERS

A. Ventilated or non-ventilated, air cooled, two (2) winding type.

B. Cores:
1. High grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses.
2. Magnetic flux densities are to be kept well below the saturation point.

C. Coils: Continuous wound with electrical grade aluminum.

D. Ventilated Units:
1. Core and coils assembly impregnated with non-hygroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture and completely isolated from the enclosure by means of vibration dampening pads.
2. Dripproof, NEMA 1, steel enclosure finished with a weather-resistant enamel and ventilation openings protected from falling dirt.

E. Furnish Taps for Transformers as follows:
1. 1 PH, 2 kVA and below: None.
2. 1 PH, 3 to 25 kVA: Two (2) 5 percent FCBN.
3. 1 PH, 25 kVA and above: Two (2) 2.5 percent FCAN and four (4) 2.5 percent FCBN.
4. 3 PH, 3 to 15 kVA: Two (2) 5 percent FCBN.
5. 3 PH, 15 kVA and above: Two (2) 2.5 percent FCAN and four (4) 2.5 percent FCBN.

F. Sound Levels:
1. Manufacturer shall guarantee not to exceed the following:
   a. Up to 9 kVA: 40 dB.
   b. 10 to 50 kVA: 45 dB.

G. Efficiency:
1. Ventilated, 15 kVA and larger: Energy efficient meeting NEMA TP 1 requirements.

H. Insulating Material (600 V and below):
1. 3 to 15 kVA units: 185 DegC insulation system with a 115 DegC rise.
2. 15 kVA and above units: 220 DegC insulation system with a 150 DegC rise.

I. Ratings: 60 Hz, voltage, KVA and phase, as indicated on the Drawings.

J. Finish: Rust inhibited primer and manufacturers standard paint inside and out.

K. Standards: IEEE C57.96, NEMA ST 20, NEMA TP 1, UL 506, UL 1561.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Indoor Locations:
1. Provide ventilated type for 15 kVA units and above.
2. Provide non-ventilated type for 9 kVA units and below.
3. Mount 9 kVA units and below on wall.
4. Mount 15 kVA units and above on chamfered 4 IN high concrete housekeeping pad or from wall and/or ceiling, at 7 FT above finished floor, using equipment support brackets per Section 26 05 00.
5. Provide rubber vibrations isolation pads.

C. Enclosures: Painted steel in all areas except stainless steel where indicated on the Drawings.

D. Ground in accordance with Section 26 05 26.

END OF SECTION

SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Additions to low voltage switchboards.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. PB 2, Deadfront Distribution Switchboards.
   2. Underwriters Laboratories, Inc. (UL):
      a. 891, Standard for Safety Dead-Front Switchboards.

B. Verify the space required for the switchboard is equal to or less than the space allocated.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data.
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
   3. See Specification Section 26 05 00 for additional requirements.
   4. Fabrication and/or layout drawings:
      a. Switchboard layout with alphanumeric designation, protective devices size and type, as indicated in the one-line diagram or switchboard schedule.
      b. Front elevation and plan drawing of the assembly.
      c. Three-line or single line and schematic diagrams.
      d. Conduit space locations within the assembly.

B. Contract Closeout Information:
   1. Operation and Maintenance Manuals:
      a. See Specification Section 01 33 04 for requirements for:
         1) The mechanics and administration of the submittal process.
         2) The content of Operation and Maintenance Manuals.
   2. Fabrication and/or layout drawings updated with as-build conditions

C. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Ground fault protection system test report signed by the projects supervising electrical foreman.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Eaton.
   2. General Electric Company.
   3. Square D Company.
   4. Siemens.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 SWITCHBOARDS

A. Ratings:
   1. Voltage, number of phases, number of wires, and main bus current rating to match existing switchboard to which this new section will be added.
   2. Assembly short circuit current and interrupting device rating to match existing.
   3. When low voltage power circuit breakers are utilized, the switchboard shall have a 30 cycle withstand rating corresponding to the breaker rating.

B. Construction:
   1. Standards: NEMA PB 2, UL 891.
   2. Completely enclosed, dead-front, self-supporting metal structure.
   3. Vertical panel sections bolted together.
   4. Frames bolted together to support and house bus, cables and other equipment.
   5. Frames and insulating blocks to support and brace main buses for short circuit stresses up to ratings indicated on the Drawings.
   6. All sections front and rear aligned.
   7. Devices front removable and load connections front and rear accessible.
   8. NEMA 3R rated weatherproof enclosure:
      a. Nonwalk-in type with sloping roof downward toward rear.
      b. Thermostatically controlled space heaters to minimize internal condensation.
      c. Power for heater derived internal to the switchboard.
   9. Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and manufacturers standard paint.

C. Buses:
   1. Material: Silver-plated copper.
   2. Main horizontal bus:
      a. Fully rated and continuous over length of switchboard with all three (3) phases arranged in the same vertical plane.
      b. Sufficient size to limit temperature rise to 65 DegC over average air temperature outside the enclosure of 40 DegC.
   3. Neutral bus: Fully rated and continuous over length of switchboard unless neutral lugs are indicated on the Drawings for termination of service entrance neutral conductors.
   4. Ground bus: 1/4 x 2 IN copper, continuous over length of switchboard and solidly grounded to each vertical section structure.
   5. Bus joints connected using through bolts and conical spring-type washers for maximum conductivity.

D. Overcurrent and Short Circuit Protective Devices:
   1. Individually mounted molded case circuit breaker.
   2. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.
   3. Factory installed.
   4. Means to padlock all feeder devices in the open position.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Arrange switchboard as shown on the Drawings.

C. Outdoor location:
   1. NEMA 3R enclosure.
   2. Install on concrete pad, align front of switchboard with top edge of pad chamfer and securely fasten to pad.

D. Miscellaneous:
   1. Provide circuit protective devices and other associated equipment as indicated on the Drawings.
   2. All control wiring shall be neatly laced and have flexibility at hinge locations.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Lighting and appliance panelboards.
   2. Power distribution panelboards.
   3. Panelboards mounted in Motor Control Centers.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. PB 1, Panelboards.
   2. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   3. Underwriters Laboratories, Inc. (UL):
      a. 50, Enclosures for Electrical Equipment, Non-Environmental Considerations.
      b. 67, Standard for Panelboards.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data.
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings:
      a. Panelboard layout with alphanumeric designation, branch circuit breakers size and type, as indicated in the panelboard schedules.

B. Contract Closeout Information:
   1. Operation and Maintenance Manuals:
      a. See Specification Section 01 33 04 for requirements for:
         1) The mechanics and administration of the submittal process.
         2) The content of Operation and Maintenance Manuals.
   2. Panelboard schedules with as-built conditions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Eaton.
   2. General Electric Company.

3. Square D Company.
4. Siemens.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MANUFACTURED UNITS

A. Standards: NEMA PB 1, NFPA 70, UL 50, UL 67.

B. Ratings:
1. Current, voltage, number of phases, number of wires as indicated on the Drawings.
2. Panelboards rated 240 Vac or less: 10,000 amp short circuit rating unless otherwise indicated on the Drawings.
3. Panelboards rated 480 Vac: As indicated on the Drawings.
4. Service Entrance Equipment rated when indicated on the Drawings.

C. Construction:
1. Interiors factory assembled and designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
2. Multi-section panelboards: Feed-through or sub-feed lugs.
3. Main lugs: Solderless type approved for copper and aluminum wire.

D. Bus Bars:
1. Main bus bars:
   a. Copper sized to limit temperature rise to a maximum of 65 DegC above an ambient of 40 DegC.
   b. Drilled and tapped and arranged for sequence phasing of the branch circuit devices.
2. Ground bus and isolated ground bus, when indicated on the Drawings: Solderless mechanical type connectors.
3. Neutral bus bars: Insulated 100 percent rated or 200 percent rated, when indicated on the Drawings and with solderless mechanical type connectors.

E. Enclosure:
1. Boxes: Code gage galvanized steel, furnish without knockouts.
   a. NEMA 4X boxes shall be stainless steel.
2. Trim assembly: Code gage steel finished with rust inhibited primer and manufacturer's standard paint inside and out.
3. Lighting and appliance panelboard:
   a. Trims supplied with hinged door over all circuit breaker handles.
   b. Trims for surface mounted panelboards, same size as box.
   c. Doors lockable with corrosion resistant chrome-plated combination lock and catch, all locks keyed alike.
   d. Nominal 20 IN wide and 5-3/4 IN deep with gutter space in accordance with NFPA 70.
   e. Clear plastic cover for directory card mounted on the inside of each door.
4. Power distribution panelboard:
   a. Trims cover all live parts with switching device handles accessible.
   b. Less than or equal to 12 IN deep with gutter space in accordance with NFPA 70.
   c. Clear plastic cover for directory card mounted front of enclosure.
5. Ratings:
   a. NEMA 1.
   b. NEMA 4X stainless steel.

F. Overcurrent and Short Circuit Protective Devices:
1. Main overcurrent protective device:
   a. Molded case circuit breaker.
2. Branch overcurrent protective devices:
   a. Mounted molded case circuit breaker.
3. See Section 26 28 00 for overcurrent and short circuit protective device requirements.
4. Factory installed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated on the Drawings, in accordance with the NFPA 70, and in accordance with manufacturer's instructions.
   1. Mounting height: 72 IN to top.

B. Support panelboard enclosures from wall studs or modular channels support structure, per Specification Section 26 05 00.

C. Provide NEMA 1, or NEMA 4X rated enclosure as indicated on the Drawings.

D. Provide each panelboard with a typed directory:
   1. Identify all circuit locations in each panelboard with the load type and location served.
   2. Mechanical equipment shall be identified by Owner-furnished designation if different than designation indicated on the Drawings.
   3. Room names and numbers shall be final building room names and numbers as identified by the Owner if different than designation indicated on the Drawings.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Motor control centers.
   2. Separately mounted motor starters (including those supplied with equipment).
   3. Manual motor starters.
   4. Modifications and/or additions to existing motor control centers.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 08 13 - Acceptance Testing.
   5. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.
   6. Section 26 43 13 - Low Voltage Surge Protective Devices (SPD).
   7. Section 26 09 16 - Control Equipment Accessories.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. International Electrotechnical Commission (IEC).
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volt Maximum).
      b. ICS 2, Controllers, Contactors and Overload Relays Rated 600 V.
   3. Underwriters Laboratories, Inc. (UL):
      a. 508, Standard for Industrial Control Equipment.
      b. 845, Motor Control Centers.

B. Miscellaneous:
   1. Verify motor horsepower loads, other equipment loads, and controls from approved shop drawings and notify Engineer of any discrepancies.
   2. Verify the required instrumentation and control wiring for a complete system and notify Engineer of any discrepancies.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings:
      a. Motor control center:
         1) Elevation drawing with overall dimensions.
         2) Starter and component schedule.
         3) Identification of units and their location in the MCC.
         4) Location of incoming line terminals.
         5) Mounting dimensions.
         6) Available conduit entrance areas.
         7) Nameplate schedule.

8) Assembly ratings (amps, volts, short circuit, etc.).
9) Unit ladder logic wiring for each unit depicting electrical interlocking and wiring between units (NEMA ICS 3 Class II) and identification of terminals where field devices or remote control signals are to be terminated (NEMA ICS 3 Class II-S) as indicated on the Drawings and/or loop descriptions.

b. Separately mounted combination starters:
   1) Unit ladder logic wiring for each unit depicting electrical wiring and identification of terminals where field devices or remote control signals are to be terminated as indicated on the Drawings and/or loop descriptions.

B. Contract Closeout Information:
1. Operation and Maintenance Manuals:
   a. See Specification Section 01 33 04 for requirements for:
      1) The mechanics and administration of the submittal process.
      2) The content of Operation and Maintenance Manuals.
   b. Fabrication and/or layout drawings updated with as-built conditions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Allen-Bradley.
2. Eaton.
3. Square D Company.
4. Siemens.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MOTOR CONTROL CENTERS

A. Ratings:
1. 600 V class, 3 PH, 60 Hz with operating voltage and number of wires as indicated on the Drawings.
2. Assembly short circuit current and interrupting device rating as indicated on the Drawings.
3. Service Entrance Equipment rated when indicated on the Drawings.

B. Construction:
1. Standards: UL 845.
2. Totally enclosed, dead front, free standing assemblies, bolted together to form a single assembly.
3. Fabricate of not less than 14 GA steel with 16 GA steel doors in standardized units.
4. Nominal size per section: 20 IN wide, 20 or 21 IN deep, and 90 IN high.
5. Enclosure:
   a. NEMA 1 gasketed.
6. Horizontal wireways:
   a. At the top, isolated from the main bus
   b. At the bottom.
   c. Easily accessible.
   d. Full length of the MCC.
7. Vertical wireway:
   a. Located in each MCC section that accepts plug-in units.
   b. Connect to top and bottom wireways.
   c. Isolated from the unit interiors.
   d. Accessible through a separate hinged door.
   e. Cable tie supports to hold wiring in place.
8. Unit doors:

a. Formed round corners and rolled edges.
b. Minimum of two (2) heavy-duty hinges or continuous piano hinge.
c. Held closed by means of captive fasteners.
d. Fabricate to be a part of the structure and not part of the starter.

9. Unit cubicles:
    a. Draw-out type for motor starters through NEMA Size 5.
    b. Guide rails for supporting and aligning starters.
    c. Operating handle:
        1) With the unit stabs engaged and door closed the handle mechanism allows complete ON/OFF control of the unit disconnect and clear indication of the disconnect status.
        2) Circuit breaker and MCP operators includes a separate TRIPPED position.
        3) Mechanical interlock to prevent the opening of the door when the disconnect is in the ON position with a defeater mechanism.
        4) Mechanical interlock to prevent the placement of the disconnect in the ON position with the door open with a defeater mechanism.
        5) Non-defeatable interlock to prevent the installation or removal of a unit unless the disconnect is in the OFF position.
        6) Padlockable in the OFF position.
    d. Control panel:
        1) Provide control devices (selector switch, indicating devices, etc.) as indicated on the Drawings per Specification Section 26 09 16.
    e. Control power:
        1) Control power transformer:
            a) 120 V secondary.
            b) Fused on primary and secondary side.
            c) Sized for 140 percent of required load.
    f. Minimum of one (1) full size space unit (12 IN) for any combination magnetic motor starter or starter without overload relay.
    g. One-half full size space unit (6 IN) for circuit breakers 100 A and less.
    h. Effectively baffled to isolate any ionized gases which may occur within unit starter.
10. Externally mounted overload relay pushbutton.
11. Assemblies effectively ventilated to allow relocation of starters and other components:
    a. Within the assembly and with the same load.
    b. Without having to compensate for changes in location.
12. Finish: Rust inhibited primer and manufacturer's standard paint inside and out.
13. Provide ample unrestricted space for conduit entry from the bottom.
14. Wiring: NEMA ICS 3 Class II, Type B-D.

C. Buses:
1. Material: Tin-plated copper.
2. Main horizontal bus:
    a. Current rating as indicated on the Drawings.
    b. Extend the full-length of the MCC with provisions for splicing additional sections to either end.
3. Vertical buses:
    a. Same current rating as main horizontal bus when incoming service conductors terminate in that section. 150 percent of vertical section loads otherwise.
    b. Securely bolted to the horizontal main bus with joint easily accessible for maintenance.
    c. Completely isolated and insulated by means of a barrier.
    d. Extended full length of vertical section to distribute incoming power to each circuit breaker and starter in structure.
        1) Starters NEMA Size 5 and larger and certain other components may be cable connected to the main bus with the approval of the Engineer.
    e. Extend Vertical bus to spaces provided for future equipment.
4. Ground bus:

a. Extend the full-length of the MCC with provisions for splicing additional sections to either end.
b. ¼ x 2 IN (600 A) tin-plated copper.
c. Solidly grounded to each structure.
d. Locate near bottom of structure.
e. Provide for lug connection of equipment ground wires.

D. Overcurrent and Short Circuit Protective Devices:
1. Main device:
a. Molded case circuit breaker.
2. Feeder devices:
a. Molded case circuit breaker.
3. Motor protection with full voltage starters:
a. Motor circuit protector.
b. Molded case circuit breaker.
4. Motor protection with reduced voltage starters:
a. Molded case circuit breaker.
b. Motor circuit protector.
5. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.
6. Factory installed.

E. Motor Starters: See requirements within this Specification Section.

F. Panelboards: Integrally mounted, see Specification Section 26 24 16.

G. Transformers: Integrally mounted, see Specification Section 26 22 13.

H. Surge Protective Device:
1. Integrally mounted, see Specification Section 26 43 13.
2. Provide for motor control centers where indicated on the Drawings.

I. Power Monitor Metering:
1. Separate compartment.
2. See Specification Section 26 09 13 for meter requirements.
3. Provide for motor control centers where indicated on the Drawings.

J. Variable Frequency Drives: See Specification Section 26 29 23.

K. Miscellaneous:
1. See Drawings for items provided by other but factory installed (e.g., submersible motor temperature/leak controller, control system gateways or switches).

2.3 SEPARATELY MOUNTED COMBINATION STARTERS

A. Standards:
1. NEMA 250, NEMA ICS 2.
2. UL 508.

B. Enclosure:
1. NEMA 4 rated:
a. Body and cover: Sheet steel finished with rust inhibiting primer and manufacturer's standard paint inside and out.
b. No knockouts, external mounting flanges, hinged and gasketed door.
2. NEMA 4X rated:
a. Body and cover: Type 304 or 316 stainless steel.
b. No knockouts, external mounting flanges, hinged and gasketed door.
3. NEMA 7 and NEMA 9 rated:
a. Cast gray iron alloy or copper-free aluminum with manufacturer's standard finish.
b. Drilled and tapped openings or tapered threaded hub.
c. Gasketed cover bolted-down with stainless steel bolts.

d. External mounting flanges.
e. Front operating handle padlockable in the OFF position.
f. Accessories: 40 mil PVC exterior coating.
4. NEMA 12 rated:
a. Body and cover: Sheet steel finished with rust inhibiting primer and manufacturer's standard paint inside and out.
b. No knockouts, external mounting flanges, hinged and gasketed door.

C. Operating Handle:
1. With the door closed the handle mechanism allows complete ON/OFF control of the unit disconnect and clear indication of the disconnect status.
2. Circuit breaker and MCP operators includes a separate TRIPPED position.
3. Mechanical interlock to prevent to prevent the opening of the door when the disconnect is in the ON position with a defeater mechanism for use by authorized personnel.
4. Mechanical interlock to prevent the placement of the disconnect in the ON position with the door open with a defeater mechanism for use by authorized personnel.
5. Padlockable in the OFF position.
6. Exceptions: NEMA 7 enclosures.

D. External mounted overload relay pushbutton.

E. Control Devices:
1. Provide control devices as indicated on the Drawings per Specification Section 26 09 16.
2. Devices will be accessible with the door closed.

F. Control Power Transformer:
1. 120V secondary.
2. Fused on primary and secondary side.
3. Sized for 140 percent of required load.

G. Fault Current Withstand Rating: Equal to the rating of the electrical gear from which it is fed.

H. Motor Starters: See requirements within this Specification Section.

I. Disconnect Switch, Overcurrent and Short Circuit Protective Devices:
1. Motor circuit protector.
2. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.
3. Factory installed.

2.4 MOTOR STARTERS

A. Standards:
1. NEMA ICS 2.
2. UL 508.

B. Full Voltage Non-Reversing (FVNR) Magnetic Starters:
1. NEMA full size rated contactor.
a. NEMA half sizes and IEC contactors are not permitted.
2. Double-break silver alloy contacts.
3. Overload relays:
a. Ambient insensitive, adjustable solid state type with phase loss protection, phase imbalance protection and manual reset.
4. Interlock and auxiliary contacts, wired to terminal blocks:
a. Holding circuit contact, normally open.
b. Overload alarm contact.
c. Normally open auxiliary contact, for remote run status.
d. Additional field replaceable auxiliary contacts as required per the control schematics indicated on the Drawings.

2.5 MANUAL MOTOR STARTERS

A. Standards:
   1. NEMA 250, NEMA ICS 2.
   2. UL 508.

B. Quick-make, quick-break toggle mechanism that is lockable in the OFF position.

C. Types:
   1. Horsepower rated, for ON/OFF control and thermal overload protection.
      a. Switch to clearly indicate ON, OFF, and TRIPPED position.

D. Voltage and current ratings and number of poles as required for the connected motor.

E. Enclosures:
   1. NEMA 1 rated:
      a. Galvanized steel or steel finished with rust inhibiting primer and manufacturer's standard paint inside and out.
      b. With or without concentric knockouts.
   2. NEMA 4X rated:
      a. Type 304 or 316 stainless steel.
      b. No knockouts, external mounting flanges.
   3. NEMA 12 rated:
      a. Body and cover: Sheet steel finished with rust inhibiting primer and manufacturer's standard paint inside and out.
      b. No knockouts, external mounting flanges.

2.6 MISCELLANEOUS

A. Control devices: See Section 26 09 16.

B. Tagging and Identification of Equipment and Wiring:
   1. See Section 10 14 00.
   2. Relays, terminals, and special devices inside motor control equipment shall have permanent markings to match identification used on manufacturer's drawings.
   3. Factory control wiring shall be marked in accordance with the manufacturer's wiring diagrams.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated on the Drawings and in accordance with manufacturer's recommendations and instructions.

B. Mounting height for surface mounted equipment:
   1. Separately mounted motor starter (to center of operating handle): 54 IN.

C. Mount MCC on 4 IN high concrete pad:
   1. Install two (2) 4 IN wide channel sills flush in pads to support and maintain alignment of the MCC.
   2. Align front of MCC with top edge of pad chamfer.

D. Overload Heaters:
   1. Size for actual motor full load current of the connected motor.

E. Combination and Manual Starter Enclosures:
   1. Permitted uses of NEMA 1 enclosure:
      a. Surface or flush mounted in architecturally finished areas.
      b. Surface mounted above 10 FT in areas designated as dry in architecturally and non-architecturally finished areas.
   2. Permitted uses of NEMA 4X enclosure:

a. Surface mounted in areas designated as wet and/or corrosive.

3. Permitted uses of NEMA 12 enclosure:

   a. Surface mounted in areas designated as dry.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: See Specification Section 26 08 13.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Wall switches.
      b. Receptacles.
      c. Device wallplates and coverplates.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 05 33 - Raceways and Boxes.
   5. Section 26 24 19 - Motor Control Equipment.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. WD 1, General Color Requirements for Wiring Devices.
      c. WD 6, Wiring Devices - Dimensional Requirements.
   2. Underwriters Laboratories, Inc. (UL):
      a. 20, General-Use Snap Switches.
      b. 498, Standard for Attachment Plugs and Receptacles.
      c. 514A, Metallic Outlet Boxes.
      d. 894, Standard for Switches for Use in Hazardous (Classified) Locations.
      e. 943, Ground-Fault Circuit-Interrupters.
      f. 1010, Standard for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.
      g. 1310, Standard for Class 2 Power Units.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Wall switches and receptacles:
      a. Bryant Electric.
      b. Cooper Wiring Devices by Eaton.
      c. Hubbell Incorporated Wiring Device-Kellems.

d. Leviton Manufacturing Company.
e. Legrand/Pass & Seymour.
f. Eaton Crouse-Hinds.
g. Appleton Electric Co.
h. Hubbell Killark.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 WALL SWITCHES

A. Basic requirements unless modified in specific requirements paragraph of switches per designated areas or types:
1. Industrial Specification Grade.
2. Quiet action, snap switch.
3. Self grounding with grounding terminal.
4. Back and side wired.
5. Solid silver cadmium oxide contacts.
6. Rugged thermoplastic and/or nylon housing and one-piece switch arm.
7. Ratings: 20 A, 120/277 Vac.
8. Switch handle type: Toggle.
9. Switch handle color: Ivory.
10. Types as indicated on the Drawings:
a. Single-pole.
b. Double-pole.
c. 3-way.
11. Standards: UL 20, UL 514A, NEMA WD 1, NEMA WD 6.

B. Architecturally Finished Areas:
1. Wallplate:
a. 302 or 304 brushed finish stainless steel.
b. Single or multiple gang as required.

C. Dry Non-architecturally Finished Areas:
1. Coverplate:
a. 302 or 304 brushed finish stainless steel.
b. Single or multiple gang as required.

D. Wet Non-architecturally Finished areas:
1. Coverplate:
a. Cast aluminum, gasketed, stainless steel hardware, natural, lacquer, or factory painted finish.
b. Operator type:
1) Side mounted rocker type handle to operate snap switch.
2) Front mouted lever type handle to operate snap switch.
3) Push/pull operator to operate snap switch.
c. Spring type door to cover snap switch.
d. Wet location rated.
e. Single or multiple gang as required.

E. Corrosive Areas:
1. Corrosion resistant nickel plated metal parts.
2. Coverplate for use on metallic outlet boxes:
a. Cast aluminum, gasketed, stainless steel hardware, natural, lacquer, or factory painted finish.
b. Single or multiple gang as required.
3. Coverplate for use on non-metallic outlet boxes:
a. High impact thermoplastic, gasketed, stainless steel screws.
1) Front mounted lever to operate snap switch.
b. Spring type door to cover snap switch.

c. Single or multiple gang as required.
4. Coverplate for use on PVC coated metallic outlet boxes:
   a. PVC coated galvanized cast iron alloy, gasketed, stainless steel hardware.
   b. PVC coated cast aluminum, stainless steel hardware.
   c. Single or multiple gang as required.

F. Hazardous and Dry Area specific requirements:
1. Rated for Class I, Division 1 and 2, Groups C and D.
2. Assembly consists of outlet box, snap switch and coverplate.
   a. NEMA 7 rated.
3. Outlet box:
   a. Cast iron alloy, galvanized and factory painted finish.
   b. Cast aluminum, natural, lacquer, or factory painted finish.
4. Snap switch (EDS Type):
   a. Enclosed in separate sealing chamber and approved for installation without additional external sealing fittings.
   b. Sealing chamber has prewired factory sealed pigtail leads.
5. Snap switch (EFS Type):
   a. Not enclosed in separate sealing chamber requiring external sealing fittings.
6. Coverplate:
   a. Cast iron alloy, stainless steel hardware, galvanized and factory painted finish.
   b. Cast aluminum, stainless steel hardware, natural, lacquer, or factory painted finish.
   c. Operator type:
      1) Front mounted lever to operate snap switch.
      2) Side rocker arm operator to operate snap switch.
7. Standards: UL 894.

G. Hazardous and Wet Area specific requirements:
1. Rated for Class I, Division 1 and 2, Groups C and D.
2. Assembly consists of outlet box, snap switch and coverplate.
   a. NEMA 3, 7 and 9 rated.
3. Outlet box:
   a. Cast aluminum, natural, lacquer, or factory painted finish.
4. Snap switch (EDS Type):
   a. Enclosed in separate sealing chamber and approved for installation without additional external sealing fittings.
   b. Sealing chamber has prewired factory sealed pigtail leads.
5. Snap switch (EFS Type):
   a. Not enclosed in separate sealing chamber requiring external sealing fittings.
6. Coverplate:
   a. Cast aluminum, stainless steel hardware, natural, lacquer, or factory painted finish.
   b. Operator type:
      1) Front mounted lever to operate snap switch.
      2) Side rocker arm operator to operate snap switch.
7. Standards: UL 894.

H. Hazardous and Corrosive Area specific requirements:
1. Rated for Class I, Division 1 and 2, Groups C and D.
2. Assembly consists of outlet box, snap switch and coverplate.
   a. NEMA 3, 7 and 9 rated.
3. Outlet box:
   a. Cast aluminum, natural, lacquer, or factory painted finish.
4. Snap switch (EDS Type):
   a. Enclosed in separate sealing chamber and approved for installation without additional external sealing fittings.
   b. Sealing chamber has prewired factory sealed pigtail leads.
5. Snap switch (EFS Type):

a. Not enclosed in separate sealing chamber requiring external sealing fittings.
6. Coverplate:
a. Cast aluminum, stainless steel hardware, natural, lacquer, or factory painted finish.
b. Operator type:
1) Front mounted lever to operate snap switch.
2) Side rocker arm operator to operate snap switch.
7. Standards: UL 894.

2.3 RECEPTACLES

A. Basic requirements unless modified in specific requirements paragraph of receptacles and per designated areas:
1. Industrial Specification Grade.
2. Straight blade.
3. Brass triple wipe line contacts.
4. One-piece grounding system with double wipe brass grounding contacts and self grounding strap with grounding terminal.
5. Back and side wired.
6. Rating: 20 A, 125 Vac.
7. High impact nylon body.
8. Receptacle body color:
a. Normal power: Ivory.
9. Duplex or simplex as indicated on the Drawings.
10. Configuration: NEMA 5-20R.
11. Standards: UL 498, UL 514A, NEMA WD 1, NEMA WD 6.

B. Receptacle type specific requirements:
1. Basic receptacles:
a. Weather-resistant when located in wet areas as indicated on the Drawings.
1) Identification: Letters “WR” on face of receptacle.
2. Ground Fault Circuit Interrupter (GFCI):
a. Specification Grade.
b. Class A protection.
c. Feed through type.
d. Test and reset buttons.
e. Self-testing.
f. Visual indicator light.
g. Weather-resistant when located in wet areas as indicated on the Drawings.
1) Identification: Letters “WR” on face of receptacle.
h. Additional standards: UL 943.

C. Dry Non-architecturally Finished Areas:
1. Coverplate:
a. 302 or 304 brushed finish stainless steel.
b. Single or multiple gang as required.

D. Wet Non-architecturally Finished Areas:
1. Coverplate:
a. Extra-duty rated, weatherproof (NEMA 3R) while in use, gasketed, stainless steel hardware, copper-free aluminum, 3.2 IN minimum cover depth for #12 AWG cords.

E. Exterior Locations:
1. Coverplate:
a. Extra-duty rated, weatherproof (NEMA 3R) while in use, gasketed, stainless steel hardware, copper-free aluminum, 3.2 IN minimum cover depth for #12 AWG cord.

F. Corrosive Areas:
1. Corrosion resistant nickel plated metal parts.
2. Receptacle body color: Yellow.

3. Coverplate for use on metallic outlet boxes:
    a. Cast aluminum, stainless steel hardware, natural, lacquer or factory painted finish.
    b. Single or multiple gang as required.
4. Coverplate for use on non-metallic outlet boxes:
    a. High impact thermoplastic, self-closing cover, stainless steel hardware.
    b. Single or multiple gang as required.

G. Corrosive and Wet Areas:
1. Corrosion resistant nickel plated metal parts.
2. Receptacle body color: Yellow.
3. Weather-resistant.
    a. Identification: Letters "WR" on face of receptacle.
4. Coverplate for use on metallic outlet boxes:
    a. Extra-duty rated, weatherproof (NEMA 3R) while in use, gasketed, stainless steel hardware, copper-free aluminum, 3.2 IN minimum cover depth for #12 AWG cord.
5. Coverplate for use on non-metallic outlet boxes:
    a. Extra-duty rated, weatherproof (NEMA 3R) while in use, gasketed, stainless steel hardware, flame retardant, UV stabilized polycarbonate, 3.2 IN minimum cover depth for #12 AWG cords.

H. Hazardous Areas:
1. Rated for Class I, Division 1 and 2, Groups C and D.
2. Assembly consists of outlet box and a combination receptacle/switch and housing.
    a. NEMA 3, 7 and 9 rated.
3. Outlet box (EDS Type):
    a. Cast aluminum, natural, lacquer, or factory painted finish.
4. Receptacle/switch and housing:
    a. Receptacle and switch enclosed in a factory sealed chamber and approved for installation without additional external sealing fittings.
    b. Insertion of "interchanger" plug and plug rotation will close the switch to energize receptacle and lock plug into the receptacle.
    c. "Interchanger" plug to be compatible with other manufacturers hazardous receptacle and work in ordinary convenience receptacles.
    d. Ordinary equipment plugs will not active the hazardous receptacle.
    e. Housing:
        1) Cast aluminum, stainless steel hardware, natural, lacquer, or factory painted finish.
        2) Spring-loaded door seats against neoprene gasket. Stainless steel spring.
5. "Interchanger" plug:
    a. Aluminum housing.
    b. 30% Glass-reinforced thermoplastic polyester housing.
    c. Provide 5 plugs for Owners use.
6. Standards: UL 894 and 1010.

I. Special Purpose Receptacles:
1. NEMA configuration as indicated on the Drawings.
2. Coverplate: See requirements per area designations herein.

2.4 MISCELLANEOUS WIRING DEVICES

A. Manual Motor Starters: Horsepower rated with or without thermal overloads, see Specification Section 26 24 19.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Mount devices where indicated on the Drawings and mounting height as noted below:

1. Light switch (to center): 48 IN.
2. Receptacle on exterior wall of building (to center): 18 IN.
3. Receptacle in non-architecturally finished areas (to center): 48 IN.
4. Telephone outlet in architecturally finished areas (to center): 18 IN.
5. Telephone outlet for wall-mounted phone (to center): 54 IN.

C. See Specification Section 26 05 33 for device outlet box requirements.

D. Where more than one (1) receptacle is installed in a room, they shall be symmetrically arranged.

E. Provide blank plates for empty outlets.

END OF SECTION

SECTION 26 28 00

OVERCURRENT AND SHORT CIRCUIT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Low voltage circuit breakers.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 05 74 – Short Circuit and Coordination Study and Arc Flash Report.
   5. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
      b. C37.16, Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations.
      c. C37.17, Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
   2. National Electrical Manufacturers Association (NEMA):
      a. AB 1, Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures. (Equivalent to UL 489)
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL):
      a. 489, Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
      b. 943, Standard for Safety for Ground-Fault Circuit-Interrupters.
      c. 1066, Standard for Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

2. Reports:
    a. As-left condition of all circuit breakers that have adjustable settings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
  1. Circuit breakers:
     a. Eaton.
     b. General Electric Company.
     c. Square D Company.
     d. Siemens.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 CIRCUIT BREAKERS

A. Molded Case Type:
  1. General:
     a. Standards: NEMA AB 1, UL 489.
     b. Unit construction.
     c. Over-center, toggle handle operated.
     d. Quick-make, quick-break, independent of toggle handle operation.
     e. Manual and automatic operation.
     f. All poles open and close simultaneously.
     g. Three (3) position handle: On, off and tripped.
     h. Molded-in ON and OFF markings on breaker cover.
     i. One-, two- or three-pole as indicated on the Drawings.
     j. Current and interrupting ratings as indicated on the Drawings.
     k. Bolt on type.
  2. Thermal magnetic type:
     a. Inverse time overload and instantaneous short circuit protection by means of a thermal magnetic element.
     b. Frame size 150 amp and below:
        1) Non-interchangeable, non-adjustable thermal magnetic trip units.
     c. Frame sizes 225 to 400 amp (trip settings less than 400A):
        1) Interchangeable and adjustable instantaneous thermal magnetic trip units.
     d. Ground Fault Circuit Interrupter (GFCI) Listed:
        1) Standard: UL 943.
        2) One- or two-pole as indicated on the Drawings.
        3) Class A ground fault circuit.
        4) Trip on 5 mA ground fault (4-6 mA range).
  3. Solid state trip type:
     a. Inverse time overload, instantaneous short circuit and ground fault protection by means of a solid state trip element, associated current monitors and flux shunt trip mechanism.
     b. Frame size 400 amp to 1200 amp (trip settings between 400 and 1200A):
        1) Standard rating.
        2) Interchangeable current sensor or rating plug.
        3) Adjustable long time pick-up setting.
           a) Adjustable from 50 to 100 percent of the current sensor or rating plug.
        4) Adjustable short time pick-up setting.
        5) Adjustable instantaneous pick-up.
        6) Fixed ground fault pick-up, when indicated on the Drawings.
     c. Frame size 1600 amp and above:
        1) 100 percent rated.

2) Interchangeable current sensor or rating plug.
3) Adjustable long time pick-up setting.
a) Adjustable from 50 to 100 percent of the current sensor or rating plug.
4) Adjustable long time delay setting.
5) Adjustable short time pick-up setting.
6) Adjustable instantaneous pick-up setting.
7) Adjustable ground fault pick-up setting, when indicated on the Drawings.
8) Adjustable ground fault delay setting, when indicated on the Drawings.

4. Motor circuit protector:
a. Adjustable instantaneous short circuit protection by means of a magnetic or solid state trip element.
b. Sized for the connected motor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Current and interrupting ratings as indicated on the Drawings.

B. Series rated systems not acceptable.

C. Devices shall be ambient temperature compensated.

D. Circuit Breakers:
1. Molded case circuit breakers shall incorporate the following, unless indicated otherwise on the Drawings:
a. Frame sizes 400 amp and less with trip setting less than 400A shall be thermal magnetic type.
b. Frame sizes 600 amp and larger shall be solid state trip type.
c. Frame sizes 1000 amp and above shall include integral ground fault protection, when indicated on the Drawings.
d. Motor circuit protectors sized for the connected motor.

3.2 FIELD QUALITY CONTROL

A. Adjustable Circuit Breakers:
1. Set all circuit breaker adjustable taps as defined in the coordination study, except adjust motor circuit protectors per the motor nameplate and NFPA 70 requirements.
a. Coordination study: See Section 26 05 74.

B. Ground Fault Protection System:
1. Single source system:
a. Main breaker using the residual sensing method system coordinated with individual feeder breakers using the residual sensing method.

C. Testing:
1. Acceptance testing: See Specification Section 26 08 13.

END OF SECTION

SECTION 26 28 16

SAFETY SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Safety switches.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
   2. Underwriters Laboratories, Inc. (UL):
      a. 98, Enclosed and Dead-Front Switches.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. Provide a Summary Table or use Exhibit A that associates the safety switch features with connected equipment tag number. Exhibit A indicates minimum data required.
      c. See Specification Section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following safety switch manufacturers are acceptable:
   1. Eaton
   2. General Electric Company.
   3. Square D Company.
   4. Siemens.
   5. Appleton Electric Company.
   6. Crouse-Hinds.
   7. Killark.

2.2 SAFETY SWITCHES

A. General:
   1. Non-fusible or fusible as indicated on the Drawings.
   2. Suitable for service entrance when required.
   3. NEMA Type HD heavy-duty construction.

4. Switch blades will be fully visible in the OFF position with the enclosure door open.
5. Quick-make/quick-break operating mechanism.
6. Deionizating arc chutes.
7. Manufacture double-break rotary action shaft and switchblade as one (1) common component.
8. Clear line shields to prevent accidental contact with line terminals.
9. Operating handle (except NEMA 7 rated enclosures):
   a. Red and easily recognizable.
   b. Padlockable in the OFF position
   c. Interlocked to prevent door from opening when the switch is in the ON position with a defeater mechanism.

B. Ratings:
1. Horsepower rated of connected motor.
2. Voltage and amperage: As indicated on the Drawings.
3. Short circuit withstand:
   a. Non-fused: 10,000A.
   b. Fused: 200,000A.

C. Accessories, when indicated in PART 3 of this Specification Section or on the Drawings:
1. Neutral kits.
2. Ground lug kits.
3. Auxiliary contact kits:
   a. Opens before main switch.
   b. Rated 10A at 125/250 Vac.
   c. One (1) N.O. and one (1) N.C. contact.

D. Enclosures:
1. NEMA 4X rated (metallic):
   a. Body and cover: Type 304 or 316 stainless steel.
   b. No knockouts, external mounting flanges, hinged and gasketed door.
2. NEMA 4X rated (nonmetallic):
   a. Body and cover: Ultraviolet light protected fiberglass-reinforced polyester boxes.
   b. No knockouts, external mounting flanges, hinged, gasketed and lockable door.
3. NEMA 7 rated:
   a. Cast gray iron alloy or copper-free aluminum with manufacturer’s standard finish.
   b. Drilled and tapped openings or tapered threaded hub.
   c. Gasketed cover bolted-down with stainless steel bolts.
   d. External mounting flanges.
   e. Operating handle padlockable in the OFF position.
4. NEMA 12 rated:
   a. Body and cover: Sheet steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
   b. No knockouts, external mounting flanges, hinged and gasketed door.

E. Overcurrent and short circuit protective devices:
1. Fuses.
2. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.

F. Standards: NEMA KS 1, UL 98.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's instructions and recommendations.
1. Unless indicated otherwise on the Drawings, mounting heights are as indicated below:

a. Safety switch (to center of operating handle): 54 IN.

B. Install switches adjacent to the equipment they are intended to serve unless otherwise indicated on the Drawings.

C. Provide auxiliary contact kit on local safety switches for motors being controlled by a variable frequency drive.
   1. The VFD is to be disabled when the switch is in the open position.

D. Permitted uses of NEMA 4X metallic enclosure:
   1. Surface mounted in areas designated as wet and/or corrosive.

E. Permitted uses of NEMA 4X nonmetallic enclosure when indicated on the Drawings:
   1. Surface mounted in areas designated as corrosive.

F. Permitted uses of NEMA 7 enclosure:
   1. Surface mounted in areas designated as Class I hazardous.
   2. Provide PVC coating in corrosive areas when PVC coated conduit is used.

G. Permitted uses of NEMA 12 enclosure:
   1. Surface mounted in areas designated as dry in non-architecturally finished areas.

END OF SECTION

EXHIBIT A

Safety Switch Summary Table

Equipment Tag	Switch Model Number	Rated Amps	Fused / Non-fused	Enclosure Type	Accessories
Example	Per MFR	60A	NF	NEMA 4X non-metallic	Ground lug, Aux Contact

SECTION 26 29 23

VARIABLE FREQUENCY DRIVES: LOW VOLTAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Variable frequency drives (VFDs) for operation of inverter duty motors.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 - Identification Devices.
   4. Section 26 05 00 - Electrical: Basic Requirements.
   5. Section 40 05 05 - Equipment: Basic Requirements.
   6. Section 40 90 05 - Control Loop Descriptions.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. ETL Testing Laboratories (ETL).
   3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 399, Recommended Practice for Industrial and Commercial Power Systems Analysis.
      b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
      c. C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
   4. National Electrical Manufacturer's Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. MG 1, Motors and Generators.
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC):
         1) Article 430, Motors Motor Circuits, and Controllers..
   6. Occupational Safety and Health Administration (OSHA).
   7. Underwriters Laboratory, Inc. (UL):
      a. 508, Standard for Industrial Control Equipment.
      b. 508A, Standard for Industrial Control Panels.

B. Qualifications:
   1. Provide drives that are listed and labeled by UL, ETL, or other Nationally Recognized Testing Laboratory (NRTL) as defined by OSHA regulations, or that have been inspected and subsequent field-labeled by such NRTL.
   2. Where listed drives and other components are installed in a common enclosure, the assembly shall be listed and labeled per UL 508 and UL 508A or equivalent NRTL standard.
      a. Entire assembly shall be affixed with a UL 508A label "Listed Enclosed Industrial Control Panel" or equivalent NRTL label prior to shipment to the jobsite.
   3. VFD Supplier shall maintain an authorized service organization within 300 miles of the Project Site.

C. Coordination:
   1. Motor and VFD coordination: See Specification Section 40 05 05.
   2. VFD shall be supplied complete with all required control components.
      a. Provide control as indicated:
         1) On the electrical Drawings.

2) As specified in this Specification Section.
3) As specified in the process control system loop descriptions.
a) See Specification Section 40 90 05.

b. VFD manufacturer shall review the application and provide, at no additional cost to the Owner, the hardware and software necessary to allow the VFD to control the driven equipment motor over its required operating range.
1) These may include, but are not limited to, analog and digital interface modules, communication interface modules, switches, lights and other devices.

c. Coordinate control devices with devices furnished with driven equipment such as vibration switches, thermal sensors, leak detectors, etc.

3. Verify plan dimensions with equipment space requirements as indicated on the Drawings.
a. Equipment which exceeds the allotted maximum dimensions may not be acceptable.
b. Equipment which reduces clear work space below the minimums established by the NFPA 70 will not be acceptable.

1.3 DEFINITIONS

A. Variable Torque (VT):
1. Defines a load characteristic in which the torque delivered from the motor to the load is reduced as speed is reduced below full rated.
2. This type of load permits the VFD and the motor to operate at reduced output current at reduced speed.

B. Constant Torque (CT):
1. Defines a load characteristic in which the torque delivered from the motor to the load remains constant as speed is varied.
2. This type of load requires the VFD to be able to continuously deliver rated output current over the entire speed range.

C. Constant Horsepower:
1. Defines a load characteristic in which the torque delivered from the motor to the load is reduced as the speed is increased.
2. This characteristic is required for operation of the VFD and motor above rated frequency to maintain output current within the rated value.

D. Inverter Duty Motor: An AC induction motor complying with all requirements of NEMA MG 1 Part 31 for definite-purpose inverter-fed motors.

E. Standard Motor: An AC induction motor that fails to comply with one (1) or more requirements of NEMA MG 1 Part 31.

F. Low Voltage: 600 Vac or less.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Provide for each VFD the following information:
a. Equipment Tag Number.
b. VFD Complete Catalog Number.
c. VFD Amp Frame Size.
d. Variable or Constant Torque Rating Basis.
e. Rated Input Current.
f. Rated Continuous Output Current.
g. Rated Short Circuit Current.
h. Verification that the VFD has been de-rated for elevation.
3. Product technical data:
a. Complete electrical ratings and performance specifications confirming compliance with specified ratings and performance.

b. Maximum rate of heat rejection from VFD and all related components and associated cooling requirements.
c. Manufacturer's installation instructions.
d. Manufacturer's programming and operating instructions.
e. See Specification Section 26 05 00 for additional requirements.

4. Fabrication and/or layout drawings:
   a. Top, front and side exterior views, with details showing maximum overall dimensions of enclosure, mounting provisions and conduit/cable entry provisions.
   b. Identify minimum clearances from other VFDs or electrical equipment required for proper cooling at top, bottom, side and back of enclosure.
   c. Three-line diagrams showing AC schematic of VFD, input, output and bypass devices including device ratings.
   d. Interior layout drawings showing location of all components within enclosure, field wiring terminal boards, and power and grounding connections.
   e. Field wiring diagrams showing locations and sizes of all electrical connections, ground terminations, and requirements for shielded wire usage or any other special installation considerations.
5. Certifications:
   a. Submit with Shop Drawings:
      1) Identification and location of closest authorized service organization.
   b. Submit prior to shipment:
      1) Certified factory test reports confirming compliance with specified requirements.
   c. Submit after installation:
      1) Certified field service reports showing:
         a) Each VFD is operational.
         b) Each VFD and its driven equipment motor are compatible.
         c) Each VFD responds correctly to the input control signals.
         d) Critical frequencies of the drive system and that the VFD has been set to lockout these frequencies.
         e) Measured harmonic levels per Harmonic Protection Requirements Article.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
   2. Approved copy of VFD schedule per Submittals Article.
   3. Manufacturer's instruction manuals.
   4. Troubleshooting procedures with a cross-reference between symptoms and corrective recommendations.
   5. Connection data to permit removal and installation of recommended smallest field-replaceable parts.
   6. Recommended spare parts list.
   7. Commissioning sheets showing "as-left" values of all user-programmable or adjustable drive parameters.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Danfoss.
   2. ABB.
   3. Eaton.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 GENERAL

A. VFDs shall consist of a rectifier-DC bus-inverter combination producing a sine-coded pulse-width-modulated (PWM) output voltage waveform.

B. VFDs, whether installed in motor control center (MCC) construction or separately-mounted, shall constitute a complete combination motor controller per NFPA 70, Article 430 and shall provide the following per the requirements of that article without the addition of any external components or devices.
   1. Motor control.
   2. Motor overload protection.
   3. Motor and motor branch circuit short circuit and ground fault protection.
   4. Motor and controller disconnecting means.

C. It is the intent of this Specification that VFDs shall be an "engineered" or "configured" drive package in which the VFD chassis, all input, output and bypass power devices, VFD accessories, ancillary switches, contactors, relays, and related control devices are selected, furnished, factory-assembled and -tested by the VFD manufacturer in a single enclosure requiring only connection of the power supply circuit, motor branch circuit, and external control wiring in the field.

2.3 PERFORMANCE AND DESIGN REQUIREMENTS

A. Application:
   1. VFD(s) shall be of sufficient capacity and shall provide a quality of output waveform for stepless motor control from 10 to 100 percent of base speed of the driven equipment.
   2. VFDs shall be compatible with:
      a. Inverter duty induction motors.
      b. Special purpose submersible induction motor/pump.
   3. VFDs shall be suitable for Constant Torque (CT) or Variable Torque (VT) applications.
      a. VFD manufacturer shall coordinate with the manufacturer of the driven equipment to identify CT and VT applications.
         1) Sludge Transfer Pumps' VFDs are to be rated for CT.
         2) Other VFDs rated as required.
   4. VFDs shall be designed to operate successfully under the following site conditions:
      a. Ambient:
         1) Temperature: 0-40 DegC.
         2) 95 percent non-condensing relative humidity.
      b. Elevation: 7200 FT above MSL.
      c. Power supply characteristics:
         1) 480Vac, 3 PH, 60 Hz, 3 wire, (+/- 10 percent).
         2) Effectively grounded.

B. Ratings and Performance Specifications:
   1. Voltage rating:
      a. Nominal: 460 or 480Vac, 3 PH, 60 Hz.
      b. Range for continuous full load operation: +/-10 percent of nominal.
      c. Voltage imbalance tolerance for full load operation: 3 percent minimum.
   2. Current ratings:
      a. Continuous:
         1) Equal to or greater than the motor nameplate full load current.
      b. Short-term overload:
         1) VT: 110 percent for 1 minute.
         2) CT: 150 percent for 1 minute.
         3) Permissible for 1 minute every 10 minutes continuously.
      c. Short circuit:
         1) As indicated on the Drawings.
         2) Where a short circuit rating is not indicated or specified for individual VFDs, each VFD shall have a rating not less than indicated on the Drawings for the MCC, switchboard or panelboard the VFD is supplied from.

3) Where specified short circuit rating indicates additional input impedance is required to protect semiconductors, provide input AC line reactors, whether required to meet harmonic performance specifications or not.

3. Efficiency:
   a. 97 percent, minimum, at full speed and full load.
   b. 93 percent, minimum at 1/2 speed and full load.
4. Displacement power factor:
   a. 95 percent, minimum from 50 percent to 100 percent speed and load.
5. Efficiency and power factor criteria apply from the input terminals to the output terminals of the VFD alone, excluding losses of input and output power circuit accessories.
6. Frequency drift:
   a. +0.5 percent of set frequency.
7. Speed regulation (motor dependent): 3 percent.
8. Speed range: 10:1.
9. Control type:
   a. Volts/Hertz ratio; constant over the entire operating range of the VFD except:
      1) When operating under voltage boost.
      2) At frequencies over 60 Hz.

C. Operational Features:
1. Insensitive to input phase sequence.
2. Continued operation with momentary voltage dips of 25 percent of rated voltage, or single phase condition: 4 second, minimum.
3. Controls power loss ride-through: 500 msec, minimum.
4. Electronic reversing.
5. DC injection braking.
6. Anti-windmilling: Synchronization of VFD starting frequency with spinning or coasting load, forward or reverse.
7. Critical frequency band lockout:
   a. Minimum of three (3) settings.
   b. Adjustable bandwidth, 1 - 5 Hz.
8. Capable of operating without the motor connected for start-up and troubleshooting.

D. The VFD shall be provided with the following minimum user-programmable parameters:
1. Carrier frequency.
2. Independent maximum and minimum speeds for forward and reverse operation.
3. Start frequency and hold time.
4. Independent linear acceleration and deceleration time.
5. Preset “jog” speed.
6. Three (3) critical frequency bands.
7. One (1) preset speed selectable by logic input.
8. Volts/Hertz ratio.
9. Voltage boost, magnitude and frequency range.
10. Process controller gain, offset and bias.
11. Current limit.
12. Overcurrent pickup.
13. Overcurrent delay.
14. Ground fault pickup.
15. DC injection level and time.

E. The VFD shall be designed such that the power circuit components are fully protected from line side disturbances and load side faults:
1. General:
   a. Shutdown conditions associated with supply circuit conditions which can be corrected external to the VFD-motor system shall be provided with automatic reset, with shutdown cause logged in memory:
      1) Input under voltage.

2) Input over voltage.
3) Input under frequency.
4) Input over frequency.
5) Input Phase loss.
6) DC Bus under voltage.

b. Shutdown conditions which indicate overload or fault within the VFD, the output circuit, or the motor shall require local manual reset at the VFD, requiring operator intervention.
1) Over temperature.
2) Blown fuse.
3) Component failure.
4) Overload.
5) Short circuit.
6) Ground fault.
7) DC Bus over voltage.
8) External safety input (e.g., motor thermal protection).
9) Logic fault.

c. When automatic shutdown occurs, VFD shall restart only when remote run signal is removed and reapplied.

d. VFD shall hold cause of trip data for a minimum of four (4) shutdowns in memory.
1) Data to be accessible through the keypad, local communication link and remotely.

2. Input protection:
a. Input circuit breaker or current-limiting fuses with externally operable disconnect.
1) Fault current interrupting rating equal to or greater than the specified withstand rating of the VFD.
2) Handle padlockable in the OFF position.

b. Provide full protection for semiconductors integral to the VFD; units requiring current-limiting fuses or circuit breakers in the supply circuit are not acceptable.

c. Incoming line transient suppression.
1) 6000V peak per IEEE C62.41.
2) Phase-to-phase and phase-to-ground protection.

d. Sustained over voltage trip.

3. Internal protection:
a. Surge suppression and power device snubbers.
b. Power devices rated at 2.5 times line voltage.
c. Instantaneous over current trip.
d. DC bus over voltage trip.
e. Power device over temperature trip.
f. Control logic circuit malfunction trip.

4. Output protection:
a. Inverse-time overload trip:
1) UL Class 10 characteristic.
b. Over voltage trip.
c. Over frequency trip.
d. Short circuit trip.
1) Line to line and line to ground.
e. Ground fault trip.

2.4 OPERATOR AND REMOTE CONTROL INTERFACE

A. Drive controls shall be microprocessor-based with on-board human machine interface and both local and remote digital communications capability.
1. All monitoring and control functions, other than those shutdowns specified to be manual reset only, shall be available both locally and remotely.

B. Control circuits shall be 120 Vac or 24 Vac or 24 Vdc.
1. 120 Vac supplied by CPT in the VFD.

a. CPT shall have minimum additional capacity of 60 VA greater than that required by control devices.
b. CPT shall have two (2) fuses on the primary side and one (1) fuse on the secondary side.
c. CPT shall have surge protection on the primary side independent of any other surge protection in the VFD.
2. 24 Vac or 24 Vdc supplied by Class 2 power supply in the VFD.
a. Power supply shall have minimum additional capacity of 33 percent greater than that required by control devices.
b. Provide two (2) current-limiting fuses on the AC supply to the power supply.
c. Power supply shall have surge protection on the primary side independent of any other surge protection in the VFD.

C. Operator Interface:
1. Door mounted sealed keypad, membrane type with LED or LCD display.
a. Messages shall be in English and engineering units.
b. Drive operating parameters shall be programmable.
c. Menu driven.
d. Password security.
e. Display fault and diagnostic data.
f. Operating parameters, fault and diagnostic data maintained in non-volatile memory with historic log of fault and diagnostic data.
g. Gold plated plug-in contacts.
2. Provide indication and control interface, integral in the keypad, as required in the sequence of operation and Drawings.
a. Minimum indications:
1) Run.
2) Stop.
3) Ready.
4) Alarm.
5) Fault.
6) Local control.
7) Remote control.
8) Control source local.
9) Control source remote.
10) Speed indication.
b. Minimum control functions:
1) Local/Remote switch.
2) Stop button.
3) Start button.
4) Reset button.
5) Speed control buttons.
3. Diagnostic indicators located externally on the face of the drive shall show the type of fault responsible for drive warning, shutdown or failure.
a. On occurrence of more than one (1) condition, each shall be recorded or indicated by the diagnostics.

D. Remote Control Interface:
1. Local portable computer interface via RS232/RS242 serial communications port:
a. Capability to:
1) Start-Stop VFD.
2) Control VFD Speed.
3) Access fault and diagnostic data.
2. Analog and discrete inputs:
a. Speed reference (setpoint) signal 4-20 mA DC.
b. Isolated process PID controller with user-programmable setpoint, gain, rate, reset and span for accepting a remote 4-20 mA DC process variable signal.

3. Analog and discrete outputs:
   a. 4-20 mA DC output for remote speed indication, as a function of frequency, calibrated 0 to 100 percent.
   b. Drive FAULT contacts.
   c. Drive RUNNING contacts.
   d. Drive selector switch in REMOTE status contacts.
4. Contacts:
   a. Contacts shall be rated 2 A inductive at 120 Vac.
   b. All contacts shall be wired to field wiring terminal boards.
5. Drive shutdown on external fault input:
   a. Provide isolated input for dry contact from external motor or system safety devices to cause immediate shutdown of VFD.
   b. Safety shutdown to be operable in all operating modes of drive, including local operation from keypad.
   c. For submersible pump/motors incorporate the temperature/leak detection monitor and shut down as indicated on the Drawings.
   d. Local safety switch, to driven equipment, auxiliary contact to lock-out VFD from running when safety switch is open.
6. Network communications capability:
   a. Provide VFD with communication card, protocol and required programming for digital communication of all VFD program and operational parameters to plant control system via:
      1) Ethernet IP.

2.5 HARMONIC PROTECTION REQUIREMENTS

A. All VFDs shall be capable of satisfactory operation from a source having voltage distortion and notch characteristics identified as acceptable for a "dedicated system" in IEEE 519 Table 10.2.

B. With all VFDs operating under worst-case harmonic current conditions, and the facility supplied from the utility the VFDs shall not produce harmonic effects in excess of the following limits at any point of common coupling (PCC).
   1. Voltage distortion and notch characteristics: IEEE 519 Table 10.2 for General System.
   2. Current distortion: IEEE 519 Table 10.3 based on $I_{SC}/I_L < 20$.

C. PCC shall be considered:
   1. Building service entrance switchboards.

D. The Engineer has performed preliminary calculations based on typical VFD data which indicate that the minimum mitigation measures required to meet the specified harmonic criteria are one (1) of the following topologies:
   1. 6-pulse rectifier topology with input line reactors or DC link reactors, minimum impedance 3 percent on drive kVA base.

E. Following start-up, with facility at full load operation, provide measurement of harmonic voltage, current and notch characteristics at each PCC according to the requirements of IEEE 519 Section 9.
   1. Values in excess of specified limits require correction by contractor and re-measurement.
   2. Provide certification of compliant measurements as part of Field Service Engineer's final report.

2.6 MOTOR PROTECTION REQUIREMENTS

A. The VFD shall produce a quality of output waveform adequate to allow the motor to produce rated torque at rated RPM continuously without exceeding the temperature rise given in NEMA MG 1 Table 31-2.

B. Provide motor overload, short circuit and ground fault protection integral to drive electronics.

C. The VFD shall not produce voltage spikes in excess of the following values at the motor terminals when operated with the feeder types shown on the Drawings and the actual installed feeder lengths.
   1. If unmitigated voltage peaks exceed the specified limits, provide output line reactors, filters, or other devices as required to meet the specified limits:
      a. Inverter duty motors: 1280 V.
      b. Rise time shall be greater than or equal to 0.1 microsecond.
   2. At a minimum provide output dv/dt filters on the DWAS Blowers and Pumps. Filters shall be installed on top of the MCC.

D. Following start-up, provide measurement of peak voltage at the terminals of each motor, unless the lead lengths are 10 percent shorter than the manufacturers published literature for maximum lead length for the type of cable installed.
   1. Values in excess of specified limits require correction by contractor and re-measurement.
   2. Provide certification of compliant measurements as part of Field Service Engineer's final report.

2.7 EQUIPMENT CONSTRUCTION

A. Fabrication and Assembly:
   1. Each VFD system shall be factory-assembled for installation in an MCC or in an enclosure for remote mounting as indicated on the Drawings, and shall utilize interchangeable plug-in printed circuit boards and power conversion components wherever possible.
      a. Factory assembly shall be performed by the VFD manufacturer or authorized agent.
      b. Systems fabricated or assembled in whole or in part by parties other than the VFD manufacturer or authorized agent will not be acceptable.
      c. Indicated VFDs shall be mounted within standard motor control center sections, and included as part of the overall motor control center.
   2. Input line reactors shall be mounted within the MCC section, or with the Engineer's permission may be mounted in a separate enclosure on top of the MCC.
   3. Cooling fans, as required, shall be provided to run when drive is running.
   4. Enclosures for separately mounted VFD's:
      a. NEMA Type 1 for installation in Electrical Rooms.
      b. NEMA Type 12 for installation in other unclassified areas.

B. Wiring:
   1. The wiring in the VFD shall be neatly installed in wire ways or with wire ties where wire ways are not practical.
      a. Where wire ties are used, the wire bundles are to be held at the back panel with a screw-mounted wire tie mounting base.
      b. Bases with a self-sticking back will not be allowed.
   2. All plug-in contacts shall be gold-plated.
   3. Provide terminal boards for all field wiring and inter-unit connections, including analog signals.
      a. Provide terminals for shield continuity where required.
   4. Terminal blocks shall be complete with marking strip, covers and pressure connectors.
      a. Non-brittle, interlocking, track-mounted type.
      b. Screw terminals will not be allowed.
      c. A terminal for each conductor of external circuits plus one (1) ground for each shielded cable.
      d. For free-standing panels, 8 IN of clearance shall be provided between terminals and the panel base for conduit and wiring space.
      e. Not less than 25 percent spare terminals shall be provided.
      f. Terminals shall be labeled to agree with identification indicated on the suppliers submittal drawings.
      g. Individually fuse each control loop or system and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

5. All grounding wires shall be attached to the enclosure sheet metal with a ring tongue terminal.
   a. The surface of the sheet metal shall be prepared to assure good conductivity and corrosion protection.
6. Wiring shall not be kinked or spliced and shall have markings on both ends or be color coded.
   a. Markings or color code shall match the manufacturer's drawings.
7. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, type MTW or SIS, insulated for not less than 600 V, with a moisture-resistant and flame-retardant covering rated for not less than 90 DegC.

C. Nameplates:
1. All devices mounted on the face of the drive shall be provided with a suitable nameplate as specified in Specification Section 10 14 00.
2. Push buttons, selector switches, and pilot lights shall have the device manufacturer's standard legend plate.
3. Relays, terminals and special devices inside the control enclosure shall have permanent markings to match identification used on manufacturer's wiring diagrams.

D. Painting: Enclosure, after being phosphate washed, shall be thoroughly cleaned and given at least one (1) coat of rust-inhibiting primer on all inner surfaces prior to fabrication.

2.8 COMPONENTS AND ACCESSORIES

A. Reactors:
1. Impedance: 3 percent.
2. Continuous current: Not less than drive rating.
3. Current overload: 150 percent for 1 minute.
4. Insulation temperature rating: 180 DegC.
5. Copper windings.
6. Saturation current rating: 3.5 to 5 times rated current.
7. Hi-potential rating: 2500 Vac line to ground and line to line, for 1 minute.
8. Noise reduction features:
   a. Epoxy over cast coil.
   b. Extra dips and bakes of varnish over continuous wound coil.

2.9 SOURCE QUALITY CONTROL

A. Factory Tests:
1. Conduct all standard tests in accordance with NEMA and ANSI standards to ensure conformance to Specification requirements.
2. Prior to final assembly:
   a. Inspect incoming components.
   b. Test and inspect power devices.
   c. Circuit cards:
      1) Component and functional tests:
      2) Burn-in chamber or temperature cycling test.
      3) System test after burn-in or temperature cycling.
3. After final assembly:
   a. Continuity and insulation test of 480 power control circuits.
   b. Drive tests:
      1) Burn-in complete drive at full load for 24 HRS.
      2) Verify all auxiliary circuits operation.
      3) Monitor output variables.
   c. Systems test:
      1) Provide inputs to field connections and simulate on-site operation.
      2) Test all auxiliary equipment.

2.10 MAINTENANCE MATERIALS

A. Provide manufacturer's recommended renewable spare parts (e.g., power and control fuses).

B. Spare parts utilized during pre-start-up or start-up and demonstration testing shall be immediately restocked, at no cost to the Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions and as indicated on the Drawings.

B. Verify the installed motor nameplate electrical requirements do not exceed the VFD capacity.

C. Provide services of manufacturer's representative to perform start-up services.

D. The selection of input and output harmonic and voltage spike protection shall also be made on the available physical space.
   1. The space available on the Drawings shall not be exceeded.

3.2 START UP

A. Pre-start-up Services:
   1. Shall be completed a minimum of 30 days prior to the start-up and demonstration period described in Specification Section 01 75 00.
   2. Shall consist of:
      a. Physical and electrical installation check.
      b. Final adjustments and calibration of drive parameters.
      c. VFD operation from simulated input signals.
   3. Shall be complete when VFD(s) are fully operational.

B. Field Quality Control:
   1. Perform field measurement of harmonics at each PCC per Harmonic Protection Requirements Article.
      a. For each individual VFD.
      b. For the maximum number of VFDs that will be operational at the same time.
      c. When all loads are at 75 percent load minimum.
      d. Duration: 1 HR minimum.
   2. Perform field measurement of the maximum voltage peak at the terminals of each motor fed from a VFD per Motor Protection Requirements Article.
      a. Use a high speed oscilloscope to produce a plot of Voltage (Y axis) versus Time (X axis).
         1) Time shall be measured in microseconds.
      b. Tests shall be performed at full:
         1) Full voltage and speed.
         2) Loaded to 75 percent minimum.
         3) Duration: 1 HR minimum.
   3. Record all data necessary for the preparation of required test reports.

C. Start-up and Demonstration Services:
   1. Supervise start-up of all units including recheck of settings made during the pre-start-up tests.
      a. Perform all work in the presence of the Owner's designated representatives.
   2. Setup all VFDs with carrier frequency at minimum value consistent with proper operation; inform Engineer of carrier frequencies set in excess of 5 kHz and reason for setting.
   3. Simulate operation of the VFD and its associated control and instrumentation system in both the manual and automatic modes.
      a. Ensure compatibility of VFD with associated control and instrumentation signals.
   4. Simulate VFD failures and demonstrate troubleshooting aids.

D. Instruct Owner's designated personnel:
   1. Minimum of 8 HRS at the jobsite.
   2. Include both field and classroom instruction.
   3. Instructions shall include proper operation and maintenance procedures including, but not limited to:
      a. Lubrication.
      b. Troubleshooting.
      c. Repair and replacement.
      d. Parts inventory.
      e. Maintenance records.

END OF SECTION

SECTION 26 32 13

PACKAGED COGENERATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Scope: There shall be furnished and installed two packaged cogeneration units. Unit shall consist of container, engine, generator, heat recovery system, cooling system, exhaust system, gas feed system, paralleling switchgear and control system, and all other appurtenances required or shown on the Drawings. The cogeneration units are to be mounted on a concrete slab. Equipment shall be supplied with a 5 year service contract when the Engineer and Owner have accepted the Facility Performance Demonstration/Certification Form.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM): A335/ A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High Temperature Service.
   2. California Air Resources Board (CARB).
   3. Code of Federal Regulations (CRF): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
   4. International Organization for Standardization (DIN/ISO): 9001, Quality Management Systems-Fundamentals and Vocabulary.
   5. National Electric Manufacturer's Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
      b. MG 1, Motors and Generators.
   6. National Electrical Contractors Association (NECA): 404, Recommended Practice for Installing Generator Sets.
   7. National Fire Protection Association (NFPA):
      a. 37, Installation and Use of Stationary Combustion Engines and Gas Turbines.
      b. 70, National Electrical Code.
      c. 110, Emergency and Standby Power Systems.
   8. School of Audio Engineering (SAE): JI 074, Engine Sound Level Measurement.
   9. Underwriters Laboratories, Inc. (UL):
      a. 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
      b. 508, Industrial Control Equipment.
      c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
      d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
      e. 2200, Stationary Engine Generator. Coordinate Mockup with Part 3, Field Quality Control, if used.
   10. The paralleling switchgear equipment manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third-party certification verifying quality assurance in design/development, production, installation and service in accordance with ISO 9001.

11. The manufacturer of this equipment shall have produced similar paralleling equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
12. The paralleling switchgear and Master Control and Power Transfer equipment shall bear a UL 891 label.

1.3 SUBMITTALS

1. Action Submittals:
   a. Dimensioned outline drawing showing plan and elevations of engine generator set and drive system.
   b. Paragraph-by-paragraph specification compliance statement, describing differences between specified and proposed equipment.
   c. Engine and generator weight, and anchoring requirements.
   d. Catalog information and technical description; include materials for block, heads, valves, rings, cylinders, pistons, crankshaft, and major bearings and wear surfaces.
   e. Complete list of accessories provided, including Lube Oil Replenishing System, Heat Recovery System.
   f. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rate, and kW output at design rated output, one-half load, and one-quarter load using biogas and natural gas. Account for design altitude, temperature corrections, and engine parasitic loads.
   g. Transient and subtransient reactances per unit.
   h. Output waveform and telephone interference factor (TIF).
   i. Paralleling switchgear including circuit breaker data, catalog number, settings, and time current curves.
   j. Control panel instrument identification inscriptions.
   k. Electrical schematic and wiring diagrams for the following:
      1) Generator paralleling switchgear and control panel.
      2) Generator.
      3) Enclosed electrical components.
      4) Jacket water heater size and voltage.
   l. Noise data for enclosed engine generator at 50 percent, 75 percent, and full load.
   m. Drawings of configuration and interconnecting piping.
   n. 3-line and one-line diagrams.
2. Informational Submittals:
   a. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
   b. Factory Test Report.
   c. Operation and Maintenance Data: As specified in Section 01 33 04, Operation and Maintenance Manuals.
   d. Description of parts and service availability.
   e. Service Contract.
   f. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 75 00, System Start-Up.

1.4 WARRANTY

A. The CHP System shall be provided with a five year warranty, effective following start-up, from the vendor in addition to manufacturer’s warranties for individual components of the system. The warranty certificate shall be submitted in writing and signed by an officer of the Packager’s firm, as part of the submittal package.

1.5 EXTRA MATERIALS

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

1. Oil filter cartridges (three pieces).

2. Spark plug sealing rings (20 pieces).
3. Spark plug (one set).
4. Spark plug carrier (one piece).
5. Ignition coil (one piece).
6. Thermoelement (Cylinder exhaust gas temperature – one piece).
7. Sealing ring (one piece).
8. Tools for spark plugs (special socket, extension, torque wrench).
9. Tools for removal of oil filter cartridges.
10. Feeler gauge set 0.35 mm.
11. One wrench, 17 by 19.
12. Screwdriver 10.
13. Grease gun.
14. Measuring device for valve wear and a set of valve cover gaskets.
15. Adapter for measurements (BNC-BNC, MIL-.ZZP).
16. Ultra-Therm 50 spray.
17. Pointed pliers (cornered).
18. Box for tools.
19. Stroboscope.

1.6 PARALLELING SWITCHGEAR SYSTEM DESCRIPTION

A. The low voltage paralleling switchgear and the master power and transfer system shall be supplied by the manufacturer of the engine generator units to be provided as specified herein. The generators shall be paralleled and the control of these two generators shall be incorporated into the design of this equipment package.

B. The master power and transfer system shall be configured to start and parallel the two generators to provide power to the treatment plant via the main plant switchboard. The paralleling switchgear shall have a breaker for each generator plus an overall main breaker for tying the power generated to the utility power. The location of this tie-in will be at the plant's existing main switchboard. A new breaker shall be installed at the plant's existing main switchboard to serve as a disconnect between the utility power and the packaged generation system power produced. Generators will normally run parallel with the Utility within the limits of biogas production. Generators shall be started and synchronized with each other, and then synchronized with the normal utility power before closing the paralleling switchgear main breaker to the plant's existing main switchboard.

C. The new generators shall be tested with the installed paralleling switchgear as specified under this section of these specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. MAN/ENER-G
   2. MTU/Collicut Energy
   3. Or Equal

B. Submit request for substitution in accordance with Section 01 25 13.

2.2 DESIGN CRITERIA

A. Generating Capacity: 220 kilowatt (per unit), minimum.

B. Thermal Capacity: 0.9 MMBTU per hour at 180 degrees F.

C. Fuel Type:
   1. Biogas

2. Specific Gravity: 0.7 to 0.9.
3. Methane: 55 to 65 percent.
4. Hydrogen Sulfide: 50 ppm.
5. Siloxane:- 0.1 mg/m 3 as Si per Siloxane species D4, D5, and D6.

D. Voltage: 480 volts, three-phase, 60-Hz.

E. Maximum sound pressure level of 65 dB(A) in 32 feet (10 m) of the container.

F. Turndown Condition:
1. Input Fuel Consumption: 2.1 MBTU per hour.
2. Minimum Electrical Output: 120 kW at 1.1 MMBTU per hour fuel consumption.

2.3 EQUIPMENT

A. General
1. The "containerized" module measuring approximately 10 feet wide by 11 feet high and 30 feet long shall contain the engine, generator, control gear and output circuit breaker. The radiator, intake air system, exhaust silencer, waste heat exchanger and heat recovery silencer are shipped loose for external mounting. The engine and generator are mounted to the base frame by means of anti-vibrational mounts with the engine and generator frame mounted on isolating pads.

B. Gas Engine:
1. Shall consist of a 1,800 rpm, four-stroke, air/gas mixture turbocharged, aftercooled, with high performance ignition system and electronically controlled air/gas mixture system.
2. Engine Block: Single-piece crankcase and cylinder block made of special casting, crank case covers for engine inspection, welded steel oil pan.
3. Crankshaft and Main Bearings: Drop-forged, precision ground, surface hardened, statically and dynamically balanced; main bearings (upper bearing shell: three-material bearing/lower bearing shell: sputter bearing) arranged between crank pins, drilled oil passages for forced feed lubrication of connecting rods.
4. Vibration Damper: Maintenance free viscous damper.
5. Flywheel: With ring gear for starter motor.
6. Pistons: Single-piece, made of light metal alloy, with piston ring carrier and oil passages for cooling; piston rings made of high quality material, main combustion chamber specially designed for lean burn operation.
7. Connecting Rods: Drop-forged, heat-treated, big end diagonally split and toothed. Big end bearings (upper bearing shell: sputter bearing/lower bearing shell: grooved bearing) and connecting rod bushing for piston pin.
8. Cylinder Liner: Chromium alloy gray cast iron, wet, individually replaceable.
9. Cylinder Head: Compatible with lean burn engines with optimized fuel consumption and emissions; water cooled, made of special casting, individually replaceable; Valve seats and valve guides and spark plug sleeves individually replaceable; exhaust and inlet valve made of high quality material.
10. Crankcase Breather: Connected to combustion air intake system.
11. Valve Train: Camshaft, with replaceable bushings, driven by crankshaft through intermediate gears, valve lubrication by splash oil through rocker arms.
12. Combustion Air/Fuel Gas System: Motorized carburetor for automatic adjustment according fuel gas characteristic. Exhaust driven turbocharger, mixture manifold with bellows, water-cooled intercooler, throttle valve and distribution manifolds to cylinders.
13. Ignition System: Fully electronic high performance ignition system, external ignition control.
14. Lubricating System: Gear-type lube oil pump to supply all moving parts with filtered lube oil, pressure control valve, pressure relief valve and full-flow filter cartridges. Cooling of the lube oil is arranged by a heat exchanger.

15. Engine Cooling System: Jacket water pump complete with distribution pipework and manifolds.
16. Exhaust System: Turbocharger and exhaust manifold.
17. Exhaust Gas Temperature Measuring: Thermocouple for each cylinder.
18. Electric Actuator: For electronic speed and output control.
19. Electronic Speed Monitoring for Speed and Output Control: By magnetic inductive pickup over ring gear on flywheel.
20. Starter Motor: Engine mounted electric starter motor.

C. Engine Accessories:
1. Insulation of Exhaust Manifold: Provide insulation of exhaust manifold that is easily installed and removed.
2. Sensors at the Engine:
    a. Jacket water temperature sensor.
    b. Jacket water pressure sensor.
    c. Lube oil temperature sensor.
    d. Lube oil pressure sensor.
    e. Mixture temperature sensor.
    f. Charge pressure sensor.
    g. Minimum and maximum lube oil level switch.
    h. Exhaust gas thermocouple for each cylinder.
    i. Knock sensors.
    j. Carburetor position control.
    k. Low coolant level switch
3. Actuator at the Engine:
    a. Actuator – throttle valve.
    b. Bypass-valve for turbocharger.
    c. Carburetor drive.

D. Generator:

1. The generator consists of the main generator (built as rotating field machine), the exciter machine (built as rotating armature machine) and the voltage regulator with cos. phi-regulator, which is powered by a permanent magnet pilot exciter.
2. Main Components:
    a. Main stator with frame.
    b. Main stator with 2/3 pitch winding to eliminate neutral currents of third order.
    c. Terminal box includes main terminals plus auxiliary terminals for thermistor connection and control of regulator.
    d. Main rotor with sufficiently sized shaft dynamically balanced as per VDI 2060, Grade QI.
    e. Drive end bracket with bearing.
    f. Non-drive end bracket with bearing.
    g. Exciter unit with permanent pilot exciter.
    h. Power factor controller.
    i. Voltage regulator.
3. Electrical Data and Features:
    a. Voltage Adjustment: Plus or minus 5 percent rated voltage (plus or minus 10 percent short-time for synchronizing).
    b. Static Voltage Accuracy: Plus or minus 1 percent at no load to full load and power factor 0.8-1.
    c. Speed variation plus or minus 3 percent, cold and hot machine.
    d. Maximum deviation of wave form according to VDE is 5 percent phase-to-phase at open circuit.
    e. Generator suitable for parallel operating with mains and other generators.

f. Sustained short circuit current at three-pole terminal short circuit: minimum three times rated current for 5 seconds.
g. Overload capacity according to IEC 34 - I/VOE 0530.
h. According to VDE 0530, the overspeed test ensues with 1.2 times of rated speed for 2 minutes.

4. Additional Components:
   a. Electronic voltage regulator.
   b. Electronic power factor regulator.
   c. Three thermistors for winding temperature monitoring.

E. Accessories:
1. Base Frame: Welded of structural steel to accommodate engine, generator and heat exchangers.
2. Flexible Coupling: With torque limiter to couple engine with generator. The coupling isolates the major subharmonics of engine firing impulses from the generator.
3. Bell Housing: To connect engine with generator housing. With two ventilation and control windows.
4. Anti-Vibration Mounts: Arranged between engine/generator assembly and base frame. Insulating pads for placement between base frame and foundation, delivered loose.
5. Exhaust Gas Connection: Connection of exhaust gas turbocharger; including flexible connection to compensate for expansions and vibrations.
6. Combustion Air Filter: Dry type air filter with replaceable filtercartridges, including flexible connection to carburetor and service indicator.
7. Interface Panel:
   a. Totally enclosed sheet steel cubicle with front door, wired to terminals, ready to operate. Cable entry at bottom.
   b. Painting: RAL 7035
   c. Protection: IP 54 external IP 10 internal (protection against direct contact with live parts).
   d. Design According to IEC 439-1 (EN 60 439-1/1990):
      1) Ambient Temperature: 0 - 100 degrees F (-17 - 37°C).
      2) Relative Humidity: 70 percent.
   e. Power supply from the starter battery charger.
   f. Power distribution to the engine mounted auxiliaries.
8. Essential Components Installed in Interface Panel:
   a. Terminal strip.
   b. Decentralized input and output cards, connected by a data businterface to the central engine control of the module control panel.
   c. Speed monitoring.
   d. Relays, contacts, fuses, engine contact switch to control valves and auxiliaries.
   e. Measuring transducer for excitation voltage.

F. Engine Jacket Water System with Mechanical Water Pump:

1. Engine Cooling Jacket Water System:
   a. Closed cooling circuit, consisting of:
      1) Expansion tank.
      2) Filling device (check and pressure reducing valves, pressure gauge).
      3) Safety valve(s).
      4) Thermostatic valve.
      5) Required pipework on module.
      6) Vents and drains.
      7) Jacket water pump, including check valve.
      8) Jacket water preheat device.

G. Automatic Lube Oil Replenishing System:

1. Automatic Lube Oil Replenishing System: Includes float valve in lube oil feed line, including inspection glass. Electric monitoring system will be provided for engine shut-down at lube oil levels "MINIMUM" and"MAXIMUM". Solenoid valve in oil feed line is only activated during engine operation. Manual override of the solenoid valve, for fillingprocedure during oil changes, is included.
2. Oil Drain: By set mounted cock.
3. Aftercooling Oil Pump:
   a. Mounted on the module base frame; it is used for the aftercooling of the turbocharger; period of operation of the pump is 15 minutes from engine stop. Consisting of:
      1) Oil pump, 250 W, 24Vdc wired to starting batteries.
      2) Oil filter.
      3) Necessary pipework.

H. Heat Recovery:
1. Engine-mounted intercooler and lube oil heat exchanger, complete with interconnecting pipe work.
2. Intercooler Heat Exchanger – The engine-mounted intercooler can be of one or two-stage design. If two-stage, the first stage is integrated with the jacket water circuit. The second stage requires low temperature water cooled from a roof mounted air-cooled radiator. If one-stage, the intercooler heat exchanger is connected only to the roof mounted air-cooled radiator.
3. Lube Oil Heat Exchanger: The heat recovery is done by a mounted heat exchanger which is integrated in the jacket water circuit.
4. Jacket Water to Plant Hot Water System Heat Exchanger: The plate- type heat exchanger transfer engine heat to the Plant Hot Water System.
5. Waste Heat Exchangers – Heat from the engine jacket water loop that can't be used by the plant is rejected to atmosphere. The jacket water loop is connected to an air cooled radiator mounted on the container roof. Heat from the low temperature side of the intercooler is also rejected to an air-cooled radiator mounted on the roof. The waste heat exchangers can be individual or dual core.
6. Exhaust Heat Exchanger -- Exhaust Gas to Plant Hot Water System. Consisting of:
   a. Inlet chamber, with flushing connection for cleaning.
   b. Tube type heat exchanger.
   c. Outlet chamber with condensate drain and flushing connection for cleaning.
   d. Thermocouple for monitoring of exhaust gas outlet temperature.
   e. Thermocouple for monitoring of tube plate temperature.
   f. Pressure relief valve integrated in the warm water circuit.
   g. Exhaust bypass valving and control system.

I. Gas Train

1. Consisting of:
   a. Gas train internally mounted.
   b. Manual shut off valve.
   c. Gas filter, filter fineness < 3 micron.
   d. Gas admission pressure regulator.
   e. Pressure gauge with push button valve.
   f. Solenoid valves.
   g. Leakage detector.
   h. Gas pressure switch (minimum).
   i. Gas pressure regulator.

J. Painting:

1. Quality:
   a. Oil resistant prime layer.
   b. Synthetic resin varnish finishing coat.

2. Color:
   a. Per manufacturer.

K. Battery System:

1. Starter Battery: 24-volt, complete with cover plate, terminals and acid tester.
2. Battery Voltage Monitoring: Monitoring by an under voltage relay.
3. Battery Charging Equipment:
   a. Capable for charging the starter battery with I/U characteristic and for the supply of all connected DC consumers.
   b. Charging device is mounted inside of the module interface panel or module control panel.

L. Electric Jacket Water Preheating:
1. Installed in the jacket water cooling circuit, consisting of:
   a. Heating elements.
   b. Water circulating pump.
2. The jacket water temperature of a stopped engine is maintained between 133 degrees F (56°C) and 140 degrees F (60°C), to allow for immediateloading after engine start.

M. Flexible Connection:

1. Following flexible connections per unit:

No. Connection	Unit	Material
2	Warm water in/outlet	Stainless steel
1	Exhaust gas outlet	Stainless steel
1	Fuel gas inlet	Stainless steel
2	Intercooler in/outlet	Stainless steel
2	Lube oil connection	Hose

   a. Sealings and flanges for all flexible connections are included.

N. Grid Monitoring Device:

1. Function: For immediate disconnection of the generator paralleling switchgear from the grid in case of grid failures.
2. Consisting of:
   a. High/low voltage monitoring.
   b. High/low frequency monitoring.
   c. Protection monitoring against micro-interruptions of the grid.
3. Scope of Supply: Digital grid protecting relay with storage of defect data, indication of reference dimensions as well as monitoring by itself.

O. Generator Paralleling Switchgear:
1. Acceptable manufacturers:
   a. Enercon Engineering, Inc.
   b. Engineer approved equal.
   c. Specific equipment to be furnished:
      1) Circuit breakers:
         a) Eaton.
         b) Square D.
         c) GE.
      2) Instrument transformers:

a) Eaton.
b) GE Instrument Transformers.
c) Square D.
3) Protective relaying:
a) Schweitzer Engineering Labs (SEL).
4) Control Switches:
a) Electroswitch Series 24 with LED indicators as required.
5) Selector switches, push buttons, etc:
a) Square D.
b) Eaton.
6) Fuse and fuse holders:
a) Buss
b) Shawmut.
7) Terminal Strips:
a) Phoenix Contact.
b) ILSCO.
c) Square D.
d) Weidmuller.

2. Switchgear:
a. Ratings:
1) Voltage, number of phases, number of wires, and main bus current rating as indicated on the Drawings.
2) Assembly short circuit current and circuit breaker fault interrupting rating as indicated on the Drawings.
3) Assembly short circuit current and circuit breaker fault interrupting rating of 65 KAIC RMS symmetrical minimum or as indicated on the Drawings.
4) Bus system with a minimum ANSI 4-cycle short circuit withstand rating of 65 KAIC.

b. Construction:
1) Standards: NEMA PB 2, UL 891.
2) Completely enclosed, dead-front, self-supporting metal structure.
3) Vertical panel sections bolted together.
4) Frames bolted together to support and house bus, cables and other equipment.
5) Frames and insulating blocks to support and brace main buses for short circuit stresses up to ratings indicated on the Drawings.
6) Certain combinations of main and feeder devices preclude the possibility of front access only and require a switchboard to be rear accessible.
7) All sections front and rear aligned.
8) Devices front removable and load connections front and rear accessible.
9) NEMA 3R rated weatherproof enclosure.
a) Walk-in type with sloping roof downward toward rear.
b) Front aisle depth: 42 IN minimum.
c) Front and rear hinged padlockable doors with wind stops for each section.
d) Steel floor in aisle space and under each vertical section.
e) Ventilating openings with replaceable filters.
f) Thermostatically controlled space heaters to minimize internal condensation.
g) Aisle doors padlockable with panic hardware.
h) Modular so future sections can be added.
i) Interior aisle LED lights providing minimum 30 FC at the floor with 3-way switches and 125V, 20A GFCI spec grade receptacles.
j) Power for heaters, light fixtures and receptacles obtained from a source indicated on the Drawings.
10) Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and manufacturer’s standard paint.

c. Buses:
1) Material: Silver-plated copper.

2) Main horizontal bus:
    a) Fully rated and continuous over length of switchboard with all three (3) phases arranged in the same vertical plane.
    b) Sufficient size to limit temperature rise to 65 DegC over average air temperature outside the enclosure of 40 DegC.
3) Neutral bus: Fully rated and continuous over length of switchboard.
4) Ground bus: 1/4 x 2 IN copper, continuous over length of switchboard, solidly grounded to each vertical section structure and meet the short time withstand rating of the largest breaker.
5) Bus joints connected using through bolts and conical spring-type washers for maximum conductivity.

d. Overcurrent and Short Circuit Protective Devices:
    1) Main overcurrent protective device:
        a) Drawout low voltage insulated case circuit breaker.
    2) Generator and feeder overcurrent protective devices:
        a) Drawout low voltage insulated case circuit breaker.
    3) All breakers shall be two –step stored energy type and shall allow for closed door racking.
    4) All breakers shall have field interchangeable electrical accessories including shunt trip, spring release, electrical operator, auxiliary contacts, and Trip Unit.
    5) Breakers to be listed to UL 489.
    6) Trip units:
        a) Incorporate “True RMS Sensing”, and have LED long-time pickup indications.
        b) Functions shall include:
            (1) Adjustable long-time pickup and delay.
            (2) Instantaneous, with option of turning instantaneous to the off position.
            (3) Ground fault pickup and delay.
                (a) Provide neutral current transformer as required.
    7) Factory installed.
    8) Means to padlock all breakers in the open position.

e. Metering and Protective Relays:
    1) Power meter:
        a) Separate compartment with hinged door.
        b) Shark 200 Digital meter for the Utility breaker.
    2) Protective Relays:
        a) Generator protective relays: SEL700G with synch check and differential.
        b) SEL 551 for each tie breaker.
    3) Set of CTs for each breaker.
    4) Set of PTs for main bus.
    5) Set of PTs for each generator.
    6) Set of PTs for Utility source.

f. Accessories:
    1) Coordinate installation methods and provide lay down brackets or other hardware to facilitate the installation of the gear without damage.

3. Master Control and Power Transfer System:
    a. Provide Master Control and Power Transfer System to monitor and control operation of entire paralleling system, including individual generator set controls, and provide power transfer functions. System synchronizer shall have voltage matching capability within three percent or better to comply with IEEE 1547.

P. Gas Warning Device:

1. Function: The gas warning device continuously monitors the air in the engine room and warns against gases which are injurious to persons' health and against explosive gas concentrations. The measuring head (catalytic sensor) is attached on the covering or nearby the ground, dependent upon the gas source.
2. Scope of Supply:
   a. Alarm Unit:
      1) 1) Voltage: 24V.
      2) 2) Frequency: 60 Hz.
   b. One gas sensor.
   c. Measuring Line: Three-phase cable, between sensor and alarm unit.

Q. Smoke Warning Device:

1. Function: The smoke warning device in combination with the smokedetector(s) which are mounted on the ceiling can provide extensive early warning signals via the high-quality optoelectronic system.
2. Design: The device has an optical display for alarm and operation and also has a reset key. The smoke warning device is installed in a plastic housing.
3. Scope of Supply:
   a. Alarm Unit:
      1) Voltage: 24V.
      2) Frequency: 60 Hz.
   b. Two smoke detectors.
   c. Connection Lines: Between smoke detector and alarm unit.

R. Lube Oil System:

1. Consisting of:
   a. Fresh oil tank.
   b. Lube oil tank.
   c. Combined electric driven fresh oil and waste oil pump.
   d. Level switches.
   e. Shut-off devices.
   f. Complete pipe work between oil tanks and engine components.
2. Through simple switch over of the pumps following functions are given:
   a. Filling of the fresh oil tank.
   b. Filling of the lube oil tank.
   c. Filling of the oil pan.
   d. Emptying of the oil pan.
   e. Emptying of the waste oil tank.

S. Exhaust Gas Silencer:

1. Material:
   a. Stainless steel.
2. Consisting of:
   a. Exhaust gas silencer.
   b. Flanges, seals, fixings.
3. Insulation:
   a. Provide insulation (4-inch (100 mm) rock wool covered with 0.03-inch (0.75 mm) galvanized steel sheet) is required to keep the sound pressure level 65 dB(A) at 32 feet (10 m)) of the container.

T. Pipe Work for Condensate:

1. The pipe work for condensate is used to drain off the condensate from the exhaust gas system (exhaust gas silencer).
2. Consisting of:
    a. Tank for Condensate Made of Plastic: The tank is constructed with two connections: one connection for the condensate inlet and a second one which is built as an overflow.
    b. Pipe Works for Condensate Made of Stainless Steel: One piece/condensate drain of the exhaust gas system. The connections are made of stainless steel (material: AISI 316 Ti).
    c. Thread connections, holding device for pipe work and equipment for the installation.
3. Provide insulation and trace heating to prevent freezing of the condensate.

U. Air Intake and Outlet System:

1. Function:
    a. Supply of the required combustion air for the gas engines.
    b. Supply and exhaust of the required cooling air to purge the radiated heat, especia1Iy the heat of the engine and the generator.
2. The air intake system (shipped loose) consists of:
    a. Weather protection.
    b. Air intake filter according to EN 779, Class G4.
    c. Birdscreen, to protect against rain and/or inclement weather.
        1) Louver damper.
        2) Motor operated.
    d. Noise attenuating system.
    e. Air intake fan, including E-motor, 480/277 V, 60 Hz, frequency controlled.
3. The air outlet system consists of:
    a. Weather protection.
    b. Birdscreen, to protect against rain and/or inclement weather.
        1) Louver damper.
        2) Motor operated.
    c. Noise attenuating system.
    d. The air intake jalousie flap opens automatically upon engine start. The air outlet jalousie flap only opens if the room temperature reaches the setpoint at which the air intake fan must start.

V. Cooling System:

1. The heat produced by the engine (jacket water, lube oil, intercooler) is dissipated through a radiator, installed outside.
2. Consisting of:
    a. Radiator.
    b. Pump.
    c. Electrical control.
    d. Expansion tank.
    e. Piping (shipped loose).
3. The radiator is designed for an ambient temperature of 100 degrees F (37°C).

W. Container:

1. 30-foot Steel Container, Module Installation:
    a. Dimensions:
        1) 1) Length: 30 feet
        2) Width: 10 feet
        3) Height: 11 feet

2. Sound Pressure Level for Horizontal Silencer Mounted on Roof: 65 dB(A) at 32 feet (10 m).
3. Ambient Temperature: The container is designed for an ambienttemperature from 0 degrees F (-17.7°C) to 100 degrees F (37 °C).
4. Base Frame: Self-supporting, i.e. the base frame is designed towithstand static loads from the installation of parts such as the engine, control panels, exhaust gas silencer and radiator.
5. Construction:
    a. Trapezoidal corrugated steel sheeting welded between the baseframe and the top frame. The sound absorbent surfaces arecomprised of rock wool covered with perforated plating. The container is of a weatherproof design and the roof is suitable for construction work.
    b. A double door to bring in the engine is situated at the front of the container beside the air outlet. There is a door into the controlroom at the front wall on the side of air inlet. A door into theengine room is situated at the long side of the container.
    c. The doors (engine room resp. control room) are designed with the same cylinder locks. The doors are design as emergency doorswhich could be opened in direction of the escape route. They are identified as such and can be opened from inside without otherassistance (panic lock).
6. Engine Room:
    a. The floor is designed as an oil pan. Connections from/to the engine room consist of:
        1) Top: Cooling water in/outlet; welded flange exhaust gas outlet; shut tightly.
        2) Roof: Suspensions for cable trough, gas train, gas pipes.
        3) Wall: Gas inlet; welded flange.
7. Control Room: The control room is ventilated by a closable air intake opening. The air is aspirated by the fans of the engine room. For thecables, a recess at the floor of the control room is planned. The control room is equipped with a plastic covering.
8. Module and container installation are essentially performed as follows:
    a. Installation and setup of the module.
    b. Installation of the control equipment in a separate control equipment room.
    c. Installation of the gas train.
    d. Installation of the lube oil equipment.
    e. Installation of the air intake and outlet ventilation system.
    f. Installation of the exhaust silencer on the roof.
    g. Installation of the radiator on the roof.
    h. Installation of lighting in the container.
    i. Installation of the auxiliary electrical installations.
    j. Completion of exhaust, fuel, oil and water piping, according to the defined scope of supply, including all necessary fittings, flexible connections and reinforcements.
    k. Footboard above the tubes.
    l. Rain drain.
    m. Total signposting.
9. Coating:
    a. Installation:
        1) Oil resistant base.
        2) Synthetic resin as coating varnish.
    b. Color: Per manufacturer

X. Engine Generator Control Panel: In accordance with general controlrequirements and component qualities specified in Section 40 98 00, Control Panels and Enclosures, and as follows:
1. Control Supply Voltage From Starter and Control Panel Batteries: 24V de.
2. Supply of power for auxiliaries from auxiliary power panel 3 x 480/277V, 60 Hz, 35 A.

3. System Elements Visualization with Central Engine and Module Control:
    a. Visualization:
        1) Industrial control with 4.5-inch QVGA TFT color graphics display and eight function keys.
        2) 10-key numeric keyboard for parameter input.
        3) Keys for START, STOP, Generator circuit breaker OPEN, Generator circuit breaker CLOSED/SELECTED, display selection keys and special functions.
    b. Interfaces:
        1) Ethernet (twisted pair) for connection to server.
        2) CAN-Bus: Bus connection to the intelligent sensors and actuators.
        3) Data bus connection to the control in- and outputs.
        4) Protection Class: IP 65.
        5) Dimensions: W by H by D equals approximately 8.4 by 10 by 3.75-inch.
    c. A clear and functional graphic compilation of measured values is displayed on the screen. User prompts are by means of direct- acting display selection keys and function keys.
4. Main Displays:
    a. Generator interconnection, with electrically measured variables and display of excitation voltage.
    b. Generator winding temperature and generator bearing temperature displays.
    c. Oil and engine cooling water circuits, with displays of oil pressure and temperature, and cooling water pressure and temperature.
    d. Exhaust gas temperatures in a column graph which also displays the average temperature.
    e. Main engine controller.
    f. Module auxiliary controller.
    g. Auxiliary systems (status display).
    h. Synchronizing.
    i. Operational data, i.e. operating hours, service hours, number of starts, active power demand (kWh), reactive power demand (kVArh), and measured values for operational logbook.
    j. System display, i.e. time, password, brightness, contrast, diagnostics.
5. Recipe Handling: Setting, display and storage of all module parameters.
6. Alarm Management: Efficient diagnostic instrumentation listing all active fault messages both tabular and chronologically, with the recorded time.
7. Central Engine and Module Control: A real-time, modular industrial control system which handles all jobs for module and engine-side sequencing control (start preparation, start, stop, synchronizing, after- cooling, control of auxiliaries), as well as all control functions.
8. Control Functions:
    a. Speed control in no-load and isolated operation.
    b. Power output control in parallel operation system; job-specific with respect to internal and external set point values.
    c. Control system for control of boost pressure; dependent upon the generator terminal power and the mixture temperature via the engine-driven air-gas mixer.
    d. Knocking Control: Adjustment of the ignition point, power output and (insofar as is locally possible) the mixture temperature in the event of detection of knocking.
    e. Load sharing between several modules in isolated operation.
    f. Linear reduction of power output in the event of excessive mixture temperature and ignition failures.
    g. Interface relays as per the interface list.
    h. Multi-transducer, to record the following electrically measured variables of the generator:
        1) Phase current (with slave pointer).
        2) Neutral conductor current.

3) Voltages Ph/Ph and Ph/N.
4) Active power (with slave pointer).
5) Reactive power.
6) Apparent power.
7) Power factor.
8) Frequency.
9) An additional 0 - 20 mA output is produced for active power, as well as a pulse output for active power demand.

9. The Following Alternator: Supervisions are integrated with the multi- transducer (maximum eight functions simultaneous):
   a. Overload/short-circuit.
   b. Over voltage.
   c. Undervoltage.
   d. Asymmetric voltage.
   e. Unbalance current.
   f. Failure exitation.
   g. Overfrequency.
   h. Underfrequency.
   i. Lockable Operation Mode Selector Switch Positions:
      1) "OFF": No operation is possible, running set will shut down.
      2) "MANUAL": Manual operation using (start, stop) is possible, unit is not available for fully automatic operation.
      3) "AUTOMATIC": Fully automatic operation, according to remote demand signal.
         a) Automatic Start: Ful1y automatic operation at full load.
         b) Stop with cooling down run for 1 minute. Continuous operation of auxiliaries for 5 minutes after engine shutdown.
   j. Demand Switch with the Positions:
      1) Demand OFF.
      2) Demand ON.
      3) Remote demand.
   k. Supply disconnecting device for auxiliaries with lockable circuit breaker.
10. Shut-down Functions with Display:
   a. Low lube oil pressure.
   b. Low lube oil level.
   c. High lube oil level.
   d. High lube oil temperature.
   e. Low jacket water pressure.
   f. High jacket water pressure.
   g. High jacket water temperature.
   h. Overspeed.
   i. Emergency stop/safety loop.
   j. Gas train failure.
   k. Start failure.
   l. Stop failure.
   m. Engine start blocked.
   n. Engine operation blocked.
   o. Misfiring.
   p. High fuel temperature.
   q. Measuring signal failure.
   r. Overload/output signal failure.
   s. Generator overload/short circuit.
   t. Generator over/undervoltage.
   u. Generator over/underfrequency.
   v. Generator asymmetric voltage.
   w. Generator unbalanced load.

x. Generator reverse power.
y. High generator winding temperature.
z. Synchronizing failure.
aa. Knocking failure.

11. Warning Functions with Display:
    a. Low jacket water temperature.
    b. CPU battery failure.
12. Operational Functions with Display:
    a. Ready to start.
    b. Operation (engine running).
    c. Generator circuit breaker "CLOSED".
13. Remote Signals (Volt Free Contacts):
    a. Ready for automatic start (to Master control).
    b. Operation (engine runs).
    c. Collective signal "shut down".
    d. Collective signal "warning".
14. External Provided Commands/Status Signals:
    a. a. Engine demand (from Master control).
15. Single Synchronizing Automatic-With Voltage Balance:
    a. For automatic synchronizing of the module with the generator circuit breaker to the grid by PLC- technology, integrated within the module control panel.
    b. Consisting of:
        1) Lockable synchronizing mode selector switch, with positions "MANUAL - OFF - AUTOMATIC".
            a) AUTOMATIC: Automatic module synchronization, after synchronizing release from the control panel.
            b) MANUAL: Manual initiation of synchronizing by push button. Speed adjustment and closing of the circuit breaker is automatically controlled via microprocessor.
            c) OFF: Synchronization is disabled.
        2) Additional PLC hardware for the fully automatic synchronizing of each module, and monitoring of the "CIRCUIT BREAKER CLOSED" signal. Logic for monitoring of:
            a) Non-logic breaker positions.
            b) Switch "ON" trouble.
            c) Switch "OFF" trouble.
        3) Automatic synchronizing device to control the electronic speed governor adjustment, double voltmeter, double frequency meter and synchronoscope.
        4) Automatic voltage balancing.
        5) Luminous push button "GENERATOR CIRCUIT BREAKER OPEN/SELECT".
            a) To indicate synchronizing mode.
            b) To indicate "Generator circuit breaker closed".
            c) For manual synchronizing selection with the synchronizing mode selector switch in the MANUAL position.
            d) For manual closing of the generator circuit breaker tothe voltage free bus bar (first connection) with synchronizing mode selector switch in the MANUAL position.
        6) Luminous push button "GENERATOR CIRCUIT BREAKER OPEN".
            a) To indicate "Generator circuit breaker open".
            b) To manually open the generator circuit breaker.
        7) Control switch.
        8) Required relays for control and monitoring.
        9) Voltage relay for monitoring of buss bar voltage (only for island operation).
    c. Operational Indications for:
        1) Generator circuit breaker CLOSED.
        2) Generator circuit breaker OPEN.

d. Fault Indications for:
   1) Generator circuit breaker return signal fault.
   2) Generator circuit breaker closing fault.
   3) Generator circuit breaker opening fault.
e. Remote Signals (Volt Free Contacts): Generator circuit breaker CLOSED.
f. The following reference and status signals must be provided by the switchgear supplier:
   1) Generator circuit breaker CLOSED.
   2) Generator circuit breaker OPEN.
   3) Generator circuit breaker READY TO CLOSE.
   4) Mains circuit breaker CLOSED.
   5) Mains Circuit Breaker OPEN:
      a) Mains voltage.
      b) Bus bar voltage.
      c) Generator voltage.
      d) Voltage transformers in star point with minimum 50VA, Class 1.
g. The following volt free interface-signals will be incorporated in switchgear:
   1) CLOSING/OPENING command for generator circuit breaker(permanent contact)
   2) Signal for circuit breaker undervoltage trip
   3) Voltage converter at star-star connection.

Y. Motor Control Panel:

1. Sheet metal IEC enclosure, components and assembly UL listed.
2. For distribution and protection of the module and container auxiliaries, with cubicle lighting.
3. Equipment:
   a. Equipped with IEC type starters for each motor.
   b. With safety disconnect switches for every load.
   c. With step down transformer 4801120V, I OkVA for container consumers.

Z. Remote Information:

1. Data transfer from engine control to customer's plant management system.
2. The module control panel works as a SLAVE.
3. Transmitted Data: Individual failure information, plant operating information, measuring values for generator power, oil pressure, oiltemperature, jacket water pressure, jacket water temperature, cylinder and average exhaust gas temperatures.

PART 3 - EXECUTION

3.1 INSTALLATION

A. In accordance with manufacturer's written instructions.

B.

3.2 FIELD FINISHING

3.3 Touchup damaged areas of painted ferrous metal in accordance with and as specified in Section 09 96 00, Painting and Protective Coatings.

3.4 SYSTEMS STARTUP

A. Field Startup and Training
   1. The vendor of the Gas Handling and Treatment System shall provide three days of startup training services for this system. Training shall include how to take gas samples and preparation on chain of custody for sample taking.

3.5 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   1. 5 person-days for installation assistance and inspection.
   2. 5 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   3. 2 person-day for prestartup classroom and field training.
   4. 2 person-days for facility startup.
   5. 2 person-days for post-startup training of Owner's personnel.

B. See Section 01 75 00, System Start-Up.

3.6 SERVICE CONTRACT

A. Provide a 5 year service contract by a manufacturer-approved provider. Service contract to include all scheduled, defined engine manufacturer recommended maintenance, services, and component replacement by factory trained and qualified technicians. Owner personnel shall perform routine daily, weekly, monthly inspections and services called for in engine manufacturer "Maintenance Schedules" independent of the number of operating hours. Owner personnel shall perform the following:
   1. Routine daily, weekly, monthly inspections, and services as called for in engine manufacturer "Maintenance Schedules" for the specific project. Typical inspections and services include:
      a. Daily visual inspection for coolant, exhaust, and fuel gas leaks; inspection of vibration dampers; inspect fuel gas piping and drain condensate; inspect heat exchangers and coolant piping, drain condensate as required; check and maintain strainers and filters.
      b. Daily entries and updating of an Operating Logbook.
      c. Daily checks of manometer readings at air intake filter housing.
      d. Cleaning of air intake housing and replacement of air filter(s) as required.
      e. Daily checks of engine oil pressure and replacement of oil filter if required.
      f. Weekly ignition voltage inspections and recording of measurements, inspection and re-gapping of spark plug electrodes as required to accomplish projected replacements at engine manufacturer scheduled intervals.
      g. Monitor and draw fuel gas, lube oil, and coolant samples on a scheduled basis.
      h. Monitor and add coolant, coolant inhibitor, and lube oil as required.
      i. Inspect, clean, and maintain engine starting batteries, cables, and terminals.
      j. Inspect coolant levels, pressures, and draw coolant samples quarterly.
      k. Replace battery in control module annually.
      l. Inspect battery in battery charger and replace as required.
   2. Factory trained and qualified technicians shall provide the following services:
      a. Perform planned maintenance, inspections, component replacement, minor, and major overhauls at engine manufacturer recommended 2000 operating hour service intervals for each engine-generator set.
      b. Review Owner daily operating logs.
      c. Provide lube oil sample kits for use by Owner to draw oil samples per engine manufacturer recommendations.
      d. Review lube oil samples for Owner and provide comment as required.
      e. Conduct coolant testing on an annual basis and provide report to Owner.
      f. Inspect engine controls, program settings; download operating systems for trend analysis and review of system performance.
   3. Factory trained and qualified technicians will perform the following inspections and services at engine manufacturer recommended 2000 operating hour intervals:
      a. 2000-4000-6000 intervals:
         1) Review Owner daily operating logs.
         2) Inspect engine controls, program settings; download operating systems for trend analysis and review of system performance.
         3) Inspect, adjust and record data for:

a) Intake and exhaust valve to valve lifter clearances.
b) Intake and exhaust valve lash adjustments.
c) Intake and exhaust valve stem projection (recession).

4) Inspect rocker arms, valve lifters, adjusting screws, tappets, and lock nuts.
5) Inspect valve cover gaskets and replace as required.
6) Inspect, maintain, and adjustments to ignition systems inclusive of:
   a) Inspect and tighten connections and terminals at ignition box.
   b) Inspect ignition harness.
   c) Inspect ignition pickups for debris, clean as required, inspect mounting distance.
   d) Inspect ignition coils and record ignition voltages.
   e) Inspection ignition plug sockets and springs.
   f) Inspection, re-gapping, and changing of spark plugs.
   g) Inspect and clean crankcase ventilation system, replace filter cartridge and media.
   h) Inspect, clean, adjust, and lubricate regulator rod linkage as required.
7) Inspect, clean, and adjust throttle valve.
8) Inspect, clean, lubricate, and adjust throttle valve: actuator control rod assemblies.
9) Perform lube oil and filter changes at defined engine manufacturer maintenance intervals however subject to lube oil analysis and lube oil condition. Increased frequency of lube oil changes result in additional charges. Provide all lube oil including make up oil for Owner personnel routine maintenance.
10) Inspect plate and frame heat exchangers, measure and record differential pressures, disassemble, clean, and reassemble heat exchangers as required.
11) Inspect gas train filter and clean filter housing.
12) Inspection of the electrical generator assembly, interior compartments, assembly, generator bearings, and generator couplings inclusive of:
    a) Inspect and lubricate generator bearings per manufacturer's recommendations.
    b) Inspect and clean generator compartment, cooling air intake and outlets.
    c) Inspect auxiliary wiring for chafing and terminations.
13) Inspect and check varister and rectifier diodes per manufacturer's recommendations.

END OF SECTION

SECTION 26 43 13
LOW VOLTAGE SURGE PROTECTION DEVICES (SPD)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Type 1 SPD - High exposure locations (motor control center, integrally mounted.)

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
      b. C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits.
      c. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
      d. C62.45, Recommended Practice on Surge Testing For Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits.
   2. Military Standard:
      a. MIL-STD-220B, Method of Insertion-Loss Measurement.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. LS 1, Low Voltage Surge Protective Devices.
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   5. Underwriters Laboratories, Inc. (UL):
      a. 1283, Standard for Electromagnetic Interference Filters.
      b. 1449, Standard for Safety Transient Voltage Surge Suppressors.

B. Qualifications:
   1. Provide devices from a manufacturer who has been regularly engaged in the development, design, testing, listing and manufacturing of SPDs of the types and ratings required for a period of 10 years or more and whose products have been in satisfactory use in similar service.
      a. Upon request, suppliers or manufacturers shall provide a list of not less than three (3) customer references showing satisfactory operation.

1.3 DEFINITIONS

A. Clamping Voltage:
   1. The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage.
   2. The voltage measured at the end of the 6 IN output leads of the SPD and from the zero voltage reference to the peak of the surge.

B. Let-Through Voltage:
   1. The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage.

2. The voltage measured at the end of the 6 IN output leads of the SPD and from the system peak voltage to the peak of the surge.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the SPD device can operate and meet its specification within its rated temperature.

D. Maximum Surge Current:
1. The maximum 8 x 20 microsecond surge current pulse the SPD device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 percent deviation of clamping voltage at a specified surge current.
2. Listed by mode, since number and type of components in any SPD may very by mode.

E. MCC: Motor Control Center.

F. Protection Modes: This parameter identifies the modes for which the SPD has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

G. Surge Current per Phase:
1. The per phase rating is the total surge current capacity connected to a given phase conductor.
   a. For example, a wye system surge current per phase would equal L-N plus L-G; a delta system surge current per phase would equal L-L plus L-G.
   b. The N-G mode is not included in the per phase calculation.

H. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for a 480/277 V system the L-L peak voltage is 679V and the L-N peak voltage is 392 V).

1.4 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data including:
   a. Manufacturer's qualifications.
   b. Standard catalog cut sheet.
   c. Electrical and mechanical drawing showing unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.
   d. Testing procedures and testing equipment data.
   e. Create a Product Data Sheet for each different model number of SPD provided (i.e., Model XYZ with disconnect and Model XYZ without disconnect, each require a Product Data Sheet).
      1) Data in the Product Data Sheet heading:
         a) SPD Type Number per PART 2 of the Specification.
         b) Manufacturer’s Name.
         c) Product model number.
      2) Data in the Product Data Sheet body:
         a) Column one: Specified value/feature of every paragraph of PART 2 of the Specification.
         b) Column two: Manufacturer’s certified value confirming the product meets the specified value/feature.
         c) Name of the nationally recognized testing laboratory that preformed the tests.
         d) Warranty information.
      3) Data in the Product Data Sheet closing:
         a) Signature of the manufacturer’s official (printed and signed).
         b) Title of the official.
      4) Date of signature.

B. Operation and Maintenance Manuals:
1. See Specification Section 01 33 04 for requirements for:

a. The mechanics and administration of submittal process.
b. The content of the Operation and Maintenance Manuals.
2. Warranty.

1.5 WARRANTY

A. Minimum of a five (5) year Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Standards: IEEE C62.41.1, IEEE C62.41.2, IEEE C62.45, NEMA LS 1, MIL-STD 220B, UL 1283, UL 1449.

2.2 TYPE 1 SPD

A. Product:
1. Integrally mounted in MCCs.
2. Hybrid solid-state high performance suppression system.
a. Do not use a suppression system with gas tubes, spark gaps or other components which might short or crowbar the line resulting in interruption of normal power flow to connected loads.
3. Do not connect multiple SPD modules in series to achieve the specified performance.
4. Designed for parallel connection.
5. Field connection: Use mechanical or compression lugs for each phase, neutral and ground that will accept bus bar or #10 through #1/0 conductors.
6. Device monitor:
a. Long-life, solid state, externally visible indicators and Form C dry contact(s) that monitors the on-line status of each mode of the units suppression filter system and power loss in any of the phases.
b. A fuse status only monitor system is not acceptable.

B. Operating Voltage: The nominal unit operating voltage and configuration as indicated on Drawings.

C. Modes of Protection: All modes.
1. Three phase (delta): L-L, L-G.
2. Three phase (wye): L-N, L-L, L-G and N-G.
3. Single phase (2 pole): L-L, L-N, L-G and N-G.
4. Single phase: L-N, L-G and N-G.

D. Maximum Continuous Operating Voltage: Less than 130 percent of system peak voltage.

E. Operating Frequency: 45 to 65 Hz.

F. Short Circuit Rating: Equal to or greater than rating of equipment SPD is connected to.

G. Maximum Surge Current: 240,000 A per phase, 120,000 A per mode minimum.

H. Minimum Repetitive Surge Current Capacity: 4000 IEEE C High waveform impulses with no degradation greater than 10 percent deviation of the clamping voltage.

I. SPD Protection:
1. Integral unit level and/or component level overcurrent fuses and sustained overvoltage thermal cutout device.
2. An IEEE C High waveforms shall not cause the fuse to open and render the SPD inoperable.

J. Maximum Clamping Voltages: Dynamic test at the 90 degree phase angle including 6 IN lead length and measured from the zero voltage reference:

System Voltage	Test Mode	IEEE C62.41 C High V & I Wave	IEEE C62.41 B Combination Wave	UL 1449
L-L < 250 V	L-L	1470 V	1000 V	800 V
L-N < 150 V	L-N	850 V	600 V	500 V
	L-G	1150 V	800 V	600 V
	N-G	1150 V	800 V	600 V
L-L > 250 V	L-L	2700 V	2000 V	1800 V
L-N > 150 V	L-N	1500 V	1150 V	1000 V
	L-G	2000 V	1550 V	1200 V
	N-G	2000 V	1550 V	1200 V

K. EMI-RFI Noise Rejection: Attenuation greater than 30 dB for frequencies between 100 kHz and 100 MHz.

2.3 SOURCE QUALITY CONTROL

A. SPD approvals and ratings shall be obtained by manufacturers from nationally recognized testing laboratories.

B. The SPD are to be tested as a complete SPD system including:
   1. Integral unit level and/or component level fusing.
   2. Neutral and ground shall not be bonded during testing.
   3. 6 IN lead lengths.
   4. Integral disconnect switch when provided.

C. The “as installed” SPD system including the manufacturers recommended circuit breaker, the SPD is connected to, will not open when tested with a IEEE C3 combination waveform.

D. Tests to be performed in accordance with IEEE C62.45:
   1. Clamping voltage performance testing using IEEE C62.41 Category waveforms.
   2. Single pulse surge current capacity test.
   3. Repetitive surge current capacity testing.
   4. Spectrum analysis for EMI-RFI noise rejection.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Type 1 SPD:
   1. Connected in parallel to the equipment.
   2. Install in dedicated electrical equipment compartment, bucket or panelboard box at the factory before shipment.
   3. Provide leads that are as short and straight as possible.
   4. Maximum lead length: 12 IN.
   5. Minimum lead size: #2 stranded AWG or bus bar.
   6. Connect leads to the equipment to be protected by one (1) of the following means:
      a. Through a circuit breaker or molded case switch mounted in the equipment.
      b. Use manufacturer recommended circuit breaker size.
      c. Circuit breaker or switch to be operable from the equipment exterior or from behind a hinged door.

END OF SECTION

SECTION 26 50 00

INTERIOR AND EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Interior building and exterior building mounted luminaires.
      b. Exterior and site luminaires.
      c. Lamps and LEDs.
      d. Ballasts and drivers.
      e. Light poles.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Division 03 - Concrete.
   4. Section 26 05 00 - Electrical: Basic Requirements.
   5. Section 26 05 19 - Wire and Cable - 600 Volt and Below.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. C78.377, Specification for the Chromaticity of Solid State Lighting Products.
   2. Federal Communications Commission (FCC):
      a. Code of Federal Regulations (CFR), 47 CFR 18, Industrial, Scientific and Medical Equipment.
   3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   4. Illuminating Engineering Society of North America (IESNA):
      a. LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products.
      b. LM-80, Measuring Lumen Maintenance of LED Light Sources.
   5. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000Volts Maximum).
      b. 410, Performance Testing for Lighting Controls and Switching Devices with Electronic Fluorescent Ballasts.
      c. LE 4, Recessed Luminaires, Ceiling Compatibility.
   6. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. C82.4, Ballasts for High-Intensity Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type).
      b. C82.11, High-Frequency Fluorescent Lamp Ballasts - Supplements.
      c. SSL 1, Electronic Drivers for LED Devices, Arrays and Systems.
   7. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 101, Life Safety Code.
   8. Underwriters Laboratories, Inc. (UL):
      a. 248-4, Low-Voltage Fuses - Part 4: Class CC Fuses.
      b. 844, Standard for Luminaires for Use in Hazardous (Classified) Locations.
      c. 924, Standard for Emergency Lighting and Power Equipment.
      d. 935, Standard for Fluorescent-Lamp Ballasts.
      e. 1012, Power Units Other Than Class 2.
      f. 1029, Standard for High-Intensity-Discharge Lamp Ballasts.

g. 1310, Class 2 Power Units.
h. 1598, Luminaires.
i. 8750, Light Emitting Diode (LED) Equipment for Use in Lighting Products.
9. United States Department of Energy (USDOE):
a. EPAct, the National Energy Policy Act.

1.3 DEFINITIONS

A. Average Rated Life for HID, fluorescent and induction luminaire light sources:
1. The time after which 50 percent of a large group of light sources will have failed and 50 percent will have survived under normal operating conditions.

B. Useful Life for LED luminaire light sources:
1. The operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions.
2. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data:
a. Provide submittal data for all products specified in PART 2 of this Specification Section.
b. Identify luminaire by Lighting Fixture Schedule designation.
c. Luminaire data sheet:
1) Name of manufacturer.
2) Complete order information (catalog number).
3) Description of construction and optics.
4) Total input wattage.
5) Luminous efficacy (lumens/Watt).
6) Photometric performance data including candlepower distribution and coefficient of utilization (CU) table.
7) Dimensional size.
8) Weight.
9) UL nameplate data for luminaires used in Class 1, Division 1 and 2 areas.
10) Effective Projected Areas (EPA) for pole mounted luminaires.
d. Solid state luminaire additional data:
1) Voltage.
2) Initial and IES L70 lumens.
3) Luminous efficacy (lumens/Watt).
4) Correlated Color Temperature (CCT).
5) Color Rendering Index (CRI).
6) Total Harmonic Distortion (THD).
7) Lamp life.
8) Driver manufacturer and model number.
9) Driver life.
10) Driver type (0-10V, constant voltage, constant current).
11) Dimming range and control device compatibility.
12) Remote driver: Maximum wire length to luminaire.
13) Emergency battery driver:
a) Compatibility with lighting module.
b) Lumen output of lighting module in emergency operation.
c) Battery life.
d) Description of testing.
e) Ambient operating temperature.

14) Toxicity Characteristic Leaching Procedure (TCLP) compliance.
15) Warranty information.

e. Luminaire lamp data sheet:
   1) Name of manufacturer.
   2) Complete order information (catalog number).
   3) Wattage.
   4) Initial and mean lumens.
   5) Luminous efficacy (lumens/Watt).
   6) Correlated Color Temperature (CCT).
   7) Color Rendering Index (CRI).
   8) Lamp life.
   9) Base configuration.
   10) Toxicity Characteristic Leaching Procedure (TCLP) compliance.
   11) Warranty information.
f. Luminaire ballast data sheet:
   1) Name of manufacturer.
   2) Complete order information (catalog number).
   3) Type and quantity of lamps it operates.
   4) Ballast factor.
   5) Input Wattage.
   6) Inrush current.
   7) Voltage.
   8) End-of-life sensing shut off.
   9) Total Harmonic Distortion (THD).
   10) T8 linear lamps: NEMA Premium mark.
   11) Dimming ballast:
       a) Dimming range.
       b) Compatible dimming control devices.
   12) Remote ballasts: Maximum wire length to luminaire.
   13) Emergency battery ballast:
       a) Lumen output of lamp in emergency operation.
       b) Battery life.
       c) Description of testing.
   14) Warranty information.
g. Pole data sheet:
   1) Name of manufacturer.
   2) Complete order information (catalog number).
   3) Description of construction.
   4) Length, shaft size and thickness.
   5) Wind loading (available luminaire EPA per wind speed).
   6) Anchor bolt template.
   7) Bolt size and material.
h. See Specification Section 26 05 00 for additional requirements.

3. Test Reports:
   a. IES LM-79 Test Report for Solid-State Luminaire.
   b. IES LM-80 Test Report Solid-State Light Source.
4. Certifications: Solid-state Luminaire Useful Life Certificate.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
      b. Submittal data for each component covered by warranty.
      c. Warranty.

1.5 WARRANTY

A. Minimum of a two (2) year Warranty from date of manufacture against failure for electromagnetic HID ballasts.

B. Minimum of a five (5) year Warranty from date of manufacture against failure for electronic HID ballasts.

C. Minimum of a five (5) year Warranty from date of manufacture against failure for electronic flourescent ballasts.

D. Minimum of a five (5) year Warranty from date of manufacture against failure for solid-state luminaiare including LED arrays, LED drivers and integral control devices. The solid-state product is considered defective if more than 15 percent of the individual light emitting diodes fail to illuminate.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Luminaires: Per Lighting Fixture Schedule.
   2. Lamps:
      a. General Electric.
      b. Osram Sylvania.
      c. Philips Lighting Company.
      d. Venture.
   3. Solid State Light Sources:
      a. Cree.
      b. Xicato.
      c. Luminaire manufacturer's proprietary system.
   4. Ballasts:
      a. General Electric.
      b. Philips Lighting Company.
      c. Osram Sylvania.
      d. Universal Lighting Technologies.
   5. LED Driver: Luminaire manufacturer's standard.
   6. Emergency ballasts:
      a. Iota Engineering.
      b. Philips Bodine.
   7. Emergency transfer devices: Philips Bodine.
   8. Poles: Luminaire manufacturer's standard.

2.2 GENERAL REQUIREMENTS

A. All Luminaires and Electrical Components:
   1. UL labeled.
   2. Luminaires complete with lamps and ballasts or LED modules and drivers.
   3. Rated for area classification as indicated on the Drawings.
      a. In Class I, Division 1 and 2 areas, the temperature rating of the luminaires and lamp or LED combination shall not exceed the auto-ignition temperature of the atmosphere in which the Luminaire is used.

B. Provide all recessed luminaires with gaskets of rubber, fiberglass, or equivalent material to prevent light leaks around flush trim.
   1. Provide recessed luminaires with trim gaskets cemented in proper position.

C. Provide standard plaster frame for all recessed luminaires installed in plaster walls or ceilings.
   1. Design, finish and fabricate material to preclude possibility of rust stain in plaster.

D. Coordinate luminaire mounting where recessed into building canopies prior to Submitting Shop Drawings. Confirm clearances and luminaire flange compatibility with construction.

E. Electrical components of recessed luminaires shall be accessible and removable through luminaire without having to remove luminaire from ceiling.

F. No live parts normally exposed to contact.

G. When intended for use in wet areas: Mark luminaire "Suitable for wet locations."

H. When intended for use in damp areas: Mark luminaire "Suitable for damp locations" or "Suitable for wet locations."

2.3 LUMINAIRES

A. Standards:
1. UL 1598.
2. UL 844 for hazardous locations.
3. NEMA LE 4 for recessed locations.

B. Housings:
1. As indicated in the Luminaire Schedule and the following:

C. Castings:
1. As indicated in the Lighting Fixture Schedule and the following:
   a. Uniform quality, free from imperfections affecting strength and appearance.
   b. Exterior surfaces, if not receiving a finish coat, shall be smooth and match adjacent surfaces. At least one coat of clear methacrylate lacquer shall be applied unless a painted finish is specified.

D. Fasteners:
1. As indicated in the Lighting Fixture Schedule and the following:
   a. Aluminum or steel luminaires: Cadmium-plated or an equivalent.
   b. Stainless steel luminaires: Stainless steel.
   c. Bronze luminaires: Bronze or stainless steel.
   d. Non-metallic luminaires: Stainless steel.

E. Finishes:
1. As indicated in the Lighting Fixture Schedule and the following:
   a. Painted surfaces:
      1) Manufacturer's standard metal pretreatment and baked or air-dried, light-stabilized enamel finish; acrylic, alkyd, epoxy, polyester or polyurethane.
      2) White finishes shall have minimum 85 percent reflectance.
   b. Unpainted surfaces:
      1) Interior: Clear anodic coating, satin finish.
      2) Exterior: Clear anodic coating.

F. Lens/Louver Frames:
1. As indicated in the Lighting Fixture Schedule and the following:
   a. Extruded aluminum with mitered corners.
   b. Hinging or other normal motion shall not cause lens or louver to drop out.
   c. No light leak between frame and housing.

G. Lenses:
1. As Indicated in the Lighting Fixture Schedule and the following:
   a. 100 percent virgin, UV stabilized acrylic.
   b. Linear fluorescent luminaires: Male conical prismatic, minimum thickness 0.150 IN, size as required.
   c. Held securely in place but must also be removable for cleaning and relamping.
   d. Luminaires with directional lenses shall include a lens orientation device to ensure that lens installation provides light distribution as designed.
   e. No light leaks between the lens and the luminaire.

H. Reflectors:
  1. As Indicated in the Lighting Fixture Schedule and the following:
     a. Linear fluorescent luminaires: High-purity #12 aluminum reflector sheet, 0.047 IN (15 GA) or heavier, free from fabrication or assembly damages. No exposed rivets, springs or other hardware after installation. Shape reflectors in modified elliptical or parabolic contour to produce no apparent brightness. Lamp image or any part of lamp shall not be visible in 45 degree zone.
     b. Down Light Reflector and Baffle Finishes: First-quality "Alzak" anodized specular finish.
     c. Troffer reflector finish: Integral reflectors shall be painted white after fabrication with a minimum reflectance value of 90 percent.

I. Gaskets:
  1. As Indicated in the Lighting Fixture Schedule and the Following:
     a. Gaskets at face plates or frames of recessed luminaires which serve as ceiling trim and which allow interior access.
     b. Moisture seal gaskets at exterior locations and in other designated wet areas.
     c. Secure frames to luminaire bodies with screws or other means, to result in tight installation, without light leaks.

J. Ventilation:
  1. Ventilation openings of adequate size and quantity to permit operation of lamps and ballast without affecting rated output or life expectancy. Include wire mesh screens.

K. Lamp Holders:
  1. Position sockets so that lamps are in optically correct relation to luminaire components.
  2. Secure sockets by screws to luminaire enclosure or husk. Spring mounted sockets are not approved. Do not use plastic or sheet metal sockets unless specified otherwise.
  3. Sockets with open circuit voltage over 300 volts: Safety type, designed to open supply circuit upon lamp removal.
  4. Mount lamp holders such that fluorescent lamps on rapid-start circuits are within 1 IN of grounded metal, a minimum of 1IN wide for full length of lamp.
  5. Halogen: Porcelain body; nickel plated brass socket, pre-lubricated with silicone compound.
  6. Fluorescent: White urea plastic body; silver plated phosphor bronze or beryllium copper contacts.
  7. High Intensity Discharge: Porcelain body; nickel plated brass socket, pre-lubricated with silicone compound. Lamp supplied must be compatible with socket orientation (horizontal, base up or base down).

L. Wiring:
  1. Factory-wired to be compatible with the project electrical and controls systems.
  2. Long tube fluorescent luminaires shall comply with NEC requirements and be supplied with a quick disconnect accessible to qualified persons before servicing or maintaining the ballast.
  3. Thermally protect halogen and HID luminaires.

M. Mounting Accessories:
  1. Provide appropriate mounting accessories for each luminaire, compatible with various structural conditions encountered.
  2. All luminaires with adjustable beam angles shall have a locking device to ensure that the beam distribution is not effected during relamping or cleaning.
  3. Recessed Luminaires:
     a. Plaster Frames: Provide frames for luminaires installed in gypsum board and concealed suspension system ceiling tile. Make frames of non-ferrous metal or suitably rustproof after fabrication.
     b. Baffles and Gaskets: As required to prevent light leakage.

c. Flanged luminaires are required in all ceiling systems except exposed grid lay-in panel type.

4. Luminaire Suspension Material:
   a. Unfinished Spaces:
      1) 1/2 IN minimum diameter swivel stem, unless otherwise noted.
      2) Safety chain on high bay type.
   b. Finished Spaces: Unless otherwise noted.
      1) Manufactured cable or stem and outlet box canopy.
         a) Contemporary design with swivel self-aligning features.
         b) Size canopy to cover outlet box, minimize size of canopy not associated with outlet box.
         c) Finish to match luminaire.
      2) Coordinate pendant location with ceiling tiles/ceiling grid.
         a) Submit coordinated mounting accessories as part of Shop Drawing submission.
      3) Luminaires mounted on suspended ceiling grids should be provided with outlet box designed for grid mounting with direct cord entry and supported by outlet box.
      4) For high intensity discharge lamps:
         a) Use stems suspended from swivel shock-absorbing fittings.

2.4 SOLID-STATE LUMINAIRES - ADDITIONAL REQUIREMENTS

A. Standards:
   1. IES LM-79, LM-80.
   2. NEMA SSL 1.
   3. UL 1012, 1310, and 8750.
   4. UL 844 for hazardous locations.

B. Solid state modules and driver to be provided and warrantied by luminaire manufacturer.

C. Solid-State Modules:
   1. Minimum uniform color temperature of 3500K.
      a. Color temperature measurement shall have a maximum 3 SDCM on the MacAdam Ellipse for frosted lensed luminaires, and 2 SDCM for other luminaire types (ANSI C78.377).
   2. Minimum color rendering index (CRI) of 80.
   3. LED module light output and efficacy: Measured in accordance with IES LM-79 standards.
   4. LED useful life and lumen maintenance: Measured in accordance with IES LM-80 standards.
   5. Driver and LED module: Minimum useful life of 50,000 HRS.
   6. Individual LEDs connected such that a failure of one LED will not result in a light output loss of the entire luminaire.

D. Driver:
   1. Compatible with solid-state modules and control devices specified.
   2. Operate from 60 Hz input source of 120V through 277V with sustained variations of +/- 10 percent (voltage and frequency).
   3. Input current Total Harmonic Distortion (THD): Less than 20 percent when operated at nominal line voltage.
   4. Power Factor: Greater than 0.90.
   5. Avoid interference with infrared devices and eliminate visible flicker.
   6. Comply with ANSI C62.41 Category A for Transient protection.
   7. Comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 18, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
   8. Dimmable drivers capable of continuous dimming over a range of 100 percent to 1 percent of rated lumen output. Dimming controlled by a 0-10VDC signal, unless otherwise specified in Luminaire Schedule.

9. Control device must be compatible with type of driver, and coordinated prior to submission of Shop Drawings. List of compatible dimming controllers must include the range of perceived brightness. No visible flicker throughout the dimming range.
10. Remote-mounting:
    a. Provide maximum allowable distances for secondary wire runs to luminaires.
    b. Provide remote mounting hardware and enclosures as required.
11. Operating temperature range must be suitable for site temperature conditions within exterior and gasketed luminaires.

2.5 EXIT SIGNS AND EMERGENCY LIGHTING UNITS

A. Standards:
1. UL 924.
2. NFPA 101.
3. Local State or City requirements.

B. Exit Signs:
1. Housing and finish: As indicated in the Lighting Fixture Schedule.
2. LED illuminated with integral driver.
3. AC powered or AC and battery powered: As indicated in the Lighting Fixture Schedule.
4. Battery powered units:
    a. Battery type: As indicated in the Luminaire Schedule.
    b. Self-testing/self-diagnostic.
        1) Electronic circuitry automatically test emergency lighting for a minimum of 30 seconds every 30 days and 90 minutes once a year.
    c. Consist of batter, charger and electronic circuitry.
    d. Solid state charging indicator light to monitor the charger and battery.
    e. Single-pole test switch.
    f. A user selectable audible alarm. The alarm shall be engaged unless noted otherwise on the Drawings.

C. Emergency Lighting Units:
1. Housing: As indicated in the Lighting Fixture Schedule.
2. Lamps: As indicated in the Lighting Fixture Schedule.
3. Battery type: As indicated in the Lighting Fixture Schedule.
4. Self-testing/self-diagnostic.
    a. Electronic circuitry automatically test emergency lighting for a minimum of 30 seconds every 30 days and 90 minutes once a year.
5. Consist of batter, charger and electronic circuitry.
6. Solid state charging indicator light to monitor the charger and battery.
7. Single-pole test switch.
8. A user selectable audible alarm. The alarm shall be engaged unless noted otherwise on the Drawings.

2.6 LAMPS

A. Medium Screw Base Fluorescent and Solid State:
1. Type and initial lumens as indicated in the Lighting Fixture Schedule.
2. Size and shape coordinated with luminaire.
3. Fluorescent:
    a. Self-ballasted.
    b. Types: Spiral, reflector.
4. Solid state:
    a. Integral driver.
    b. Types: A and PAR.

B. Fluorescent:
1. T8 (265 mA) programmed start linear medium bi-pin lamps (G13):
    a. Correlated color temperature of 3500 degrees Kelvin.

b. Minimum color rendering index (CRI) of 80.
c. Minimum initial lumen ratings for each lamp type shall be:
1) 2850 lumens for 48 IN, 32 watt F32T8 lamp.
d. Average rated life:
1) 30,000 HRS at 3 HRS per start.
2) 36,000 HRS at 12 HRS per start.
e. Low-mercury, green-tipped type manufactured to be in compliance with the EPA's Toxicity Characteristic Leaching Procedure (TCLP).

C. High Intensity Discharge (HID) Lamps:
1. Metal halide lamps:
a. In an open luminaire, the lamp shall be rated for use in an open luminaire and incorporate a protective arc tube shroud design.
b. Ceramic metal-halide lamps.
1) Lamps shall have a correlated color temperature of 3000 degrees Kelvin.
2) Minimum color rendering index (CRI) for coated lamps is 81.
3) Minimum initial lumen ratings for medium base PAR lamps and single-ended G-8.5 and G-12 metal halide lamps shall be:
a) 2225 lumens for 39 watt, PAR-30L (ANSI C130/M130) lamp.
b) 3600 lumens for 39 watt, T-6 (ANSI C130/M130) lamp.
c) Refer to Luminaire Schedule to determine spot or flood distribution of PAR lamps.
4) Average rated life: 10,000 HRS.
5) Designated on the Lighting Fixture Schedule by a 'CMH' prefix.
c. Medium base pulse-start lamps.
1) Coated lamps shall have a correlated color temperature of 3000 degrees Kelvin.
2) Minimum color rendering index (CRI) for coated lamps is 85.
3) Minimum initial lumen ratings for metal halide lamps with a medium base shall be:
a) 3200 lumens for 50 watt, ED-17 (ANSI M148/M110/E) coated lamp.
b) 4900 lumens for 70 watt, ED-17 (ANSI M143/M98/E) coated lamp.
c) 8500 lumens for 100 watt, ED-17 (ANSI M140/M90/E) coated lamp.
d) 12,000 lumens for 150 watt, ED-17 (ANSI M142/M102/E) coated lamp.
4) Average rated life:
a) 10,000 HRS for 50 watt lamps.
b) 15,000 HRS for all other lamps.
5) Designated on the Luminaire Schedule by a 'MH' prefix.
a) Coated lamps are designated by a '/C' suffix.
b) Protected lamps are designated by a '/P' suffix.
d. Mogul base pulse-start lamps:
1) Clear lamps shall have a correlated color temperature of between 3600 and 4100 degrees Kelvin.
2) Minimum color rendering index (CRI) for clear lamps is 62.
3) Minimum initial lumen ratings for metal halide lamps with a mogul base in a universal position shall be:
a) 23,000 lumens for 250 watt, ED-28 (ANSI M153/M138/E) clear lamp.
b) 30,600 lumens for 320 watt, ED-28 (ANSI M154/M132/E) clear lamp.
c) 42,000 lumens for 400 watt, ED-28 (ANSI M155/M135/M128/E) clear lamp.
4) Average rated life:
a) 15,000 HRS for 250 watt lamps.
b) 20,000 HRS for all other clear lamps.
5) Designated on the Luminaire Schedule by a 'MS' prefix.

2.7 BALLASTS

A. Fluorescent High-Frequency Electronic Ballasts:
1. General characteristics:

a. High frequency electronic type and operate lamp(s) at a frequency above 31 kHz to avoid interference with infrared devices and eliminate visible flicker.
    1) Avoid frequency ranges of 27-31 kHz, 34-41 kHz, and 55-61 kHz.
b. Lamp Current Crest Factor of 1.7 or less.
c. Power Factor greater than 0.98.
d. Input current shall have Total Harmonic Distortion (THD) of less than 20 percent when operated at nominal line voltage with primary lamp.
e. Operate from 60 Hz input source of 120V through 277V with sustained variations of +/- 10 percent (voltage and frequency).
f. Contain auto restart circuitry in order to restart lamps without resetting power.
g. Class A sound rating or quieter.
h. Provided with integral leads or poke-in wire trap connectors color coded per ANSI C82.11.
i. Tolerate sustained open circuit and short circuit output conditions.
j. UL listed, Class P.
k. Standards:
    1) UL 935.
    2) ANSI C62.41 Category A for Transient protection.
    3) ANSI C82.11 where applicable.
    4) Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 18, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
    5) NEMA 410 for in-rush current limits.
    6) Manufactured in a factory certified to ISO 9001 Quality System Standards.

2. Fluorescent high-frequency electronic ballasts for T8 linear twin-tube lamps:
    a. Type per Lighting Fixture Schedule:
        1) Programmed start.
    b. Minimum Ballast Factor of:
        1) 0.85 for Normal Output.
    c. Minimum starting temperature of 0 DegF.
    d. Five year warranty from date of manufacture for operation at a maximum case temperature of 158 DegF.

B. Fluorescent Emergency Ballasts:
1. General characteristics.
    a. UL924 listed for installation inside, on top of, or remote from the luminaire. Mount inside ballast channel of luminaire wherever possible.
    b. Self-testing/self-diagnostic fluorescent emergency ballast.
        1) Electronic circuitry shall be self-testing in design and automatically test emergency lighting for a minimum of 30 seconds every 30 days and 90 minutes once a year.
    c. Consist of a high temperature, maintenance-free nickel-cadmium battery, charger and electronic circuitry.
    d. Solid state charging indicator light to monitor the charger and battery.
    e. Single-pole test switch.
    f. A user selectable audible alarm. The alarm shall be engaged unless noted otherwise on the Drawings.
    g. Mount components (battery, charger, inverter) in a common enclosure constructed of 20 gage (minimum) steel housing.
    h. Provide a remote indicator light when luminaire construction prevents visible mounting within luminaire.
    i. Emergency ballast shall delay AC ballast operation for approximately 3 seconds to prevent false tripping of AC ballast end-of-life shutdown circuits.
    j. Ambient temperature rating: 32 DegF to 122 DegF.
    k. Five year warranty from date of manufacture.

C. High Intensity Discharge (HID) Ballasts:
1. General characteristics:
    a. Standards:

1) NEMA/ANSI C82.4.
2) UL 1029.

b. Produced in a factory certified to ISO 9001 Quality System Standards.
c. Contain no Polychlorinated Biphenyl (PCB’s).

2. Electronic HID (Metal Halide):
   a. Voltage sensing and operate from a nominal line voltage range of 120-277 volts, +/-10 percent, 50/60 Hz.
   b. Furnished with integral, color-coded leads.
   c. Total Harmonic Distortion (THD): Less than 15 percent.
   d. Power Factor: Greater than 90 percent.
   e. Lamp end-of-life detection and shutdown circuit.
   f. Sound Rated A.
   g. Output frequency to the lamps shall be less than 200 Hz to prevent acoustic resonance inside the lamp arc tube and to minimize visible flicker.
   h. Lamp Current Crest Factor: Less than 1.5.
   i. Thermally protected to shut off when operating temperatures reach unacceptable levels.
   j. Dimming when specified:
      1) Incorporate a 0-10V dimming interface and control function.
      2) Lamp shall warm up at full power for 15 minutes.
      3) Dimming range: 50 to 100 percent.
   k. Meet Federal Communications Commission rules and regulations, Title 47 CFR Part 18, for Non-Consumer equipment.
   l. Three-year warranty from the date of manufacture for operation at a case temperature of 122 DegF or less.

2.8 POLES

A. As Indicated in the Lighting Fixture Schedule and the following:
   1. Designed for attached luminaire EPA with a 90 mph maximum wind velocity at the base with a 1.3 wind gust factor.
   2. Additional features:
      a. Handhole near base of pole.
      b. Grounding lug accessible at handhole.
      c. Galvanized anchor bolts.
      d. Anchor bolt covers.

2.9 MAINTENANCE MATERIALS

A. Furnish a minimum of 2 or 10 percent of total of each type and wattage of lamps, whichever is greater.

B. Furnish a minimum of 10 percent of total of each type and amperage of fuses for fixtures indicated to be fused.

C. Spare parts are to be stored in a box clearly labeled as to its contents.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate Luminaire Types with Ceiling Construction:
   1. Provide mounting hardware for the ceiling system in which the luminaire is to be installed.

B. Provide mounting brackets and/or structural mounting support for wall-mounted luminaires.
   1. Do not support luminaire from conduit system.
   2. When luminaire is supported from outlet boxes, install per NFPA 70.
   3. Supports for luminaire mounted on exterior walls shall not be attached to exterior face of the wall.

C. Support surface mounted luminaires from the building structure and not from the ceiling suspension system.
   1. Luminaires up to 4 FT wide and 4 FT long: A minimum of four supporting points, one at each corner.
   2. Luminaires 8 FT long: A minimum of five support points, one at center of luminaire and one at each corner.
   3. Luminaires smaller than 2 FT in length: A minimum of two supporting points.

D. Provide pendant luminaires with swivel hangers which will allow luminaire to swing in any direction but will not permit stem to rotate.
   1. Provide hangers with enclosure rating (NEMA 1, 4, or 7) equal to enclosure requirements of area in which they are installed.
   2. Swivel hangers for luminaires in mechanical equipment areas: Shock absorbing type.
   3. Secure low and high bay luminaires with safety chain or safety aircraft cable to the building structure.
      a. Chain or cable to prevent luminaire from falling more than 3 IN before the luminaire is caught by the chain or cable.

E. Pendant Mounted, Open, Industrial Fluorescent Luminaire:
   1. Not in continuous rows:
      a. Supported by conduit or by approved chains or cable:
      b. Hardwired to ceiling mounted junction box.
   2. In continuous rows:
      a. Supported rigidly with conduit and fasten luminaire to each other or mount on continuous metal channel per Specification Section 26 05 00.
      b. Hardwired to ceiling mounted junction box.
      c. Provide reflector alignment clips.

F. Provide access panels for recessed luminaires that require access for maintenance when such access is not provided for in design of luminaire.
   1. Locate luminaires in accordance with reflected ceiling plans.

G. Locate luminaire in exact center of ceiling tile unless otherwise indicated.
   1. Relocate miss-installed luminaire and replace damaged ceiling materials.

H. Mount luminaire at heights indicated in Specification Section 26 05 00 or per Luminaire Schedule or as indicted on the Drawings.

I. Install exterior luminaires so that water can not enter or accumulate in the wiring compartment.

J. Where indicated, provide two-level control of three (3) and/or four (4) lamp fluorescent luminaires.
   1. Provide two (2) ballasts per luminaire and control inside lamp(s) in each luminaire by one (1) switch or set of switches and the outside two (2) lamps by a second switch or group of switches.

K. Emergency Battery Ballasts:
   1. Where emergency battery ballasts are shown controlled via switching device, wire ballast so lamps will not operate when normal power is available and switching device turns lights off. Lamps will operate in emergency mode regardless of switch position.
   2. Luminaire manufacturer to supply the emergency battery ballasts with luminaire.

L. Ground luminaire and ballasts.

3.2 POLE INSTALLATION

A. Drawings Indicate the Intended Location of Light Pole:
   1. Field conditions may affect actual location.
   2. Coordinate location with all existing or new utilities and pavement.

B. Anchor Base Plated Poles:
   1. Mounted on cast-in-place foundations, as detailed on the Drawings.

a. Concrete and reinforcing steel, in accordance with Division 03 Specification Sections.

2. Protect pole finish during installation.
   a. Repair damage to pole finish with manufacturer approved repair kit.

C. Ground poles as indicated on the Drawings.

D. Conductors:
1. See Specification Section 26 05 19 for required underground conductors.
2. Use interior building wire, as specified in Specification Section 26 05 19, from pole base to luminaire, #12 AWG minimum.

E. Overcurrent and Short Circuit Protection:
1. Protect each phase with a UL Class CC fuse:
   a. Size: Three (3) times load current.
   b. Standard: UL 248-4.
2. Fuseholder:
   a. Watertight, in-line and break-a-way style.
   b. Accept up to a 30 A, 600 V fuse.
   c. Neutral conductor shall utilize a fuseholder with a solid copper rod.
   d. Conductor terminal: Adequate size for the installed conductors.

3.3 LIGHTING CONTROL

A. See Specification Section 26 09 16 for lighting control equipment.

B. Exterior wall mounted and pole mounted fixtures controlled as detailed on the Drawings.

3.4 ADJUST AND CLEAN

A. See Specification Section 01 74 13.

B. Replace all inoperable lamps with new lamps prior to final acceptance.

C. Aim all emergency lighting units, so that, the path of egress is illuminated.

END OF SECTION

SECTION 28 31 00
FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Fire Alarm Control Units.
      b. Fire Alarm Annunciator Panel.
      c. Initiating Devices.
      d. Notification Appliances.
      e. Miscellaneous Devices.

B. Related Specification divisions include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 90 00 - Instrumentation and Control Basic Requirements
   4. Section 26 05 33 - Raceways and Boxes.

1.2 QUALITY ASSURANCE

A. Referenced Standards (appropriate editions as adopted by Authority(ies) Having Jurisdiction (AHJ) and including all local amendments):
   1. Americans with Disabilities Act (ADA):
      a. Accessibility Guidelines for Buildings and Facilities (ADAAG).
      b. ADA Standards for Accessible Design.
   2. FM Global (FM):
      a. All applicable standards.
      b. All components FM approved.
   3. National Electrical Manufacturers Association (NEMA).
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC):
         1) Article 760, Fire Alarm Systems.
      b. 72, National Fire Alarm and Signaling Code.
      c. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems
      d. 101, Life Safety Code
   5. National Institute for Certification in Engineering Technologies (NICET).
   6. Underwriters Laboratories, Inc. (UL):
      a. 38, Standard for Manual Signaling Boxes for Fire Alarm Systems.
      b. 268, Smoke Detectors for Fire Alarm Systems.
      c. 268A, Standard for Smoke Detectors for Duct Applications.
      d. 464, Standard for Audible Signaling Appliances.
      e. 497B, Standard for Protectors for Data Communication and Fire Alarm Circuits.
      f. 521, Standard for Heat Detectors for Fire Protective Signaling Systems.
      g. 864, Standard for Control Units and Accessories for Fire Alarm Systems.
      h. 1971, Standard for Signaling Devices for the Hearing Impaired.
   7. Building code:
      a. International Code Council (ICC):
         1) International Building Code and associated standards, referred to herein as Building Code.

B. Design Criteria:

1. Provide a complete fire alarm system as described in the Contract Documents and according to criteria of the AHJ) and all applicable national and local codes such as NFPA, ADAAG, Building Code, etc.
    a. Where system requirements described in the Contract Documents exceed those of the AHJ and/or NFPA, meet the requirements of both.
    b. Contractor shall perform a thorough examination of Contract Documents and shall coordinate with other disciplines and trades, e.g. verification of wet and corrosive area locations requiring equipment rated for that type of environment.
    c. Contractor shall be responsible for providing a fully functional and code compliant fire alarm system at no additional cost to the Owner.
2. Submit documents after design has been approved by Authority Having Jurisdiction (AHJ).
3. The fire alarm system shall be designed by a NICET Fire Alarm Systems Level III or IV engineering technician.
    a. The designer is responsible for understanding the construction of the building to take in consideration ceiling heights, ceiling construction (flat or not flat), and other features of the building that will effect the layout of devices as required to provide a fire alarm system that is fully compliant with NFPA 72.
4. If required by state regulations, a Professional Fire Protection Engineer shall seal drawings submitted to the AHJ.

C. Service Organization Qualifications:
1. Offer an annual maintenance contract including complete service and equipment costs for maintenance of complete system.
2. Ten (10) years experience minimum serving fire alarm systems.
3. Provide for 24 hour emergency service. Response time to site shall be 24 HRS of less and service office shall be within 250 miles of site.
4. System shall be installed under the direct supervision of a technician who is factory trained by manufacturer and is certified as a minimum of NICET Level II in Fire Alarm Systems.

D. Field quality control:
1. Manufacturer's field services: Provide service by a factory-authorized and certified service representative to supervise field assembly and connection of components and pre-testing, testing, and adjustment of system.
2. Pre-testing: Determine, through pre-testing, conformance of system to requirements of drawings and specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.
3. Inspection:
    a. Inspect equipment installation, interconnection with system devices, mounting locations, and mounting methods.
    b. Verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.

E. Authority Having Jurisdiction (AHJ) review:
1. Concurrent or prior to submission to Engineer, submit shop drawing and product data to Authority Having Jurisdiction (AHJ).
2. Upon receipt of comments from AHJ, make resubmissions, if required, to make clarifications or revisions to obtain approval.
3. The AHJ shall witness final testing and inspection in order to obtain final approval for system.

1.3 DEFINITIONS

A. For the purposes of providing materials and installing electrical work the following definitions shall be used.
1. Outdoor Area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.

2. Architecturally Finished Area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.
3. Non-architecturally Finished Area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.
   a. Corrosive Areas: Rooms or areas identified on the Drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or the presence of corrosive gases.
4. Hazardous areas: Class I, II or III areas as defined in NFPA 70.
5. Shop Fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.
6. Service Organization: Commercial entity comprised of professionals capable of providing the technical knowledge and a supply of replacement equipment required for the comprehensive maintenance of a fire alarm system.

1.4 SYSTEM DESCRIPTION

A. Automatic and manual, addressable, general alarm and non-coded evacuation alarm, supervised, closed-circuit, 24 Vdc microprocessor based fire detection and alarm system.

B. Provide components and features as required by the applicable codes, AHJ and/or Fire Department, including but not limited to following.
1. Main FACU in as indicated on the Drawings.
2. Remote Fire Alarm Annunciators (FAA's).
3. Remote FACU's as required for system expansion.
   a. Independent Systems: Each system shall be monitored both for the presence of an alarm condition and for a trouble condition. Independent systems such as smoke detection subsystems, alternate suppression system releasing panels, and kitchen fire extinguishing system shall each be monitored and provided with a separate address}
4. Notification appliance booster panels as required for system expansion.
5. Printer terminals.
6. Manual stations.
7. Heat sensors.
8. Smoke sensors.
9. Ductwork smoke sensors.
10. Remote alarm indicator for concealed smoke sensors.
11. Smoke sensors with auxiliary relays.
12. Sprinkler and standpipe flow switch and main waterflow detector circuits.
13. Main, post indicator valve, and indicating sprinkler valve tamper switch circuits.
14. Sprinkler system pressure switch monitoring circuits.
15. A non-silenceable 24 Vdc notification appliance circuit serving a dedicated, exterior alarm device activated upon a waterflow alarm.
   a. Exterior water flow alarm device shall be a weatherproof audible/visible notification device provided on the exterior of the building located above the Fire Department Connection (FDC).
16. Fan control relays.
17. Visual and audible notification appliances.
18. Fire alarm system wire, with all wiring in conduit.
19. Tone generator.
20. Dry contact output relays for connection to Plant Control System for supervisory, trouble and alarm conditions.

C. Basic Performance:
1. Signal Line Circuits (SLC) shall be wired Class B (NFPA Style 4).
2. Notification Appliance Circuits (NAC) shall be wired Class B.
3. Each SLC and NAC shall be limited to only 80 percent of its total capacity at the time of initial installation.

4. Fire alarm system and all associated equipment and devices shall be suited to the environment in which it is installed, e.g. in wet or corrosive areas all equipment shall be appropriately rated as explosion-proof, intrinsically safe, etc.

1.5 SUBMITTALS

A. Shop Drawings:
  1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
  2. Shop drawings submittal shall include minimum required documentation as prescribed in NFPA 72. This includes, but is not limited to, the following:
    a. Written narrative providing design intent and system description.
    b. Floor plan layout showing location of all devices and control equipment:
      1) Indicate salient features of each device (e.g., weatherproof, strobe candela rating).
      2) Designate where protective equipment is provided (e.g. pull station covers, device guards, etc).
      3) Explosion-proof or Intrinsically safe ratings for devices.
    c. Wiring diagrams (including riser diagram).
    d. Include system details including location of FACU and all devices and circuiting.
    e. System power and battery backup calculations and voltage drop calculations to assure that system will operate in accordance with prescribed backup time periods and under all voltage conditions per UL and NFPA standards.
    f. Provide equipment technical data sheet Submittal for all products specified in product section (PART 2), below.
    g. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs.
    h. Provide list of all input and output points in system with label indicating location or use of IDC, SLC, NAC, relay, sensor, and auxiliary control circuits.
    i. Equipment design considerations for future expansion as indicated.
    j. Operating instructions for FACU.
    k. Completed NFPA 72 record of inspection and testing (see Contract Closeout Information: below for additional requirements).
    l. Copy of site specific software
    m. Name of local service organization.
    n. Documentation of AHJ approval for system submittal.

B. Contract Closeout Information:
  1. Operation and Maintenance Data:
    a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
      1) Contract Closeout Information:Include data for each type product, including all features and operating sequences, both automatic and manual.
  2. Field test reports.
  3. Owner instruction report.
  4. Prorata warranty for batteries.
  5. Spare parts: Furnish extra materials, packaged with protective covering for storage, and identified with labels clearly describing contents as follows:
    a. Manual Stations: Furnish quantity equal to 15 percent of number of manual stations installed but no less than one.
    b. Notification Appliances: Furnish quantity equal to 5 percent of each type and number of units installed, but not less than one of each type.
    c. Automatic initiation devices including but not limited to smoke sensors and heat sensors: Furnish quantity equal to 5 percent of each type and number of units installed but not less than one of each type.
    d. Detector or Sensor Bases: Furnish quantity equal to 2 percent of each type and number of units installed but not less than one of each type.

1.6 AREA DESIGNATIONS

A. Designation of an area will determine the NEMA rating of the electrical equipment enclosures, types of conduits and installation methods to be used in that area.
   1. Outdoor areas:
      a. Wet.
      b. Also, corrosive and/or hazardous when specifically designated on the Drawings or in the Specification Sections.
   2. Indoor areas:
      a. Dry.
      b. Also, wet, corrosive and/or hazardous when specifically designated on the Drawings or in the Specification Sections.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable.
   1. Fire alarm system:
      a. Edwards Systems Technology (EST).
      b. Gamewell FCI.
      c. Notifier.
      d. Monaco.
      e. Siemens Industry.
      f. Silent Knight.
      g. Simplex Grinnell.
      h. Cooper Wheelock.
   2. Manufacturer must have a service organization local to the project site.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

C. All Equipment:
   1. UL listed as a product of a single manufacturer under appropriate category.
   2. Equipment shall not be modified or installed to alter or void UL label or listing.
   3. FM approved.
   4. Approved by Fire Marshal.

2.2 MAIN FIRE ALARM CONTROL UNIT (FACU)

A. FACU shall perform operations as described in Fire Alarm System Operation:

B. The Fire Alarm system shall have 100 point minimum initiating device capacity with the capability to add additional 100 point minimum initiating device control modules.

C. Construction shall be modular with solid-state, microprocessor-based electronics.
   1. An 80-character LCD display shall indicate alarms, supervisory service conditions and any troubles.

D. Keyboards or keypads shall not be required to operate system during fire alarm conditions.

E. Provide necessary switches, relays, indicator lamps, wiring terminals, etc., to provide complete operation supervising, control, and testing facilities for entire system.

F. FACU shall allow for loading or editing special instructions and operating sequences as required.
   1. System shall be capable of on-site programming to accommodate and facilitate expansion, building parameter changes or changes as required by local codes.

2. All software operations shall be stored in a non-volatile programmable memory within FACU.

G. System shall have provisions for disabling and enabling all circuits individually for maintenance and testing purposes.

H. System shall be capable of logging and storing 300 events in a history log.
   1. These events shall be stored in a battery protected random access memory.
   2. Each recorded event shall include time and date of that event's occurrence.
   3. System shall have capability of recalling alarms, supervisory conditions, trouble conditions, acknowledgments, silencing and reset activities in chronological order for purpose of recreating an event history.

I. FACU shall be listed under UL 864.

J. FACU shall be in an enclosed NEMA 1 metal enclosure with glass door specifically designed for public areas.
   1. Mounting: Surface.
   2. Finish: Red baked enamel.

K. Each addressable device shall be represented individually in FACU.
   1. Indicate TROUBLE by a discreet LCD readout for each supervised circuit.
   2. Indicate ALARM by a discreet LCD readout for each alarm initiating addressable device.
   3. Include individual supervisory and alarm relays in each circuit arranged so that ground or open condition in any circuit or group of circuits, will not affect proper operation of any other device.

L. FACU shall include the capability to report alarm and trouble conditions via a telephone line to a third party alarm reporting services.

M. FACU shall include a system testing capability to help ensure that zoning and supervision have been maintained throughout system.
   1. Actuation of the enable walk test program at FACU shall activate "Walk-Test" mode of system which shall cause the following to occur:
      a. Third party reporting connection circuit shall be disconnected or put in test mode with central station.
      b. Control relay functions shall be bypassed.
      c. FACU shall indicate a trouble condition.
      d. FACU shall, at a minimum, be capable of causing audible signals to activate for 2 seconds upon alarm activation of any initiation device.
      e. FACU shall automatically reset itself after code is complete.
      f. Any momentary opening of alarm initiating or alarm indicating circuit wiring shall cause audible signals to sound continuously for 4 seconds to indicate trouble condition.
      g. System shall have 4 distinctive walk test groups such that only a portion of system need be disabled during testing and an alarm in any other area will be processed normally.

N. General Alarm Circuits: Positive non-interfering type so that a second device can be annunciated simultaneously, or closely following first zone.

O. Power Supply:
   1. Power limited operation per NFPA 70, Article 760.
   2. 120 Vac dedicated circuit from panel board to integral 24 Vdc regulated power supply in FACU and battery charger.
      a. The power supply shall provide all panel and peripheral device power needs.
   3. If the FACU cannot provide power for the required number of notification appliances a power extender shall be used.
      a. An additional 120 Vac dedicated circuit from a panel board shall be used to power the power extenders power supply and battery charger.
   4. Provide transient voltage surge suppression (TVSS) for Main FACU for power supply and communication channel(s).

P. Battery:
1. Low maintenance sealed type, for fire alarm use with automatic battery charger.
2. Fire alarm systems without voice evacuation capability shall be provided with batteries capable of operating maximum normal load of system for 24 HRS and then capable of operating system for 5 minutes in alarm condition.
3. Fire alarm systems with voice evacuation capability shall be provided with batteries capable of operating maximum normal load of system for 24 HRS and then capable of operating system for 15 minutes in alarm condition.
4. Size batteries for the total maximum number of devices that can be connected to the FACU not the install number of devices.
5. The notification appliance power extender shall have the same battery requirements as the FACU.

2.3 FIRE ALARM ANNUNCIATOR PANEL (FAA)

A. Provide annunciator(s) at main entrance or other location(s) as required by AHJ and Owner.

B. Annunciator provides remote annunciation using a two-line 40 character, back-lit, alphanumeric, LCD readout.
1. The readout shall display, in descriptive English language; system status, alarm type, supervisory conditions, troubles, and location.

C. LED's and a tone-alert audible indication is provided for alarm, supervisory on trouble conditions.
1. Each condition has an acknowledge push-button switch that silences the tone-alert but leaves the LED on until all conditions are returned to normal.

D. FAA shall be an enclosed in a NEMA 4X metal enclosure designed for public areas:
1. Mounting: Surface.
2. Finish: Red baked enamel.

2.4 REMOTE FACU'S

A. Remote FACU's:
1. Remote FACU shall be provided as required.
2. Remote FACU's are not indicated on plans but shall be provided and located per manufacturer's requirements in telecommunications closets.
3. Provide 20 percent spare capacity minimum at each remote FACU location either through spare monitor and control points or spare remote FACU's.

B. Remote FACU Cabinets:
1. Communications between remote FACU's and FACU shall be Style 4.
2. The remote FACU shall contain the same type of equipment as found in the main FACU including addressable cards, power supplies, amplifiers, and all other integral devices for a complete operational system.
3. Provide transient voltage surge suppression (TVSS) for each remote FACU for power supply and communication channel(s).

C. Provide low maintenance sealed type battery designed for fire alarm use with automatic battery charger.

2.5 INITIATING DEVICES

A. Addressable Manual Pull Stations:
1. Pull-type with handle which shall lock in a protruding manner to facilitate quick visual identification of activated station.
   a. Reset using key or special tool after operation.
   b. Non-coded.
   c. Single action.
2. High impact red Lexan with operating directions in white letters.
   a. Semi-flush mounted in architecturally finished areas.

b. Surface mounted in non-architecturally finished areas.
c. Surface mounted with clear Lexan weatherproof protective shield in areas designated as wet or corrosive.
3. Stations shall be keyed alike with FACU.
4. Standards: UL 38.

B. Addressable Detector Base:
1. Plug-in arrangement:
a. Detector and associated encapsulated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection.
b. The plug connection requires no springs for secure mounting and contact maintenance.
c. Terminals in the fixed base accept building wiring.
d. Detector construction shall have a mounting base with a twist-lock detecting head that is lockable.
e. The locking feature must be field removable when not required.
f. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the Control Unit.
2. LED that will flash each time it is scanned by the Control Unit.
a. When the Control Unit determines that a detector is in an alarm or a trouble condition, the Control Unit shall command the LED on that detector's base to turn on steady indicating that abnormal condition exists.
b. Detectors which do not provide a visible indication of an abnormal condition at the detector location shall not be acceptable.
3. Each detector shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another detector type.
a. The Control Unit shall operate with the installed device but shall initiate a "Wrong Device" or “Incorrect Device ID” trouble condition until the proper type is installed or the programmed detector type is changed.
4. Addressability: Detectors include a communication transceiver in the detector or mounting base having a unique identification and capability for status reporting to the FACU.
5. Provide auxiliary relays in detector base to provide local control of equipment as described under system operation.
a. Provide separate 24 Vdc supply to detector base with auxiliary relays to guarantee that sufficient power will be available to operate relays.

C. Addressable Heat Detectors:
1. Fixed temperature type or combination rate-of-rise and fixed temperature type.
2. Rated at 135 DegF for ordinary areas where normal ceiling temperatures do not exceed 100 DegF F, or rated 190 DegF F for up to 150 DegF F ceiling temperatures.
3. Self-restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
4. Quantity and spacing based upon manufacturer’s UL listed spacing and the following:
a. Provide detectors in accordance with NFPA 72 and the requirements of the AHJ.
b. Devices shall be suitable for environment in which they are installed.
c. For ceilings higher than the base UL listing, reduce spacing as required by manufacturer and NFPA 72.
5. The detector's electronics shall be immune from false alarms caused by EMI and RFI.
6. Standards: UL 521.

D. Addressable Smoke Detectors:
1. Photoelectric type that utilizes a sensor chamber with a light source and a photosensitive element that detects products of combustion.
2. Self-restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
3. Quantity and spacing based upon manufacturer’s UL listed spacing and the following:
a. Provide detectors in accordance with NFPA 72 and the requirements of the AHJ.
b. Devices shall be suitable for environment in which they are installed.

c. Spacing shall be reduced for increased air changes as required by NFPA 72.
4. Detectors in non-accessible or controlled access locations shall be provided with a remotely located test switch to provide for ease of testing.
5. The detector's electronics shall be immune from false alarms caused by EMI and RFI.
6. Standards: UL 268.

E. Air Duct Smoke Detector:
1. Duct smoke detectors shall utilize addressable photoelectric type detector as specified herein.
2. Duct housing mounted directly to outside of duct with a sampling tube extended across duct to sample air movement.
3. Duct housing couplings slotted to insure proper alignment of sampling and exhaust tubes.
a. Tube lengths as required per duct width.
4. Detector housing shall have an alarm LED visible through front cover.
5. Remote red LED alarm indicators shall be provided on the wall or ceiling adjacent to detectors above the ceiling or that are not visible from the ground.
a. Duct detectors in non-accessible locations shall be provided with a remotely located test switch to provide for ease of testing.
6. Standards: UL 268A.

F. Addressable Monitor Modules:
1. Provides addressability and supervision to a conventional initiating device (e.g., tamper switches, pressure switches, flow switches, etc).
a. The conventional initiating device shall be wired Class B, Style B.
2. Integral or remote LED shall be provide that will flash each time it is scanned by the FACU.
a. When the FACU determines that a monitor module is in an alarm or a trouble condition, the FACU shall command the LED on that module to turn on steady, change color, or otherwise indicate that an abnormal condition exists.

G. Sprinkler System Devices where applicable:
1. Provide monitor module as specified herein for waterflow switches(s).
2. Provide monitor module as specified herein for pressure switch(es).
3. Provide monitor module as specified herein, for tamper switches associated with main water valve, post indicator valve (PIV) or OS&Y valves.

2.6 AUTOMATIC CONTROL DEVICES

A. Fan Control Relays:
1. Compatible with unit being controlled.
2. Industrial grade relays shall be furnished.
3. Provide enclosures suitable for environment.
4. Provide engraved phenolic nameplate on enclosure identifying fan or air handling unit being controlled.
5. Coil voltage as required.

B. Automatic door equipment: Automatic doors in rated walls shall be connected to fire alarm system to interrupt power to door operator or door hold open device.

C. Electric locks: Provide connections to electric locks at egress doors to unlock them upon initiation of any fire alarm in facility.

2.7 NOTIFICATION APPLIANCES

A. Alarm Horns:
1. Electric-vibrating polarized type, operating on 24 Vdc, with provision for housing the operating mechanism behind a grille.
2. Horns produce a sound pressure level of 85 dB, measured at 10 FT.
3. Housing: Red with white "FIRE" lettering.
a. Semi-flush or flush mounted in architecturally finished areas.
b. Surface-mounted in non-architecturally finished areas.

4. Horns shall be weatherproof in areas designated as wet.

B. Alarm Strobes:
1. White tamper resistant lexan lens with 24 Vdc xenon strobe.
2. Provide Candela rating as required per ADA and synchronize of multiple strobes when required.
3. Housing: Red with white "FIRE" lettering.
a. Semi-flush or flush mounted in architecturally finished areas.
b. Surface-mounted in non-architecturally finished areas.
4. Strobes shall be weatherproof in areas designated as wet or in areas indicated in the schedules herein.

C. Combination Audio/Visual Devices:
1. Shall be mounted in an integral unit and shall have the same features as the individual units specified in the previous sub sections.

D. Standards: UL 464, UL 1971.

2.8 WIRING

A. Conduit:
1. 1/2 IN minimum.
2. See Specification Section 26 05 33.

B. Conductors:
1. Insulation type per NFPA 70, Article 760.
2. 120 Vac and power supply connections: 12 GA, minimum.
3. Low-voltage general alarm circuits: 14 GA, minimum.
4. Low-voltage Initiating circuits: 18 GA, minimum.
5. Annunciator and data communication circuits: As required by manufacturer, UL listed.
6. Use larger wire sizes when recommended by equipment manufacturer and per voltage drop calculations.

C. Outlet Boxes: See Specification Section 26 05 33.

2.9 SYSTEM OPERATION

A. Activation of any alarm-causing Initiating device shall cause the following:
1. General evacuation notification via activation of audible and visual notification appliances.
2. Automatic control devices to operate as defined by the operating sequences.
3. Alarm information shall be displayed at the FACU.

B. All fire alarm signals are automatically locked on the display of the FACU and remote FACU's until originating device is returned to normal and FACU is manually reset.
1. Audible alarm signals shall be silence-able from FACU allowing for re-initiation following a subsequent alarm.
a. Silencing of alarm signals shall not impair ability of system to continue to perform as specified.

C. Air Handling Equipment Fan Control:
1. De-energize indicated air-handling equipment and interlocked exhaust fans upon alarm and close all associated smoke dampers.
2. See Drawings and Specification Section 40 90 00 for mechanical equipment sequence of operation and coordinate all fan controls.
3. Fans shall not restart until FACU is manually reset.

D. Activation of any system trouble shall initiate the following:
1. Common audible trouble signal shall sound and common trouble light shall illuminate at the FACU, any FAA's, and any remote FACU's.
2. Specific device in trouble shall be indicated.

E. Audible trouble signal shall be silenceable by FACU.

1. Visual trouble indication remains until trouble condition is corrected.
    a. A subsequent trouble condition received after manually silencing shall cause audible trouble signal to resound.
    b. Restoration of system to normal causes audible trouble signal until silencing switch is returned to normal position.
2. Trouble signal(s) will be initiated under following conditions:
    a. Open on an initiation or alarm indicating circuit.
    b. Open in wiring to any FAA or any remote FACU's.
    c. Ground fault condition.
    d. Auxiliary manual control switch out of normal position.
    e. Loss of 120 Vac operating power to the Main FACU or any Remote FACU's.
    f. Low or no battery voltage condition.

F. Install isolated loop circuit protectors on all fire alarm data communication circuits, SLC and NAC wiring, including shields, which extends beyond the a building.
    1. The isolated loop circuit protector shall be located as close as practicable to the point at which the circuits leave or enter a building.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all fire alarm equipment and wiring in accordance with local and national codes and NFPA 72 and Article 760 of NFPA 70.

B. Install all wiring in raceways and all devices in boxes:
    1. Install raceways and boxes in accordance with Specification Section 26 05 33.
    2. In unfinished areas, exposed fire alarm conduit shall be red in color.
    3. All boxes are to be red in color (either painted or a manufacturer's red box).

C. Install all components as indicated and in accordance with manufacturer's wiring diagrams, instructions and recommendations.

D. Make all fire alarm wiring continuous from terminal to terminal or from terminal to device pigtail lead.
    1. Circuit splices not permitted.
    2. Wiring joints, only when required at device pigtail leads shall utilize insulated conical spring connector.

E. Color coding or other identification is required for all fire alarm wiring.
    1. Coordinate requirements with Owner.

F. Installation of equipment and devices that pertain to other work in contract shall be closely coordinated with appropriate subcontractors.
    1. Coordinate 8 IN minimum square access door with rubber gasket in duct approximately 2 FT upstream from smoke detector for testing and servicing.

G. Detection devices shall be protected during construction as required by NFPA 72.

H. Device Mounting Schedule:
    1. Dimensions are to center of item unless otherwise indicated.
    2. Mounting heights as indicated below unless otherwise indicated on the Contract Drawings.
        a. Manual pull stations (Install per ADA and ADAAG Standards):
            1) Forward Reach
                a) Unobstructed: Maximum 48 IN.
                b) Obstructed High Reach (depth less than 20 IN): Maximum 48 IN.
                c) Obstructed High Reach (depth greater than 20 IN): Maximum 44 IN.
            2) Side Reach
                a) Unobstructed: Maximum 48 IN.
            3) Obstructed High Reach (reach depth less than 10 IN): Maximum 48 IN.

4) Obstructed High Reach (reach depth greater than 10 IN): Maximum 46 IN.
b. Notification appliances: Lens is not less than 80 IN and not greater than 96 IN.
c. Control panels and remote annunciators: 72 IN to top (display at eye level).

3.2 TESTING

A. Obtain services of factory trained representative of system manufacturer to supervise installation and its progress, supervise final connections to equipment and provide testing to assure that system is in proper operating condition, and is in compliance with all applicable regulations.

B. Entire system shall test free from opens, grounds, and short circuits.

C. Test system to satisfaction of Engineer and state and local fire authorities in accordance with NFPA 72, state and local codes and manufacturer's requirements.

D. Acceptance Operational Tests:
1. Perform operational system tests to verify conformance with specifications:
a. Each alarm initiating device installed shall be operationally tested.
b. Each device shall be tested for alarm and trouble conditions.
c. Fire Alarm Contractor shall submit written certification that Fire Alarm System installation is complete including all punch-list items.
d. Test battery operated emergency power supply. Test emergency power supply to minimum durations specified.
e. Test supervising station signal transmitter. Coordinate testing with supervising station monitoring firm/entity.
f. Test each notification appliance installed for proper operation. Submit written report indicating sound pressure levels at specified distances.
g. Test FACU.
2. Provide minimum 5 business days notice of acceptance test performance schedule to Owner, and local Authority Having Jurisdiction (AHJ).

E. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by system test that total system meets Specifications and complies with applicable standards.

F. Report of Tests and Inspections: Provide written record of inspections, tests, and detailed test results in form of test log. Use NFPA 72 Forms for documentation.

G. Final Test, Record of Completion, and Certificate of Occupancy:

H. Test system as required by Authority Having Jurisdiction in order to obtain certificate of occupancy. Provide completed NFPA 72 Record of Completion form to Owner and AHJ.

3.3 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris from all devices and equipment panels. Clean panel internally using methods and materials recommended by manufacturer.

B. Occupancy Adjustments: When requested within one year of date of substantial completion, provide on-site assistance in adjusting sound pressure levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to three visits to site for this purpose.

3.4 TRAINING

A. Provide services of factory-authorized service representative to demonstrate system and train Owner's personnel in operation of system as specified below.
1. Train Owner's maintenance personnel in procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of system.
2. Provide minimum of 8 HRS training.
3. Schedule training with Owner at least 2 weeks in advance.
4. Fill out Owner instruction reports.

B. Refer to Division 01 for additional training and startup requirements.

END OF SECTION

SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Site clearing, tree protection, stripping topsoil and demolition.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 31 23 00 - Earthwork.
   4. Section 32 91 05 - Topsoiling and Finished Grading.

PART 2 - PRODUCTS - (NOT APPLICABLE TO THIS SPECIFICATION SECTION)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect existing trees and other vegetation to remain against damage.
   1. Do not smother trees by stockpiling construction materials or excavated materials within drip line.
   2. Avoid foot or vehicular traffic or parking of vehicles within drip line.
   3. Provide temporary protection as required.

B. Repair or replace trees and vegetation damaged by construction operations.
   1. Repair to be performed by a qualified tree surgeon.
   2. Remove trees which cannot be repaired and restored to full-growth status.
   3. Replace with new trees of minimum 4 IN caliper.

C. Owner will obtain authority for removal and alteration work on adjoining property.

3.2 SITE CLEARING

A. Topsoil Removal:
   1. Strip topsoil to depths encountered.
      a. Remove heavy growths of grass before stripping.
      b. Stop topsoil stripping sufficient distance from such trees to prevent damage to main root system.
      c. Separate from underlying subsoil or objectionable material.
   2. Stockpile topsoil where directed by Engineer.
      a. Construct storage piles to freely drain surface water.
      b. Seed or cover storage piles to prevent erosion.
   3. Do not strip topsoil in wooded areas where no change in grade occurs.
   4. Borrow topsoil: Reasonably free of subsoil, objects over 2 IN DIA, weeds and roots.

B. Clearing and Grubbing:
   1. Clear from within limits of construction all trees not marked to remain.
      a. Include shrubs, brush, downed timber, rotten wood, heavy growth of grass and weeds, vines, rubbish, structures and debris.

2. Grub (remove) from within limits of construction all stumps, roots, root mats, logs and debris encountered.
   a. Totally grub under areas to be paved.
   b. Grubbing in lawn areas:
      1) In cut areas, totally grub.
      2) In fill areas, where fill is less than 3 FT totally grub ground.
      3) Where fill is 3 FT or more in depth, stumps may be left no higher than 6 IN above existing ground surface.

C. Disposal of Waste Materials:
   1. Do not burn combustible materials on site.
   2. Remove all waste materials from site.
   3. Do not bury organic matter on site.

3.3 ACCEPTANCE

A. Upon completion of the site clearing, obtain Engineer's acceptance of the extent of clearing, depth of stripping and rough grade.

END OF SECTION

SECTION 31 21 33

TRENCHING, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavation, trenching, backfilling and compacting for all underground utilities.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
   4. Division 26 - Electrical.
   5. Section 31 23 00 - Earthwork.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. C33, Standard Specification for Concrete Aggregates.
      b. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
      c. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
      d. D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
      e. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      f. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

B. Qualifications: Hire an independent soils laboratory to conduct in-place moisture-density tests for backfilling to assure that all work complies with this Specification Section.

1.3 DEFINITIONS

A. Excavation: All excavation will be defined as unclassified.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
   3. Submit respective pipe or conduit manufacturer's data regarding bedding methods of installation and general recommendations.
   4. Submit sieve analysis reports on all granular materials.

B. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Trench shield (trench box) certification if employed:
      a. Specific to Project conditions.

b. Re-certified if members become distressed.
c. Certification by registered professional structural engineer, registered in the state where the Project is located.
d. Engineer is not responsible to, and will not, review and approve.

1.5 PROJECT CONDITIONS

A. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving.
1. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and adjoining property owners.

B. Provide full access to public and private premises and fire hydrants, at street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.

C. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.

D. Verify location of existing underground utilities.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Backfill Material:
1. As approved by Engineer.
a. Free of rock cobbles, roots, sod or other organic matter, and frozen material.
b. Moisture content at time of placement: 3 percent plus/minus of optimum moisture content as specified in accordance with ASTM D698
2. Gravel trench backfill materials:
a. See Geotechnical report.

B. Subgrade Stabilization Materials:
1. See . Geotechnical report

C. Bedding Materials:
1. As approved by the Soils Engineer.
2. Granular bedding materials:
a. ASTM C33, gradation 67 (3/4 IN to No. 4 sieve) defined below:

Sieve Size	1 IN	3/4 IN	3/8 IN	No. 4	No. 20
Percent Passing by Weight	100	90-100	20-55	0-10	0

1) Well graded gravel.
3. Flowable fill:
a. Description: Flowable fill shall be a mixture of cement, fly ash, fine sand, water, and air having a consistency which will flow under a very low head.
b. Material characteristics:
1) The approximate quantities of each component per cubic yard of mixed material shall be as follows:
a) Cement (Type I or II): 50 LBS.
b) Fly ash: 200 LBS.
c) Fine sand: 2,700 LBS.
d) Water: 420 LBS.
e) Air content: 10 percent.
2) Actual quantities shall be adjusted to provide a yield of 1 cubic yard with the materials used.
3) Approximate compressive strength should be 85 to 175 psi.

4) Fine sand shall be an evenly graded material having not less than 95 percent passing the No. 4 sieve and not more than 5 percent passing the No. 200 sieve.
5) Mixing and handling of the material shall be in accordance with Specification Section 03 31 31.

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and dispose of unsuitable materials as directed by Soils Engineer.

3.2 EXCAVATION

A. Prior to construction, the Contractor shall excavate and field verify the horizontal and vertical location of all potential conflicting utilities at no additional cost to the owner. Should a conflict exist between the field information and the plans, the Contractor shall notify the Engineer so the conflict can be resolved with minimum delay. Contractor shall use vacuum excavation techniques for all initial trenching operations to locate and verify all existing utilities. The cost of vacuum excavation shall be considered incidental to the cost of all trench excavation work.

B. Unclassified Excavation: Remove rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by Soils Engineer.

C. Excavation for Appurtenances:
1. 12 IN (minimum) clear distance between outer surface and embankment.
2. See Specification Section 31 23 00 for applicable requirements.

D. Groundwater Dewatering:
1. Where groundwater is, or is expected to be, encountered during excavation, install a dewatering system to prevent softening and disturbance of subgrade to allow subgrade stabilization, pipe, bedding and backfill material to be placed in the dry, and to maintain a stable trench wall or side slope.
2. Groundwater shall be drawn down and maintained at least 3 FT below the bottom of any trench or manhole excavation prior to excavation.
3. Review soils investigation before beginning excavation and determine where groundwater is likely to be encountered during excavation.
   a. Employ dewatering specialist for selecting and operating dewatering system.
4. Keep dewatering system in operation until dead load of pipe, structure and backfill exceeds possible buoyant uplift force on pipe or structure.
5. Dispose of groundwater to an area which will not interfere with construction operations or damage existing construction.
6. Install groundwater monitoring wells as necessary.
7. Shut off dewatering system at such a rate to prevent a quick upsurge of water that might weaken the subgrade.
8. Cost of groundwater dewatering shall be included in the lineal foot unit price of the pipe installation.

E. Trench Excavation:
1. Excavate trenches by open cut method to depth shown on Drawings and necessary to accommodate work.
   a. Support existing utility lines and yard piping where proposed work crosses at a lower elevation.
      1) Stabilize excavation to prevent undermining of existing utility and yard piping.
2. Open trench outside buildings, units, and structures:
   a. No more than the distance between two manholes, structures, units, or 300 LF, whichever is less.
   b. Field adjust limitations as weather conditions dictate.
3. Trenching within buildings, units, or structures:

a. No more than 100 LF at any one time.

4. Any trench or portion of trench, which is opened and remains idle for seven (7) calendar days, or longer, as determined by the Owner, may be directed to be immediately refilled, without completion of work, at no additional cost to Owner.
   a. Said trench may not be reopened until Owner is satisfied that work associated with trench will be prosecuted with dispatch.
5. Observe following trenching criteria:
   a. Trench size:
      1) Excavate width to accommodate free working space.
      2) Maximum trench width at top of pipe or conduit may not exceed outside diameter of utility service by more than the following dimensions:

OVERALL DIAMETER OF UTILITY SERVICE	EXCESS DIMENSION
33 IN and less	18 IN
more than 33 IN	24 IN

      3) Cut trench walls vertically from bottom of trench to 1 FT above top of pipe, conduit, or utility service.
      4) Keep trenches free of surface water runoff.
         a) Include cost in Bid.
         b) No separate payment for surface water runoff pumping will be made.

F. Trenching for Electrical Installations:
1. Observe the preceding Trench Excavation paragraph in PART 3 of this Specification Section.
2. Modify for electrical installations as follows:
   a. Open no more than 600 LF of trench in exterior locations for trenches more than 12 IN but not more than 30 IN wide.
   b. Any length of trench may be opened in exterior locations for trenches which are 12 IN wide or less.
   c. Do not over excavate trench.
   d. Cut trenches for electrical runs with minimum 30 IN cover, unless otherwise specified or shown on Drawings.
   e. See Division 26 for additional requirements.

G. Flowable Fill:
1. Flowable fill shall be:
   a. Discharged from a mixer by any means acceptable to the Engineer into the area to be filled.
   b. Placed in 4 FT maximum lifts to the elevations indicated.
      1) Allow 12 HR set-up time before placing next lift or as approved by the Engineer.
      2) Contractor shall place flowable fill lifts in such a manner as to prevent flotation of the pipe.
2. Flowable fill shall not be placed on frozen ground.
3. Subgrade on which flowable fill is placed shall be free of disturbed or softened material and water.
4. Conform to appropriate requirements of Specification Section 31 23 00.
5. Flowable fill batching, mixing, and placing may be started if weather conditions are favorable, and the air temperature is 34 DegF and rising.
6. At the time of placement, flowable fill must have a temperature of at least 40 DegF.
7. Mixing and placing shall stop when the air temperature is 38 DegF or less and falling.
8. Each filling stage shall be as continuous an operation as is practicable.
9. Contractor shall prevent traffic contact with flowable fill for at least 24 HRS after placement or until flowable fill is hard enough to prevent rutting by construction equipment.

10. Flowable fill shall not be placed until water has been controlled or groundwater level has been lowered in conformance with the requirements of the preceding Groundwater Dewatering paragraph in PART 3 of this Specification Section.

3.3 PREPARATION OF FOUNDATION FOR PIPE LAYING

A. Over-Excavation:
   1. Backfill and compact to 90 percent of maximum dry density per ASTM D698.
   2. Backfill with granular bedding material as option.

B. Rock Excavation:
   1. Excavate minimum of 6 IN below bottom exterior surface of the pipe or conduit.
   2. Backfill to grade with suitable earth or granular material.
   3. Form bell holes in trench bottom.

C. Subgrade Stabilization:
   1. Stabilize the subgrade when directed by the Owner.
   2. Observe the following requirements when unstable trench bottom materials are encountered.
      a. Notify Owner when unstable materials are encountered.
         1) Define by drawing station locations and limits.
      b. Remove unstable trench bottom caused by Contractor failure to dewater, rainfall, or Contractor operations.
         1) Replace with subgrade stabilization with no additional compensation.

3.4 BACKFILLING METHODS

A. Do not backfill until tests to be performed on system show system is in full compliance to specified requirements.

B. Carefully Compacted Backfill:
   1. Furnish where indicated on Drawings, specified for trench embedment conditions and for compacted backfill conditions up to 12 IN above top of pipe or conduit.
   2. Comply with the following:
      a. Place backfill in lifts not exceeding 8 IN (loose thickness).
      b. Hand place, shovel slice, and pneumatically tamp all carefully compacted backfill.
      c. Observe specific manufacturer's recommendations regarding backfilling and compaction.
      d. Compact each lift to specified requirements.

C. Common Trench Backfill:
   1. Perform in accordance with the following:
      a. Place backfill in lift thicknesses capable of being compacted to densities specified.
      b. Observe specific manufacturer's recommendations regarding backfilling and compaction.
      c. Avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.

D. Water flushing for consolidation is not permitted.

E. Backfilling for Electrical Installations:
   1. Observe the preceding Carefully Compacted Backfill paragraph or Common Trench Backfill paragraph in PART 3 of this Specification Section or when approved by the Engineer.
   2. Modify for electrical installation as follows:
      a. Observe notes and details on electrical drawings for fill in immediate vicinity of direct burial cables.

3.5 COMPACTION

A. General:

1. Place and assure bedding, backfill, and fill materials achieve an equal or higher degree of compaction than undisturbed materials adjacent to the work.
2. In no case shall degree of compaction below minimum compactions specified be accepted.
3. Compaction requirement's shall comply with Geotechnical Report.

3.6 FIELD QUALITY CONTROL

A. Testing:
1. Perform in-place moisture-density tests as directed by the Owner.
2. Perform tests through recognized testing laboratory approved by Owner.
3. Costs of "Passing" tests paid by Owner.
4. Perform additional tests as directed until compaction meets or exceeds requirements.
5. Cost associated with "Failing" tests shall be paid by Contractor.
6. Reference to Engineer in this Specification Section will imply Soils Engineer when employed by Owner and directed by Engineer to undertake necessary inspections as approvals as necessary.
7. Assure Owner has immediate access for testing of all soils related work.
8. Ensure excavations are safe for testing personnel.

END OF SECTION

SECTION 31 23 00
EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Earthwork.
2. Where conflicts occur between this specification and the geotechnical report the report shall govern.

B. Related Specification Sections include but are not necessarily limited to:
1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 01 - General Requirements.
3. Section 07 26 00 - Under Slab Vapor Retarder.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
1. ASTM International (ASTM):
    a. C33, Standard Specification for Concrete Aggregates.
    b. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
    c. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700 kN-m/m)).
    d. D3786, Standard Test Method for Bursting Strength of Textile Fabrics--Diaphragm Bursting Strength Tester Method.
    e. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
    f. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
    g. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

1.3 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
3. Certifications.
4. Test reports:
    a. Soils inspection and testing results.

B. Samples:
1. Submit samples and source of fill and backfill materials proposed for use.
2. Submit samples and source of borrow materials proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill and Backfill: Selected material approved by Soils Engineer from site excavation or from off site borrow.

B. Granular Fill Under Building Floor Slabs-On-Grade: Clean, crushed, nonporous rock, crushed or uncrushed gravel complying with ASTM C33 gradation size No. 67, 3/4 IN to No. 4.

C. Granular Fill Under Base Slabs with Pressure Relief Valves:
   1. Drainage material: Conform to ASTM C33, Size No. 67.
   2. Filter material: Conform to ASTM C33 requirements for fine aggregate.

D. Geotextile Filter Fabric:
   1. Nonwoven type.
   2. Equivalent opening size: 50-100 (U.S. Standard Sieve).
   3. Permeability coefficient (cm/second): 0.07 minimum, 0.30 maximum.
   4. Grab strength: 90 LBS minimum in either direction in accordance with ASTM D4632 requirements.
   5. Mullen burst strength: 125 psi minimum in accordance with ASTM D3786 requirements.

E. Vapor Barrier: Refer to Specification Section 07 26 00.

PART 3 - EXECUTION

3.1 PROTECTION

A. Protect existing surface and subsurface features on-site and adjacent to site as follows:
   1. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing items indicated to remain in place.
   2. Protect and maintain bench marks, monuments or other established reference points and property corners.
      a. If disturbed or destroyed, replace at own expense to full satisfaction of Owner and controlling agency.
   3. Verify location of utilities.
      a. Omission or inclusion of utility items does not constitute nonexistence or definite location.
      b. Secure and examine local utility records for location data.
      c. Take necessary precautions to protect existing utilities from damage due to any construction activity.
      d. Repair damages to utility items at own expense.
      e. In case of damage, notify Engineer at once so required protective measures may be taken.
   4. Maintain free of damage, existing sidewalks, structures, and pavement, not indicated to be removed.
      a. Any item known or unknown or not properly located that is inadvertently damaged shall be repaired to original condition.
      b. All repairs to be made and paid for by Contractor.
   5. Provide full access to public and private premises, fire hydrants, street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.
   6. Maintain stockpiles and excavations in such a manner to prevent inconvenience or damage to structures on-site or on adjoining property.
   7. Avoid surcharge or excavation procedures which can result in heaving, caving, or slides.

B. Salvageable Items: Carefully remove items to be salvaged, and store on Owner's premises unless otherwise directed.

C. Dispose of waste materials, legally, off site.
   1. Burning, as a means of waste disposal, is not permitted.

3.2 SITE EXCAVATION AND GRADING

A. All excavation is considered unclassified.

B. The work includes all operations in connection with excavation, borrow, construction of fills and embankments, rough grading, and disposal of excess materials in connection with the preparation of the site(s) for construction of the proposed facilities.

C. Excavation and Grading:
   1. Perform as required by the Contract Drawings.
   2. Contract Drawings may indicate both existing grade and finished grade required for construction of Project.
      a. Stake all units, structures, piping, roads, parking areas and walks and establish their elevations.
      b. Perform other layout work required.
      c. Replace property corner markers to original location if disturbed or destroyed.
   3. Preparation of ground surface for embankments or fills:
      a. Before fill is started, scarify to a minimum depth of 6 IN in all proposed embankment and fill areas.
      b. Where ground surface is steeper than one vertical to four horizontal, plow surface in a manner to bench and break up surface so that fill material will bind with existing surface.
   4. Protection of finish grade:
      a. During construction, shape and drain embankment and excavations.
      b. Maintain ditches and drains to provide drainage at all times.
      c. Protect graded areas against action of elements prior to acceptance of work.
      d. Reestablish grade where settlement or erosion occurs.

D. Borrow:
   1. Provide necessary amount of approved fill compacted to density equal to that indicated in this Specification.
   2. Include cost of all borrow material in original proposal.
   3. Fill material to be approved by Soils Engineer prior to placement.

E. Construct embankments and fills as required by the Contract Drawings:
   1. Construct embankments and fills at locations and to lines of grade indicated.
      a. Completed fill shall correspond to shape of typical cross section or contour indicated regardless of method used to show shape, size, and extent of line and grade of completed work.
   2. Provide approved fill material which is free from roots, organic matter, trash, frozen material, and stones having maximum dimension greater than 6 IN.
      a. Ensure that stones larger than 4 IN are not placed in upper 6 IN of fill or embankment.
      b. Do not place material in layers greater than 8 IN loose thickness.
      c. Place layers horizontally and compact each layer prior to placing additional fill.
   3. Compact by sheepsfoot, pneumatic rollers, vibrators, or by other equipment as required to obtain specified density.
      a. Control moisture for each layer necessary to meet requirements of compaction.

3.3 ROCK EXCAVATION

A. NA

3.4 USE OF EXPLOSIVES

A. Blasting with any type of explosive is prohibited.

3.5 FIELD QUALITY CONTROL

A. Costs of inspection services indicated herein as being performed by the Soils Engineer shall be paid out of Testing Allowance.

B. Moisture density relations, to be established by the Soils Engineer required for all materials to be compactd.

C. Extent of compaction testing will be as necessary to assure compliance with specifications.

D. Give minimum of 24 HR advance notice to Soils Engineer when ready for compaction or subgrade testing and inspection.

E. Should any compaction density test or subgrade inspection fail to meet specification requirements, perform corrective work as necessary.

F. Pay for all costs associated with corrective work and retesting resulting from failing compaction density tests.

3.6 COMPACTION DENSITY REQUIREMENTS

A. Obtain approval from Soils Engineer with regard to suitability of soils and acceptable subgrade prior to subsequent operations.

B. Provide dewatering system necessary to successfully complete compaction and construction requirements.

C. Remove frozen, loose, wet, or soft material and replace with approved material as directed by Soils Engineer.

D. Stabilize subgrade with well graded granular materials as directed by Soils Engineer.

E. Assure by results of testing that compaction densities comply with the following requirements:

1. Sitework:

LOCATION	COMPACTION DENSITY
Under Paved Areas, Sidewalks and Piping:	
Cohesive soils	100 percent per ASTM D698
Cohesionless soils	75 percent relative density per ASTM D4253 and ASTM D4254
Unpaved Areas:	
Cohesive soils	85 percent of ASTM D698
Cohesionless soils	60 percent relative density per ASTM D4253 and ASTM D4254

2. Structures:

LOCATION	COMPACTION DENSITY
Inside of structures under foundations, under equipment support pads, under slabs-on-grade and scarified existing subgrade under fill material	95 percent per ASTM D1557
Outside structures next to walls, piers, columns and any other structure exterior member	90 percent per ASTM D1557

3. Specific areas:

LOCATION	COMPACTION DENSITY
Outside structures under equipment support foundations	95 percent per ASTM D1557
Under void	85 percent per ASTM D1557
Granular fill under base slabs with pressure relief valves, and under building floor slabs-on-grade	75 percent relative density per ASTM D4253 and ASTM D4254

3.7 EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES

A. General:
   1. In general, work includes, but is not necessarily limited to, excavation for structures and retaining walls, removal of underground obstructions and undesirable material, backfilling, filling, and fill, backfill, and subgrade compaction.
   2. Obtain fill and backfill material necessary to produce grades required.
      a. Materials and source to be approved by Soils Engineer.
      b. Excavated material approved by Soils Engineer may also be used for fill and backfill.
   3. In this Specification Section, the word "foundations" includes footings, base slabs, foundation walls, mat foundations, grade beams, piers and any other support placed directly on soil.
   4. In the paragraphs of this Specification Section, the word "soil" also includes any type of rock subgrade that may be present at or below existing subgrade levels.

B. Excavation Requirements for Structures:
   1. General:
      a. Do not commence excavation for foundations for structures until Soils Engineer approves:
         1) The removal of topsoil and other unsuitable and undesirable material from existing subgrade.
         2) Density and moisture content of site area compacted fill material meets requirements of specifications.
         3) Site surcharge or mass fill material can be removed from entire construction site or portion thereof.
         4) Surcharge or mass fill material has been removed from construction area or portions thereof.
      b. Engineer grants approval to begin excavations.
   2. Dimensions:
      a. Excavate to elevations and dimensions indicated or specified.
      b. Allow additional space as required for construction operations and inspection of foundations.
   3. Removal of obstructions and undesirable materials in excavation includes, but is not necessarily limited to, removal of old foundations, existing construction, unsuitable subgrade soils, expansive type soils, and any other materials which may be concealed beneath present grade, as required to execute work indicated on Contract Drawings.
      a. If undesirable material and obstructions are encountered during excavation, remove material and replace as directed by Soils Engineer.
   4. Level off bottoms of excavations to receive foundations, floor slabs, equipment support pads, or compacted fill.
      a. Remove loose materials and bring excavations into approved condition to receive concrete or fill material.
      b. Where compacted fill material must be placed to bring subgrade elevation up to underside of construction, scarify existing subgrade upon which fill material is to be placed to a depth of 6 IN and then compact to density stated in this Specification Section before fill material can be placed thereon.

c. Do not carry excavations lower than shown for foundations except as directed by Soils Engineer or Engineer.
d. If any part of excavations is carried below required depth without authorization, maintain excavation and start foundation from excavated level with concrete of same strength as required for superimposed foundation, and no extra compensation will be made to Contractor therefore.

5. Make excavations large enough for working space, forms, dampproofing, waterproofing, and inspection.
6. Notify Soils Engineer and Engineer as soon as excavation is completed in order that subgrades may be inspected.
   a. Do not commence further construction until subgrade under compacted fill material, under foundations, under floor slabs-on-grade, under equipment support pads, and under retaining wall footings has been inspected and approved by the Soils Engineer as being free of undesirable material, being of compaction density required by this specification, and being capable of supporting the allowable foundation design bearing pressures and superimposed foundation, fill, and building loads to be placed thereon.
   b. Soils Engineer shall be given the opportunity to inspect subgrade below fill material both prior to and after subgrade compaction.
   c. Place fill material, foundations, retaining wall footings, floor slabs-on-grade, and equipment support pads as soon as weather conditions permit after excavation is completed, inspected, and approved and after forms and reinforcing are inspected and approved.
   d. Before concrete or fill material is placed, protect approved subgrade from becoming loose, wet, frozen, or soft due to weather, construction operations, or other reasons.
7. Dewatering:
   a. Where groundwater is or is expected to be encountered during excavation, install a dewatering system to prevent softening and disturbance of subgrade below foundations and fill material, to allow foundations and fill material to be placed in the dry, and to maintain a stable excavation side slope.
   b. Groundwater shall be maintained at least 3 FT below the bottom of any excavation.
   c. Review soils investigation before beginning excavation and determine where groundwater is likely to be encountered during excavation.
   d. Employ dewatering specialist for selecting and operating dewatering system.
   e. Keep dewatering system in operation until dead load of structure exceeds possible buoyant uplift force on structure.
   f. Dispose of groundwater to an area which will not interfere with construction operations or damage existing construction.
      1) Install groundwater monitoring wells as necessary.
   g. Shut off dewatering system at such a rate to prevent a quick upsurge of water that might weaken the subgrade.
8. Subgrade stabilization:
   a. If subgrade under foundations, fill material, floor slabs-on-grade, or equipment support pads is in a frozen, loose, wet, or soft condition before construction is placed thereon, remove frozen, loose, wet, or soft material and replace with approved compacted material as directed by Soils Engineer.
   b. Provide compaction density of replacement material as stated in this Specification Section.
   c. Loose, wet, or soft materials, when approved by Soils Engineer, may be stabilized by a compacted working mat of well graded crushed stone.
   d. Compact stone mat thoroughly into subgrade to avoid future migration of fines into the stone voids.
   e. Remove and replace frozen materials as directed by Soils Engineer.
   f. Method of stabilization shall be performed as directed by Soils Engineer.
   g. Do not place further construction on the repaired subgrades, until the subgrades have been approved by the Soils Engineer.

9. Do not place floor slabs-on-grade including equipment support pads until subgrade below has been approved, piping has been tested and approved, reinforcement placement has been approved, and Contractor receives approval to commence slab construction.
   a. Do not place building floor slabs-on-grade including equipment support pads when temperature of air surrounding the slab and pads is or is expected to be below 40 DegF before structure is completed and heated to a temperature of at least 50 DegF.
10. Protection of structures:
    a. Prevent new and existing structures from becoming damaged due to construction operations or other reasons.
    b. Prevent subgrade under new and existing foundations from becoming wet and undermined during construction due to presence of surface or subsurface water or due to construction operations.
11. Shoring:
    a. Shore, sheet pile, slope, or brace excavations as required to prevent them from collapsing.
    b. Remove shoring as backfilling progresses but only when banks are stable and safe from caving or collapse.
12. Drainage:
    a. Control grading around structures so that ground is pitched to prevent water from running into excavated areas or damaging structures.
    b. Maintain excavations where foundations, floor slabs, equipment support pads or fill material are to be placed free of water.
    c. Provide pumping required to keep excavated spaces clear of water during construction.
    d. Should any water be encountered in the excavation, notify Engineer and Soils Engineer.
    e. Provide free discharge of water by trenches, pumps, wells, well points, or other means as necessary and drain to point of disposal that will not damage existing or new construction or interfere with construction operations.
13. Frost protection:
    a. Do not place foundations, slabs-on-grade, equipment support pads, or fill material on frozen ground.
    b. When freezing temperatures may be expected, do not excavate to full depth indicated, unless foundations, floor slabs, equipment support pads, or fill material can be placed immediately after excavation has been completed and approved.
    c. Protect excavation from frost if placing of concrete or fill is delayed.
    d. Where a concrete slab is a base slab-on-grade located under and within a structure that will not be heated, protect subgrade under the slab from becoming frozen until final acceptance of the Project by the Owner.
    e. Protect subgrade under foundations of a structure from becoming frozen until structure is completed and heated to a temperature of at least 50 DegF.

C. Fill and Backfill Inside of Structure and Below Foundations, Base Slabs, Floor Slabs, Equipment Support Pads and Piping:
   1. General:
      a. Subgrade to receive fill or backfill shall be free of undesirable material as determined by Soils Engineer and scarified to a depth of 6 IN and compacted to density specified herein.
      b. Surface may be stepped by at not more than 12 IN per step or may be sloped at not more than 2 percent.
      c. Do not place any fill or backfill material until subgrade under fill or backfill has been inspected and approved by Soils Engineer as being free of undesirable material and compacted to specified density.
   2. Obtain approval of fill and backfill material and source from Soils Engineer prior to placing the material.
   3. Granular fill under floor slabs-on-grade: Place all floor slabs-on-grade on a minimum of 6 IN of granular fill unless otherwise indicated.

4. Vapor barrier: Install a continuous vapor barrier under floor slabs-on-grade as required by Specification Section 07 26 00 and shown on Contract Drawings.
5. Fill and backfill placement:
   a. Prior to placing fill and backfill material, optimum moisture and maximum density properties for proposed material shall be obtained from Soils Engineer.
   b. Place fill and backfill material in thin lifts as necessary to obtain required compaction density.
   c. Compact material by means of equipment of sufficient size and proper type to obtain specified density.
   d. Use hand operated equipment for filling and backfilling next to walls.
   e. Do not place fill and backfill when the temperature is less than 40 DegF and when subgrade to receive fill and backfill material is frozen, wet, loose, or soft.
   f. Use vibratory equipment to compact granular material; do not use water.
6. Where fill material is required below foundations, place fill material, conforming to the required density and moisture content, outside the exterior limits of foundations located around perimeter of structure the following horizontal distance whichever is greater:
   a. As required to provide fill material to indicated finished grade.
   b. 5 FT.
   c. Distance equal to depth of compacted fill below bottom of foundations.
   d. As directed by Soils Engineer.

D. Filling and Backfilling Outside of Structures.
1. This paragraph of this Specification applies to fill and backfill placed outside of structures above bottom level of both foundations and piping but not under paving.
2. Provide material as approved by Soils Engineer for filling and backfilling outside of structures.
3. Fill and backfill placement:
   a. Prior to placing fill and backfill material, obtain optimum moisture and maximum density properties for proposed material from Soils Engineer.
   b. Place fill and backfill material in thin lifts as necessary to obtain required compaction density.
   c. Compact material with equipment of proper type and size to obtain density specified.
   d. Use only hand operated equipment for filling and backfilling next to walls and retaining walls.
   e. Do not place fill or backfill material when temperature is less than 40 DegF and when subgrade to receive material is frozen, wet, loose, or soft.
   f. Use vibratory equipment for compacting granular material; do not use water.
4. Backfilling against walls:
   a. Do not backfill around any part of structures until each part has reached specified 28-day compressive strength and backfill material has been approved.
   b. Do not start backfilling until concrete forms have been removed, trash removed from excavations, pointing of masonry work, concrete finishing, dampproofing and waterproofing have been completed.
   c. Do not place fills against walls until floor slabs at top, bottom, and at intermediate levels of walls are in place and have reached 28-day required compressive strength to prevent wall movement.
   d. Bring backfill and fill up uniformly around the structures and individual walls, piers, or columns.

E. Backfilling Outside of Structures Under Piping or Paving:
1. When backfilling outside of structures requires placing backfill material under piping or paving, the material shall be placed from bottom of excavation to underside of piping or paving at the density required for fill under piping or paving as indicated in this Specification Section.
2. This compacted material shall extend transversely to the centerline of piping or paving a horizontal distance each side of the exterior edges of piping or paving equal to the depth of backfill measured from bottom of excavation to underside of piping or paving.

3. Provide special compacted bedding or compacted subgrade material under piping or paving as required by other Specification Sections for the Project.

3.8 SPECIAL REQUIREMENTS

A. Erosion Control:
1. Conduct work to minimize erosion of site.
2. Construct stilling areas to settle and detain eroded material.
3. Remove eroded material washed off site.
4. Clean streets daily of any spillage of dirt, rocks or debris from equipment entering or leaving site.

END OF SECTION

SECTION 32 12 16

ASPHALTIC CONCRETE VEHICULAR PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Asphaltic concrete vehicular paving.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Federal Specifications (FS):
      a. TT-P-115F, Paint, Traffic (Highway, White and Yellow).
   2. Construction standards: State of New Mexico, Department of Transportation, "NMDOT," Standard Specifications for Highway and Bridge Construction, as amended to date.

B. Miscellaneous:
   1. Should conflicts arise between standard specifications of government agencies mentioned herein and Contract Documents, Contract Documents shall govern.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
   3. Asphalt design mix.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Asphaltic Concrete: Per City of Santa Fe Standards.

2.2 MIXES

A. Comply with mix design category per City of Santa Fe Standards.

PART 3 - EXECUTION

3.1 APPLICATION

A. Construct to line, grade and section as shown on Drawings and in accordance with referenced State Specifications.

B. Install compacted layer of asphaltic base course in accordance with NMDOT Specifications.

C. Tolerance of Finished Grade: +0.10 FT from required elevations.

END OF SECTION

SECTION 32 16 13

CONCRETE CURB AND GUTTER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete curb and gutter.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 03 31 30 - Concrete, Materials and Proportioning.
   4. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
   5. Section 03 05 05 - Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. M153,Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
      b. M171, Standard Specification for Sheet Materials for Curing Concrete.
      c. M182, Burlap Cloth Made from Jute or Kenef.
      d. M213, Preformed Expansion Joint Fillers for Concrete Paving and Structure Construction (Nonextruding and Resilient Bituminous Types).
      e. M233, Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
   2. American Concrete Institute (ACI):
      a. 305R, Hot Weather Concreting.
      b. 306R, Cold Weather Concreting.
   3. ASTM International (ASTM):
      a. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      b. C33, Standard Specification for Concrete Aggregates.
      c. C150, Standard Specification for Portland Cement.
      d. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      e. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3).
      f. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      g. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   4. Federal Specification (FS):
      a. SS-S-1614, Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
   3. Mix design(s) in accordance with Specification Section 03 31 30 and Specification Section 03 05 05.

4. Drawings detailing all reinforcing.
5. Test reports:
    a. Concrete cylinder test results from field quality control.

B. Samples:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Samples of fabricated jointing materials and devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Chemical admixtures:
    a. Sika Chemical Corporation.
    b. BASF Admixtures, Inc.
    c. Protex Industries.
    d. W. R. Grace and Company.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MATERIALS

A. Portland Cement:
1. ASTM C150, Type I or II.

B. Aggregates:
1. ASTM C33, gradation size #67, 3/4 IN to #4.

C. Water:
1. Potable quality.

D. Admixtures:
1. Comply with Specification Section 03 31 30.

E. Reinforcing Bars:
1. ASTM A615, Grade 60.

F. Preformed Joint Filler:
1. Nonextruding cork, self-expanding cork, sponge rubber or cork rubber.
2. AASHTO M153 or AASHTO M213.

G. Hot-Poured Joint Sealing Material:
1. FS SS-S-1614.

H. Membrane Curing Compound:
1. ASTM C309.

I. Cover Materials for Curing:
1. Burlap:
    a. AASHTO M182.
    b. Minimum Class 2, 8 OZ material (1 YD x 42 IN).
2. Polyethylene film, AASHTO M171.

J. Paper Subgrade Cover:
1. Polyethylene film, AASHTO M171.

K. Concrete Treatment:
1. Boiled linseed oil mixture.
2. AASHTO M233.

L. Forms:
   1. Steel or wood.
   2. Size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment.
   3. Free of distortion and defects.
   4. Full depth.
   5. Metal side forms:
      a. Minimum 7/32 IN thick.
      b. Depth equal to edge thickness of concrete.
      c. Flat or rounded top minimum 1-3/4 IN wide.
      d. Base 8 IN wide or equal to height, whichever is less.
      e. Maximum deflection 1/8 IN under center load of 1700 LBS.
      f. Use flexible spring steel forms or laminated boards to form radius bends.

2.3 MIXES

A. Mix design to provide 4,000 psi 28-day compressive strength, 1-1/2 IN +1 IN slump, 6 percent air.

B. Comply with Specification Section 03 31 30 and Specification Section 03 31 31.

PART 3 - EXECUTION

3.1 PREPARATION

A. Subgrade Preparation:
   1. Prepare using methods, procedures, and equipment necessary to attain required compaction densities, elevation and section.
   2. Scarify and recompact top 6 IN of fills and embankments which will be under concrete curb and gutters.
   3. Remove soft or spongy areas.
      a. Replace with aggregate material.
   4. Compact to the following densities:
      a. Cohesive soils: 95 percent per ASTM D698.
      b. Noncohesive soils: 75 percent relative per ASTM D4253 and ASTM D4254.
   5. Assure moisture content is within limits prescribed to achieve required compaction density.
   6. Following compaction, trim and roll to exact cross section.
   7. Check with approved grading template.
   8. Perform density tests on subgrade to determine that subgrade complies with the specification.

B. Aggregate Course:
   1. Place material in not more than 6 IN thick layers.
   2. Spread, shape, and compact all material deposited on the subgrade during the same day.
   3. Compact to 75 percent relative per ASTM D4253 and ASTM D4254.

C. Loose and Foreign Material:
   1. Remove loose and foreign material immediately before application of paving.

D. Appurtenance Preparation:
   1. Block out or box out curb inlets and curb returns.
   2. Provide for joint construction as detailed and dimensioned on Drawings.
   3. Adjust manholes, inlets, valve boxes and any other utility appurtenances to design grade.
      a. Secure to elevation with concrete.
      b. Place concrete up to 5 IN below design grade.
   4. Clean and oil forms.

3.2 INSTALLATION

A. Concrete Production:

1. Comply with Specification Section 03 31 31.

B. Forms:
   1. Form support:
      a. Compact soil foundation and cut to grade to support forms and superimposed machine loads.
      b. Use bearing stakes driven flush with bottom of form to supplement support as necessary.
      c. Do not use earth pedestals.
   2. Staking forms:
      a. Joint forms neatly and tightly.
      b. Stake and pin securely with at least three (3) pins for each 10 FT section.
   3. Clean and oil forms prior to placement of concrete.
   4. Set forms sufficiently in advance of work (minimum of 2 HRS) to permit proper inspection.
   5. Previously finished pavement or sidewalk contiguous with new work may serve as side form when specifically approved.

C. Reinforcing:
   1. Lap nonwelded bars 12 IN minimum.
   2. Support:
      a. Place bars securely on chairs at called-for height.

D. Joints:
   1. Hold locations and alignment to within +1/4 IN.
   2. Finish concrete surface adjacent to previous section to within +1/8 IN, with tooled radius of 1/4 IN.
   3. Expansion joints:
      a. Locate at 48 FT intervals and at all intersection curb returns.
      b. Stake in place load transfer device consisting of dowels.
      c. Supporting and spacing means and premolded joint filler as per Drawing details.
      d. Provide preformed joint filler at all junctions with existing curb and gutter or other structures.
   4. Contraction joints:
      a. Locate at 6 FT intervals.
      b. Use steel template at least 1/4 IN thick, conforming to cross section of curb and gutter.
      c. Remove template where concrete has set sufficiently to prevent spalling or adhesion of concrete.
      d. If machine placed, use tooled joint formed in freshly placed concrete.
      e. Groove dimensions shall be 3/8 IN at surface and 1/4 IN at root.
   5. Install construction joints at end of day's work or wherever concreting must be interrupted for 30 minutes or more.
   6. Thoroughly clean and fill joints with joint sealing material as specified.
   7. Upper surface of filled joint to be flush to 1/8 IN below finished surface.

E. Place Concrete:
   1. Comply with Specification Section 03 31 31.
   2. Construct driveway openings, ramps, and other features as per Drawing details.

F. Cold and Hot Weather Concreting:
   1. Cold weather:
      a. Cease concrete placing when descending air temperature in shade falls below 40 DegF.
      b. Do not resume until ambient temperature has risen to 40 DegF.
      c. If placing is authorized below 40 DegF by Engineer, maintain temperature of mix between 60 and 80 DegF.
      d. Heat aggregates or water or both.
      e. Water temperature may not exceed 175 DegF.
      f. Aggregate temperature may not exceed 150 DegF.
      g. Remove and replace frost-damaged concrete.

h. Salt or other antifreeze is not permitted.
i. Comply with ACI 306R.

2. Hot weather:
   a. Cease concrete placing when plastic mix temperature cannot be maintained under 90 DegF.
   b. Aggregates or water or both may be cooled.
   c. Cool water with crushed ice.
   d. Cool aggregates by evaporation of water spray.
   e. Never batch cement hotter than 160 DegF.
   f. Comply with ACI 305R.

G. Finishing:
1. Bring combination curb and gutter to grade by running straightedge over steel templates with sawing motion.
2. Float surface with a wood float to draw cement to surface.
3. Broom finish after floating.
4. Tool edges with suitable edger.
5. Upon removal of forms, fill honeycombed or unevenly filled sections immediately with cement mortar.
6. Assure that expansion joints are cleared of concrete, both at bottom of gutter and back of curb.

H. Curing:
1. Apply membrane curing compound complying with ASTM C309, and in accordance with manufacturer's directions but at a minimum rate of 200 SF per gallon.
2. Apply curing compound within 4 HRS after finishing or as soon as surface moisture has dissipated.
3. Cure for 7 days.
4. When average daily temperature is below 50 DegF, provide insulative protection of 12 IN minimum thickness loose dry straw, or equivalent, for 10 days.

I. Protection of Concrete:
1. Protect new curb and gutter and its appurtenances from traffic for minimum of 14 days.
2. Repair or replace parts of curb and gutter damaged by traffic, or other causes, occurring prior to final acceptance.

J. Opening to Traffic:
1. After 14 days, area may, at Owner's discretion, be opened to traffic if job cured test cylinders have attained a compressive strength of 3,000 LBS per square inch when tested in accordance with ASTM standard methods.
2. Prior to opening to traffic, clean and refill joints as required with specified filler material.

K. Clean Up:
1. Assure clean up work is completed within two (2) weeks after work has been opened to traffic.
2. No new work will begin until clean up work has been completed, or is maintained within two (2) weeks after work has been opened to traffic.

3.3 FIELD QUALITY CONTROL

A. Provide test cylinders in accordance with Specification Section 03 05 05.

END OF SECTION

SECTION 32 16 23

CONCRETE SIDEWALK AND STEPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete sidewalk and steps.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 03 31 30 - Concrete, Materials and Proportioning.
   4. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
   5. Section 03 05 05 - Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. M153, Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
      b. M171, Sheet Materials for Curing Concrete.
      c. M182, Burlap Cloth Made from Jute or Kenaf.
      d. M213, Preformed Expansion Joint Fillers for Concrete Paving and Structure Construction (Nonextruding and Resilient Bituminous Types).
      e. M224, Use of Protective Sealers for Portland Cement Concrete.
      f. M233, Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
   2. American Concrete Institute (ACI):
      a. 305R, Hot Weather Concreting.
      b. 306R, Cold Weather Concreting.
   3. ASTM International (ASTM):
      a. A185, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
      b. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      c. A1064, Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
      d. C33, Standard Specification for Concrete Aggregates.
      e. C150, Standard Specification for Portland Cement.
      f. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      g. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
      h. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      i. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   4. Federal Specification (FS):
      a. SS-S-1614, Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements.
      b. TT-S 00227 E(3), Sealing Compound: Elastomeric Type, Multi-Component (for Calking, Sealing, and Glazing in Buildings and Other Structures).

1.3 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
3. Mix design(s) in accordance with Specification Section 03 31 30 and Specification Section 03 05 05.
4. Qualifications of concrete installer.
5. Drawings detailing all reinforcing.
6. Concrete cylinder test results from field quality control.

B. Samples:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Samples of fabricated jointing materials and devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Chemical admixtures:
    a. Sika Chemical Corporation.
    b. BASF Admixtures, Inc.
    c. Protex Industries.
    d. W. R. Grace and Company.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MATERIALS

A. Portland Cement:
1. ASTM C150, Type I or II.

B. Aggregates:
1. ASTM C33, gradation size #67, 3/4 IN to #4.

C. Water:
1. Potable quality.

D. Admixtures:
1. Comply with Specification Section 03 31 30.

E. Reinforcing Bars:
1. ASTM A615, Grade 60.

F. Welded Wire Reinforcement:
1. ASTM A185 or ASTM A1064.
2. Flat.
3. Clean, free from dirt, scale, rust.

G. Preformed Joint Filler:
1. Nonextruding cork, self-expanding cork, sponge rubber or cork rubber.
2. Meet AASHTO M153 or AASHTO M213.

H. Hot-Poured Joint Sealing Material:
1. FS SS-S-1614.

I. Sidewalk Joint Sealant:
   1. Two compound, polyurethane sealant.
   2. Class A, Type 1.
   3. Self-leveling.
   4. Nontracking.
   5. FS TT-S 00227 E(3).

J. Membrane Curing Compound:
   1. ASTM C309.

K. Cover Materials for Curing:
   1. Burlap:
      a. AASHTO M182.
      b. Minimum Class 2, 8 OZ material (1 YD x 42 IN).
   2. Polyethylene film:
      a. AASHTO M171.

L. Paper Subgrade Cover:
   1. Polyethylene film, AASHTO M171.

M. Concrete Treatment:
   1. Boiled linseed oil mixture.
   2. Meets AASHTO M233.

N. Forms:
   1. Steel or wood.
   2. Size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment.
   3. Free of distortion and defects.
   4. Full depth.
   5. Metal Side Forms:
      a. Minimum 7/32 IN thick.
      b. Depth equal to edge thickness of concrete.
      c. Flat or rounded top minimum 1-3/4 IN wide.
      d. Base 8 IN wide or equal to height, whichever is less.
      e. Maximum deflection 1/8 IN under center load of 1700 LBS.
      f. Use flexible spring steel forms or laminated boards to form radius bends.

2.3 MIXES

A. Mix design to provide 4,000 psi 28-day compressive strength, 1-1/2 IN +1 IN slump, 6 percent air.

B. Comply with Specification Section 03 31 30 and Specification Section 03 31 31.

PART 3 - EXECUTION

3.1 PREPARATION

A. Subgrade Preparation:
   1. Prepare using methods, procedures, and equipment necessary to attain required compaction densities, elevation and section.
   2. Scarify and recompact top 6 IN of fills and embankments which will be sidewalk and step areas.
   3. Remove soft or spongy areas.
      a. Replace with aggregate material.
   4. Compact to the following densities:
      a. Cohesive soils: 95 percent per ASTM D698.
      b. Noncohesive soils: 75 percent relative per ASTM D4253 and ASTM D4254.
   5. Assure moisture content is within limits prescribed to achieve required compaction density.

6. Following compaction, trim and roll to exact cross section.
    a. Check with approved grading template.
7. Perform density tests on subgrade to determine that subgrade complies with the specification.

B. Aggregate Course:
1. Place material in not more than 6 IN thick layers.
2. Spread, shape, and compact all material deposited on the subgrade during the same day.
3. Compact to 75 percent relative per ASTM D4253 and ASTM D4254.

C. Loose and Foreign Material:
1. Remove loose and foreign material immediately before application of paving.

D. Appurtenance Preparation:
1. Block out or box out curb inlets and curb returns.
2. Provide for joint construction as detailed and dimensioned on Drawings.
3. Adjust manholes, inlets, valve boxes and any other utility appurtenances to design grade.
    a. Secure to elevation with concrete.
    b. Place concrete up to 5 IN below design grade.
4. Clean and oil forms.

3.2 ERECTION, INSTALLATION AND APPLICATION

A. Concrete Production:
1. Comply with Specification Section 03 31 31.

B. Forms:
1. Form support:
    a. Compact soil foundation and cut to grade to support forms.
    b. Use bearing stakes driven flush with bottom of form to supplement support as necessary.
    c. Do not use earth pedestals.
2. Staking forms:
    a. Joint forms neatly and tightly.
    b. Stake and pin securely with at least three (3) pins for each 10 FT section.
3. Clean and oil forms prior to placement of concrete.
4. Set forms sufficiently in advance of work (minimum 2 HRS) to permit proper inspection.
5. Previously finished pavement or curb and gutter contiguous with new work may serve as side form when specifically approved.

C. Reinforcing:
1. Lap mats one (1) full space.
2. Tie end transverse member of upper mat securely to prevent curling.
3. Lap nonwelded bars 12 IN minimum.
4. Support:
    a. Place bars securely on chairs at called-for height.
    b. Place other fabric on the first of a two-course pour and cover promptly with final pour, or place fabric by a fabric-placer if procedure is reviewed and approved by Engineer.

D. Joints:
1. Hold locations and alignment to within + 1/4 IN.
2. Finish concrete surface adjacent to previous section to within + 1/8 IN, with tooled radius of 1/4 IN.
3. Metal keyway joints:
    a. Form by installing metal joint strip, left in place.
    b. Stake and support like side form.
    c. Provide dowels or tie bars.
4. Weakened plane joints:
    a. Locate at 6 FT intervals.
    b. Tool groove in freshly placed concrete with tooling device.

c. Groove dimensions shall be 3/8 IN at surface and 1/4 IN at root.
5. Install construction joints at end of day's work or wherever concreting must be interrupted for 30 minutes or more.
6. Expansion joints:
   a. Locate at 48 FT intervals and at all intersection curb returns.
   b. Stake in place load transfer device consisting of dowels.
   c. Supporting and spacing means and premolded joint filler as per Drawing details.
   d. Provide preformed joint filler at all junctions with existing sidewalks, steps, or other structures.
7. Thoroughly clean and fill joints with joint sealing material as specified.
8. Upper surface of filled joint to be flush to 1/8 IN below finish surface.

E. Place Concrete:
1. Comply with Specification Section 03 31 31.
2. Construct driveway openings and other features as per Drawing details.

F. Cold and Hot Weather Concreting:
1. Cold weather:
   a. Cease concrete placing when descending air temperature in shade falls below 40 DegF.
   b. Do not resume until ambient temperature has risen to 40 DegF.
   c. If placing is authorized below 40 DegF by Engineer, maintain temperature of mix between 60 and 80 DegF.
   d. Heat aggregates or water or both.
   e. Water temperature may not exceed 175 DegF.
   f. Aggregate temperature may not exceed 150 DegF.
   g. Remove and replace frost damaged concrete.
   h. Salt or other antifreeze is not permitted.
   i. Comply with ACI 306R.
2. Hot weather:
   a. Cease concrete placing when plastic mix temperature cannot be maintained under 90 DegF.
   b. Aggregates or water or both may be cooled.
   c. Cool water with crushed ice.
   d. Cool aggregates by evaporation or water spray.
   e. Never batch cement hotter than 160 DegF.
   f. Comply with ACI 305R.

G. Finishing:
1. As soon as placed, strike off and screed to crown and cross section, slightly above grade, so that consolidation and finishing will bring to final Drawing elevations.
2. Maintain uniform ridge full width with first pass of first screed.
3. Test with 6 FT straightedges equipped with long handles and operated from sidewalk.
4. Draw excess water and laitance off from surface.
5. Float finish so as to leave no disfiguring marks but to produce a uniform granular or sandy texture.
6. Broom finish after floating.
7. Tool edges with suitable edger.
8. Provide exposed aggregate surfaces in areas indicated on the Drawings.
9. Provide method such as abrasive blasting, bush hammering, or surface retarder acceptable to the Engineer.

H. Curing:
1. Apply membrane curing compound complying with ASTM C309, and in accordance with manufacturer's directions but at a rate of minimum 200 SF per gallon.
2. Apply curing compound within 4 HRS after finishing or as soon as surface moisture has dissipated.
3. Cure for minimum of seven (7) days.

4. When average daily temperature is below 50 DegF, provide insulative protection of 12 IN minimum thickness loose dry straw, or equivalent, for 10 days.
5. Linseed oil sealant:
    a. For concrete sidewalk and step, seal surface with linseed oil.
    b. Apply linseed oil to clean surface as per AASHTO M224 after concrete has cured for 1 month.
    c. Apply first application at rate of 67 SY per gallon.
    d. Apply second application to a dry surface at rate of 40 SY per gallon.

I. Protection of Concrete:
1. Protect new sidewalk, steps, and their appurtenances from traffic for a minimum of 14 days.
2. Repair or replace parts of sidewalk and steps damaged by traffic, or other causes, prior to final acceptance.

J. Opening to Traffic:
1. After 14 days, area may, at Owner's discretion, be opened to traffic if job cured cylinders have attained a compressive strength of 3000 LBS per square inch when tested in accordance with ASTM standard methods.
2. Prior to opening to traffic, clean and refill joints as required with specified filler material.

K. Clean Up:
1. Assure clean-up work is completed within two (2) weeks after sidewalk has been opened to traffic.
2. No new work will begin until clean-up work has been completed, or is maintained within 2 weeks after sidewalk has been opened to traffic.

L. Handrails:
1. Provide handrails where required and as per Drawing details.

3.3 FIELD QUALITY CONTROL

A. Provide test cylinders in accordance with Specification Section 03 05 05

END OF SECTION

SECTION 32 91 05

TOPSOILING AND FINISHED GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Topsoiling and finished grading.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 31 10 00 - Site Clearing.
   4. Section 31 23 00 - Earthwork.

C. Location of Work: All areas within limits of grading and all areas outside limits of grading which are disturbed in the course of the work.

1.2 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Project Data: Test reports for furnished topsoil.

1.3 SITE CONDITIONS

A. Verify amount of topsoil stockpiled and determine amount of additional topsoil, if necessary to complete work.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil:
   1. Original surface soil typical of the area.
   2. Existing topsoil stockpiled under Specification Section 31 10 00.
   3. Capable of supporting native plant growth.

2.2 TOLERANCES

A. Finish Grading Tolerance: 0.1 FT plus/minus from required elevations.

PART 3 - EXECUTION

3.1 PREPARATION

A. Correct, adjust and/or repair rough graded areas.
   1. Cut off mounds and ridges.
   2. Fill gullies and depressions.
   3. Perform other necessary repairs.
   4. Bring all sub-grades to specified contours, even and properly compacted.

B. Loosen surface to depth of 2 IN, minimum.

C. Remove all stones and debris over 2 IN in any dimension.

3.2 ROUGH GRADE REVIEW

A. Reviewed by Engineer in Specification Section 31 10 00.

3.3 PLACING TOPSOIL

A. Do not place when subgrade is wet or frozen enough to cause clodding.

B. Spread to compacted depth of 4 IN for all disturbed earth areas.

C. If topsoil stockpiled is less than amount required for work, furnish additional topsoil at no cost to Owner.

D. Provide finished surface free of stones, sticks, or other material 1 IN or more in any dimension.

E. Provide finished surface smooth and true to required grades.

F. Restore stockpile area to condition of rest of finished work.

3.4 ACCEPTANCE

A. Upon completion of topsoiling, obtain Engineer's acceptance of grade and surface.

B. Make test holes where directed to verify proper placement and thickness of topsoil.

END OF SECTION

SECTION 40 05 05

EQUIPMENT: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Requirements of this Specification Section apply to all equipment provided on the Project including those found in other Divisions even if not specifically referenced in individual "Equipment" Articles of those Specification Sections.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 03 31 30 - Concrete, Materials and Proportioning.
   4. Section 05 50 00 - Metal Fabrications.
   5. Section 07 92 00 - Joint Sealants.
   6. Section 09 96 00 – High Performance Industrial Coatings.
   7. Section 10 14 00 - Identification Devices.
   8. Division 43, 44, 46 – Various Equipment.
   9. Division 12 - Furnishings.
   10. Division 41 - Conveying Systems.
   11. Division 26 - Electrical.
   12. Section 40 05 13 - Pipe and Pipe Fittings: Basic Requirements.
   13. Section 40 91 10 - Primary Meters and Transmitters.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Bearing Manufacturers Association (ABMA).
   2. American Gear Manufacturers Association (AGMA).
   3. ASTM International (ASTM):
      a. E1934, Standard Guide for Examining Electrical and Mechanical Equipment with Infrared Thermography.
      b. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   4. Hydraulic Institute (HI):
      a. 9.6.4, Centrifugal and Vertical Pumps for Vibration Measurements and Allowable Valves.
   5. International Electrotechnical Commission (IEC).
   6. Institute of Electrical and Electronics Engineers, Inc. (IEEE).
   7. International Organization for Standardization (ISO):
      a. 1940, Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances.
   8. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ICS 6, Enclosures for Industrial Control and System.
      c. MG 1, Motors and Generators.
   9. InterNational Electrical Testing Association (NETA):
      a. ATS, Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.
   10. National Fire Protection Association (NFPA):
       a. 70, National Electrical Code (NEC):
          1) Article 430, Motors, Motor Circuits, and Controllers.
   11. National Institute for Certification in Engineering Technologies (NICET).

12. National Institute of Standards and Technology (NIST).
13. Occupational Safety and Health Administration (OSHA):
    a. 29 CFR 1910, Occupational Safety and Health Standards, referred to herein as OSHA Standards.
14. Underwriters Laboratories, Inc. (UL).
    a. 508, Standard for Safety Industrial Control Equipment.
    b. 508A, Standard for Safety Industrial Control Panels.
15. Vibration Institute.

B. Vibration Testing Program:
1. Testing firm:
    a. An independent firm performing, as the sole or principal part of its business for a minimum of 10 years, the inspection, testing, calibration, and adjusting of systems.
    b. Must have an established monitoring and testing equipment calibration program with accuracy traceable in an unbroken chain, according to NIST.
2. Field personnel:
    a. Minimum of one (1) year field experience covering all phases of field vibration testing and data gathering.
    b. Qualified Vibration Category I certification from the Vibration Institute.
3. Analysis personnel:
    a. Minimum three (3) years combined field testing and data analysis experience.
    b. Qualified Vibration Category II certification from the Vibration Institute.

C. Infrared Thermography Testing Program:
1. Testing firm:
    a. An independent firm performing, as the sole or principal part of its business for a minimum of 10 years, the inspection, testing, calibration, and adjusting of systems.
    b. Must have an established monitoring and testing equipment calibration program with accuracy traceable in an unbroken chain, according to NIST.
2. Field personnel:
    a. Minimum of one (1) year field experience covering all phases of field thermography testing and data gathering.
    b. Supervisor certified by NETA or NICET.
3. Analysis personnel:
    a. Minimum three (3) years combined field testing and data analysis experience.
    b. Supervisor certified by NETA or NICET.

D. Electrical Equipment and Connections Testing Program:
1. Testing firm:
    a. An independent firm performing, as the sole or principal part of its business for a minimum of 10 years, the inspection, testing, calibration , and adjusting of systems.
    b. Must have an established monitoring and testing equipment calibration program with accuracy traceable in an unbroken chain, according to NIST.
2. Field personnel:
    a. Minimum of one (1) year field experience covering all phases of electrical equipment inspection, testing, and calibration.
    b. Relay test technician having previous experience with testing and calibration of relays of the same manufacturer and type used on project and proficient in setting and testing the types of protection elements used.
    c. Supervisor certified by NETA or NICET.
3. Analysis personnel:
    a. Minimum three (3) years combined field testing and data analysis experience.
    b. Supervisor certified by NETA or NICET.

E. Miscellaneous:
1. A single manufacturer of a "product" to be selected and utilized uniformly throughout Project even though:
    a. More than one (1) manufacturer is listed for a given "product" in Specifications.

b. No manufacturer is listed.

2. Equipment, electrical assemblies, related electrical wiring, instrumentation, controls, and system components shall fully comply with specific NEC requirements related to area classification and to NEMA 250 and NEMA ICS 6 designations shown on Electrical Power Drawings or defined in Division 26.
3. Variable speed equipment applications: The driven equipment manufacturer shall have single source responsibility for coordination of the equipment and VFD system and ensure their compatibility.

1.3 DEFINITIONS

A. Product: Manufactured materials and equipment.

B. Major Equipment Supports - Supports for Equipment:

1. Located on or suspended from elevated slabs with supported equipment weighing 2000 LBS or greater, or;
2. Located on or suspended from roofs with supported equipment weighing 500 LBS or greater, or;
3. Located on slab-on-grade or earth with supported equipment weighing 5000 LBS or more.

C. Equipment:

1. One (1) or more assemblies capable of performing a complete function.
2. Mechanical, electrical, instrumentation or other devices requiring an electrical, pneumatic, electronic or hydraulic connection.
3. Not limited to items specifically referenced in "Equipment" articles within individual Specifications.

D. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
2. Installer and applicator are synonymous.

1.4 SUBMITTALS

A. Shop Drawings:

1. General for all equipment:
    a. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
    b. Data sheets that include manufacturer's name and complete product model number.
        1) Clearly identify all optional accessories that are included.
    c. Acknowledgement that products submitted comply with the requirements of the standards referenced.
    d. Manufacturer's delivery, storage, handling, and installation instructions.
    e. Equipment identification utilizing numbering system and name utilized in Drawings.
    f. Equipment installation details:
        1) Location of anchorage.
        2) Type, size, and materials of construction of anchorage.
        3) Anchorage setting templates.
        4) Manufacturer's installation instructions.
    g. Equipment area classification rating.
    h. Shipping and operating weight.
    i. Equipment physical characteristics:
        1) Dimensions (both horizontal and vertical).
        2) Materials of construction and construction details.
    j. Equipment factory primer and paint data.
    k. Manufacturer's recommended spare parts list.
    l. Equipment lining and coatings.
    m. Equipment utility requirements include air, natural gas, electricity, and water.
    n. Ladders and platforms provided with equipment:

1) Certification that all components comply fully with OSHA requirements.
2) Full details of construction/fabrication.
3) Scaled plan and sections showing relationship to equipment.

2. Mechanical and process equipment:
   a. Operating characteristics:
      1) Technical information including applicable performance curves showing specified equipment capacity, rangeability, and efficiencies.
      2) Brake horsepower requirements.
      3) Copies of equipment data plates.
   b. Piping and duct connection size, type and location.
   c. Equipment bearing life certification.
   d. Equipment foundation data:
      1) Equipment center of gravity.
      2) Criteria for designing vibration, special or unbalanced forces resulting from equipment operation.
3. Electric motor:
   a. Motor manufacturer and model number.
   b. Complete motor nameplate data.
   c. Weight.
   d. NEMA design type.
   e. Enclosure type.
   f. Frame size.
   g. Winding insulation class and temperature rise.
   h. Starts per hour.
   i. Performance data:
      1) Guaranteed minimum efficiencies at 100 percent, 75 percent, and 50 percent of full load
      2) Guaranteed minimum power factor at 100 percent, 75 percent, and 50 percent of full load.
      3) Locked rotor and full load current at rated terminal voltage and minimum permissible or specified terminal voltage.
      4) Starting, full load, and breakdown torque at rated terminal voltage and minimum permissible or specified terminal voltage.
   j. Bearing data and lubrication system.
   k. Thermal protection system including recommended alarm and trip settings for winding and bearing RTD's.
   l. Fabrication and/or layout drawings:
      1) Dimensioned outlined drawing.
      2) Connection diagrams including accessories (strip heaters, thermal protection, etc.).
   m. Certifications:
      1) When utilized with a reduced voltage starter, certify that motor and driven equipment are compatible.
      2) When utilized with a variable frequency controller, certify motor is inverter duty and the controller and motor are compatible.
         a) Include minimum speed at which the motor may be operated for the driven machinery.
   n. Electrical gear:
      1) Unless specified in a narrow-scope Specification Section, provide the following:
         a) Equipment ratings: Voltage, continuous current, kVA, watts, short circuit with stand, etc., as applicable.
      2) Control panels:
         a) Panel construction.
         b) Point-to-point ladder diagrams.
         c) Scaled panel face and subpanel layout.
         d) Technical product data on panel components.
         e) Panel and subpanel dimensions and weights.

f) Panel access openings.
g) Nameplate schedule.
h) Panel anchorage.

4. Systems schematics and data:
   a. Provide system schematics where required in system specifications.
      1) Acknowledge all system components being supplied as part of the system.
      2) Utilize equipment, instrument and valve tag numbers defined in the Contract Documents for all components.
      3) Provide technical data for each system component showing compliance with the Contract Document requirements.
      4) For piping components, identify all utility connections, vents and drains which will be included as part of the system.
5. For factory painted equipment, provide paint submittals in accordance with Specification Section 09 91 00.
6. Qualifications for :
   a. Vibration testing firm and personnel.
   b. Infrared thermography testing firm and personnel.
   c. Electrical equipment and connections testing firm and personnel.
7. Testing plans, in accordance with PART 3 of this Specification Section:
   a. Vibration testing.
   b. Thermography testing.
   c. Electrical equipment and connection testing.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 3304 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
   1. Sample form letter for equipment field certification.
   2. Certification that equipment has been installed properly, has been initially started up, has been calibrated and/or adjusted as required, and is ready for operation.
   3. Certification for major equipment supports that equipment foundation design loads shown on the Drawings or specified have been compared to actual loads exhibited by equipment provided for this Project and that said design loadings are equal to or greater than the loads produced by the equipment provided.
   4. Field noise testing reports if such testing is specified in narrow-scope Specification Sections.
   5. Notification, at least one (1) week in advance, that motor testing will be conducted at factory.
   6. Certification from equipment manufacturer that all manufacturer-supplied control panels that interface in any way with other controls or panels have been submitted to and coordinated with the supplier/installer of those interfacing systems.
   7. Motor test reports.
   8. Certification prior to Project closeout that electrical panel drawings for manufacturer-supplied control panels truly represent panel wiring including any field-made modifications.
   9. Provide three (3) bound final written reports documenting vibration monitoring and testing for specified equipment.
      a. Include the acceptance criteria of all equipment tested.
      b. Provide individual tabbed sections for information associated with each piece of tested equipment.
   10. Preliminary field quality control testing format to be used as a basis for final field quality control reporting.
   11. Testing and monitoring reports in accordance with PART 3 of this Specification Section.
   12. Certification that driven equipment and VFD are compatible.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Motors:
      a. Baldor.
      b. General Electric.
      c. Marathon Electric.
      d. Siemens.
      e. Teco-Westinghouse.
      f. U.S. Motors.
      g. WEG.
   2. Mechanical variable speed drives:
      a. Reeves.
      b. U.S. Motors (VariDrive).

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MANUFACTURED UNITS

A. General:
   1. Furnished equipment manufacturer’s field quality control services and testing as specified in the individual equipment Specification Sections.
   2. Execute pre-demonstration requirements in accordance with Specification Section 01 75 00.
   3. Perform and report on all tests required by the equipment manufacturer’s Operation and Maintenance Manual.
   4. Provide testing of electrical equipment and connections in accordance with Division 26.
   5. Equip testing and analysis personnel with all appropriate project related reference material required to perform tests, analyze results, and provide documentation including, but not limited to:
      a. Contract Drawings and Specifications.
      b. Related construction change documentation.
      c. Approved Shop Drawings.
      d. Approved Operation and Maintenance Manuals.
      e. Other pertinent information as required.

B. Equipment Monitoring and Testing Plans:
   1. Approved in accordance with Shop Drawing submittal schedule.
   2. Included as a minimum:
      a. Qualifications of firm, field personnel, and analysis personnel doing the Work.
      b. List and description of testing and analysis equipment to be utilized.
      c. List of all equipment to be testing, including:
         1) Name and tag numbers identified in the Contract Documents.
         2) Manufacturer’s serial numbers.
         3) Other pertinent manufacturer identification,

C. Instruments Used in Equipment and Connections Quality Control Testing:
   1. Minimum calibration frequency:
      a. Field analog instruments: Not more than 6 months.
      b. Field digital instruments: Not more than 12 months.
      c. Laboratory instruments: Not more than 12 months.
      d. If instrument manufacturer’s calibration requirements are more stringent, those requirements shall govern.
   2. Carry current calibration status and labels on all testing instruments.
   3. See individual testing programs for additional instrumentation compliance requirements.

D. Testing and Monitoring Program Documentation:

1. Provide reports with tabbed sections for each piece of equipment tested.
2. Include all testing results associated with each piece of equipment under that equipment's tabbed section.
   a. Include legible copies of all forms used to record field test information.
3. Prior to start of testing, submit one (1) copy of preliminary report format for Engineer review and comment
   a. Include data gathering and sample test report forms that will be utilized.
4. In the final report, include as a minimum, the following information for all equipment tested:
   a. Equipment identification, including:
      1) Name and tag numbers identified in the Contract Documents.
      2) Manufacturer's serial numbers.
      3) Other pertinent manufacturer identification,
   b. Date and time of each test.
   c. Ambient conditions including temperature, humidity, and precipitation.
   d. Visual inspection report.
   e. Description of test and referenced standards, if any, followed while conducting tests.
   f. Results of initial and all retesting.
   g. Acceptance criteria.
   h. "As found" and "as left" conditions.
   i. Corrective action, if required, taken to meet acceptance.
   j. Verification of corrective action signed by the Contractor, equipment supplier, and Owner's representative.
   k. Instrument calibration dates of all instruments used in testing.
5. Provide three (3) bound final reports prior to Project final completion.

E. Vibration Monitoring and Testing Program:
1. Perform vibration monitoring and testing for equipment specified in other Divisions during the Equipment Demonstration Period.
2. Provide vibration testing on all rotating and reciprocating equipment having driver 25 HP and greater.
3. Additional requirements for vibration monitoring and testing equipment:
   a. Frequency response: 0.18 Hz to 25 kHz.
   b. Resolution: 6400 lines.
   c. Amplitude range: 18 bit for 96 dB dynamic range.
   d. Supports measurements of acceleration, velocity, displacement, envelope demodulation for bearing defect detection.
   e. Capable of two-place computer balancing.
   f. Requirements for vibration sensor:
      1) Sensitivity: +/- 5 percent at 25 DegC= 100 mV/g.
      2) Acceleration range: 80 g peak.
      3) Amplitude nonlinearity: 1 percent.
      4) Frequency response:
         a) +/- 5 percent = 3-5000 Hz.
         b) +/- 10 percent = 1-9000 Hz.
      5) Permanently attach vibration test and monitoring mounting pads to mechanical equipment at location recommended by the equipment manufacturer or as recommended by the testing firm.
      6) Acceptability of equipment conditions, except pumps, based on ISO 1940-1 Balance Quality Grade G2.5 criteria.
      7) Acceptability of pumping equipment to be based on HI 9.6.4 criteria.
      8) Repair or replace equipment shown to be out of range of the acceptable tolerance until the equipment meets or exceeds acceptability standards.

F. Infrared Thermography Testing Program:
1. Perform infrared thermography testing for equipment specified in other Divisions during the Equipment Demonstration Period.

a. Perform on all rotating and reciprocating equipment having drivers 25 HP or greater.
b. Perform on electrical equipment and connections: See Specification Section 26 08 13.

2. Additional requirements for infrared thermography monitoring and testing equipment:
   a. Temperature range: -10 to 350 DegC.
   b. Accuracy: +/-2 percent or 2 DegC, whichever is greater.
   c. Repeatability: +/-1 percent or 1 DegC, whichever is greater.
   d. Temperature indication resolution: 0.1 DegC.
   e. Minimum focus distance: 0.3 meters.
   f. Output in color palettes: JPEG, BMP, or other digital format compatible with Windows.
3. Perform inspection per ASTM E1934.
   a. Operate VFD driven equipment at 100 percent speed during thermographic inspection.
4. Acceptability of electrical connections and components based on temperature comparison between components and ambient air temperatures not greater than 10 DegC per ASTM E1934.
5. Acceptability of motors and equipment bearings based on temperature rise not greater than 5 DegC above the equipment and/or bearing manufacturers published criteria.
6. Repair or replace equipment shown to be out of range of the acceptable tolerance until the equipment meets or exceeds acceptability standards.

G. Electrical Equipment and Connections Testing Program:
1. Perform testing on Division 26 equipment and connections in accordance with Division 26 requirements.
2. Testing of motors:
   a. After installation and prior to energizing the motor, perform inspections and tests per NETA ATS 7.15 for all motors 25 HP or above.
   b. Bump motor to check for correct rotation.
3. Repair or replace equipment shown to be out of range of the acceptable tolerance until the equipment meets or exceeds acceptability standards.

H. Other Testing:
1. Perform tests and inspections not specifically listed but required to assure equipment is safe to energize and operate.
2. Subbase that supports the equipment base and that is made in the form of a cast iron or steel structure that has supporting beams, legs, and cross members that are cast, welded, or bolted shall be tested for a natural frequency of vibration after equipment is mounted.
   a. The ratio of the natural frequency of the structure to the frequency of the disturbing force shall not be between 0.5 and 1.5.

I. Electric Motors:
1. Where used in conjunction with adjustable speed AC or DC drives, provide motors that are fully compatible with the speed controllers.
2. Design for frequent starting duty equivalent to duty service required by driven equipment.
3. Design for full voltage starting.
4. Design bearing life based upon actual operating load conditions imposed by driven equipment.
5. Size for altitude of Project.
6. Furnish with stainless steel nameplates which include all data required by NEC Article 430.
7. Use of manufacturer's standard motor will be permitted on integrally constructed motor driven equipment specified by model number in which a redesign of the complete unit would be required in order to provide a motor with features specified.
8. AC electric motors less than 1/3 HP:
   a. Single phase, 60 Hz, designed for the supply voltage shown on the Drawings.
   b. Permanently lubricated sealed bearings conforming to ABMA standards.
   c. Built-in manual reset thermal protector or integrally mounted manual motor starter with thermal overload element with stainless steel enclosure.
9. AC electric motors 1/3 to 1 HP:

a. Single or 3 PH, 60 Hz, designed for the supply voltage shown on the Drawings.
b. Permanently lubricated sealed bearings conforming to ABMA standards.
    1) For single phase motors, provide built-in manual reset thermal protector or integrally mounted manual motor starter with thermal overload element.

10. AC electric motors 1-1/2 to 10 HP:
    a. Single or 3 PH, 60 Hz, designed for the supply voltage indicated on the Drawings.
    b. Permanently lubricated sealed bearings conforming to ABMA standards.
    c. For vertical motors provide 15 year, average-life thrust bearings conforming to ABMA standards.
11. AC electric motors greater than 10 HP:
    a. Single or 3 PH, 60 Hz, designed for the supply voltage indicated on the Drawings.
    b. Oil or grease lubricated antifriction bearings conforming to ABMA standards.
        1) Design bearing life for 90 percent survival rating at 50,000 HRS of operation for motors up to and including 100 HP.
        2) For motors greater than 100 HP, design bearing life for 90 percent survival rating at 100,000 HRS of operation.
    c. For vertical motors provide 15 year, average-life thrust bearings conforming to ABMA standards.
    d. Thermal protection:
        1) For motors 50 HP and above controlled from a variable frequency drive and for all other motors 200 HP and above, provide integral thermal detectors with normally closed contacts that will open on over-temperature, or resistance type temperature detector (RTD) complete with monitor and alarm panel having a normally closed contact that will open on over-temperature.
            a) Two (2) thermal sensing devices per phase in each phase hot-spot location.
            b) Monitor and alarm panel:
                (1) For constant speed motors, install panel in and energize from the motor starter equipment.
                (2) For variable speed motors, install panel in and energize from the variable speed drive equipment.
12. Severe duty motor to have the following minimum features:
    a. All cast iron construction.
    b. Gasketed conduit box.
    c. Epoxy finish for corrosion protection.
    d. Hydroscopic varnish on windings for corrosion protection.
    e. Drain plug and breather.

J. NEMA Design Squirrel Cage Induction Motors:
1. Provide motors designed and applied in compliance with NEMA and IEEE for the specific duty imposed by the driven equipment.
2. Motors to meet NEMA MG 1 (NEMA Premium) efficiencies.
3. Do not provide motors having a locked rotor kVA per HP exceeding the NEMA standard for the assigned NEMA code letter.
4. For use on variable frequency type adjustable speed drives, provide:
    a. Induction motors that are in compliance with NEMA MG 1, Part 31.
    b. Nameplate identification meeting NEMA MG 1 Part 31 requirements.
    c. Insulated drive end bearing on all motors.
    d. Insulated non-drive end bearings, at a minimum, on all motors with horizontal shaft 100 HP and larger.
    e. An insulated bearing carrier on the non-drive end for vertical shaft motors 100 HP and larger.
    f. Shaft grounding ring on all motors:
        1) Factory installed, maintenance free, circumferential, bearing protection ring with conductive microfiber shaft contacting material.
        2) Electro Static Technology AEGIS SGR Bearing Protection Ring or approved equal.

5. Design motor insulation in accordance with NEMA standards for Class F insulation with Class B temperature rise above a 40 DegC ambient.
6. Design motors for continuous duty.
7. Size motors having a 1.0 service factor so that nameplate HP is a minimum of 15 percent greater than the maximum HP requirements of the driven equipment over its entire operating range.
    a. As an alternative, furnish motors with a 1.15 service factor and size so that nameplate HP is at least equal to the maximum HP requirements of the driven equipment over its entire operating range.
8. Motor enclosure and winding insulation application:
    a. The following shall apply unless modified by specific Specification Sections:

MOTOR LOCATION	MOTOR ENCLOSURE / WINDING INSULATION
Unclassified Indoor Areas	DPFG (for horizontal motors), WP-I (for vertical motors) / Standard Insulation
Wet indoor Areas	TEFC / Standard Insulation
Wet outdoor Areas	TEFC / Extra Dip and Bake for Moisture
Corrosive Areas	TEFC, Severe/ Chemical Duty
Class I, Division 1 Areas	Explosion Proof, Approved for Class I Division 1 Locations
Class I, Division 2 Areas	Explosion Proof, Approved for Division 1 Locations, or TEFC with maximum external frame temperature compatible with the gas in the area

NOTE: Provide TENV motors in the smaller horsepower ratings where TEFC is not available.

9. Provide oversize conduit box complete with clamp type grounding terminals inside the conduit box.

K. Submersible Motors: Refer to individual narrow-scope Specification Sections for submersible motor requirements.

L. V-Belt Drive:
1. Provide each V-belt drive with sliding base or other suitable tension adjustment.
2. Provide V-belt drives with a service factor of at least 1.6 at maximum speed.
3. Provide staticproof belts.

M. Mechanical Variable Speed Drives:
1. Oil-lubricated shaft-mounted reduction gear drive capable of 300 percent shock load and providing a 1.5 service factor in accordance with AGMA.
2. Assure infinite speed adjustment over a 1:1 range.
3. Secure drive to equipment base.
4. Flexible coupling between drive shaft and equipment shaft.

2.3 COMPONENTS

A. Gear Drives and Drive Components:
1. Size drive equipment capable of supporting full load including losses in speed reducers and power transmission.
2. Provide nominal input horsepower rating of each gear or speed reducer at least equal to nameplate horsepower of drive motor.
3. Design drive units for 24 HR continuous service, constructed so oil leakage around shafts is precluded.
4. Utilize gears, gear lubrication systems, gear drives, speed reducers, speed increasers and flexible couplings meeting applicable standards of AGMA.

5. Gear reducers:
   a. Provide gear reducer totally enclosed and oil lubricated.
   b. Utilize antifriction bearings throughout.
   c. Provide worm gear reducers having a service factor of at least 1.20.
   d. Furnish other helical, spiral bevel, and combination bevel-helical gear reducers with a service factor of at least 1.50.

2.4 ACCESSORIES

A. Guards:
   1. Provide each piece of equipment having exposed moving parts with full length, easily removable guards, meeting OSHA requirements.
   2. Interior applications:
      a. Construct from expanded galvanized steel rolled to conform to shaft or coupling surface.
      b. Utilize non-flattened type 16 GA galvanized steel with nominal 1/2 IN spacing.
      c. Connect to equipment frame with hot-dip galvanized bolts and wing nuts.
   3. Exterior applications:
      a. Construct from 16 GA stainless steel or aluminum.
      b. Construct to preclude entrance of rain, snow, or moisture.
      c. Roll to conform to shaft or coupling surface.
      d. Connect to equipment frame with stainless steel bolts and wing nuts.

B. Anchorage:
   1. Cast-in-place anchorage:
      a. Provide ASTM F593, Type 316 stainless steel anchorage for all equipment.
      b. Configuration and number of anchor bolts shall be per manufacturer's recommendations.
      c. Provide two (2) nuts for each bolt.
   2. Drilled anchorage:
      a. Adhesive anchors per Specification Section 05 50 00.
      b. Epoxy grout per Specification Section 03 31 30.
      c. Threaded rods same as cast-in-place.

C. Data Plate:
   1. Attach a stainless steel data plate to each piece of rotary or reciprocating equipment.
   2. Permanently stamp information on data plate including manufacturer's name, equipment operating parameters, serial number and speed.

D. Gages:
   1. Provide gages in accordance with Specification Section 40 91 10.
   2. Provide at the following locations:
      a. Inlet and outlet of all reciprocating, centrifugal and positive displacement mechanical and process equipment.
      b. At locations identified on Drawings.
   3. Utilize tapping sleeves for mounting per Specification Section 40 05 13.

E. Lifting Eye Bolts or Lugs:
   1. Provide on all equipment 50 LBS or greater.
   2. Provide on other equipment or products as specified in the narrow-scope Specification Sections.

F. Platforms and Ladders:
   1. Design and fabricate in accordance with OSHA Standards.
   2. Fabricate components from aluminum.
   3. Provide platform surface: Non-skid grating, unless specified in narrow-scope Specification Sections.

2.5 FABRICATION

A. Design, fabricate, and assemble equipment in accordance with modern engineering and shop practices.

B. Manufacture individual parts to standard sizes and gages so that repair parts, furnished at any time, can be installed in field.

C. Furnish like parts of duplicate units to be interchangeable.

D. Ensure that equipment has not been in service at any time prior to delivery, except as required by tests.

E. Furnish equipment which requires periodic internal inspection or adjustment with access panels which will not require disassembly of guards, dismantling of piping or equipment or similar major efforts.
   1. Quick opening but sound, securable access ports or windows shall be provided for inspection of chains, belts, or similar items.

F. Provide common, lipped base plate mounting for equipment and equipment motor where said mounting is a manufacturer's standard option.
   1. Provide drain connection for 3/4 IN PVC tubing.

G. Machine the mounting feet of rotating equipment.

H. Fabricate equipment which will be subject to Corrosive Environment in such a way as to avoid back to back placement of surfaces that can not be properly prepared and painted.
   1. When such back to back fabrication can not be avoided, provide continuous welds to seal such surfaces from contact with corrosive environment.
   2. Where continuous welds are not practical, after painting seal the back to back surfaces from the environment in accordance with Specification Section 07 92 00.

I. Critical Speed:
   1. All rotating parts accurately machined and in as near perfect rotational balance as practicable.
   2. Excessive vibration is sufficient cause for equipment rejection.
   3. Ratio of all rotative speeds to critical speed of a unit or components: Greater than 1.2.

J. Control Panels Engineered and Provided with the Equipment by the Manufacturer:
   1. Manufacturer's standard design for components and control logic unless specific requirements are specified in the specific equipment Specification Section.
   2. NEMA or IEC rated components are acceptable, whichever is used in the manufacturer's standard engineered design, unless specific requirements are required in the specific equipment Specification Section.
   3. Affix entire assembly with a UL 508A label "Listed Enclosed Industrial Control Panel" prior to delivery.
      a. Control panels without an affixed UL 508A label shall be rejected.

2.6 SHOP OR FACTORY PAINT FINISHES

A. Electrical Equipment:
   1. Provide factory-applied paint coating system(s) for all electrical equipment components except those specified in Specification Section 09 91 00 to receive field painting.
      a. Field painted equipment: See Specification Section 09 91 00 for factory applied primer/field paint compatibility requirements.

B. Field paint other equipment in accordance with Specification Section 09 91 00.
   1. See Specification Section 09 91 00 for factory applied primer/field paint compatibility requirements.

2.7 SOURCE QUALITY CONTROL

A. Motor Tests:
   1. Test motors in accordance with NEMA and IEEE standards.
   2. Provide routine test for all motors.
   3. The Owner reserves the right to select and have tested, either routine or complete, any motor included in the project.
      a. The Owner will pay all costs, including shipping and handling, for all motors successfully passing the tests.
      b. The Contractor shall pay all costs, including shipping and handling, for all motors failing the tests.
      c. If two (2) successive motors of the same manufacturer fail testing, the Owner has the right to reject all motors from that manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment as shown on Drawings and in accordance with manufacturer's directions.

B. Utilize templates for anchorage placement for slab-mounted equipment.

C. For equipment having drainage requirements such as seal water, provide 3/4 IN PVC or clear plastic tubing from equipment base to nearest floor or equipment drain.
   1. Route clear of major traffic areas and as approved by Engineer.

D. DO NOT construct foundations until major equipment supports are approved.

E. Extend all non-accessible grease fittings using stainless steel tubing to a location which allows easy access of fittings from closest operating floor level.

F. Equipment Base:
   1. Construct level in both directions.
   2. Take particular care at anchor bolt locations so these areas are flat and level.

G. Machine Base:
   1. Mount machine base of rotating equipment on equipment base.
      a. Level in both directions, using a machinist level, according to machined surfaces on base.
   2. Level machine base on equipment base and align couplings between driver and driven unit using steel blocks and shims.
      a. Size blocks and shims to provide solid support at each mounting bolt location.
         1) Provide area size of blocks and shims approximately 1-1/2 times area support surface at each mounting bolt point.
      b. Provide blocks and shims at each mounting bolt.
         1) Furnish blocks and shims that are square shape with "U" cut out to allow blocks and shims to be centered on mounting bolts.
      c. After all leveling and alignment has been completed and before grouting, tighten mounting bolts to proper torque value.

H. Couplings:
   1. Align in the annular and parallel positions.
      a. For equipment rotating at 1200 rpm or less, align both annular and parallel within 0.001 IN tolerance for couplings 4 IN size and smaller.
         1) Couplings larger than 4 IN size: Increase tolerance 0.0005 IN per inches of coupling diameter, i.e., allow 6 IN coupling 0.002 IN tolerance, and allow a 10 IN coupling 0.004 IN tolerance.
      b. For equipment rotating at speeds greater than 1200 rpm allow both annular and parallel positions within a tolerance rate of 0.00025 IN per inch coupling diameter.

2. If equipment is delivered as a mounted unit from factory, verify factory alignment on site after installation and realigned if necessary.
3. Check surfaces for runout before attempting to trim or align units.

I. Grouting:
1. After machine base has been shimmed, leveled onto equipment base, couplings aligned and mounting bolts tightened to correct torque value, place a dam or formwork around base to contain grouting between equipment base and equipment support pad.
    a. Extend dam or formwork to cover leveling shims and blocks.
    b. Do not use nuts below the machine base to level the unit.
2. Saturate top of roughened concrete subbase with water before grouting.
    a. Add grout until entire space under machine base is filled to the top of the base underside.
    b. Puddle grout by working a stiff wire through the grout and vent holes to work grout in place and release any entrained air in the grout or base cavity.
3. When the grout has sufficiently hardened, remove dam or formwork and finish the exposed grout surface to fine, smooth surface.
    a. Cover exposed grout surfaces with wet burlap and keep covering sufficiently wet to prevent too rapid evaporation of water from the grout.
    b. When the grout has fully hardened (after a minimum of seven (7) days) tighten all anchor bolts to engage equipment base to grout, shims, and equipment support pad.
    c. Recheck driver-driven unit for proper alignment.

3.2 INSTALLATION CHECKS

A. For all equipment specifically required in detailed specifications, secure services of experienced, competent, and authorized representative(s) of equipment manufacturer to visit site of work and inspect, check, adjust and approve equipment installation.
1. In each case, representative(s) shall be present during placement and start-up of equipment and as often as necessary to resolve any operational issues which may arise.

B. Secure from equipment manufacturer's representative(s) a written report certifying that equipment:
1. Has been properly installed and lubricated.
2. Is in accurate alignment.
3. Is free from any undue stress imposed by connecting piping or anchor bolts.
4. Has been operated under full load conditions and that it operated satisfactorily.
    a. Secure and deliver a field written report to Owner immediately prior to leaving jobsite.

C. No separate payment shall be made for installation checks.
1. All or any time expended during installation check does not qualify as Operation and Maintenance training or instruction time when specified.

3.3 IDENTIFICATION OF EQUIPMENT AND HAZARD WARNING SIGNS

A. Identify equipment and install hazard warning signs in accordance with Specification Section 10 14 00.

3.4 FIELD PAINTING AND PROTECTIVE COATINGS

A. For required field painting and protective coatings, comply with Specification Section 09 91 00.

3.5 WIRING CONNECTIONS AND TERMINATION

A. Clean wires before installing lugs and connectors.

B. Terminate motor circuit conductors with copper lugs bolted to motor leads.

C. Tape stripped ends of conductors and associated connectors with electrical tape.
1. Wrapping thickness shall be 150 percent of the conductor insulation thickness.

D. Connections to carry full ampacity of conductors without temperature rise.

E. Terminate spare conductors with electrical tape.

3.6 FIELD QUALITY CONTROL

A. Furnish equipment manufacturer services as specified in the individual equipment Specifications.

B. Inspect wire and connections for physical damage and proper connection.

C. After installation and prior to energizing the motor, provide insulation resistance test of all motors 25 HP and above.
   1. Conduct test with 500 or 1000 Vdc megger.
   2. Test each phase separately.
   3. Disconnect all extraneous leads to the motor.
   4. Comply with NEMA MG 1 safety requirements and test procedures.

D. Bump motor to check for correct rotation:
   1. Ensure motor has been lubricated.
   2. Check prior to connection to driven equipment.

E. Subbase that supports the equipment base and that is made in the form of a cast iron or steel structure that has supporting beams, legs and cross member that are cast welded or bolted, shall be tested for a natural frequency of vibration after equipment is mounted.
   1. Keep the ratio of the natural frequency of the structure to the frequency of the disturbing force out of the range from 0.5 to 1.5.

F. Equipment Vibration Monitoring and Testing:
   1. Utilize an Engineer approved testing agency to perform vibration monitoring and testing on equipment defined in the schedule at the end of this Section.
   2. Permanently attach vibration test and monitoring mounting pads to the equipment at locations recommended by the equipment manufacturer or as recommended by the vibration testing agency.
   3. Utilize mounting pads suitable for permanent installation and for incorporation into a predictable maintenance program.
   4. For variable speed equipment provide vibration testing at 1 Hz increments throughout entire operating range.
   5. Diagnosis to include, but is not limited to the following:
      a. Unbalance.
      b. Misalignment.
      c. Bent shaft.
      d. Journal bearing related problems.
      e. Rolling contract bearing problems.
      f. Mechanical looseness.
      g. Resonance.
      h. Foundation flexibility.
      i. Electrically induced problems.
      j. Pump problems.
      k. Fan problems.
      l. Coupling problems.
      m. Drive belt problems.
      n. Gear problems.
      o. Centrifugal compressor problems.
      p. Electric motor induced vibration from VFD or VFD carrier frequency.
   6. Provide machinery condition diagnosis based on an acceptable machinery vibration severity guide or machinery fault guide analysis provided by the testing agency, ISO 1940 Balance Quality Grade 6.3 as a minimum.
   7. Tolerances for pumping equipment shall be per HI published standards.

8. Repair or replace equipment shown to be out of range of the specified tolerance until the equipment meets the specified normal operation range required in the machinery fault guide analysis.
9. Document testing with written report.
   a. Report to include initial testing results, acceptance criteria, corrective action taken to meet acceptance, verification of corrective action and acceptance report and baseline.

3.7 DEMONSTRATION

A. Demonstrate equipment in accordance with Specification Section 01 75 00.

3.8 EQUIPMENT VIBRATION TESTING SCHEDULE

EQUIPMENT NAME	TAG NO.	SPECIFICATION REFERENCE

END OF SECTION

SECTION 40 05 13

PIPE AND PIPE FITTINGS: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Process piping systems.
   2. Utility piping systems.
   3. Plumbing piping systems.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 31 21 33 - Trenching, Backfilling, and Compacting for Utilities.
   4. Section 09 96 00 – High Performance Industrial Coatings.
   5. Section 10 14 00 - Identification Devices.
   6. Section 40 05 05 - Equipment: Basic Requirements.
   7. Section 40 91 10 - Primary Meters and Transmitters.
   8. Section 40 05 16 - Pipe Support Systems.
   9. Section 40 05 51 - Valves: Basic Requirements.
   10. Section 40 42 00 - Pipe, Duct and Equipment Insulation.
   11. Section 40 41 13 - Heat Tracing Cable.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. M36, Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains (Equivalent ASTM A760).
      b. M190, Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches.
      c. M252, Standard Specification for Corrugated Polyethylene Drainage Tubing.
      d. M294, Interim Specification for Corrugated Polyethylene Pipe 12 to 24 Inch Diameter.
   2. American Iron and Steel Institute (AISI).
   3. American Society of Mechanical Engineers (ASME):
      a. B16.3, Malleable Iron Threaded Fittings.
      b. B16.5, Pipe Flanges and Flanged Fittings.
      c. B16.9, Factory-Made Wrought Steel Butt-Welding Fittings.
      d. B16.22, Wrought Copper and Bronze Solder - Joint Pressure Fittings.
      e. B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
      f. B36.19, Stainless Steel Pipe.
      g. B40.100, Pressure Gauges and Gauge Attachments.
   4. ASTM International (ASTM):
      a. A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
      b. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
      c. A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
      d. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
      e. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
      f. A197, Standard Specification for Cupola Malleable Iron.

g. A234, Standard Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
h. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
i. A312, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
j. A518, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
k. A536, Standard Specification for Ductile Iron Castings.
l. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
m. A760, Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains.
n. A774, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
o. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
p. B88, Standard Specification for Seamless Copper Water Tube.
q. C14, Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
r. C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
s. C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
t. C443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
u. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
v. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength and Perforated.
w. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
x. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
y. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
z. D4101, Standard Specification for Polypropylene Plastic Injection and Extrusion Materials.
aa. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
bb. F441, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
cc. {F491, Standard Specification for Poly(Vinylidene Fluoride)(PVDF) Plastic-Lined Ferrous Metal Pipe and Fittings.}

5. American Water Works Association (AWWA):
a. B300, Standard for Hypochlorites.
b. C200, Standard for Steel Water Pipe - 6 IN and Larger.
c. C207, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 IN through 144 IN.
d. C208, Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
e. C606, Standard for Grooved and Shouldered Joints.
f. C651, Standard for Disinfecting Water Mains.
g. C800, Standard for Underground Service Line Valves and Fittings.

6. American Water Works Association/American National Standards Institute (AWWA/ANSI):
a. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
b. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

c. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
d. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
e. C153/A21.53, Standard for Ductile-Iron Compact Fittings for Water Service.
7. Chlorine Institute, Inc. (CI):
a. Pamphlet 6, Piping Systems for Dry Chlorine.
8. Cast Iron Soil Pipe Institute (CISPI):
a. 301, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
9. International Plumbing Code (IPC).
10. National Fire Protection Association (NFPA):
a. 54, National Fuel Gas Code.
b. 69, Standard on Explosion Prevention Systems.
11. Underwriters Laboratories, Inc. (UL).

B. Coordinate flange dimensions and drillings between piping, valves, and equipment.

1.3 DEFINITIONS

A. Hazardous Gas Systems: Digester gas, chlorine gas, sulfur dioxide gas, carbon dioxide gas, lab gases.

B. PVDF: Polyvinylidene fluoride.

1.4 SYSTEM DESCRIPTION

A. Piping Systems Organization and Definition:
1. Piping services are grouped into designated systems according to the chemical and physical properties of the fluid conveyed, system pressure, piping size and system materials of construction.
2. See PIPING SPECIFICATION SCHEDULES in PART 3.

1.5 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data including:
a. Acknowledgement that products submitted meet requirements of standards referenced.
b. Copies of manufacturer's written directions regarding material handling, delivery, storage and installation.
c. Separate schedule sheet for each piping system scheduled in this Specification Section showing compliance of all system components.
1) Attach technical product data on gaskets, pipe, fittings, and other components.
3. Fabrication and/or layout drawings:
a. Exterior yard piping drawings (minimum scale 1 IN equals 10 FT) with information including:
1) Dimensions of piping lengths.
2) Invert or centerline elevations of piping crossings.
3) Acknowledgement of bury depth requirements.
4) Details of fittings, tapping locations, thrust blocks, restrained joint segments, harnessed joint segments, hydrants, and related appurtenances.
5) Acknowledge designated valve or gate tag numbers, manhole numbers, instrument tag numbers, pipe and line numbers.
6) Line slopes and vents.
b. Interior piping drawings (minimum scale 1/8 IN equals 1 FT) with information including:
1) Dimensions of piping from column lines or wall surfaces.
2) Centerline dimensions of piping.

3) Centerline elevation and size of intersecting ductwork, conduit/conduit racks, or other potential interferences requiring coordination.
4) Location and type of pipe supports and anchors.
5) Locations of valves and valve actuator type.
6) Details of fittings, tapping locations, equipment connections, flexible expansion joints, connections to equipment, and related appurtenances.
7) Acknowledgement of valve, equipment and instrument tag numbers.
8) Provisions for expansion and contraction.
9) Line slopes and air release vents.
10) Rough-in data for plumbing fixtures.

c. Schedule of interconnections to existing piping and method of connection.

B. Operation and Maintenance Manuals:
1. See Specification Section 01 33 04 for requirements for:
a. The mechanics and administration of the submittal process.
b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
1. Qualifications of lab performing disinfection analysis on water systems.
2. Test reports:
a. Copies of pressure test results on all piping systems.
b. Reports defining results of dielectric testing and corrective action taken.
c. Disinfection test report.
d. Notification of time and date of piping pressure tests.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe coating during handling using methods recommended by manufacturer.
1. Use of bare cables, chains, hooks, metal bars or narrow skids in contact with coated pipe is not permitted.

B. Prevent damage to pipe during transit.
1. Repair abrasions, scars, and blemishes.
2. If repair of satisfactory quality cannot be achieved, replace damaged material immediately.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Insulating unions:
a. "Dielectric" by Epco.
2. Dirt strainers (Y type):
a. Mueller (#351).
b. Sarco.
c. Armstrong.
3. Chemical strainers (Y type):
a. Chemtrol.
b. Asahi.
4. Dry disconnect couplings:
a. Kamlock.
5. Dielectric flange kit:
a. PSI.
b. Maloney.
c. Central Plastics.
6. Pipe saddles (for gage installation):
a. Dresser Style 91 (steel and ductile iron systems).

b. Dresser Style 194 (nonmetallic systems).
7. Expansion joint at FRP and poly tanks:
a. PROCO.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 PIPING SPECIFICATION SCHEDULES

A. Piping system materials, fittings and appurtenances are subject to requirements of specific piping specification schedules located at the end of PART 3 of this Specification Section.

2.3 COMPONENTS AND ACCESSORIES

A. Insulating Components:
1. Dielectric flange kits:
a. Flat faced.
b. 1/8 IN thick dielectric gasket, phenolic, non-asbestos.
c. Suitable for 175 psi, 210 DegF.
d. 1/32 IN wall thickness bolt sleeves.
e. 1/8 IN thick phenolic insulating washers.
2. Dielectric unions:
a. Screwed end connections.
b. Rated at 175 psi, 210 DegF.
c. Provide dielectric gaskets suitable for continuous operation at union rated temperature and pressure.

B. Dirt Strainers:
1. Y-type.
2. Composition bronze.
3. Rated for test pressure and temperature of system in which they are installed.
4. 20 mesh Monel screen.
5. Threaded bronze plug in the blowoff outlet.
6. Threaded NPT end connections.

C. Strainers for Chemical Applications:
1. Y-type.
2. Strainers of same material, test pressure, and temperature rating as system in which strainer is placed.

D. Reducers:
1. Furnish appropriate size reducers and reducing fittings to mate pipe to equipment connections.
2. Connection size requirements may change from those shown on Drawings depending on equipment furnished.

E. Protective Coating and Lining:
1. Include pipe, fittings, and appurtenances where coatings, linings, paint, tests and other items are specified.
2. Field paint pipe in accordance with Specification Section 09 91 00.

F. Underground Warning Tape:
1. See Specification Section 10 14 00.

G. Pressure Gages:
1. See Specification Section 40 05 05 and Specification Section 40 91 10.

H. Dry Disconnect Couplings:
1. Adapters:
a. Male adapters: Size shown on Drawings.
b. Adapters:
1) Female NPT end connection for sludge and flush applications.

2) Male NPT end connection for chemical applications.
c. Construct adapters for sludge applications from cast iron or steel.
d. Construct adapters for chemical and PVC system applications 3 IN and below from polypropylene.
1) Above 3 IN size, provide stainless steel units.
2. Couplers:
a. Built-in valve and spring loaded poppet which close automatically when disconnected.
b. Designed to remain with only one (1) arm locked in closed position.
c. Construct couplers for sludge applications fabricated from material utilized for adapters.
d. Construct couplers for chemical and PVC system applications 3 IN and less from polypropylene with stainless steel arms and pins.
1) Above 3 IN, provide stainless steel units.
e. Gasket: Compatible with conveyed liquid.
3. Dust caps: For all adapters.

I. Sacrificial Anode Cathodic Protection:
1. 3 LB magnesium sacrificial anodes, prepackaged in a cloth bag containing 75 percent hydrated gypsum, 20 percent bentonite and 5 percent anhydrous sodium sulphate.
2. TW 600 V or an HMWPE insulated copper lead attached to the anode.

J. Valves:
1. See schematics and details for definition of manual valves used in each system under 4 IN in size.
a. See Specification Section 40 05 23 schedule for valve types 4 IN and above and for automatic valves used in each system.
2. See Specification Section 40 05 23.

K. Expansion Joints at FRP and Poly Tanks:
1. Materials:
a. Bellows: PTFE-62.
b. Flanges: PVC, ductile iron.
c. Limit bolts and nuts: 316 stainless steel.
d. Reinforcing rings: Stainless steel.
2. Pressure rating at 70 DegF: 70 psig.
3. Minimum axial movement: 3/8 IN.

PART 3 - EXECUTION

3.1 EXTERIOR BURIED PIPING INSTALLATION

A. Unless otherwise shown on the Drawings, provide a minimum of 3 FT and maximum of 6 FT earth cover over exterior buried piping systems and appurtenances conveying water, fluids, or solutions subject to freezing.

B. Enter and exit through structure walls, floors, and ceilings by using penetrations and seals specified in Specification Section 01 73 20 and as shown on Drawings.

C. When entering or leaving structures with buried mechanical joint piping, install joint within 2 FT of point where pipe enters or leaves structure.
1. Install second joint not more than 6 FT nor less than 4 FT from first joint.

D. Install expansion devices as necessary to allow expansion and contraction movement.

E. Laying Pipe In Trench:
1. Excavate and backfill trench in accordance with Specification Section 31 21 33.
2. Clean each pipe length thoroughly and inspect for compliance to specifications.
3. Grade trench bottom and excavate for pipe bell and lay pipe on trench bottom.

4. Install gasket or joint material according to manufacturer's directions after joints have been thoroughly cleaned and examined.
5. Except for first two (2) joints, before making final connections of joints, install two (2) full sections of pipe with earth tamped along side of pipe or final with bedding material placed.
6. Lay pipe in only suitable weather with good trench conditions.
    a. Never lay pipe in water except where approved by Engineer.
7. Seal open end of line with watertight plug if pipe laying stopped.
8. Remove water in trench before removal of plug.

F. Lining Up Push-On Joint Piping:
1. Lay piping on route lines shown on Drawings.
2. Deflect from straight alignments or grades by vertical or horizontal curves or offsets.
3. Observe maximum deflection values stated in manufacturer's written literature.
4. Provide special bends when specified or where required alignment exceeds allowable deflections stipulated.
5. Install shorter lengths of pipe in such length and number that angular deflection of any joint, as represented by specified maximum deflection, is not exceeded.

G. Anchorage and Blocking:
1. Provide reaction blocking, anchors, joint harnesses, or other acceptable means for preventing movement of piping caused by forces in or on buried piping tees, wye branches, plugs, or bends.
2. Place concrete blocking so that it extends from fitting into solid undisturbed earth wall.
    a. Concrete blocks shall not cover pipe joints.
3. Provide bearing area of concrete in accordance with drawing detail.

H. Install underground hazard warning tape per Specification Section 10 14 00.

I. Install underground tracer wire per Specification Section 10 14 00.

J. Install insulating components where dissimilar metals are joined together.

3.2 INTERIOR AND EXPOSED EXTERIOR PIPING INSTALLATION

A. Install piping in vertical and horizontal alignment as shown on Drawings.

B. Alignment of piping smaller than 4 IN may not be shown; however, install according to Drawing intent and with clearance and allowance for:
1. Expansion and contraction.
2. Operation and access to equipment, doors, windows, hoists, moving equipment.
3. Headroom and walking space for working areas and aisles.
4. System drainage and air removal.

C. Enter and exit through structure walls, floor and ceilings using penetrations and seals specified in Specification Section 01 73 20 and as shown on the Drawings.

D. Install vertical piping runs plumb and horizontal piping runs parallel with structure walls.

E. Pipe Support:
1. Use methods of piping support as shown on Drawings and as required in Specification Section 40 05 16.
2. Where pipes run parallel and at same elevation or grade, they may be grouped and supported from common trapeze-type hanger, provided hanger rods are increased in size as specified for total supported weight.
    a. The pipe in the group requiring the least maximum distance between supports shall set the distance between trapeze hangers.
3. Size pipe supports with consideration to specific gravity of liquid being piped.

F. Locate and size sleeves and castings required for piping system.
1. Arrange for chases, recesses, inserts or anchors at proper elevation and location.

G. Use reducing fittings throughout piping systems.
   1. Bushings will not be allowed unless specifically approved.

H. Equipment Drainage and Miscellaneous Piping:
   1. Provide drip pans and piping at equipment where condensation may occur.
   2. Hard pipe stuffing box leakage to nearest floor drain.
   3. Avoid piping over electrical components such as motor control centers, panelboards, etc.
      a. If piping must be so routed, utilize 16 GA, 316 stainless steel drip pan under piping and over full length of electrical equipment.
      b. Hard pipe drainage to nearest floor drain.
   4. Collect system condensate at drip pockets, traps and blowoff valves.
   5. Provide drainage for process piping at locations shown on Drawings in accordance with Drawing details.
   6. For applications defined above and for other miscellaneous piping which is not addressed by a specific piping service category in PART 1, provide 304 stainless steel piping and fittings.
      a. Size to handle application with 3/4 IN being minimum size provided.

I. Unions:
   1. Install in position which will permit valve or equipment to be removed without dismantling adjacent piping.
   2. Mechanical type couplings may serve as unions.
   3. Additional flange unions are not required at flanged connections.

J. Install expansion devices as necessary to allow expansion/contraction movement.

K. Provide full face gaskets on all systems.

L. Anchorage and Blocking:
   1. Block, anchor, or harness exposed piping subjected to forces in which joints are installed to prevent separation of joints and transmission of stress into equipment or structural components not designed to resist those stresses.

M. Equipment Pipe Connections:
   1. Equipment - General:
      a. Exercise care in bolting flanged joints so that there is no restraint on the opposite end of pipe or fitting which would prevent uniform gasket pressure at connection or would cause unnecessary stresses to be transmitted to equipment flanges.
      b. Where push-on joints are used in conjunction with flanged joints, final positioning of push-on joints shall not be made until flange joints have been tightened without strain.
      c. Tighten flange bolts at uniform rate which will result in uniform gasket compression over entire area of joint.
         1) Provide tightening torque in accordance with manufacturer's recommendations.
      d. Support and match flange faces to uniform contact over their entire face area prior to installation of any bolt between the piping flange and equipment connecting flange.
      e. Permit piping connected to equipment to freely move in directions parallel to longitudinal centerline when and while bolts in connection flange are tightened.
      f. Align, level, and wedge equipment into place during fitting and alignment of connecting piping.
      g. Grout equipment into place prior to final bolting of piping but not before initial fitting and alignment.
      h. To provide maximum flexibility and ease of alignment, assemble connecting piping with gaskets in place and minimum of four (4) bolts per joint installed and tightened.
         1) Test alignment by loosening flange bolts to see if there is any change in relationship of piping flange with equipment connecting flange.
         2) Realign as necessary, install flange bolts and make equipment connection.
      i. Provide utility connections to equipment shown on Drawings, scheduled or specified.
   2. Plumbing and HVAC equipment:

a. Make piping connections to plumbing and HVAC equipment, including but not limited to installation of fittings, strainers, pressure reducing valves, flow control valves and relief valves provided with or as integral part of equipment.
b. Furnish and install sinks, fittings, strainers, pressure reducing valves, flow control valves, pressure relief valves, and shock absorbers which are not specified to be provided with or as integral part of equipment.
c. For each water supply piping connection to equipment, furnish and install union and gate or angle valve.
    1) Provide wheel handle stop valve at each laboratory sink water supply.
    2) Minimum size: 1/2 IN.
d. Furnish and install "P" trap for each waste piping connection to equipment if waste is connected directly to building sewer system.
    1) Size trap as required by IPC.
e. Stub piping for equipment, sinks, lavatories, supply and drain fittings, key stops, "P" traps, miscellaneous traps and miscellaneous brass through wall or floor and cap and protect until such time when later installation is performed.

N. Provide insulating components where dissimilar metals are joined together.

O. Instrument Connections:
1. See drawing details.

3.3 CONNECTIONS WITH EXISTING PIPING

A. Where connection between new work and existing work is made, use suitable and proper fittings to suit conditions encountered.

B. Perform connections with existing piping at time and under conditions which will least interfere with service to customers affected by such operation.

C. Undertake connections in fashion which will disturb system as little as possible.

D. Provide suitable equipment and facilities to dewater, drain, and dispose of liquid removed without damage to adjacent property.

E. Where connections to existing systems necessitate employment of past installation methods not currently part of trade practice, utilize necessary special piping components.

F. Where connection involves potable water systems, provide disinfection methods as prescribed in this Specification Section.

G. Once tie-in to each existing system is initiated, continue work continuously until tie-in is made and tested.

3.4 ACCESS PROVISIONS

A. Provide access doors or panels in walls, floors, and ceilings to permit access to valves, piping and piping appurtenances requiring service.

B. Size of access panels to allow inspection and removal of items served, minimum 10 x 14 IN size.

C. Fabricate door and frame of minimum 14 GA, stretcher leveled stock, cadmium plated or galvanized after fabrication and fitted with screw driver lock of cam type.

D. Provide with key locks, keyed alike, in public use areas.

E. Furnish panels with prime coat of paint.

F. Style and type as required for material in which door installed.

G. Where door is installed in fire-rated construction, provide door bearing UL label required for condition.

3.5 HEAT TRACING

A. See Specification Section 40 41 13 - Heat Tracing Cable.

3.6 PRESSURE GAGES

A. Provide at locations shown on the Drawings and specified.

B. See Specification Section 40 05 05.

3.7 FIELD QUALITY CONTROL

A. Pipe Testing - General:
1. Test piping systems as follows:
    a. Test exposed, non-insulated piping systems upon completion of system.
    b. Test exposed, insulated piping systems upon completion of system but prior to application of insulation.
    c. Test concealed interior piping systems prior to concealment and, if system is insulated, prior to application of insulation.
    d. Test buried piping (insulated and non-insulated) prior to backfilling and, if insulated, prior to application of insulation.
2. Utilize pressures, media and pressure test durations as specified in the PIPING SPECIFICATION SCHEDULES.
3. Isolate equipment which may be damaged by the specified pressure test conditions.
4. Perform pressure test using calibrated pressure gages and calibrated volumetric measuring equipment to determine leakage rates.
    a. Select each gage so that the specified test pressure falls within the upper half of the gage's range.
    b. Notify the Engineer 24 HRS prior to each test.
5. Completely assemble and test new piping systems prior to connection to existing pipe systems.
6. Acknowledge satisfactory performance of tests and inspections in writing to Engineer prior to final acceptance.
7. Bear the cost of all testing and inspecting, locating and remedying of leaks and any necessary retesting and re-examination.

B. Pressure Testing:
1. Testing medium: Unless otherwise specified in the PIPING SPECIFICATION SCHEDULES, utilize the following test media.
    a. Process and plant air systems:

PIPE LINE SIZE	SPECIFIED TEST PRESSURE	TESTING MEDIUM
2 IN and smaller	75 psi or less	Air or water
2 IN and smaller	Greater than 75 psi	Water
Greater than 2 IN	3 psi or less	Air or water
Greater than 2 IN	Greater than 3 psi	Water

    b. Laboratory gases and natural gas systems: Cylinder nitrogen.
    c. Liquid systems:

PIPE LINE SIZE (DIA)	GRAVITY OR PUMPED	SPECIFIED TEST PRESSURE	TESTING MEDIUM
Up to and including 48 IN	Gravity	25 psig or less	Air or water
Above 48 IN	Gravity	25 psig or less	Water
All sizes	Pumped	250 psig or less	Water

2. Allowable leakage rates:

a. Hazardous gas systems, all exposed piping systems, all pressure piping systems and all buried, insulated piping systems which are hydrostatically pressure tested shall have zero leakage at the specified test pressure throughout the duration of the test.
b. Hydrostatic exfiltration and infiltration for sanitary and stormwater sewers (groundwater level is below the top of pipe):
   1) Leakage rate: 200 GAL per inch diameter per mile of pipe per day at average head on test section of 3 FT.
   2) Average head is defined from groundwater elevation to average pipe crown.
   3) Acceptable test head leakage rate for heads greater than 3 FT: Acceptable leakage rate (gallons per inch diameter per mile per day) equals 115 by (actual test head to the 1/2 power).
c. Hydrostatic infiltration test for sanitary and stormwater sewers (groundwater level is above the top of pipe):
   1) Allowable leakage rate: 200 GAL per inch diameter per mile of pipe per day when depth of groundwater over top of pipe is 2 to 6 FT.
   2) Leakage rate at heads greater than 6 FT: Allowable leakage rate (gallons per inch diameter per mile of pipe per day) equals 82 by (actual head to the 1/2 power).
d. Large diameter (above 48 IN) gravity plant piping systems shall have a maximum exfiltration of 25 gpd per inch-mile.
e. Non-hazardous gas and air systems which are tested with air shall have a maximum pressure drop of 5 percent of the specified test pressure throughout the duration of the test.
f. For low pressure (less than 25 psig) air testing, the acceptable time for loss of 1 psig of air pressure shall be:

PIPE SIZE (IN DIA)	TIME, MINUTES/100 FT
4	0.3
6	0.7
8	1.2
10	1.5
12	1.8
15	2.1
18	2.4
21	3.0
24	3.6
27	4.2
30	4.8
33	5.4
36	6.0
42	7.3
48	7.6

3. Hydrostatic pressure testing methodology:
   a. General:
      1) All joints, including welds, are to be left exposed for examination during the test.
      2) Provide additional temporary supports for piping systems designed for vapor or gas to support the weight of the test water.
      3) Provide temporary restraints for expansion joints for additional pressure load under test.
      4) Isolate equipment in piping system with rated pressure lower than pipe test pressure.
      5) Do not paint or insulate exposed piping until successful performance of pressure test.
   b. Soil, waste, drain and vent systems:

1) Test at completion of installation of each stack or section of piping by filling system with water and checking joints and fittings for leaks.
2) Eliminate leaks before proceeding with work or concealing piping.
3) Minimum test heights shall be 10 FT above highest stack inlet.

c. Larger diameter (above 36 IN) gravity plant piping:
1) Plug downstream end of segment to be tested.
a) Provide bracing as required.
2) Fill segment and upstream structure to normal operating level as per hydraulic profile.
3) Allow 24 HRS for absorption losses.
a) Refill to original level.
4) Provide reservoir to maintain constant head over duration of test.
5) Record reservoir water volume at beginning and end of test.

4. Natural gas systems - testing methodology:
a. Maintain specified test pressure until each joint has been thoroughly examined for leaks by means of soap suds and glycerine.
b. Wipe joints clean after test.

5. Air testing methodology:
a. General:
1) Assure air is ambient temperature.

b. Low pressure air testing:
1) Place plugs in line and inflate to 25 psig.
2) Check pneumatic plugs for proper sealing.
3) Introduce low pressure air into sealed line segment until air pressure reaches 4 psig greater than ground water that may be over the pipe.
a) Use test gage conforming to ASME B40.100 with 0 to 15 psi scale and accuracy of 1 percent of full range.
4) Allow 2 minutes for air pressure to stabilize.
5) After stabilization period (3.5 psig minimum pressure in pipe) discontinue air supply to line segment.
6) Record pressure at beginning and end of test.

C. Dielectric Testing Methods and Criteria:
1. Provide electrical check between metallic non-ferrous pipe or appurtenances and ferrous elements of construction to assure discontinuity has been maintained.
2. Wherever electrical contact is demonstrated by such test, locate the point or points of continuity and correct the condition.

3.8 CLEANING, DISINFECTION AND PURGING

A. Cleaning:
1. Clean interior of piping systems thoroughly before installing.
2. Maintain pipe in clean condition during installation.
3. Before jointing piping, thoroughly clean and wipe joint contact surfaces and then properly dress and make joint.
4. Immediately prior to pressure testing, clean and remove grease, metal cuttings, dirt, or other foreign materials which may have entered the system.
5. At completion of work and prior to Final Acceptance, thoroughly clean work installed under these Specifications.
a. Clean equipment, fixtures, pipe, valves, and fittings of grease, metal cuttings, and sludge which may have accumulated by operation of system, from testing, or from other causes.
b. Repair any stoppage or discoloration or other damage to parts of building, its finish, or furnishings, due to failure to properly clean piping system, without cost to Owner.

6. After erection of piping and tubing, but prior to installation of service outlet valves, blow natural gas, liquefied petroleum gas, and digester gas systems clear of free moisture and foreign matter by means of air, nitrogen or carbon dioxide.
    a. Oxygen shall never be used.
7. Clean chlorine piping in accordance with CI Pamphlet 6.
8. Purge all neat liquid polymer tubing or piping between the neat polymer storage tank or tote and the polymer blending units with mineral oil to remove residual water prior to introducing neat polymer. Following purging, drain as much of the mineral oil out of the system as possible. Dispose of purged fluids and waste mineral oil in accordance with local environmental regulations.

B. Disinfection of Potable Water Systems:
1. After favorable performance of pressure test and prior to Final Acceptance, thoroughly flush entire potable water piping system including supply, source and any appurtenant devices and perform disinfection as prescribed.
2. Perform work, including preventative measures during construction, in full compliance with AWWA C651.
3. Perform disinfection using sodium hypochlorite complying with AWWA B300.
4. Flush each segment of system to provide flushing velocity of not less than 2.5 FT per second.
5. Drain flushing water to sanitary sewer.
    a. Do not drain flushing water to receiving stream.
6. Use continuous feed method of application.
    a. Tag system during disinfection procedure to prevent use.
7. After required contact period, flush system to remove traces of heavily chlorinated water.
8. After final flushing and before placing water in service, obtain an independent laboratory approved by the Owner to collect samples and test for bacteriological quality.
    a. Repeat entire disinfection procedures until satisfactory results are obtained.
9. Secure and deliver to Owner, satisfactory bacteriological reports on samples taken from system.
    a. Ensure sampling and testing procedures are in full compliance to AWWA C651, local water purveyor and applicable requirements of State of New Mexico.

C. Purging Digester gas:
1. Existing piping:
    a. Turn off gas supply.
    b. Vent line pressure outdoors.
    c. If section exceeds the following, then remaining gas shall be displaced with an inert gas.
        1) 50 FT for 2-1/2 IN pipe.
        2) 30 FT for 3 IN pipe.
        3) 15 FT for 4 IN pipe.
        4) 10 FT for 6 IN pipe.
        5) Any length for 8 IN or larger pipe.
2. New piping:
    a. Including but not limited to:
        1) All fuel gas piping.
        2) Digesters.
        3) Digester gas equipment.
        4) Fuel gas trains.
    b. Purge air filled system with fuel gas:
        1) Providing piping length is less than:
            a) 30 FT for 3 IN pipe.
            b) 15 FT for 4 IN pipe.
            c) 10 FT for 6 IN pipe.
            d) Any length for 8 IN and larger pipe.

2) Providing a moderately rapid and continuous flow of fuel gas is introduced.
a) Introduce fuel gas at one (1) end.
b) Vent air at opposite end.
3) Provided fuel gas flow is continuous without interruption until vented gas is free of air.
4) The point of discharge shall not be left unattended during purging.
c. If the piping is 3 IN or larger and exceeds lengths stated above.
1) Purge air with inert gas in accordance with NFPA 54 and NFPA 69.
2) Purge inert gas with fuel gas.
3. Discharge of purged gases:
a. Open end of piping shall not discharge into confined spaces or areas where there are sources of ignition.

3.9 LOCATION OF BURIED OBSTACLES

A. Furnish exact location and description of buried utilities encountered and thrust block placement.

B. Reference items to definitive reference point locations such as found property corners, entrances to buildings, existing structure lines, fire hydrants and related fixed structures.

C. Include such information as location, elevation, coverage, supports and additional pertinent information.

D. Incorporate information on "As-Recorded" Drawings.

3.10 PIPE INSULATION

A. Insulate pipe and pipe fittings in accordance with Specification Section 40 42 00.

3.11 SCHEDULES

A. PIPING SPECIFICATION SCHEDULE - SYSTEM 1 - NOT USED-

B. PIPING SPECIFICATION SCHEDULE - SYSTEM 2 - NOT USED-

C. PIPING SPECIFICATION SCHEDULE - SYSTEM 3
1. General:
a. Piping symbol and service:
1) TWAS – Thickened Waste Activated Sludge
2) DS – Digested Sludge
3) OF – Overflow
4) SCM - Scum
b. Test requirements:
1) Test medium: Water.
2) Pressure:
a) See Table A.
3) Duration: 6 HRS.
c. Gaskets:
1) Flanged, push-on and mechanical joints (ductile iron): Rubber, AWWA C111.
2) Grooved coupling joints (ductile and steel): Rubber, AWWA C606.
2. System components:
a. Pipe size: 3 through 36 IN.
1) Exposed service:
a) Material: Ductile iron. Class 53 if flanged. If grooved type joint system, use pipe thickness per AWWA C606.
b) Reference: ANSI C115.
c) Lining: Glass lining.
d) Coating: HPIC, See Specification Section 09 96 00.
e) Fittings: Either ANSI C110 ductile or gray iron.

f) Joints: Flanged or grooved type mechanical coupling (AWWA C606) joints. With both systems, provide screwed-on flanges at equipment, valves and structure penetrations. Provide harnessed couplings where indicated on Contract Drawings.

2) Buried service:
   a) Materials: Ductile iron, Pressure Class 250.
   b) Reference: ANSI C151.
   c) Lining: Glass lining.
   d) Coating: Bituminous.
   e) Fittings: Either ANSI C110 ductile or gray iron. Optional ANSI C153 ductile iron compact fittings for sizes 3 to 16 IN.
   f) Joints: Push-on with mechanical (stuffing box) type joints at fittings and valves for pipe sizes up to 24 IN. Mechanical couplings to be harnessed. For pipe sizes above 24 IN, provide push-on restrained joint pipe connections at joints, fittings, and valves.
   g) Green polyethylene encasement per AWWA C105.

D. PIPING SPECIFICATION SCHEDULE - SYSTEM 4 - NOT USED -

E. PIPING SPECIFICATION SCHEDULE - SYSTEM 5

1. General:
   a. Piping symbol and service:
      1) NG – Natural Gas
   b. Test requirements:
      1) Per Code
   c. Gaskets and O-rings: EPDM.
2. System components:
   a. Pipe size: Through 26 IN.
      1) Exposed service:
         a) Material: Steel, Grade B, black. Schedule 40.
         b) Reference: ASTM A53.
         c) Lining: None.
         d) Coating: HPIC, See Specification 09 9600
         e) Fittings: Malleable iron meeting ASTM 197, ANSI B16.3 Class 150.
         f) Joints: Threaded ANSI B16.9 steel butt- or socket-welded joints.
      2) Buried service:
         a) Materials: Polyethylene.
         b) Reference: ASTM D2513.
         c) Lining: None.
         d) Coating: None.
         e) Fittings: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.
         f) Joints: Fusion jointing system or as directed by local gas company.
3. Natural Gas Piping Installation:
   a. Install piping in accordance with NFPA, local gas company regulations, codes and local ordinances, complete with necessary appurtenances.
   b. Install buried pipe at approximately 30 IN deep.
   c. Gas cocks:
      1) Install before gas utilization equipment connected to system, at each branch main and at connection to meter.
      2) Design to operate safely under pressures indicated.
      3) Install ground joint unions at intervals to facilitate repairs.
      4) Cocks shall be of type and lubricant recommended by manufacturer for this class of service, and as approved by local gas company.
   d. Pipe drainage:
      1) Drain horizontal piping to risers.

2) Locate drains where required for system drainage.
3) Install tee fitting with bottom outlet plugged or provide with threaded, capped nipple at bottom of risers or in accordance with applicable codes.

e. Make piping connections with shellacked joints or ground joint unions.
f. Provide vents from gas regulators, pressure reducing valves, and other vented devices to the outdoors and terminate in accordance with applicable codes.
g. Connect piping to pressure reducing valve outside each building as shown on drawings and schedule.
h. Provide flexible connections to vibration isolated equipment suitable for pressures, local and national codes and intended application.
i. Remove cutting and threading burrs.
j. Plug each gas outlet (including valves) with threaded plugs or caps immediately after installation and retain until the piping or equipment connections are completed.
k. Continuously ground gas piping electrically, bond tightly to the grounding connection.
l. Install piping parallel to other piping, but maintain a minimum 12 IN clearance between gas piping and any piping that could reach 200 DEGF.
m. All gas piping in air plenums to be all-welded and encased in a Schedule 40 pipe sleeve.
   1) Ends of the sleeve open to atmosphere or sealed with the annullus vented (gas pipe size) to atmosphere.

F. PIPING SPECIFICATION SCHEDULE - SYSTEM 6

1. General:
   a. Piping symbol and service
      1) HWS – Hot Water Supply
      2) HWR – Hot Water Return
   b. Test requirements pressure lines:
      1) Test medium: Water.
      2) Pressure: See Table A.
      3) Duration: 6 HRS.
2. System components:
   a. Pipes size: Through 26 IN.
      1) Exposed service:
         a) Material:
            (1) Threaded: Steel, Grade B, black. Schedule 40.
            (2) Grooved type joint system: Use pipe thickness per AWWA C606.
         b) Reference: ASTM A53.
         c) Lining: None.
         d) Coating: HPIC, See Specification Section 09 96 00.
         e) Fittings: Malleable iron or steel meeting ASTM A234 and ANSI B16.3 or steel meeting ASTM A106, Grade B.
         f) Joints:
            (1) Threaded or grooved type mechanical coupling (AWWA C606) joints.
            (2) Provide rigid flanges at equipment, valves and structure penetrations above 2 IN and unions at those locations 2 IN and below.
      2) Buried service:
         a) Materials: Steel, Grade B, black. Schedule 40.
         b) Reference: ASTM A53.
         c) Lining: None.
         d) Coating: Bituminous.
         e) Fittings: Malleable iron or steel meeting ASTM A234 and ANSI B16.3 or steel meeting ASTM A106, Grade B.
         f) Joints: Threaded.

G. PIPING SPECIFICATION SCHEDULE - SYSTEM 7 – NOT USED –

H. PIPING SPECIFICATION SCHEDULE - SYSTEM 8 – NOT USED –

I. PIPING SPECIFICATION SCHEDULE - SYSTEM 9

1. General:
    a. Piping symbol and service:
        1) NPW – Non-Potable Water
    b. Test requirements:
        1) Test medium: Water.
        2) Pressure: 125 psig.
        3) Duration: 6 HRS.
2. System components:
    a. Pipe size to 1 IN:
        1) Exposed service:
            a) Materials: Stainless steel tubing, TP-304L.
            b) Reference: ASTM A269.
            c) Lining: None.
            d) Coating: None.
            e) Fittings: Stainless steel 304L compression type tube fittings.
            f) Joints: Compression type couplings, unions at equipment and valves.
            g) Minimum wall thickness:
                (1) 1/16 IN OD: 0.010 IN.
                (2) 1/8 to 1/4 IN OD: 0.028 IN.
                (3) 5/16 to 1/2 IN OD: 0.049 IN.
                (4) 5/8 to 1 IN OD: 0.065 IN.
    b. Pipe size 1 IN to 3 IN:
        1) Exposed service:
            a) Materials:
                (1) Threaded: Galvanized Steel, Schedule 40.
                (2) Grooved type joint system: Use pipe thickness per AWWA C606.
            b) Reference: ASTM A53.
            c) Lining: Galvanized.
            d) Coating: HPIC, See Specification Section 09 96 00.
            e) Fittings: Malleable iron or steel meeting ASME B16.3 and ASTM A234.
            f) Joints:
                (1) Threaded or grooved type mechanical coupling (AWWA C606) joints.
                (2) With both systems, provide rigid flanges at equipment, valves and structure penetrations above 2 IN and unions at those locations 2 IN and below.
        2) Buried service:
            a) Materials: Steel, Schedule 40, Grade B.
            b) Reference: ASTM A53.
            c) Lining: None.
            d) Coating: Bituminous.
            e) Fittings: Malleable iron meeting ASME B16.3.
            f) Joints: Threaded.
    c. Pipe size 3 IN through 24 IN:
        1) Exposed service:
            a) Materials:
                (1) Flanged: Ductile iron.
                (2) Grooved type mechanical joint system: Use pipe thickness per AWWA C606.
            b) Reference: AWWA/ANSI C115/A21.15.
            c) Lining: Cement.
            d) Coating: HPIC; See Specification Section 09 96 00.
            e) Fittings: Either AWWA/ANSI C110/A21.10 ductile or gray iron.

f) Joints:
   (1) Flanged or grooved type mechanical coupling (AWWA C606) joints.
   (2) With both systems, provide screwed-on flanges at valves, equipment and structure penetration.

2) Buried service:
   a) Materials: Ductile iron.
   b) Reference: AWWA/ANSI C151/A21.51.
   c) Lining: Cement.
   d) Coating: Bituminous.
   e) Fittings:
      (1) Either AWWA/ANSI C110/A21.10 ductile or gray iron.
      (2) Optional: AWWA/ANSI C153/A21.53 ductile iron compact fittings for sizes 3 IN to 16 IN.
   f) Joints: Push-on with mechanical (stuffing box type) joint at fittings and valves.

J. PIPING SPECIFICATION SCHEDULE - SYSTEM 10

1. General:
   a. Piping symbol and service:
      1) PW – Potable Water
      2) CW – City Water
      3) W - Water
   b. Test requirements:
      1) Test medium: Water.
      2) Pressure: See Table A.
      3) Duration: 6 HRS.
   c. Gaskets and O-rings:
      1) O-rings: Neoprene or rubber.
      2) Flanged, push-on and mechanical joints (ductile iron): Rubber, AWWA C111.
      3) Flanged joints (steel): Rubber, ANSI C207.
      4) Grooved coupling joints (ductile and steel): Rubber, AWWA C606.
2. System components:
   a. Pipe size: To 3 IN.
      1) Exposed service:
         a) Material: Copper tubing, Type L.
         b) Solder: Cadmium and lead-free solder compatible with tubing and fittings materials.
         c) Reference: ASTM B88.
         d) Lining: None.
         e) Coating: HPIC, See Specification Section 09 96 00.
         f) Fittings: Wrought copper or bronze fittings meeting ANSI B16.22.
         g) Joints: Soldered or brazed with unions at valves and equipment.
      2) Buried service:
         a) Material: Copper tubing, Type K.
         b) Reference: ASTM B88.
         c) Lining: None.
         d) Coating: None.
         e) Fittings: ANSI B16.22 or B16.26.
         f) Joints: Flared.
   b. Pipe size 3 IN through 24 IN:
      1) Exposed service:
         a) Materials:
            (1) Flanged: Ductile iron.
            (2) Grooved type mechanical joint system: Use pipe thickness per AWWA C606.

b) Reference: AWWA/ANSI C115/A21.15.
c) Lining: Cement.
d) Coating: HPIC; See Specification Section 09 96 00.
e) Fittings: Either AWWA/ANSI C110/A21.10 ductile or gray iron.
f) Joints:
(1) Flanged or grooved type mechanical coupling (AWWA C606) joints.
(2) With both systems, provide screwed-on flanges at valves, equipment and structure penetration.

2) Buried service:
a) Materials: Ductile iron.
b) Reference: AWWA/ANSI C151/A21.51.
c) Lining: Cement.
d) Coating: Bituminous.
e) Fittings:
(1) Either AWWA/ANSI C110/A21.10 ductile or gray iron.
(2) Optional: AWWA/ANSI C153/A21.53 ductile iron compact fittings for sizes 3 IN to 16 IN.
f) Joints: Push-on with mechanical (stuffing box type) joint at fittings and valves.

3. Install drain tees with capped nipples of IPS brass 3 IN long at low points. If low point occurs in concealed piping, provide approved flush access panel. These drains are not shown on Drawings.
4. Slope water lines down to drain points not less than 1 IN in 60 FT.
5. Install all threaded piping with clean-cut tapered threads and with ends thoroughly reamed after cutting to remove burrs. Pipe joint cement permitted only on external threads.
6. For screwed nipples for connections to flush valves, lavatory supplies, and other equipment with threaded connections use iron, copper, or brass pipe.
7. Install ball, butterfly and plug valves where indicated or required to adequately service all parts of system and equipment.
a. Install valves on each branch serving restroom.
b. Install valves on inlet and outlet connections of heat exchangers and on other equipment connected to water lines.
8. Install unions between valves and connections to each piece of equipment, and install sufficient number of unions throughout piping system to facilitate installation and servicing. On copper pipe lines, install wrought, solder-joint, copper to copper unions for lines 2 IN and smaller and, for lines 2-1/2 IN and over install brass flange unions.
9. Construct and equip plumbing fixtures and equipment with anti-siphon devices as to entirely eliminate any danger of siphoning waste material into potable water supply system.
10. Where exposed pipes 6 IN in size and smaller pass through floors, finished walls, or finished ceilings, fit with nickel or chrome-plated plates large enough to completely close hole around pipes. Secure plates to pipe by set screw in approved manner.
11. Size supply branches to individual fixtures as scheduled or indicated on Drawings.
12. Install piping so as to be free to expand with proper loops, anchors and joints without injury to system or structure.
13. Provide branches to wall hydrants or hose bibbs in exterior locations with interior shutoff and drain valves.
14. Provide approved type vacuum breaker and backflow preventer installations indicated or as required by Code.
15. Install concealed in finished structures such as administration and office facilities and at locations shown on Drawings.

K. PIPING SPECIFICATION SCHEDULE - SYSTEM 11
1. General:
a. Piping symbol and service
1) RWE – Reuse Water

b. Test requirements:
   1) Test medium: Water.
   2) Pressure:
      a) See Table A.
   3) Duration: 6 HRS.
c. Gaskets:
   1) Flanged, push-on and mechanical joints (ductile iron): Rubber, AWWA C111.
   2) Grooved coupling joints (ductile and steel): Rubber, AWWA C606.

2. System components:
   a. Pipe size: 3 through 36 IN.
      1) Buried service:
         a) Materials: : PVC AWWA C900 DR 18 – 4”-12”.
         b) Not used
         c) Lining: NA
         d) Coating: NA
         e) Fittings: Either ANSI C110 ductile or gray iron. Optional ANSI C153 ductile iron compact fittings for sizes 3 to 16 IN.
         f) Joints: Pipe supplier shall calculated length of pipe required to be restrained . All fittings and push-on joints within the calculated distance from a fitting shall be restrained with MEGA LUG type restraining glands.
         g) See Section 40 05 31.

L. PIPING SPECIFICATION SCHEDULE - SYSTEM 12 – NOT USED -

M. PIPING SPECIFICATION SCHEDULE - SYSTEM 13

1. General:
   a. Piping symbol and service:
      1) DG –Digester Gas
   b. Test requirements:
      1) Test medium: Air.
      2) Pressure: 10 psig.
      3) Duration: 6 HRS.
   c. Gaskets:
      1) Flanged joints: AISI 304 stainless steel, spiral wound, non-asbestos filler, 3/16 IN thick with compression ring to match required flange dimensions.
2. System components:
   a. Pipe size 1 IN and greater:
      1) Exposed service:
         a) Material: Stainless steel, Schedule 10S, Grade TP316L.
         b) References: ASTM A312, ASME B36.19.
         c) Lining: None.
         d) Coating: None.
         e) Fittings: Butt welded stainless meeting ASTM A774.
         f) Joints: Butt welded with ASTM A182 stainless steel flanges at equipment and valves.
      2) Buried service:
         a) Material: Stainless steel, Schedule 40S, Grade TP316L.
         b) References: ASTM A312, ASME B36.19.
         c) Lining: None.
         d) Coating: None.
         e) Fittings: Butt welded stainless meeting ASTM A774.
         f) Joints: Butt welded.

N. PIPING SPECIFICATION SCHEDULE - SYSTEM 14 – NOT USED

O. PIPING SPECIFICATION SCHEDULE - SYSTEM 21

1. General:
   a. Piping symbol and service:
      1) DR – Drain
      2) SAN – Sanitary
      3) V - Vent
   b. Test requirements:
      1) Test medium: Water.
      2) Pressure: See Table A.
      3) Duration: 6 HRS.
   c. Gaskets: Rubber, ASTM C564.
2. System components:
   a. Pipe size: 1-1/4 and 1-1/2 IN:
      1) Exposed service.
         a) Material: Galvanized steel, Schedule 40.
         b) Reference: ASTM 53.
         c) Lining: Galvanized.
         d) Coating: HPIC, See Specification Section 09 96 00.
         e) Fittings: Cast iron drainage.
            (1) ASTM A126, Class B.
         f) Joints: Threaded.
   b. Pipe size: 2 IN and larger:
      1) Exposed service.
         a) Material: Cast iron soil pipe.
         b) Reference: ASTM A74, CISPI 301.
         c) Lining: None.
         d) Coating: HPIC; See Specification Section 09 96 00.
         e) Fittings: ASTM A74.
         f) Joints: No-hub with elastomeric sealing sleeve and stainless steel clamp assembly conforming to CISPI 301.
      2) Buried service (to 5 FT outside of structure):
         a) Material: Cast-iron soil pipe.
         b) Reference: ASTM A74.
         c) Lining: None.
         d) Coating: Bituminous.
         e) Fittings: ASTM A74.
         f) Joints: Hub and spigot.

Soil and Waste Piping Installation:

1. Install horizontal soil or waste lines less than 4 IN diameter with a slope of not less than 1/4 IN/FT or 2 percent toward the point of disposal.
2. Install 4 IN and larger piping at 1/8 IN per foot.
3. Install as close to construction as possible to maintain maximum head room.
4. Make changes of direction with 1/8 bends and junctions with wye fittings.
5. Use short wye fittings in vertical pipe only.
6. Install handhole test tee at base of each stack.
7. Install cleanouts at dead ends, at changes of direction and at 50 FT intervals on horizontal runs. Where cleanouts occur in concealed spaces, provide with extensions to floors above or to walls as required.
8. Install piping true to grade and alignment. Begin at the system low point.
9. Locate vertical extensions of underground piping below partition walls for concealment in wall. In locations where hubs are wider than partition, set hubs 1 IN below final floor.
10. Install concealed in finished structures such as administration and office facilities and at locations shown on Drawings.
11. For hub and spigot joints, install hub facing flow.

Vent Piping Installation:

12. Run vent stack parallel to each soil or waste stack to receive branch vents from fixtures.
13. Originate each vent stack from soil or waste pipe at its base.
14. Where possible, combine soil, waste or vent stacks before passing through roof so as to minimize roof openings.
15. Offset pipes running close to exterior walls away from such walls before passing through roof to permit proper flashing.
16. Provide pipes passing through roofs with cast iron increasers minimum of 12 IN below roof one size larger than pipe but in no case less than 4 IN.
17. Terminate each vent with approved frostproof jacket.
18. Carry vent stacks 4 IN and larger full size through roof. Extend vent stacks at least 12 IN above roofing.
19. Pipe vents from pressure regulating devices in compliance with local codes.
20. Install concealed in finished structures such as administration and office facilities and at locations shown on Drawings.

3.12 TABLE A - SERVICE SYSTEM SUMMARY

Service	Symbol	System No.	Construction	Size (in)	Material	Test Pressure (PSI)
Potable Water	PW,W, CW	10	Exposed and Buried	3/4 - 3	Copper	150
Potable Water	PW,W, CW	10	Buried and Exposed	3 - 8	Ductile	150
Hot Water Supply/Return	HWS, HWR	6	Buried and Exposed	ALL	Steel	125
Non-Potable Water	NPW	9	Exposed	To 1	Stainless	125
Non-Potable Water	NPW	9	Buried and Explosed	1 - 3	Steel	125
Non-Potable Water	NPW	9	Buried and Exposed	4 - 8	Ductile	125
Thickened Waste Activated Sludge	TWAS	3	Buried and Exposed	6	DIP / Glass Lined	100
Digested Sludge	DS	3	Buried and Exposed	6	DIP / Glass Lined	100
Overflow	OF	3	Buried and Exposed	6	DIP / Glass Lined	100
Scum	SCM	3	Buried and Exposed	6	DIP / Glass Lined	100
Drain, Sanitary, Vent	DR, SAN, V	21	Exposed	1-1/4 – 1-1/2	Galvanized Steel	
Drain, Sanitary, Vent	DR, SAN, V	21	Buried and Exposed	2 - 8	Cast Iron Soil Pipe	
Natural Gas	NG	5	Exposed	ALL	Steel	25

Natural Gas	NG	5	Buried	ALL	PE	25
Digester Gas	DG	13	Buried and Exposed	–ALL	316L Stainless Steel	10
Reuse Water	RWE	11	Buried	12	PVC	125

END OF SECTION

SECTION 40 05 16
PIPE SUPPORT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe support and anchor systems.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 09 96 00 – High Performance Industrial Coatings.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B31.1, Power Piping.
      b. B31.3, Process Piping.
   2. ASTM International (ASTM):
      a. A36, Standard Specification for Carbon Structural Steel.
      b. A510, Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
      c. A575, Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
      d. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
   3. American Welding Society (AWS):
      a. D1.1, Structural Welding Code - Steel.
   4. Manufacturers Standardization Society of the Valve and Fittings Industry Inc. (MSS):
      a. SP-58, Pipe Hangers and Supports - Materials, Design and Manufacture.
      b. SP-69, Pipe Hangers and Supports - Selection and Application.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
      c. Itemized list of wall sleeves, anchors, support devices and all other items related to pipe support system.
      d. Scale drawings showing guides, hangers, supports, anchors, structural members and appurtenances to describe the pipe support system.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the applicable Articles below are acceptable.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MANUFACTURED UNITS

A. Hanger Rods:
   1. Material:
      a. ASTM A36.
      b. ASTM A510, Grade 1020.
      c. ASTM A575, Grade M1020.
      d. ASTM A576, Grade 1020.
      e. Minimum allowable tensile stress of 12,000 psi at 650 DegF per MSS SP-58.
   2. Continuously threaded.
   3. Electro-galvanized or cadmium plated after threads are cut.
   4. Load limit:

NOMINAL ROD DIAMETER	MAXIMUM SAFE LOAD, (LBS)
3/8 IN DIA (min)	610
1/2 IN DIA	1,130
5/8 IN DIA	1,810
3/4 IN DIA	2,710
7/8 IN DIA	3,770
1 IN DIA	4,960

B. Hangers:
   1. Hangers for use directly on copper pipe: Copper or cadmium plated.
   2. Hangers for use other than directly on copper pipe: Cadmium plated or galvanized.
   3. Hanger type schedule:

APPLICATION	PIPE SIZE	HANGER TYPE
All except noted	4 IN and less	ANVIL Figure 108 with Figure 114
All except noted	Over 4 IN	ANVIL Figure 590
Steam, condensate and hot water	All	ANVIL Figure 181, Figure 82

C. Concrete Inserts for Hanger Rods:
   1. Continuous slots: Unistrut #P1000.
   2. Individual inserts: ANVIL Figure 281.
   3. Self-drilling expansion anchors: Phillips flush-end or snap-off end type.

D. Beam Clamps for Hanger Rods:
   1. Standard duty.
   2. ANVIL Figure 133.

E. Trapeze Hangers for Suspended Piping:
   1. Material: Steel.
   2. Galvanized.
   3. Angles, channels, or other structural shapes.
   4. Curved roller surfaces at support point corresponding with type of hanger required.

F. Vertical Pipe Supports:
   1. At base of riser.
   2. Lateral movement:
      a. Clamps or brackets.

G. Expanding Pipe Supports:
   1. Spring hanger type.
   2. MSS SP-58.

H. Pipe Support Saddle:

1. For pipe located 3 FT or less from floor elevation, except as otherwise indicated on Drawings.
2. ANVIL Figure 264.

I. Pipe Support Risers:
   1. Schedule 40 pipe.
   2. Galvanized.
   3. As recommended by saddle manufacturer.

J. Pipe Support Base Plate:
   1. 4 IN larger than support.
   2. Collar 3/16 IN thickness, circular in shape, and sleeve type connection to pipe.
   3. Collar fitted over outside of support pipe and extended 2 IN from floor plate.
   4. Collar welded to floor plate.
   5. Edges ground smooth.
   6. Assembly hot-dipped galvanized after fabrication.

K. Pipe Covering Protection Saddle:
   1. For insulated pipe at point of support.
   2. ANVIL Figure 167, Type B.

L. Wall Brackets:
   1. For pipe located near walls and 8 FT or more above floor elevation or as otherwise indicated on the Drawings.
   2. ANVIL Figure 199.

M. Pipe Anchors:
   1. For locations shown on the Drawings.
   2. 1/4 IN steel plate construction.
   3. Hot-dipped galvanized after fabrication.
   4. Designed to prevent movement of pipe at point of attachment.

N. Pipe Guides:
   1. For locations on both sides on each expansion joint or loop.
   2. To ensure proper alignment of expanding or contracting pipe.
   3. ANVIL Figure 256.

2.3 DESIGN REQUIREMENTS

A. Supports capable of supporting the pipe for all service and testing conditions.
   1. Provide 5 to 1 safety factor.

B. Allow free expansion and contraction of the piping to prevent excessive stress resulting from service and testing conditions or from weight transferred from the piping or attached equipment.

C. Design supports and hangers to allow for proper pitch of pipes.

D. For chemical and waste piping, design, materials of construction and installation of pipe hangers, supports, guides, restraints, and anchors:
   1. ASME B31.3.
   2. MSS SP-58 and MSS SP-69.
   3. Except where modified by this Specification.

E. For steam and hot and cold water piping, design, materials of construction and installation of pipe hangers, supports, guides, restraints, and anchors:
   1. ASME B31.1.
   2. MSS SP-58 and MSS SP-69.

F. Check all physical clearances between piping, support system and structure.
   1. Provide for vertical adjustment after erection.

G. Support vertical pipe runs in pipe chases at base of riser.

1. Support pipes for lateral movement with clamps or brackets.

H. Place hangers on outside of pipe insulation.
   1. Use a pipe covering protection saddle for insulated pipe at support point.
   2. Insulated piping 1-1/2 IN and less: Provide a 9 IN length of 9 LB density fiberglass insulation at saddle.
   3. Insulated piping over 1-1/2 IN: Provide a 12 IN length of 9 LB density fiberglass insulation on saddle.

I. Provide 20 GA galvanized steel pipe saddle for fiberglass and plastic support points to ensure minimum contact width of 4 IN.

J. Pipe Support Spacing:
   1. General:
      a. Factor loads by specific weight of liquid conveyed if specific weight is greater than water.
      b. Locate pipe supports at maximum spacing scheduled unless indicated otherwise on the Drawings.
      c. Provide at least one (1) support for each length of pipe at each change of direction and at each valve.
   2. Steel, stainless steel, cast-iron pipe support schedule:

PIPE SIZES - IN	MAXIMUM SPAN - FT
1-1/2 and less	5
2 thru 4	10
5 thru 8	15
10 and greater	20

   3. Copper pipe support schedule:

PIPE SIZES - IN	MAXIMUM SPAN - FT
2-1/2 and less	5
3 thru 6	10
8 and greater	15

   4. PVC pipe support schedule:

PIPE SIZES - IN	MAXIMUM SPAN - FT
1-1/4 and less	3
1-1/2 thru 3	4
4 and greater	5

* Maximum fluid temperature of 120 DegF.

   5. Support each length and every fitting:
      a. Bell and spigot piping:
         1) At least one (1) hanger.
         2) Applied at bell.
      b. Mechanical coupling joints:
         1) Place hanger within 2 FT of each side of fittings to keep pipes in alignment.
   6. Space supports for soil and waste pipe and other piping systems not included above every 5 FT.
   7. Provide continuous support for nylon tubing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide piping systems exhibiting pulsation, vibration, swaying, or impact with suitable constraints to correct the condition.
   1. Included in this requirement are movements from:
      a. Trap discharge.
      b. Water hammer.
      c. Similar internal forces.

B. Weld Supports:
   1. AWS D1.1.
   2. Weld anchors to pipe in accordance with ASME B31.3.

C. Locate piping and pipe supports as to not interfere with open accesses, walkways, platforms, and with maintenance or disassembly of equipment.

D. Inspect hangers for:
   1. Design offset.
   2. Adequacy of clearance for piping and supports in the hot and cold positions.
   3. Guides to permit movement without binding.
   4. Adequacy of anchors.

E. Inspect hangers after erection of piping systems and prior to pipe testing and flushing.

F. Install individual or continuous slot concrete inserts for use with hangers for piping and equipment.
   1. Install concrete inserts as concrete forms are installed.

G. Welding:
   1. Welding rods: ASTM and AWS standards.
   2. Integral attachments:
      a. Include welded-on ears, shoes, plates and angle clips.
      b. Ensure material for integral attachments is of good weldable quality.
   3. Preheating, welding and postheat treating: ASME B31.3, Chapter V.

H. Field Painting:
   1. Comply with Specification Section 09 91 00.

END OF SECTION

SECTION 40 05 17

PIPE: COPPER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Copper piping, fittings, and appurtenances.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 31 21 33 - Trenching, Backfilling, and Compacting for Utilities.
   4. Section 40 05 13 - Pipe and Pipe Fittings: Basic Requirements.
   5. Section 40 05 16 - Pipe Support Systems.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B16.22, Wrought Copper and Bronze Solder - Joint Pressure Fittings.
      b. B16.23, Cast Bronze Solder Joint Drainage Fittings - DWV.
      c. B16.26, Cast Bronze Alloy Fittings for Flared Copper Tubes.
   2. ASTM International (ASTM):
      a. B32, Standard Specification for Solder Metal.
      b. B42, Standard Specification for Seamless Copper Pipe, Standard Sizes.
      c. B88, Standard Specification for Seamless Copper Water Tube.
      d. B306, Standard Specification for Copper Drainage Tube (DWV).
   3. American Welding Society (AWS):
      a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.

1.3 SUBMITTALS

A. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

B. See Specification Section 40 05 13.

1.4 MATERIALS

A. Copper Tubing:
   1. Pressure non-buried: ASTM B88, Type L hard.
   2. Pressure buried: ASTM B88, Type K.
   3. Non-pressure: ASTM B306.

B. Copper Pipe: ASTM B42, regular strength.

C. Fittings:
   1. Pressure non-buried: ASME B16.22.
   2. Pressure buried: ASME B16.22 or ASME B16.26.
   3. Non-pressure: ASME B16.23

D. Soldering and Brazing:
   1. Non-buried:
      a. ASTM B32 solder with a tin/antimony ratio of 95/5 and non-corrosive flux up to 180 DegF water temperature.
      b. At 180 DegF and above, use brazing alloy with melting temperature above 1000 DegF and suitable flux.
   2. Buried: Silver solder per AWS A5.8M/A5.8.

E. See Piping Schedules in Specification Section 40 05 00.

F. Unions:
   1. Pipe sizes 2 IN and smaller: Copper, ground joint.
   2. Pipe sizes 2-1/2 IN and larger: Brass flanged unions.

PART 2 - EXECUTION

2.1 INSTALLATION

A. Comply with Specification Section 40 05 05.

2.2 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Specification Section 40 05 13.

B. Utilize only annealed (soft) type tubing where flared joints are used and drawn temper (hard) type tubing where soldered or brazed joints are used.

C. Support exposed piping in accordance with Specification Section 40 05 00 and Specification Section 40 05 16.

D. Install buried piping in accordance with Specification Section 31 21 33 and Specification Section 40 05 00.

END OF SECTION

SECTION 40 05 23
PIPE: STAINLESS STEEL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Stainless steel tubing, piping, fittings and appurtenances.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 40 05 13 - Pipe and Pipe Fittings: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125 and 250).
      b. B31.1, Power Piping.
   2. ASTM International (ASTM):
      a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
      b. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
      c. A312, Standard Specification for Seamless, Welded, and Heavy Cold Worked Austenitic Stainless Steel Pipes.
      d. A320, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service.
      e. A530, Standard Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.
      f. A774, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
      g. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 05 00.
   3. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
   4. Fabrication details and welding procedure specifications for all work to be done under this Specification Section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Tubing:
   1. ASTM A269.
   2. Filler material: Extra low carbon (ELC) with 0.03 percent maximum carbon.

B. Pipe, unless noted otherwise on individual piping system in Specification Section 40 05 00:

1. ASTM A778.
2. ASTM A312.

C. Pipe Fittings:
   1. ASTM A774.

D. Flanges, unless noted otherwise on individual piping system in Specification Section 40 05 00:
   1. Flat faced.
   2. Welding neck or slip on type.
   3. ASTM A182, Type 316L.

E. Nuts, Bolts and Washers, unless noted otherwise on individual piping system in Specification Section 40 05 00:
   1. ASTM A320, Type 316.
   2. Two (2) nuts provided for 1 IN DIA bolt applications and larger.

F. Expansion Joints, unless noted otherwise on individual piping system in Specification Section 40 05 00:
   1. Bellows: 316 stainless steel.
   2. Liner: 316 stainless steel.
   3. Flanges: 316 stainless steel
   4. Control Tie-Rods: 316 stainless steel.

G. Elastomeric Bellows Type Expansion Joint (for hot air service):
   1. Refer to Section 40 05 00 for expansion joints for liquid service.
   2. Manufacturers:
      a. Mercer Series 500 or equal.
   3. Two Arch construction.
   4. Material: EPDM (tube and cover)
   5. Restraint: Provide control rods sized to restrain joint at test pressure.
      a. Materials: 316 stainless steel.
   6. Allow for minimum of 1 IN of lateral movement.
   7. Pressure Rating: Working pressure of joint equal or greater than test pressure of connecting piping. Provide minimum 25 psig rating.

H. Gasket Material, unless noted otherwise on individual piping system in Specification Section 40 05 00:
   1. Rubber or neoprene.
   2. Temperature rating of 250 DegF.

I. Flexible Metal Hose:
   1. General: Braided stainless steel flexible hose.
   2. Connections: Provide ANSI 125 flanged connections.
   3. Length: Minimum 12 IN or as noted on the Drawings.
   4. Pressure: Working pressure of hose equal or greater than test pressure of connecting piping.

2.2 FABRICATION

A. All tube, piping, fitting product to be immersion pickled subsequent to manufacturing and fabrication operations and prior to shipping.
   1. Pickling solution of 6-10 percent nitric acid and 3-4 percent hydrofluoric acid.
   2. Temperature and exact concentrations to be such only a modest etch is produced but all oxidation and ferrous contamination is removed from metal surface.
   3. All pickling solution residues are to be neutralized after pickling.

B. Diameter tolerance and wall thickness tolerance are to conform to ASTM A530.

C. Joints:
   1. Shop welded circumferential buttweld joints.
   2. ASME B16.1, Class 150.

D. Elastomeric Bellows Type Expansion Joints:
1. Ensure aerial travel in expansion joints of 3.1 IN minimum for 15,000 cycles or 5.2 IN for 1000 cycles.
2. Furnish each assembly with a minimum of two control tie rods.
3. Fabricate with 125 LB flanged end connections.

E. Expansion Joints:
1. Fabricate for 15 psi internal pressure and 250 DegF operation.
2. Ensure aerial travel in expansion joints of 3.1 IN minimum for 15,000 cycles or 5.2 IN for 1000 cycles.
3. Furnish each assembly with minimum four control tie rods.
4. Fabricate with 125 LB flanged end connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to installation, inspect and verify condition of piping and appurtenances.
1. Installation constitutes installer's acceptance of condition for satisfactory installation.

3.2 PREPARATION

A. Correct defects or conditions which may interfere with or prevent a satisfactory installation.

B. Ensure ends of pipe to be fitted with flanges have all protrusions ground flush.

3.3 INSTALLATION

A. Ensure all pipe cutting, threading and jointing conforms to requirements of ASME B31.1.
1. Lubricate all pipe threads with Teflon tape.

B. Welding:
1. Provide welds sound and free from embedded scale or slag, and tensile strength at weld not less than pipe.
2. Perform butt welds only with an inert gas shielded process.
3. Adequate inert gas protection is to be provided to the top and under or backside of the weld to protect from atmospheric contamination.
4. Filler metal is to be applied to all manually-performed welds appropriate for the base material being welded.
5. Only inert gas shielded welding processes are to be used for spool fabrication.
6. Provide butt welds with 100 percent penetration to the interior or back side of the weld joint.
7. Weld reinforcement on both sides of the weld are to be smooth, uniform and no more than 1/16 IN in height.

C. Joining Method - Flanges:
1. Leave 1/8 IN to 3/8 IN flange bolts projecting beyond face of nut after tightening.
   a. Coordinate dimensions and drillings of flanges with flanges for valves, equipment, and other systems.
   b. Tighten bolts evenly around pipe until following range of torques is achieved:

BOLT SIZE, IN	RANGES OF TORQUE, FT/LBS
5/8	40 - 60
3/4	60 - 90
1	70 - 100
1-1/4	90 - 120

D. Expansion Joints:
1. Install in accordance with manufacturer's instructions.

2. Apply anti-seize compound to all exposed steel threads.
3. Install when outside temperature is between 50 to 70 degree F.

3.4 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Specification Section 40 05 00.

3.5 CLEANING

A. Clean in accordance with Specification Section 40 05 00.

END OF SECTION

SECTION 40 05 31
PIPE: PLASTIC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Plastic pipe.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 05 13 - Pipe and Pipe Fittings: Basic Requirements.

1.2 QUALITY ASSURANCE

A. See Specification Section 40 05 13.

B. Referenced Standards:
   1. ASTM International (ASTM):
      a. PVC (polyvinyl chloride) materials:
         1) D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
         2) D1785, Standard Specification for Poly(Vinyl Chloride) PVC Plastic Pipe, Schedules 40, 80 and 120.
         3) D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
         4) D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
         5) D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
         6) D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
         7) F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
         8) F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
         9) F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
         10) F949, Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings.
      b. Installation:
         1) D2321, Standard Practice for Underground Installation of Thermosplastic Pipe for Sewers and Other Gravity-Flow Applications.
   2. American Water Works Association (AWWA):
      a. PVC (polyvinyl chloride) materials:
         1) C900, Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 IN Through 12 IN, for Water Distribution.
         2) C905, Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 IN through 48 IN, for Water Transmission and Distribution.
      b. Polyethylene (PE) materials:
         1) C901, Standard for Polyethylene (PE) Pressure Pipe and Tubing, 1/2 IN through 3 IN, for Water Service.
   3. NSF International (NSF).

1.3 SUBMITTALS

A. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

B. See Specification Section 40 05 13.

PART 2 - PRODUCTS

2.1 PVC PRESSURE PIPING (EXPOSED)

A. General:
   1. Provide Schedule 80 pipe with Schedule 80 fittings and appurtenances to locations shown on Drawings.
   2. Furnish materials in full compliance to following material specifications:
      a. Manufacture pipe, fittings and appurtenances from polyvinyl chloride (PVC) compound which meets the requirements of Type 1, Grade 1 (12454-B) Polyvinyl Chloride as outlined in ASTM D1784.
      b. Manufacture pipe, fittings and valves from materials that have been tested and approved for conveying potable water by the NSF.

B. Pipe:
   1. Furnish pipe meeting requirements of ASTM D1785.
   2. Pipe 2 IN and less to be solvent welded.
   3. Pipe larger than 2 IN may be either flanged or solvent welded unless shown otherwise on Drawings.

C. Fittings: Provide ASTM D2467 PVC socket type fittings having the same pressure and temperature rating as the pipe.

D. Flanges/Unions:
   1. Furnish flanges and unions at locations shown on Drawings.
   2. Provide either flanges or unions at valves, penetrations through structures and equipment connections.
   3. For pipe larger than 2 IN, provide 150 LB socket type PVC flange.
   4. For pipe 2 IN and less, provide socket type PVC union with Buna O-rings.
   5. Use flat, full faced natural rubber gaskets at flanged connections.
      a. Furnish heavy hex head bolts, each with one (1) heavy hex nut, ASTM F593 Type 316 stainless steel.
   6. Use spacers supplied by pipe manufacturer when mating raised-faced flanges to other flanges.

E. Installation:
   1. Field threading PVC will not be permitted.
      a. Perform required threaded connections or attachments by the use of factory molded socket by threaded adapters.
      b. Female adapters are not acceptable.
   2. Employ installation and pipe support practices and solvent welding all in compliance to the manufacturer's printed recommendation.
      a. Continuously support PVC piping at liquid operating temperatures in excess of 100 DegF.
      b. For vertical piping, band the pipe at intervals to rigidly support load of twice vertical load.
      c. Support riser clamps on spring hangers.
      d. Do not clamp PVC tightly or restrict movement for expansion and contraction.

2.2 PRESSURE PIPING (UNDERGROUND)

A. Materials: Furnish materials in full compliance with following requirements:
   1. 1/2-3 IN: AWWA C901 PE with Pressure Class of 150 psi per Table A3, AWWA C901.

2. 4-12 IN: AWWA C900 PVC with Pressure Class of 150 psi per Table 2, AWWA C900.
3. 14-36 IN: AWWA C905 PVC DR-18.
4. Joints for polyethylene pipe shall be fusion type in accordance with AWWA C901.
5. Joints for PVC pipe shall be the elastomeric-gasket type with a pressure rating not less than pipe pressure rating meeting performance requirements of ASTM D3139.

B. Installation:
1. Field threading of PVC pipe will not be permitted.
2. Perform installation procedures, handling, thrust blocking, connections, and other appurtenant operations in full compliance to the manufacturer's printed recommendations and in full observance to plan details when more stringent.

2.3 PVC DRAINAGE, SEWER PIPING AND UNDERGROUND AIR DUCTS

A. Materials:
1. Furnish materials in full compliance to the following material specification.
2. PVC pipe shall be rigid, unplasticized polyvinyl chloride (PVC) made of PVC plastic having a cell classification of 12454-B or 12454-C as described in specification ASTM D1784.
3. The requirements of this Specification are intended to provide for pipe and fittings suitable for non-pressure drainage of wastewater and surface water.
4. Joining systems shall consist of an elastomeric gasket joint meeting requirements of ASTM D3212.
5. Supply to the Engineer all information and sample of joining method for his evaluation.
   a. Only jointing methods acceptable to the Engineer will be permitted.
6. Provide pipe and fittings meeting or exceeding the following requirements:
   a. 4-27 IN DIA: ASTM D3034 and ASTM F679, SDR 35.
   b. 8-30 IN DIA: ASTM F794.
   c. 4-18 IN DIA: ASTM F949.
7. Ensure impact strengths and pipe stiffnesses in full compliance to these Specifications.

B. Installation: Install pipe and fittings in accordance with ASTM D2321 and as recommended by the manufacturer.
1. Provide for a maximum deflection of not more than 5 percent.

C. Infiltration and Exfiltration:
1. The maximum allowable infiltration measured by test shall not exceed 100 GAL per inch of pipe diameter per mile per 24 HRS.
2. For exfiltration, all the pipe and fittings shall exceed performance requirements by an air test procedure as specified in Section 40 05 13.
3. Observe full instructions of the Engineer for carrying of testing procedures.
   a. Perform tests only during presence of the Engineer or his authorized representative.
4. Should any test on any section of pipe line disclose either infiltration rates greater than allowed or disclose air loss rate greater than that permitted, locate and repair the defective joints or pipes at no cost to Owner and retest until requirements stated are met.

D. Deflection:
1. After backfilling, each section of pipe shall be checked for deflection by pulling a mandrel through the pipe.
2. Pipe with deflection exceeding 5 percent of the inside diameter shall have backfill removed and replaced to provide a deflection of less than 5 percent.
3. Any repaired pipe shall be retested.

2.4 PVC TUBING

A. General: Provide nylon tubing with fittings and appurtenances as shown on Drawings.

B. Materials:
1. Furnish clear outer braided tubing with braid outside the walls.
2. Have tubing manufactured of nylon with working temperatures from 5 to 180 DegF.

3. Design tubing with a minimum safety factor of 4 to 1 ratio of burst pressure to working pressure at maximum temperature.
4. Provide tubing with working pressure of 75 psi at 180 DegF.
5. Ensure that tubing is self-extinguishing and fire resistant.

C. Fittings:
1. Install tubing with nylon fittings and connectors.
2. Use barbed type adapters with stainless steel clamps.
3. Provide fittings capable of withstanding temperatures from a -70 to 250 DegF.
4. Ensure fittings have the same pressure and temperature rating as the tubing.

PART 3 - EXECUTION

3.1 IDENTIFICATION

A. Identify each length of pipe clearly at intervals of 5 FT or less.
1. Include manufacturer's name and trademark.
2. Nominal size of pipe, appurtenant information regarding polymer cell classification and critical identifications regarding performance specifications and NSF approvals when applicable.

3.2 PRESSURE PIPING (UNDERGROUND)

A. Installation:
1. Field threading of PVC pipe will not be permitted.
2. Perform installation procedures, handling, thrust blocking, connections, and other appurtenant operations in full compliance to the manufacturer's printed recommendations and in full observance to plan details when more stringent.

3.3 PVC DRAINAGE, SEWER PIPING AND UNDERGROUND AIR DUCTS

A. Installation: Install pipe and fittings in accordance with ASTM D2321 and as recommended by the manufacturer.
1. Provide for a maximum deflection of not more than 5 percent.

B. Infiltration and Exfiltration:
1. The maximum allowable infiltration measured by test shall not exceed 100 GAL per inch of pipe diameter per mile per 24 HRS.
2. For exfiltration, all the pipe and fittings shall exceed performance requirements by an air test procedure as specified in Section 40 05 00.
3. Observe full instructions of the Engineer for carrying of testing procedures.
   a. Perform tests only during presence of the Engineer or his authorized representative.
4. Should any test on any section of pipe line disclose either infiltration rates greater than allowed or disclose air loss rate greater than that permitted, locate and repair the defective joints or pipes at no cost to Owner and retest until requirements stated are met.

C. Deflection:
1. After backfilling, each section of pipe shall be checked for deflection by pulling a mandrel through the pipe.
2. Pipe with deflection exceeding 5 percent of the inside diameter shall have backfill removed and replaced to provide a deflection of less than 5 percent.
3. Any repaired pipe shall be retested.

3.4 PVC TUBING

A. Fittings:
1. Install tubing with nylon fittings and connectors.
2. Use barbed type adapters with stainless steel clamps.
3. Provide fittings capable of withstanding temperatures from a -70 to 250 DegF.
4. Ensure fittings have the same pressure and temperature rating as the tubing.

END OF SECTION

SECTION 40 05 51

VALVES: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Valving, actuators, and valving appurtenances.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 09 96 00 – High Performance Industrial Coatings.
   4. Section 40 05 05 - Equipment: Basic Requirements.
   5. Section 40 05 13 - Pipe and Pipe Fittings: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B1.20.1, Pipe Threads, General Purpose.
      b. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
      c. B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
   2. ASTM International (ASTM):
      a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
      b. D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
      c. D638, Standard Test Method for Tensile Properties of Plastics.
      d. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
      e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
      f. D2240, Standard Test Method for Rubber Property-Durometer Hardness.
   3. American Water Works Association (AWWA):
      a. C207, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 IN through 144 IN.
      b. C500, Standard for Metal-Seated Gate Valves for Water Supply Service.
      c. C504, Standard for Rubber-Seated Butterfly Valves.
      d. C507, Standard for Ball Valves, 6 IN through 48 IN (150 MM through 1200 MM).
      e. C509, Standard for Resilient-Seated Gate Valves for Water Supply Service.
      f. C541, Standard for Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
      g. C542, Standard for Electric Motor Actuators for Valves and Slide Gates.
      h. C550, Standard for Protective Coatings for Valves and Hydrants.
      i. C606, Standard for Grooved and Shouldered Joints.
   4. American Water Works Association/American National Standards Institute (AWWA/ANSI):
      a. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. MG 1, Motors and Generators.

1.3 DEFINITIONS

A. The following are definitions of abbreviations used in this Specification Section or one (1) of the individual valve sections:
   1. CWP: Cold water working pressure.
   2. SWP: Steam working pressure.
   3. WOG: Water, oil, gas working pressure.
   4. WWP: Water working pressure.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
      c. Valve pressure and temperature rating.
      d. Valve material of construction.
      e. Special linings.
      f. Valve dimensions and weight.
      g. Valve flow coefficient.
      h. Wiring and control diagrams for electric or cylinder actuators.
   3. Test reports.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
   1. Verification from valve actuator manufacturer that actuators have been installed properly, that all limit switches and position potentiometers have been properly adjusted, and that the valve actuator responds correctly to the valve position command.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, refer to individual valve Specification Sections for acceptable manufacturers.

2.2 MATERIALS

A. Refer to individual valve Specification Sections.

2.3 VALVE ACTUATORS

A. Valve Actuators - General:
   1. Provide actuators as shown on Drawings or specified.
   2. Counter clockwise opening as viewed from the top.
   3. Direction of opening and the word OPEN to be cast in handwheel or valve bonnet.
   4. Size actuator to produce required torque with a maximum pull of 80 LB at the maximum pressure rating of the valve provided and withstand without damage a pull of 200 LB on handwheel or chainwheel or 300 foot-pounds torque on the operating nut.
   5. Unless otherwise specified, actuators for valves to be buried, submerged or installed in vaults or manholes shall be sealed to withstand at least 20 FT of submergence.
   6. Extension stem:
      a. Install where shown or specified.

b. Solid steel with actuator key and nut, diameter not less than stem of valve actuator shaft.
c. Pin all stem connections.
d. Center in valve box or grating opening band with guide bushing.

B. Buried Valve Actuators:
1. Provide screw or slide type adjustable cast iron valve box, 5 IN minimum diameter, 3/16 IN minimum thickness, and identifying cast iron cover rated for traffic load.
2. Box base to enclose buried valve gear box or bonnet.
3. Provide 2 IN standard actuator nuts complying with AWWA C500, Section 3.16.
4. Provide at least two (2) tee handle keys for actuator nuts, with 5 FT extension between key and handle.
5. Extension stem:
    a. Provide for buried valves greater than 4 FT below finish grade.
    b. Extend to within 6 IN of finish grade.
6. Provide concrete pad encasement of valve box as shown for all buried valves unless shown otherwise.

C. Plastic Valve Vault:
1. Provide in non-traffic areas only on valve applications 3-1/2 IN and less.
2. Nominal 7-1/2 IN DIA top section.
3. Design unit for screw type extension section having nominal 9 IN DIA bell.
4. Cast iron ring and lid.
5. Constructed of injection molded polyolefin compound with fibrous inorganic component reinforcing and UV stabilization.
6. Armor Access Boxes.

D. Exposed Valve Manual Actuators:
1. Provide for all exposed valves not having electric or cylinder actuators.
2. Provide handwheels for gate and globe valves.
    a. Size handwheels for valves in accordance with AWWA C500.
3. Provide lever actuators for plug valves, butterfly valves and ball valves 3 IN DIA and smaller.
    a. Lever actuators for butterfly valves shall have a minimum of 5 intermediate lock positions between full open and full close.
    b. Provide at least two (2) levers for each type and size of valve furnished.
4. Gear actuators required for plug valves, butterfly valves, and ball valves 4 IN DIA and larger.
5. Provide gearing for gate valves 20 IN and larger in accordance with AWWA C500.
6. Gear actuators to be totally enclosed, permanently lubricated and with sealed bearings.
7. Provide chain actuators for valves 6 FT or higher from finish floor to valve centerline.
    a. Cadmium-plated chain looped to within 3 FT of finish floor.
    b. Equip chain wheels with chain guides to permit rapid operation with reasonable side pull without "gagging" the wheel.
8. Provide cast iron floor stands where shown on Drawings.
    a. Stands to be furnished by valve manufacturer with actuator.
    b. Stands or actuator to include thrust bearings for valve operation and weight of accessories.

E. Submerged Actuators:
1. Mount the valve actuator on top of an extension bonnet 3 FT above any adjacent personnel access.
2. The valve and bonnet connection shall be flanged and watertight.
3. Provide a top brace support for the bonnet.
    a. Mount the brace 6 IN below the top of the wall as shown.
4. Materials:
    a. Extension bonnet: Cast iron ASTM A126 or steel.
    b. Brace and anchor bolts: Type 304 stainless steel.

F. Electric Actuators (480 V, 3 PH):
1. Conform to AWWA C542.
2. Provide electric valve actuators with integral control devices and a remote pushbutton station.
3. Furnish electric actuator integral with valve consisting of:
   a. Motor.
   b. Gearing.
   c. Handwheel.
   d. Limit and torque switches.
   e. Lubricants.
   f. Heating elements.
   g. Wiring.
   h. Terminals for motor power and controls.
   i. Drive nut.
4. Housing/enclosure:
   a. Provide cast iron gear housing and cast iron load bearing enclosure.
   b. Non load bearing enclosure and housing: Aluminum or cast iron.
   c. Rated for area classification shown on Drawings.
   d. Provide O-ring seals for covers and entries.
   e. Terminal and limit switch compartment covers are to be fastened to gear housing by stainless steel fasteners with capture device to prevent loss.
5. Motors:
   a. Provide motors that are totally enclosed, high torque design made expressly for valve actuator service and capable of operating the valve under full differential pressure for complete open-close and reverse cycle of travel at least twice in immediate succession without overheating.
   b. Design motors in accordance with NEMA MG 1 standards, with Class B insulation, and to operate successfully at any voltage within 10 percent above or below rated voltage.
   c. Provide positive method to ensure motor bearings are permanently lubricated.
   d. Provide three (3) thermal switches imbedded in windings:
      1) 120 degrees apart.
      2) Provide motor shutdown at high temperature.
   e. Motor housing:
      1) Aluminum or cast iron.
      2) Totally enclosed nonventilated with cooling fins.
   f. Provide motor capable of operating in any position.
   g. Provide motor sealed from gearcase to allow any mounting position.
   h. Provide motors suitable for 480 V, 3 PH, 60 Hz.
6. Gearing:
   a. Provide power gearing consisting of heat treated steel helical gears, carburized and hardened alloy steel worm, and alloy bronze worm gear, all grease or oil bath lubricated, designed for 100 percent overload, and effectively sealed against entrance of foreign matter.
   b. Provide gearing mechanism constructed to permit field changes of reduction gear ratio.
   c. Design actuators so that motor comes up to speed before stem load is encountered in either opening or closing operation.
   d. Limit switch gearings and feedback device reduction gearing:
      1) Steel or bronze.
   e. Support rotating shafts with anti-friction bearings.
   f. Provide separate drive nut/thrust bearing assembly:
      1) Mounted to base of actuator.
      2) High tensile bronze.
      3) Quarter turn actuator: Provide 90 degree mounting intervals.
      4) Provide grease fitting on drive assembly.
7. Handwheel:
   a. Permanently attached for manual operation.

b. Positive declutch mechanism to engage and disengage handwheel.
c. Handwheel shall not rotate during motor operation.
d. Inoperable motor shall not prevent manual operation.

8. Limit torque and thrust loads in both closing and opening directions by torque limit switches.
   a. Provide torque switches with micrometer adjustment and reference setting indicator.
      1) Assure adjustment variation of approximately 40 percent in torque setting.
   b. Provide switches having rating of not less than 6 A at 120 Vac and 2.2 A at 115 Vdc.
   c. Limit and torque switches shall have totally sealed contacts.
9. Furnish electric actuator with two (2) geared limit switch assemblies with each switch assembly having four (4) separate limit switches:
   a. Assure each limit switch assembly is geared to driving mechanism and is independently adjustable to trip at any point at and between the fully open and fully closed valve position.
   b. Provide minimum of two (2) normally open contacts and two (2) normally closed contacts at each end of valve travel.
   c. Provide switches with inductive contact rating of not less than 6 A at 120 Vac, 3 A at 240 Vac, 1.5 A at 480 Vac, 2.2 A at 115 Vdc and 1.1 A at 230 Vdc.
   d. Limit switches shall be fully adjustable when power is applied to actuator.
10. Provide space heating elements sized to prevent condensation in both motor and geared limit switch compartment(s).
   a. Furnish heating elements rated at 120 Vac with heaters continuously energized.
11. Open-close actuator controls:
   a. Provide control assembly with necessary holding relays, reversing starter, control transformers of sufficient capacity to provide control power, space heating element power and valve position transmitter.
   b. Provide control assembly in an enclosure rated for the defined area classification.
   c. Controls for open/close actuator:
      1) Provide remote pushbutton station with enclosure rated for area classification shown on Drawings with:
         a) Open pushbutton.
         b) Close pushbutton.
         c) Stop pushbutton.
         d) Remote/local switch.
         e) Full open light.
         f) Full close light.
         g) Open and close relays as required.
      2) Provide control enclosure to accept:
         a) Remote open/close switches.
      3) Provide contacts in control enclosure:
         a) Remote/local contact.
         b) Full open contact.
         c) Full close contact.
      4) Wire all components to an internal terminal strip and include mounted wiring diagram inside enclosure.
12. Additional requirements for modulating valve actuators:
   a. Proportional position servo-amplifier mounted integral with the actuator control compartment.
   b. Positioning of valve shall be proportional to a 4-20 mA signal input to the position servo-amplifier when remote control has been selected.
   c. Servo-amplifier adjustments shall include zero, span, gain, and dead-band.
   d. Provide 4-20 mA signal position control as shown on the Drawings that interfaces with the position control/position feedback instrumentation wiring to and from PLC.

G. Electric Actuators (120 V, 1 PH):
   1. General:

a. Self contained including motor, gearing, torque switch, limit switches and cast housing.
b. Electrical enclosure: NEMA 4 or NEMA 7 to comply with area rating classification shown on Drawings.
c. Factory assembled requiring only field connection of power and control wires.
d. Comply with Specification Section 40 05 05.

2. Motors:
   a. Produce 1.5 times the required torque.
   b. Sized for two (2) complete open-close cycles without overheating.
   c. One (1) fully closed to fully open cycle to occur within 60 SEC.
   d. Class F insulation.
   e. Operate at plus or minus 10 percent voltage.
   f. 120 Volt, single phase, 60 Hz.
   g. Provide thermal cutout switch and internal heater for actuator enclosure.
   h. Control wiring as shown on Drawing control diagrams.
3. Remote pushbutton station:
   a. Enclosure: NEMA 4 stainless steel.
   b. Control relays shall include:
      1) Open relay.
      2) Closed relay.
      3) Remote control device and/or PLC interface relay.
   c. Push-to-test indicating lights shall include:
      1) Open.
      2) Closed.
      3) Remote.
   d. Selector switches shall include:
      1) Local-Remote.
      2) Open-Close.
   e. Space heater for enclosure.
   f. Control wiring as shown on control diagrams.
   g. Wire all components to an internal terminal strip and include mounted wiring diagram inside enclosure.

H. Cylinder Actuators:
1. General:
   a. Self contained unit including actuator and controls.
   b. Electrical enclosure to meet area classification shown on Drawings.
   c. Factory assembled requiring field supply connection and control wires.
2. Cylinders:
   a. Conform to AWWA C541, pneumatic.
   b. Cylinder barrel: Bronze.
   c. Heads and caps: Bronze.
   d. Cylinder pistons: Bronze.
   e. Double acting and operate on 60 psig water or air supply.
   f. Cylinder rated for 150 psig.
   g. Any hoses between control and cylinder to be oil resistant and arranged to avoid sharp bending from hose weight.
   h. Provide supply filter.
   i. Position cylinder above or to side of valve.
   j. For pneumatically operated pump check service provide air-oil tandem cylinder actuator with speed control valves on oil cylinder.
3. Controls:
   a. Provide pre-piped, pre-wired control:
      1) Pipe with corrosion-resistant metal.
      2) Provide four-way, two-position, 110 V solenoid valve in weatherproof enclosure.
      3) Provide open-closed signal limit switches.

4) Speed control valves, to independently control opening and closing speed between 10 and 60 SEC.
5) Manual-automatic selector valve on supply to solenoid.
6) For modulating valves, provide a positioner, input signal 4-20 mA, including signal converter.
7) For modulating valves, provide valve position transmitter, 4-20 mA, including signal converter, where shown.
8) For pump check valves, provide additional two-way solenoid valve with speed control to allow rapid close on loss of electric power.

2.4 FABRICATION

A. End Connections:
1. Provide the type of end connections for valves as required in the Piping Schedules presented in Specification Section 40 05 13 or as shown on the Drawings.
2. Comply with the following standards:
   a. Threaded: ASME B1.20.1.
   b. Flanged: ASME B16.1, Class 125 unless otherwise noted or AWWA C207.
   c. Bell and spigot or mechanical (gland) type: AWWA/ANSI C111/A21.11.
   d. Soldered: ASME B16.18.
   e. Grooved: Rigid joints per Table 5 of AWWA C606.

B. Refer to individual valve Specification Sections for specifications of each type of valve used on Project.

C. Nuts, Bolts, and Washers:
1. Wetted or internal to be bronze or stainless steel.
   a. Exposed to be zinc or cadmium plated.

D. On Insulated Piping: Provide valves with extended stems to permit proper insulation application without interference from handle.

E. Epoxy Interior Coating: Provide epoxy interior coating for all ferrous surfaces in accordance with AWWA C550.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Painting Requirements: Comply with Specification Section 09 91 00 for painting and protective coatings.

C. Setting Buried Valves:
1. Locate valves installed in pipe trenches where buried pipe indicated on Drawings.
2. Set valves and valve boxes plumb.
3. Place valve boxes directly over valves with top of box being brought to surface of finished grade.
4. Install in closed position.
5. Place valve on firm footing in trench to prevent settling and excessive strain on connection to pipe.
6. After installation, backfill up to top of box for a minimum distance of 4 FT on each side of box.

D. Support exposed valves and piping adjacent to valves independently to eliminate pipe loads being transferred to valve and valve loads being transferred to the piping.

E. For grooved coupling valves, install rigid type couplings {or provide separate support to prevent rotation of valve from installed position}.

F. Install electric or cylinder actuators above or horizontally adjacent to valve and gear box to optimize access to controls and external handwheel.

G. For threaded valves, provide union on one (1) side within 2 FT of valve to allow valve removal.

H. Install valves accessible for operation, inspection, and maintenance.

3.2 ADJUSTMENT

A. Adjust valves, actuators and appurtenant equipment to comply with Specification Section 01 75 00.
   1. Operate valve, open and close at system pressures.

B. For all 120 Vac and 480 Vac electric actuators, employ and pay for services of valve actuator manufacturer's field service representative to:
   1. Inspect valve actuators covered by this Specification Section.
   2. Supervise adjustments and installation checks:
      a. Open and close valves electrically under local manual and demonstrate that all limit switches are properly adjusted and that switch contacts are functioning properly by verifying the inputs are received at the remote input/output (RIO) panels or local control panel as appropriate.
      b. Position modulating valves electrically under local manual control and demonstrate that the valve position feedback potentiometer is properly adjusted and that the feedback signal is received at the RIO panels or local control panel as appropriate.
      c. Simulate a valve position command signal at the RIO panel or local control panel as appropriate and demonstrate that the valve is controlled to the desired position without excessive hunting.
   3. Provide Owner with a written statement that the valve actuator manufacturer has verified that the actuators have been installed properly, that all limit switches and position potentiometers have been properly adjusted and that the valve actuator responds correctly to the valve position command.

END OF SECTION

SECTION 40 20 16
PIPE: DUCTILE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Ductile iron piping, fittings, and appurtenances.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 05 13 - Pipe and Pipe Fittings: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B1.1, Unified Inch Screw Threads (UN and UNR Thread Form).
      b. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. ASTM International (ASTM):
      a. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
   3. American Water Works Association (AWWA):
      a. C203, Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied.
      b. C606, Standard for Grooved and Shouldered Joints.
   4. American Water Works Association/American National Standards Institute (AWWA/ANSI):
      a. C105/A21.5, Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
      b. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
      c. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
      d. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
      e. C150/A21.50, Standard for Thickness Design of Ductile-Iron Pipe.
      f. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
   5. Society of Automotive Engineers (SAE):
      a. AMS-QQ-P-416, Cadmium Plating - Electro-deposited.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 05 13.
   3. Certification of factory hydrostatic testing.
   4. If mechanical coupling system is used, submit piping, fittings, and appurtenant items which will be utilized to meet system requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Flanged adaptors:
      a. Rockwell (Style 912 (cast)).
      b. Dresser Style 127 (cast)).
   2. Compression sleeve coupling:
      a. Rockwell (Style 431 (cast)).
      b. Dresser (Style 153 (cast)).
   3. Mechanical coupling:
      a. Victaulic (Style 31).
      b. Tyler.
   4. Glass lining:
      a. Ceramic Coating (Non-Stick Glass Lining).
      b. Permutit (SG-14 Glass Lining).
   5. Insulating couplings:
      a. Rockwell (Style 416).
      b. Dresser (Style 39).
   6. Reducing couplings:
      a. Rockwell (Style 415).
      b. Dresser (Style 62).
   7. Transition coupling:
      a. Rockwell (Style 413).
      b. Dresser (Style 62).
   8. Polyethylene encasement tape:
      a. Chase (Chasekote 750).
      b. Kendall (Polyken 900).
      c. 3 M (Scotchrap 50).
   9. Restrained joints:
      a. American (Lock Fast) - 12 IN and below.
      b. U.S. Pipe (TR-Flex) - 4 IN to 54 IN.
      c. American (Lock Fast) - Above 12 IN.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MATERIALS

A. Ductile Iron Pipe:
   1. AWWA/ANSI C115/A21.15.
   2. AWWA/ANSI C150/A21.50.
   3. AWWA/ANSI C151/A21.51.

B. Fittings and Flanges:
   1. AWWA/ANSI C110/A21.10.
   2. AWWA/ANSI C115/A21.15.
   3. Flanges drilled and faced per ASME B16.1 for both 125 and 250 psi applications.

C. Nuts and Bolts:
   1. Buried: Cadmium-plated meeting SAE AMS-QQ-P-416, Type 1, Class 2 (Cor-Ten) for buried application.
   2. Exposed: Mechanical galvanized ASTM B695, Class 40.
   3. Heads and dimensions per ASME B1.1.
   4. Threaded per ASME B1.1.
   5. Project ends 1/4 to 1/2 IN beyond nuts.

D. Gaskets: See individual piping system requirements in Section 40 05 13.

E. If mechanical coupling system is used, utilize pipe thickness and grade in accordance with AWWA C606.

F. Polyethylene Encasement: See AWWA/ANSI C105/A21.5.

G. See Piping Schedules in Section 40 05 13.

2.3 MANUFACTURED UNITS

A. Couplings:
   1. Flanged adaptors:
      a. Unit consisting of steel or carbon steel body sleeve, flange, followers, Grade 30 rubber gaskets.
      b. Provide units specified in Article 2.1.
      c. Supply flanges meeting standards of adjoining flanges.
      d. Rate entire assembly for test pressure specified on piping schedule for each respective application.
   2. Compression sleeve coupling:
      a. Unit consisting of steel sleeve, followers, Grade 30 rubber gaskets.
      b. Provide units specified in Article 2.1.
      c. Supply flanges meeting standards of adjoining flanges.
      d. Entire assembly to be rated for test pressure specified on piping schedule for each respective application.
      e. Provide field coating for buried couplings per AWWA C203.
   3. Mechanical couplings:
      a. Use of mechanical couplings and fittings in lieu of flanged joints is acceptable where specifically specified in Section 40 05 13.
      b. Utilize units defined in Article 2.1.

2.4 FABRICATION

A. Furnish and install without outside coatings of bituminous material any exposed pipe scheduled to be painted.

B. Furnish cast parts with lacquer finish compatible with finish coat.

C. Glass Lining:
   1. Minimum two-coat process.
      a. Base coat heated to solidly fuse glass to pipe surface.
      b. Subsequent coat(s) heated to form integral bond with preceding coat.
   2. Final finish parameters:
      a. Thickness: 8-12 mils.
      b. Hardness: Above 5 on MOHS scale.
      c. Density: 2.5-3.0 grams per cubic centimeter.
      d. Metal to lining bonding: Capable of withstanding strain of 0.0001 IN/IN without damage to lining.
   3. Complete compatibility between fittings and piping.

2.5 LININGS AND COATINGS

A. Where specified in piping schedule, provide linings to a minimum thickness of 40 mils.
   1. Polyethylene, "Polybond" by American Pipe.
   2. Polyurethane, "Polythane" by U.S. Pipe.
   3. Ceramic epoxy, "Protecto 401" by U.S. Pipe.
   4. Calcium aluminate, "Sewper Coat" by Griffin Pipe.

2.6 SOURCE QUALITY CONTROL

A. Factory Test:
   1. Subject pipe to hydrostatic test of not less than 500 psi with the pipe under the full test pressure for at least 10 seconds.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Joining Method - Push-On Mechanical (Gland-Type) Joints:
   1. Install in accordance with AWWA/ANSI C111/A21.11.
   2. Assemble mechanical joints carefully according to manufacturer's recommendations.
   3. If effective sealing is not obtained, disassemble, thoroughly clean, and reassemble the joint.
   4. Do not overstress bolts.
   5. Where piping utilizes mechanical joints with tie rods, align joint holes to permit installation of harness bolts.

B. Joining Method - Push-On Joints:
   1. Install in accordance with AWWA/ANSI C151/A21.51.
   2. Assemble push-on joints in accordance with manufacturer's directions.
   3. Bevel and lubricate spigot end of pipe to facilitate assembly without damage to gasket.
      a. Use lubricant that is non-toxic, does not support the growth of bacteria, has no deteriorating effects on the gasket material, and imparts no taste or odor to water in pipe.
   4. Assure the gasket groove is thoroughly clean.
   5. For cold weather installation, warm gasket prior to placement in bell.
   6. Taper of bevel shall be approximately 30 degrees with centerline of pipe and approximately 1/4 IN back.

C. Joining Method - Flanged Joints:
   1. Install in accordance with AWWA/ANSI C115/A21.15.
   2. Extend pipe completely through screwed-on flanged and machine flange face and pipe in single operation.
   3. Make flange faces flat and perpendicular to pipe centerline.
   4. When bolting flange joints, exercise extreme care to ensure that there is no restraint on opposite end of pipe or fitting which would prevent uniform gasket compression or would cause unnecessary stress, bending or torsional strains to be applied to cast flanges or flanged fittings.
   5. Allow one (1) flange free movement in any direction while bolts are being tightened.
   6. Do not assemble adjoining flexible joints until flanged joints in piping system have been tightened.
   7. Gradually tighten flange bolts uniformly to permit even gasket compression.

D. Joining Method - Mechanical Coupling Joint:
   1. Arrange piping so that pipe ends are in full contact.
   2. Groove and shoulder ends of piping in accordance with manufacturer's recommendations.
   3. Provide coupling and grooving technique assuring a connection which passes pressure testing requirements.

E. Flange Adaptors 12 IN and Less:
   1. Locate and drill holes for anchor studs after pipe is in place and bolted tight.
   2. Drill holes not more than 1/8 IN larger than diameter of stud projection.

F. Cutting:
   1. Do not damage interior lining material during cutting.
   2. Use abrasive wheel cutters or saws.
   3. Make square cuts.
   4. Bevel and free cut ends of sharp edges after cutting.

G. Support exposed pipe in accordance with Section 40 05 16.

H. Install buried piping in accordance with Section 40 05 13.

I. Install restrained joint systems where specified in Section 40 05 13 under specific piping system.

3.2 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Section 40 05 13.

END OF SECTION

SECTION 40 41 13
HEAT TRACING CABLE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Heat tracing cable as required for heat tracing of pipes as indicated on the Drawings.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Division 40 - Process Interconnections.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Power requirements for each circuit based upon actual length of heat trace and maintained temperature.
      b. Circuit breaker rating based upon inrush current at minimum expected start-up temperature.
      c. Length of heat tape for each pipe size and run.
      d. Coordinate and verify length and Watts/FT of heat tape required based upon pipe size and insulation thickness.
         1) Include the calculations to support the heat tape output.
      e. See Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings:
      a. Wiring diagrams showing physical locations of thermostats and heat trace power supply.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Test reports: Megger test results.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Shall be stored such that they are not exposed to sunlight or other UV rays.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Thermon.
   2. Chemelex Division; Raychem Corp.
   3. Chromalox.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 HEAT TRACING

A. Design Parameters:
   1. Pipe diameter, length and material: See Drawings and Division 40 Specifications.
   2. Flange, valve, pipe support size: See Drawings and Division 40 Specifications.
   3. Pipe insulation type and thickness: See Drawings and Division 40 Specifications.
   4. Temperatures requirements:
      a. Low ambient temperature for the specific location: -20 DegF.
      b. Start-up temperature (alarm thermostat set point):
         1) Water/wastewater lines: 40 DegF.
      c. Maintain temperature (power thermostat set point):
         1) Water/wastewater lines: 40 DegF.
      d. High temperature exposure with power off: 185 DegF.
   5. Wind factor for the specific location: 50 MPH.
   6. Electrical requirements:
      a. Voltage: 120 VAC.
      b. Circuit breaker: Field coordinate if other than 20A GFEPCI type.
   7. Safety factor: 10 percent.

B. Self-regulating or power-limiting parallel circuit construction consisting of an inner core of conductive material between parallel copper bus wires, with inverse temperature - conductivity characteristics with metal overbraid.

C. Thermostats adjustable between 35 and 200 DegF minimum with maximum differential range of 9 DegF, furnished complete with NEMA 4 enclosures in all areas, stainless steel temperature bulb and capillary.

D. All necessary or required components and accessories, such as power connection boxes, end seals, straps, tape and fitting brackets.

E. In noncorrosive and nonhazardous locations, insulation shall be Polyolefin.

F. In corrosive, hazardous and hydrocarbon locations insulation shall be Fluoropolymer (Teflon).

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after piping has been tested and approved.

3.2 INSTALLATION

A. Insulate and heat trace wet pipe systems as indicated on Drawings.

B. Install materials in accordance with manufacturer's instructions.
   1. Each circuit shall not exceed the manufacturer's recommended maximum length.

C. For Metallic Piping:
   1. Heat tracing shall be installed completely wired.

2. Cut heat trace to lengths as required and secure to pipe with glass or polyester fiber tape.

D. For Nonmetallic Piping:
1. Allow for extra heat trace output because nonmetallic pipe has a lower heat transfer.
    a. Heat tracing shall be installed completely wired.
2. Cut heat trace to lengths as required and secure to pipe with aluminum tape through out the length of the trace.

E. Protection and Control Requirements:
1. Protection by a GFEPCI circuit breaker.
    a. Breaker amperage rating shall be coordinated with Contractor when different than the Contract Drawings.
2. Provide an ambient sensing thermostat for power and line sensing thermostat for alarm.
3. The alarm thermostat shall be placed on the opposite end of the circuit from the power thermostat or power connection to allow for annunciation of partial failure of a circuit or the loss of power from a tripped GFEPCI circuit breaker.
4. Provide a monitoring module that monitors the voltage (circuit breaker status) to each circuit.
5. The alarm from the alarm thermostat and monitor module shall be annunciated on the indicated control system.

3.3 TESTING

A. Megger the cables at the manufacturers recommended voltage level three (3) times.
1. Before installation.
2. After attachment to pipe but before insulation is installed.
3. After pipe insulation is installed but before energization.

END OF SECTION

SECTION 40 42 00

PIPE, DUCT AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Insulation:
      a. Piping insulation.
      b. Duct insulation.
      c. Equipment insulation.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 05 16 - Pipe Support Systems.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of Guarded-Hot-Plate Apparatus.
      b. C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
      c. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
      d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
      e. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
      f. C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
      g. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
      h. D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber.
      i. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
      j. E96, Standard Test Methods for Water Vapor Transmission of Materials.
      k. F25, Standard Test Method for Sizing and Counting Airborne Particulate Contamination in Cleanrooms and Other Dust-Controlled Areas.
   2. National Fire Protection Association (NFPA):
      a. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   3. Underwriters Laboratories, Inc. (UL):
      a. 723, Standard for Test for Surface Burning Characteristics of Building Materials.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.

c. Submit complete specification of insulation materials, adhesives, cement, together with manufacturer's recommended methods of application and coverage for coatings and adhesives.

3. Submit itemized schedule by building of proposed insulation systems showing density, thermal conductivity, thickness, adhesive, jackets and vapor barriers.
4. Certifications: Products will meet the requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Elastomeric insulation:
    a. Rubatex.
    b. Armstrong.
2. Fiberglass insulation:
    a. Certainteed Corporation.
    b. Schuller (Manville).
    c. Owens Corning.
    d. Knauf.
3. PVC jacket:
    a. Ceel-Co.
    b. PIC Plastics.
4. Equipment insulation:
    a. Certainteed Corporation.
    b. Schuller (Manville).
    c. Owens Corning.
5. Ductwork insulation:
    a. Certainteed.
    b. Schuller (Manville).
    c. Owens Corning.
6. High density perlite:
    a. Johns Manville.
    b. Industrial Insulation Group (LIC).
7. High density calcium silicate:
    a. Industrial Insulation Group (LIC).

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 PIPING INSULATION - ELASTOMERIC

A. General:

1. Insulation fire and smoke hazard ratings for composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation), as tested by procedure ASTM E84, NFPA 255 and UL 723, not exceeding:
    a. Flame spread: 25.
    b. Smoke developed: 50.
2. Accessories (adhesives, mastics, cements, and tapes: Same component ratings as listed above.
3. Indicate on product labels or their shipping cartons: Flame and smoke ratings do not exceed above requirements.
4. Permanent treatment of jackets or facings to impart flame and smoke safety is required.
    a. Water-soluble treatments are prohibited.
5. Insulated shields at pipe support points.

B. Pipe, Fitting, and Valve Insulation:

1. Flexible elastomeric closed cell pipe insulation.
   a. Average thermal conductivity not to exceed 0.27 (Btu-IN)/(HR-FT^2-DegF) at mean temperature of 75 DegF, temperature range -40 to 220 DegF; permeability not to exceed 0.20 by ASTM E96; water absorption 3 percent by ASTM D1056 and ozone resistance.
2. Provide minimum insulation thickness conforming to schedules or as shown on the Drawings.

2.3 PIPING INSULATION - FIBERGLASS

A. Pipe and Fitting Insulation:
   1. Preformed fiberglass pipe insulation:
      a. Density: 4 LBS/CF.
      b. Temperature rated: 650 DegF.
      c. Average thermal conductivity not to exceed 0.22 (Btu-IN)/ (HR-FT^2-DegF) at mean temperature of 75 DegF.
      d. Fire hazard rating:
         1) UL 723, ASTM E84, NFPA 255.
         2) Flame spread not exceeding 25 and smoke developed not exceeding 50.
   2. Moisture adsorption:
      a. ASTM C553.
      b. Not greater than 0.5 percent moisture by volume when exposed to moisture laden air at 120 DegF and 96 percent RH.
   3. Fungi and bacteria resistance:
      a. ASTM C665.
      b. Does not breed or promote growth.
      c. Flame attenuated glass fibers bonded with thermosetting resin.
   4. Piping jackets (general applications):
      a. Aluminum: 16 mil embossed aluminum.
      b. PVC: Preformed 0.028 IN thick PVC jackets fabricated from B.F. Goodrich PVC sheeting V-66 with proven resistance to ultraviolet degradation when temperatures do not exceed the limits of PVC.
      c. Piping jacket not required on concealed piping.
   5. Provide minimum insulation thickness conforming to schedules or as shown on the Drawings.

2.4 PIPE INSULATION INSERTS AT HANGERS

A. High Density Perlite:
   1. Pre-formed.
   2. Fire hazard rating:
      a. UL 723, ASTM E84, NFPA 255.
      b. Flame spread: Zero (0).
      c. Smoke developed: Zero (0).
   3. Average density: 13 LBS/CF.
   4. Compressive strength: 80 psi to produce 5 percent compression.
   5. Maximum surface temperature: 1,200 DegF.

B. High Density Calcium Silicate:
   1. Pre-formed.
   2. Fire hazard rating:
      a. UL 723, ASTM E84, NFPA 255.
      b. Flame spread: Zero (0).
      c. Smoke developed: Zero (0).
   3. Average density: 14 LBS/CF.
   4. Compressive strength: 100 psi to produce 5 percent compression.
   5. Maximum surface temperature: 1,200 DegF.

2.5 EQUIPMENT INSULATION

A. Insulation for Equipment:
   1. Fire hazard classification:
      a. UL 723, ASTM E84, NFPA 255.
      b. Flame spread not exceeding 25 and smoke developed not exceeding 50.
   2. Provide minimum insulation thickness conforming to Schedules, or as shown on Drawings.

2.6 DUCTWORK INSULATION: FIBERGLASS

A. Flexible Insulation:
   1. Scheduled thickness: Schuller (Manville) Microlite.
   2. Factory-applied foil scrim vapor barrier facing.
   3. Average thermal conductivity not to exceed 0.27 (Btu-IN)/ (HR-FT^2-DegF) at a mean temperature of 75 DegF (installed).
   4. Minimum density: 0.75 LB/CF.
   5. Fire hazard classification:
      a. UL 723, ASTM E84, NFPA 255.
      b. Flame spread not exceeding 25 and smoke developed not exceeding 50.

B. Semi-Rigid Insulation for Indoor Installation:
   1. Scheduled thickness Schuller (Manville) #814 SPIN-GLASS fiberglass duct insulation.
   2. Factory applied vapor barrier facing-white scrim foil.
   3. Average thermal conductivity not to exceed 0.23 (Btu-IN)/ (HR-FT^2-DegF) at a mean temperature of 75 DegF.
   4. Minimum density: 3.0 LB/CF.
   5. Moisture adsorption:
      a. ASTM C553.
      b. Not greater than 0.5 percent moisture by volume when exposed to moisture laden air at 120 DegF and 96 percent RH.

C. Semi-Rigid Insulation for Outdoor Installation:
   1. Outside ducts: Surface with scheduled thickness of Schuller (Manville) 800 Series SPIN-GLASS #815 fiberglass duct insulation.
   2. Factory-applied foil scrim vapor barrier facing.
   3. Average thermal conductivity not to exceed 0.23 (Btu-IN)/ (HR-FT^2-DegF) at mean temperature of 75 DegF.
   4. Minimum density: 3 LBS/CF.
   5. Finish with Benjamin Foster #4610 weatherproof mastic with white glass fabric membrane.
   6. Fungi and bacteria resistance:
      a. ASTM C665.
      b. Does not breed or promote growth.

D. Provide minimum insulation thickness conforming to Schedule, or as shown on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. General:
   1. Piping below ground covered with earth will not be insulated except as specified in Specification Section 40 05 13 and Specification Section 40 05 42.
   2. Consider ductwork, piping and equipment as exposed, except as otherwise indicated.
   3. Consider ductwork, piping and equipment in walls, partitions, floors, pipe chases, pipe shafts and duct shafts as concealed.
      a. Consider ductwork, piping and equipment above ceilings as concealed.
   4. Provide release for insulation application after installation and testing is complete.

a. Apply insulation on clean, dry surfaces after inspection.
5. Provide insulation continuous through wall, roof and ceiling openings, pipe hangers, supports and sleeves.
6. Provide insulation with vapor barrier for piping, ductwork and equipment where surfaces may be cooler than surrounding air temperatures.
    a. Provide vapor barrier (0.17 perm-IN; ASTM C553) continuous and unbroken.
    b. Hangers, supports, anchors, and related items that are secured directly to cold surfaces must be adequately insulated and vapor-sealed to prevent condensation.
7. Apply specified adhesives, mastics and coatings at the manufacturer's recommended coverage per unit volume.

C. Piping Insulation - Elastomeric:
1. Do not insulate until satisfactory completion of required pressure testing.
2. Apply insulation to clean, dry surfaces.
3. Slip insulation on pipe prior to connection.
    a. Whenever the slip-on technique is not possible provide insulation neatly slit and snapped over the pipe.
4. Fabricate and install fitting cover insulation according to manufacturer's recommendations.
5. Seal joints, slits, miter-cuts and other exposed edges of insulation with adhesive, recommended by the insulation manufacturer, to ensure complete vapor barrier.

D. Piping Insulation - Fiberglass:
1. Apply over clean dry pipe.
    a. Butt all joints together firmly.
2. Seal joints, slits, miter-cuts and other exposed edges of insulation as recommended by the insulation manufacturer.
3. Insulate fittings, valves, and flanges with insulation thickness equal to adjacent pipe.
4. PVC pipe jacket:
    a. Apply jacketing with a minimum of 1 IN overlap.
        1) Weld longitudinal and circumferential seams with adhesives as recommended by manufacturer.
    b. Provide slip-joints every 30 FT and between fittings if distance exceeds 8 FT.
        1) Construct slip-joints by overlapping jacket sections 6 to 10 IN.
    c. Provide premolded PVC covers of same material and manufacturer as jacket for fittings, valves, flanges, and related items in insulated piping systems.
5. Aluminum pipe jacket:
    a. Field-applied aluminum jacket with vapor-sealed longitudinal and butt joints.
    b. Provide smooth and straight joint with a minimum 2 IN overlap.
    c. Secure joints with corrosion-resistant screws spaced 0.25 to 0.50 IN back from edge.
    d. Center spacing of screws 5 IN maximum or as required to provide smooth tight-fitted joints.
    e. Place joints on least exposed side of piping to obtain neat appearance.

E. Equipment: Install per manufacturer's instructions.

F. Ductwork Insulation - Fiberglass:
1. Flexible insulation:
    a. Butt edges tightly.
        1) Secure insulation with Benjamin Foster 85-20 adhesive applied in 6 IN strips on 12 IN centers and/or pins, applied on not more than 18 IN centers so that the insulation conforms to the duct surfaces uniformly and firmly.
    b. Seal joints with facing overlap or 4 IN wide strips of like facing material adhered and stapled in place.
    c. Properly seal any penetration in vapor barrier facing with Benjamin Foster 85-20.
    d. Cut insulation slightly longer than the perimeter of the duct to ensure full thickness at corners.
2. Semi-rigid insulation and duct interior lining board:

a. Impaling over pins.
   1) Apply insulation with edges tightly butted.
   2) Apply insulation with mechanically welded fasteners to the duct and secured with speed clips.
   3) Clip pins off close to clip.
   4) Space pins as required to hold insulation firmly against duct surface but not less than one (1) pin per 1.5 SF.
   5) Seal joints and speed clips with 3 IN wide strip of facing adhered with Benjamin Foster 85-20 adhesive.

b. If the welded pin method is impossible, secure insulation to the duct with Benjamin Foster 85-20 adhesive.
   1) Cover the entire surface of duct with adhesive.
   2) Use corner metal angle to protect edge of insulation.
   3) Protect edge of insulation.
   4) Seal joints as above.

G. Install interior duct lining board as indicated above.
   1. Overall length shall be as indicated on the Drawings or a minimum of 10 LF past any type of air supply fan.

3.2 REPAIR

A. Whenever any factory applied insulation or job-applied insulation is removed or damaged, replace with the same quality of material and workmanship.

3.3 SCHEDULES

A. Refrigeration Lines:
   1. Elastomeric.
   2. All pipe sizes, provide two layers of 3/4” thickness. Install so seams do not line up between the two layers.

B. Drain Lines
   1. Elastomeric
   2. 1/2 IN thickness.

C. Pipe, Fittings and Valves:
   1. Fiberglass.

APPLICATION	PIPE SIZE	THICKNESS	JACKET
Non-Potable Cold Water	1-1/2 IN and less	1 IN	PVC
	Over 1-1/2 IN	1-1/2 IN	PVC
Heating Water (120 - 230 DegF)	1-1/2 IN and less	1-1/2 IN	Interior: PVC Exterior: Alum.
	Over 1-1/2 IN	2 IN	Interior: PVC Exterior: Alum.

D. Equipment:

EQUIPMENT	INSULATION SYSTEM
Hot water and steam, heating equipment, heat exchangers, air separators, strainers, condensate, receivers	2 IN fiberglass insulation. Glass mesh jacket adhered and coated with two (2) coats of Foster 30-36 white insulation coatings.
Hot water pumps, flash tanks, compression tanks	Uninsulated
Below drain pans serving cooling coils, pre-heat systems, domestic water heaters	1 IN flexible elastomeric closed cell sheet.
Cold water meter	Uninsulated

E. Ductwork:
1. Fiberglass.

DUCT SERVICE	INSULATION AND THICKNESS
Exterior ductwork	2 IN semi-rigid for outdoor installation
Intake air ducts, inside building	2 IN semi-rigid with vapor barrier
Supply air ducts downstream of cooling coils	1-1/2 IN flexible with vapor barrier
Exhaust air ducts, inside building	2 IN semi-rigid
Exhaust air ducts, outside building	2 IN semi-rigid for outdoor installation

END OF SECTION

SECTION 40 50 10
PLUG VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Plug valves.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 05 51 - Valves: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125 and 250.
   2. ASTM International (ASTM):
      a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
      b. A536, Standard Specification for Ductile Iron Castings.
      c. D2240, Standard Test Method for Rubber Property-Durometer Hardness.
   3. American Water Works Association (AWWA):
      a. C504, Standard for Rubber-Seated Butterfly Valves.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 05 51.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.
   2. See Specification Section 40 05 51.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed under the specific valve types are acceptable.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 NON-LUBRICATED ECCENTRIC PLUG VALVES (SEWAGE)

A. Acceptable Manufacturers:
   1. DeZurik.
   2. Millikin.
   3. ValMatic.
   4. Victaulic.

B. Materials:
   1. Body: Cast-iron ASTM A126, Class B.
   2. Plug: One-piece construction ductile iron, ASTM A536 65-45-12 or cast iron, ASTM A126 Class B.
   3. Plug facing: Grease and/or petroleum-resistant resilient Neoprene or Buna-N compound, 70 Type A durometer hardness per ASTM D2240.
   4. Shaft bearing bushings: Permanently lubricated TFE or Delrin sleeve type stainless steel or bronze.
   5. Valve seats: Welded-in overlay of 90 percent nickel, minimum Brinell hardness of 200, (minimum 1/8 IN thick).
   6. Stem seal: Nitrile butadiene packing or Buna-N dual U-cups per AWWA C504, Section 3.7.

2.3 LUBRICATED SEAL PLUG VALVES (NATURAL GAS APPLICATIONS)

A. Acceptable Manufacturers:
   1. Nordstrom.
   2. Walworth.
   3. Millikin.

B. Materials:
   1. Body: Cast iron ASTM A126, Class B.
   2. Plug: Cast iron ASTM A126, Class B.
   3. Plug facing: Teflon on tapered plug.
   4. Valve seats: Gas-resistant lubricant/sealant.

2.4 NON-LUBRICATED ECCENTRIC PLUG (HEATING-COOLING WATER APPLICATIONS)

A. Acceptable Manufacturers:
   1. DeZurik Figure 499.
   2. Millikin Series 603.
   3. Victaulic Series 365.

B. Materials:
   1. Body: Cast iron, ASTM A126, Class B.
   2. Plug: Bronze or nickel-plated cast iron.
   3. Bearings: Bronze or nickel.
   4. Plug seal: Isobutene-isoprene (250 DegF).

2.5 ACCESSORIES

A. Refer to Drawings and valve schedule for type of actuator.
   1. Furnish actuator integral with valve.

B. Refer to Specification Section 40 05 23 for actuator requirements.

2.6 DESIGN REQUIREMENTS

A. Non-Lubricated Eccentric Plug Valves (Wastewater, Sludge):
   1. Port area:
      a. Valves 4 IN through 20 IN: Equal to or exceed 80 percent of full pipe area.
      b. Valves greater than 20 IN: 100 percent equivalent full pipe area.
   2. Valve body: Fitted with bolted bonnet.
   3. End connections: See Specification Section 40 05 51.
   4. Stem seal: Adjustable and replaceable without disassembling valve or bonnet.
   5. Designed for seating drip tight in any flow direction.
   6. Rating:
      a. 1/2 through 12 IN, 175 psi working pressure.
      b. 14 through 36 IN, 150 psi working pressure.

c. Three-way valves, 125 psi working pressure.

7. Actuator:
    a. Actuator gearing in enclosure suitable for running in oil with seals on shaft to prevent entry of dirt or water.
    b. Positive identification on actuator indicating valve position.
    c. Adjustable stop to set closing torque.

B. Lubricated Plug Valves (Natural Gas):
1. Pressure lubricated valve with sealed ports and grooves.
    a. Re-seatable under full pressure in any position.
2. Pressure rating: 200 psi WOG.
3. Port area: Minimum 60 percent of pipe area.
4. Acceptable to local gas company.

C. Non-Lubricated Eccentric Plug Valve-(HVAC):
1. Port area: Valves 1/2 IN through 2-1/2 IN: Equal to or exceed 100 percent of full pipe area.
2. Valve body: Fitted with threaded bonnet or bolted bonnet.
3. End connections:
    a. Flanges: In full accordance with ASME B16.1, Class 125 including facing, drilling and thickness.
    b. Threaded connection: In full compliance with NPT.
4. Stem seal: Self-adjusting U-cups or multiple O-ring seals.
5. Shut-off: Designed for setting drip-tight at the full rated pressure.

2.7 FABRICATION

A. See Specification Section 40 05 51.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 40 05 51.

B. Install valves with valve stem horizontal, plug seat on inlet side and with plug rotating up into the open position for valves in horizontal lines.

C. Install valve with actuator above pipe or plug centerline.

END OF SECTION

SECTION 40 50 30
CHECK VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
  1. Check valves.

B. Related Specification Sections include but are not necessarily limited to:
  1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
  2. Division 01 - General Requirements.
  3. Section 40 05 51 - Valves: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
  1. American Society of Mechanical Engineers (ASME):
     a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  2. American Water Works Association (AWWA):
     a. C508, Standard for Swing-Check Valves for Waterworks Service, 2 IN through 24 IN NPS.
  3. Manufacturers Standardization Society of the Valve and Fittings Industry Inc. (MSS):
     a. SP-71, Cast Iron Swing Check Valves, Flanged and Threaded Ends.
     b. SP-80, Bronze Gate, Globe, Angle and Check Valves.

1.3 DEFINITIONS

A. PVDF: Polyvinylidene fluoride.

1.4 SUBMITTALS

A. Shop Drawings:
  1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
  2. See Specification Section 40 05 51.

B. Operation and Maintenance Manuals:
  1. See Specification Section 01 33 04 for requirements for:
     a. The mechanics and administration of the submittal process.
     b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, manufacturers listed under the valve with types are acceptable.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 CHECK VALVES: 2.5 IN AND SMALLER

A. Class 125 Bronze Swing Check Valves (Fuel Oil, Compressed Air, Water, Wastewater):
  1. Comply with MSS SP-80.
  2. Acceptable manufacturers:

a. Nibco T413-Y.
b. Stockham B-319Y.
3. Materials:
a. Body, bonnet, disc: Bronze.
4. Design requirements:
a. 125 psi steam to 406 DegF, 200 psi WOG.
b. Horizontal swing, renewable disc.

B. Class 150 Bronze Lift Check Valves (Fuel Oil, Compressed Air):
1. Comply with MSS SP-80.
2. Acceptable manufacturers:
a. Stockham B-322B.
b. Powell 158B.
3. Materials:
a. Body, cap, disc holder: Bronze.
b. Disc: Buna-N.
4. Design requirements:
a. 150 psi to 150 DegF, 300 psi WOG.
b. Lift check, union cap.

C. Class 200 Bronze Swing Check Valves (Steam 125 to 200 psi):
1. Comply with MSS SP-80.
2. Acceptable manufacturers:
a. Nibco T473B.
b. Stockham B345.
3. Materials:
a. Body, bonnet, disc: Bronze.
4. Design requirements:
a. 200 psi steam to 550 DegF, 400 psi WOG.
b. Horizontal swing, Y-pattern.
c. Renewable disc.

2.3 SWING CHECK VALVES: 3 IN TO 24 IN

A. Swing Check Valves (Water, Wastewater, Sludge):
1. Comply with AWWA C508.
2. Acceptable manufacturers:
a. Clow.
b. American Darling.
c. Golden Anderson.
3. Materials:
a. Body and cover: Cast iron.
b. Seat ring, hinge: Bronze.
c. Disc:
1) 3 to 4 IN: Bronze.
2) 6 to 24 IN: Cast iron with bronze face.
3) 6 to 24 IN: Cast iron with rubber face.
d. Hinge shaft: Stainless steel.
e. Bearings, connecting hardware: Bronze.
4. Design requirements:
a. 175 psi working pressure (3 to 12 IN).
b. 150 psi working pressure (14 to 24 IN).
c. Furnish with outside weight and lever or lever and spring.

B. Class 125 Iron Check Valves (Steam to 125 psi, Fuel Oil):
1. Comply with MSS SP-71.
2. Acceptable manufacturers:
a. Nibco F-918B.

b. Stockham 373 1/2.
3. Materials:
a. Iron body, bronze mounted.
b. Seat ring, disc face: Bronze.
c. Hinge pin: Bronze or stainless steel.
d. Connecting hardware: Bronze or plated steel.
4. Design requirements:
a. 125 psi steam to 450 DegF, 200 psi WOG.
b. Bolted cap.

C. Class 250 Iron Check Valves (Steam 125 to 250 psi):
1. Comply with MSS SP-71, Type 1.
2. Acceptable manufacturers:
a. Nibco F-968-B.
b. Stockham F-947.
3. Materials:
a. Iron body, bronze mounted.
b. Seat ring, disc face: Bronze.
c. Hinge pin: Brass.
d. Connecting hardware: Bronze.
4. Design requirements:
a. 250 psi steam to 450 DegF, 500 psi WOG.
b. Bolted cap.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 40 05 51.
1. Install in accordance with manufacturer's instructions.

SECTION 40 62 16

COMPUTER NETWORK AND HUMAN MACHINE INTERFACE (HMI) SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Computer network and HMI hardware requirements, which include, but are not necessarily limited to:
      a. LED-backlit LCD Flat Panel Monitors.
      b. Engineering and Operator Workstations.
      c. Servers.
      d. Panel Mounted OITs (Operator Interface Terminals)
      e. Managed Ethernet Switches.
      f. Ethernet Rack Switches.
      g. Ethernet Switches (unmanaged).
      h. Rack Mount Media Converters.
      i. Rack Mount Fiber Optic Patch Panels.
      j. Panel Mounted Fiber Optic Patch Panels.
      k. Server Racks.
      l. Routers.
      m. Rack Mount UPS.
      n. Software.
      o. Accessories and Maintenance Materials.

B. Related Specification Sections include, but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   4. Section 40 90 05 – Functional Descriptions
   5. Section 40 94 43 – Programmable Logic Controller (PLC) Control System
   6. Section 40 96 52 – Configuration Requirements: Human Machine Interface (HMI) and Reports
   7. Section 40 97 00 – Control Auxiliaries
   8. Section 40 98 00 – Control Panels and Enclosures

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 802.3, Information Technology - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.
         1) 802.3u: IEEE Standards for Local and Metropolitan Area Networks: Supplement to Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100 Mb/s Operation, Type 100BASE-T.
         2) 802.3x: IEEE Standards for Local and Metropolitan Area Networks: Specification for 802.3 Full Duplex Operation.

1.3 DEFINITIONS

A. HMI: Human Machine Interface.

B. LED-backlit LCD: Light Emitting Diode backlit Liquid Crystal Display.

C. OIT: Operator Interface Terminal.

D. OPC: "OLE for Process Control", a software standard utilizing a client/server model that makes interoperability possible between automation/control applications and field systems/devices.

E. PC: Personal Computer.

F. RAID: Redundant Array of Independent Disks, a method of storing the same data in different places on multiple hard disks.

G. RAM: Random Access Memory.

H. SDRAM: Synchronous Dynamic RAM.

I. SNMP: Simple Network Management Protocol, a set of protocols for managing complex networks.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. See Specification Section 40 90 00.
3. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.

B. Contract Closeout Information:
1. Operation and Maintenance Data:
    a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed within the following Articles are acceptable.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 LED-BACKLIT LCD FLAT PANEL MONITORS

A. Acceptable Manufacturers:
1. Dell
2. HP

B. Provide LED-backlit LCD Flat Panel Type Monitors as shown on the Drawings and the Schedule herein.

C. Design Requirements:
1. Type of display: Color TFT active matrix LCD.
2. Native Resolution:
    a. 27 IN: 2560 x 1440.
3. Aspect ratio: 16:9 (widescreen).
4. Image brightness: Minimum 300 cd/m2.
5. Backlight technology: LED
6. Display image contrast ratio: 800:1 or higher.
7. Maximum sync rate (vertical scan rate x horizontal scan rate): At least 75 Hz x 80 KHz.
8. Viewing angle: 170 degrees both vertical and horizontal.
9. Adjustable tilt, pivot, height and swivel features.
10. Anti-glare flat screen.
11. Output ports: 1 X Audio line-out and 1 X audio headphone port
12. Connectivity: DVI video connection, 1 HDMI connector, 4 X USB 3.0 ports and 1 DP 1.2 connector
13. Power input: 120 Vac.

14. Speakers: integral display mounted soundbar.

D. Schedule:

EQUIPMENT NO	DESCRIPTION	QTY	SUPPLIED BY	REMARKS
ADM-WRK-001	Admin Bldg. Engineering Workstation Monitors	2 (Two)	Systems Integrator	Install in Admin Bldg Control Room
ADM-WRK-002	Admin Bldg. Operator Workstation Monitors	2 (Two)	Systems Integrator	Install in Admin Bldg Control Room
MAINT-WRK-003	Maintenance Bldg. Operator Workstation Monitors	2 (Two)	Systems Integrator	Install in Maintenance Bldg.

2.3 ENGINEERING AND OPERATOR WORKSTATIONS

A. Acceptable Manufacturers:
   1. Dell Precision 7910
   2. HP Z640

B. Provide PCS Engineering Workstations as shown on the Drawings and the Schedule herein.

C. Design Requirements:
   1. Processor: Intel® Xeon® E5 8 Core
   2. Processing speed: At least 3.0 GHz.
   3. RAM: At least 32 GB DDR4 2133-SDRAM, expandable to 64 GB DDR4 2133-SDRAM. 4 SODIMM slots
   4. Hard Disk Drives:
      a. Capacity: At least 1 TB (8GB Cache) each. Furnish two (2) hard drives.
      b. Interface: SATA 3.0.
      c. On-board RAID 1 configuration (mirrored array), factory integrated.
   5. RAID configuration: Hard drives shall be configured in RAID 1 configuration such that if one hadr drives fails then other drive shall take over operation without interruption of server function. Both drives shall mirror each other for real-time backup.
   6. Chip: Quad-core or better.
   7. Operating System: Microsoft® Windows™ 10 Professional, 64-bit.
   8. DVD-RW drive: Slim SATA DVD writer
   9. Graphics: 2 GB graphics NVIDIA® video card
   10. Audio: HD with internal speaker.
   11. Expansion bays:
      a. Two (2) internal 3.5” bays with acoustic dampening rail assemblies pre-installed.
      b. 1 dedicated 9.5 mm splim optical disk drive bay.
   12. Communication ports as listed below:
      a. All communication ports as required by functional requirements of Contract Documents.
      b. Minimum four (4) USB 3.0, 2 USB 2.0, 1 RJ45 (NIC), 1 audio line-in, 1 audio line-out.
      c. Ethernet 10/100/1000 MB/s.
   13. Ethernet networking cards for LAN communication.
   14. Power input: 120 Vac.
   15. Case style: Tower.
   16. Case color: Black.
   17. Keyboards:
      a. Incorporate Standard QWERTY design with numeric keypad and assigned function keys.

b. Sculptured keys.
c. Tactile feedback.

18. Mouse: High performance mouse with laser sensor and tilt wheel.

D. Schedule:

EQUIPMENT NO	DESCRIPTION	SUPPLIED BY	REMARKS
ADM-WRK-001	Admin Bldg. Engineering Workstation	Systems Integrator	Install in Admin Bldg Control Room
ADM-WRK-002	Admin Bldg. Operator Workstation Monitors	Systems Integrator	Install in Admin Bldg Control Room
MAINT-WRK-003	Maintenance Bldg. Operator Workstation Monitors	Systems Integrator	Install in Maintenance Bldg.

2.4 SERVERS

A. Acceptable Manufacturers:
1. Dell PowerEdge R700 series
2. HP ProLiant DL360

B. Provide HMI Network servers as shown on the Drawings and Schedule herein.

C. Design Requirements:
1. Provide redundant HMI Network Servers:
   a. Automatic switchover from a Primary to Standby I/O Server in the event of a Primary Server failure.
   b. Switchover without any user intervention or special scripting required.
   c. Switchover from Primary to Standby Server in less than one (1) second when a communication failure is detected.
2. Maintain cache of data for a configurable time period, such that requests from multiple display station clients minimize unnecessary requests to field controllers by reading from the Control Network Server cache rather than directly polling the field devices.
3. Design and fabrication:
   a. Rack mounted 1U or 2U form factor.
   b. Minimum 3.4 GHz processing speed.
   c. SDRAM:
      1) Minimum 16 GB RDIMM.
      2) Expandable with a minimum of 4 expansion slots.
      3) Memory type: DDR4
      4) Utilize ECC (Error Correcting Code) memory.
   d. Hot-swappable redundant power supplies and cooling fans.
   e. Hard drives:
      1) RAID 6 configuration.
      2) Four (4) hard drives
      3) Hot-swappable SCSI drives.
      4) Total memory: Minimum 500 GB, 1.5 TB for historical data servers.
   f. Power Input: 120 Vac.
4. Operating System: Microsoft Windows Server 2016 Essentials.

D. Schedule:

EQUIPMENT NO	DESCRIPTION	SUPPLIED BY	REMARKS
IO-SRV-001	I/O Server No. 1	Systems Integrator	Install in Network Interface Cabinet NIP-100

EQUIPMENT NO	DESCRIPTION	SUPPLIED BY	REMARKS
IO-SRV-002	I/O Server No. 2	Systems Integrator	Install in Network Interface Cabinet NIP-100
HIST-SRV-001	Historian Server	Systems Integrator	Install in Network Interface Cabinet NIP-100

2.5 PANEL MOUNTED OPERATOR INTERFACE TERMINALS (OIT)

A. Acceptable Manufacturers:
   1. Schneider Electric Magelis XBT GT XBTGT6340

B. Provide Panel Mounted Operator Interface Panels (OITs) as shown on the Drawings and the Schedule herein.

C. Design and Fabrication:
   1. Display: Color active matrix TFT
   2. Touch screen display
   3. Size: 12.1 inches
   4. Resolution: 800 X 600 pixels SVGA
   5. 512 kB SRAM with lithium backup battery
   6. 24 Vdc power supply.
   7. Real time battery-backed clock, time stamp data
   8. Communicate via Ethernet to Plant's HMI Network.
   9. USB port for external data logging, USB flash drive support.
   10. Provide password protection to prevent unauthorized entries for a minimum of two (2) levels:
       a. Authorization to operate.
       b. Authorization to adjust setpoints.
   11. Operating temperature: 32 DegF to 131 DegF.
   12. Humidity: 10 to 90 percent RH non-condensing.
   13. Configuration software:
       a. OIT shall be configured and graphics developed using latest version of configuration software per Paragraph 2.15 D of this Specification licensed to Owner.
       b. Use Schneider Electric Vijeo Designer software for developing OIT graphics. Systems Integrator and Equipment Vendors shall provide a licenced copy of the development software at no additional cost to Owner.

D. Schedule:

EQUIPMENT NO.	DESCRIPTION	LOCATION	SUPPLIED BY
LCP-201	Digester Local Control Panel OIT	Digester Bldg. Equipment Room	Systems Integrator
LCP-100	Admin. Bldg. Local Control Panel OIT	Admin Bldg. (Control Room)	Systems Integrator
LCP-601	Gas Conditioning System Local Control Panel OIT	Cogeneration Area	Equipment Vendor
LCP-801	Generator Master Control Panel OIT	Cogeneration Area	Equipment Vendor

2.6 MANAGED ETHERNET SWITCHES

A. Acceptable Manufacturers:
   1. Moxa EDS-518A Series

2. Hirschmann Managed Ethernet Switch model RS40
3. Cisco IE 3000

B. Provide managed Ethernet switches as shown on the Drawings and the Schedule herein.

C. Managed Ethernet Switches:
1. Design and fabrication:
a. Support Ethernet 100 MBit/s.
b. Support SNMP and Web based management.
c. Rapid Spanning Tree Protocol.
d. IGMP (Internet Group Management Protocol) support for IP multicast filtering to enable switches to automatically route messages only to appropriate ports.
e. AT least Four (4) 10/100 BASE-FX backbone fiber ports for connection to multimode fiber via type ST connectors.
1) Quantity as required for communication with devices as depicted in the Contract Documents.
f. At least six (6) 10/100 BASE-TX twisted pair ports (RJ45)
g. At least two (2) 100BASE-FX ST connector uplink ports
h. Check all received data for validity.
1) Discard invalid and defective frames or fragments.
i. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link test pulses in accordance with IEEE 802.3.
j. Monitor attached fiber optic lines for open circuit conditions in accordance with IEEE 802.3.
k. As applicable, meet requirements of IEEE 802.3.
l. Power switch with 24 Vdc power input.
m. UL listed
n. Provide LED status lights to indicate:
1) Power: Supply voltage present.
2) Fault.
3) Port status.
o. Environmental rating:
1) Operating temperature: 32 Deg F to 122 Deg F.
2) Humidity: 95 percent relative humidity, non-condensing.
2. Function in self-healing ring structure.
a. If one section in the ring fails, the ring structure changes to a line structure within 0.5 seconds.

D. Schedule:

EQUIPMENT NO.	DESCRIPTION	LOCATION	SUPPLIED BY
LCP-100	Admin Bldg. Local Control Panel Ethernet Switch	Admin. Bldg. (Control Room)	Systems Integrator
LCP-201	Digester Bldg. Local Control Panel Ethernet Switch	Digester Bldg. Equipment Room	Systems Integrator
LCP-MAINT	Maintenance Bldg. Ethernet Switch	Maintenance Bldg.	Systems Integrator
LCP-401	Dewatering Bldg Local Contro Panel Ethernet Switch	Dewatering Bldg	Systems Integrator
LCP-601	Gas Conditioning System Local Control Panel Ethernet Switch	Cogeneration Area	Equipment Vendor
LCP-801	Generator Master Control Panel Ethernet Switch	Cogeneration Area	Equipment Vendor

2.7 ETHERNET RACK SWITCHES

A. Acceptable Manufacturers:
   1. Cisco Catalyst 3850

B. Provide Ethernet rackmount switches as shown on the Drawings and the Schedule herein.

C. Ethernet Rack Switches:
   1. Design and fabrication:
      a. 24 Ethernet 10/100/1000 Mbit/s RJ45 copper ports
      b. 4 X Gigabit Ethernet backbone uplink module for connection to multimode fiber via type LC connectors.
      c. Support for redundant power supplies
      d. Support IEEE 802.3bz to go beyond 1 Gb/s with Cat5e or Cat6 cables
      e. Support SNMP and Web based management.
      f. Rapid Spanning Tree Protocol.
      g. IGMP (Internet Group Management Protocol) support for IP multicast filtering to enable switches to automatically route messages only to appropriate ports.
      h. Check all received data for validity.
         1) Discard invalid and defective frames or fragments.
      i. Monitor connected TP/TX line segments for short-circuit or interrupt using regular link test pulses in accordance with IEEE 802.3.
      j. Monitor attached fiber optic lines for open circuit conditions in accordance with IEEE 802.3.
      k. As applicable, meet requirements of IEEE 802.3.
      l. 1 rack unit (RU) form factor
      m. Software support for IPv4 and IPv6 routing, multicast routing, modular quality of service (QoS), flexible netwflow (FNF) and enchanced security features.
      n. Power switch with 24 Vdc power input.
      o. Provide LED status lights to indicate:
         1) Power: Supply voltage present.
         2) Fault.
         3) Port status.
      p. Environmental rating:
         1) Operating temperature: 32 Deg F to 122 Deg F.
         2) Humidity: 95 percent relative humidity, non-condensing.
   2. Function in redundant self-healing ring structure.
      a. If one section in the ring fails, the ring structure changes a counter-rotating ring topology within 0.1 seconds.
   3. Contractor shall obtain 90-day access to Cisco Technical Assistance Center (TAC) support to obtain Cisco support, if required, during configuration.

D. Schedule:

EQUIPMENT NO.	DESCRIPTION	LOCATION	QUANTITY	SUPPLIED BY
NIP-100	Admin Bldg. Network Interface Panel	Server Room	1	Systems Integrator

2.8 RACK MOUNT MEDIA CONVERTERS

A. Acceptable Manufacturers:
   1. SignaMax 16-bay chassis with SignaMax 065-11xx series media converters
   2. TP-Link 14 slot chassis TL-MC1400 with TP-link MCxxx media converters

B. Rack Mount Media Converters:

1. Design and fabrication:
    a. 14 or 16 bays to house media converters.
    b. Hot-swappable, easy and quick replacement to ensure non-stop reliable operation
    c. Operating temperature: 32 degF to 103 degF
    d. Relative humidity: 5% to 95% (non-condensing)
    e. Power supplies: Shall be provided with hot-swappable and load sharing power supplies, 2 supplied. Input: 90-240 VAC, 47-63 Hz, Output: 12 Vdc.
    f. UL certified
    g. Units shall be desgined for rack mounting in 19” racks.
    h. Manufacturer provided documentation labels shall be furnished.
    i. All fiber connections shall be compatible with LC connectors.

C. Schedule:

EQUIPMENT NO.	DESCRIPTION	LOCATION	SUPPLIED BY
NIP-100	Admin Bldg Network Interface Panel	Server Room	Systems Integrator

2.9 RACK MOUNT FIBER OPTIC PATCH PANELS

A. Acceptable Manufacturers:
  1. Corning™ model CCH-04U

B. Rack Mount Fiber Optic Patch Panels:
  1. Design and fabrication:
    a. Closet Connector Housings (CCH) shall provide interconnect or cross-connect capabilities between outside panel, rise or distribution fiber cables.
    b. Housings shall accept upto 12 Corning™ CCH connector panels.
    c. Units shall be desgined for rack mounting in 19” racks.
    d. Unit shall be 4U (4 rack units).
    e. Unit shall feature a clear-door, removable front and rear enclosures and a platinum-painted interior for maximum visibility and access.
    f. Manufacturer provided starin relief brackets, routing clips and guides and mounting brackets shall be furnished.
    g. Manufacturer provided documentation labels shall be furnished.
    h. Unit hsall be provided with a removable tinted polycarbonate front door.
    i. Furnish manufacturer provided CCH splice cassettes model CCH-CS. PCS Systems Integrator shall determine quantity.
    j. Furnish at least 8 (right) Corning™ CCH connector panels in each unit or as required.
    k. All fiber connections shall be compatible with LC connectors.

C. Schedule:

EQUIPMENT NO.	DESCRIPTION	LOCATION	SUPPLIED BY
NIP-100	Admin Bldg Network Interface Panel	Server Room	Systems Integrator

2.10 PANEL MOUNT FIBER OPTIC PATCH PANELS

A. Acceptable Manufacturers (no exceptions)
  1. Corning™ model SPH-01P

B. Cabinet (Panel) Mount Fiber Optic Patch Panels:
  1. Design and fabrication:

a. DIN rail mountable single panel housing shall allow fiber optic cable protection and connectivity in control panels.
b. Metal housing with smooth, black powder coat finish.
c. Housings shall accept one (1) Corning™ CCH connector panels with LC connectors.

C. Schedule:

EQUIPMENT NO.	DESCRIPTION	LOCATION	SUPPLIED BY
LCP-100	Admin Bldg. Local Control Panel Ethernet Switch	Admin. Bldg. (Control Room)	Systems Integrator
LCP-201	Digester Bldg. Local Control Panel Ethernet Switch	Digester Bldg. Equipment Room	Systems Integrator
LCP-MAINT	Maintenance Bldg. Ethernet Switch	Maintenance Bldg.	Systems Integrator
LCP-401	Dewatering Bldg Local Contro Panel Ethernet Switch	Dewatering Bldg	Systems Integrator
LCP-601	Gas Conditioning System Local Control Panel Ethernet Switch	Cogeneration Area	Equipment Vendor
LCP-801	Generator Master Control Panel Ethernet Switch	Cogeneration Area	Equipment Vendor

2.11 SERVER RACKS:

A. Acceptable Manufactures:
1. Rittal
2. Pentair / Hoffman
3. Hammond

B. Provide Server Racks as shown on the Drawings and the Schedule herein.

C. Design and fabrication:
1. Width: 19 23 IN.
2. Depth: Minimum 30 IN.
3. Height: As per schedule in D. below
4. Open rack to enable air movement. Steel side covers which are removable via quarter-turn fasteners.
5. Material: Aluminum or steel with powder coat finish.
6. Leveling feet and rollers.
7. Sliding shelves.
8. Anti-tip stabilizer feet for floor mount racks.
9. Sliding tray to hold portable computer/keyboard.
10. Rack mounted power strips and cable management.
11. Furnish manufacturer supplied stainless steel mounting accessories for wall mount racks.

D. Schedule:

TAG NO.	LOCATION	SIZE	REMARKS
NIP-100	Admin Bldg. Network Interface Panel	42U	Install in Server Room

2.12 ROUTERS

A. Acceptable Manufacturers:
   1. Cisco model 4331 Integrated Services Router (ISR)

B. Provide routers as shown on the Drawings and the Schedule herein.

C. Design Requirements:
   1. Support for multiple, diverse access links: T1/E1, T3/E3, xDSL, Gigabit and 10-Gigabit Ethernet
   2. Modular interfaces with online removal and insertion (OIR) for module upgrades without network disruption.
   3. GUI based device management capability for configuring routing, firewall, VPN, WAN and LAN.
   4. Built-in Cisco IOS firewall. PCS Systems Integrator shall configure and enable firewall in the connection to the Foxboro system to provide controlled access policies for the sharing of data between networks.

D. Schedule:

EQUIPMENT NO	DESCRIPTION	LOCATION
NIP-100	Admin Bldg. Network Interface Panel (NIP) Router	Installed in Admin Bldg Network Interface Panel (NIP)

2.13 RACK MOUNTABLE UPS

A. Acceptable Manufacturers:
   1. Emerson Liebert GXT3 UPS 3000VA
   2. APC by Schneider Electric Smart-UPS 3000VA model SMT3000RM2U

B. Provide rack mount UPS as shown on the Drawings and the Schedule herein.

C. Design Requirements:
   1. Nominal input voltage: 120VAC
   2. Nominal output voltage: 120 VAC
   3. Ouput voltage distortion: Less than 5%
   4. Battery type: Maintenance-free sealed lead-acid battery. Leakproof battery.
   5. Recharge time: < 3 hours
   6. Expected battery life: 3-5 years
   7. ENERGY STAR® qualified model
   8. Built-in power factor correction and frequency conversion
   9. Manual bypass capability
   10. Support for up to four battery cabinets
   11. Capability to handle:
       a. Power spikes and transients
       b. EMI/RFI noise
       c. Voltage sags and brownout conditions
       d. Harmonics
   12. User replacable hot-swappable batteries
   13. UPS shall be sized for 200% of associated rack full-load power. UPS shall provide power for a minimum of 30 minutes following loss of primary power.
   14. At a minimum UPS shall provide the following Form C relay (dry) contacts:
       a. UPS on battery power
       b. Low battery
       c. UPS general fault

d. Provide Liebert IntelliSlot Relay Interface Card or APC Dry Contact I/O SmartSlot Card for the above described dry contacts.

15. UPS shall be provided with a USB port to allow connection to a computer to use with manufacturer provided diagnostics and configuration software. Software shall be capable of running full diagnostics on the connected UPS to display the battery health and available battery life on full charge as well as any alarms and warnings of imminent failure.

D. Schedule:

EQUIPMENT NO	DESCRIPTION	LOCATION
NIP-100	Admin Bldg Network Interface Panel (NIP) UPS	Installed in Admin Bldg Network Interface Panel (NIP)

2.14 SOFTWARE

A. Provide all software and associated programming/configuration required to meet performance requirements of the Contract Documents.

1. At substantial completion of the Project:
   a. Turn current licenses for all software over to the Owner in the Owner's name and install the latest version, upgrade or service pack for all software.
   b. Provide the respective software supplier's Comprehensive Support Contract for all software covering a full one (1) year warranty period following substantial completion which shall provide no cost software upgrades, service packs and tech support from the software supplier.

B. HMI Software:

1. Subject to compliance with the Contract Documents, the following HMI software packages are acceptable without exceptions:
   a. Schneider Electric Citect™ SCADA 2016
2. The HMI software shall be the manufacturers standard off-the-shelf software and the latest stable version released at the time of procurement.
3. Development License: HMI software shall be provided with a development studio license. Development studio shall be an intuitive integrated graphics development environment. License shall be issued to and shall be the property of the Owner. Provide two (2) development licenses, one for each I/O Server.
4. The HMI software shall load and run on operator and engineering workstations running Microsoft Windows® 10 Enterprise 64-bit Operating System.
5. HMI software shall have built-in security features compatible with Microsoft Windows® security.
6. HMI software shall be able to browse all tags in the associated PLC controllers.
7. PCS Systems Integrator shall develop HMI screens and graphics in accordance with the reqquirements of Specification Section 40 96 52.
8. The HMI shall provide the ability to design high-level graphics for complex applications either by using its own drawing editor or by importing graphic files from other drawing packages such as AutoCAD®, CorelDRAW® and PhotoshopTM. Specifically, the HMI shall allow importing of the following file formats: WMF, .CLP, .BMP, .TIF, .GIF, .PCX, and .JPEG. The HMI shall include, but not be limited to, the following graphic object animations: position, rotation, size, visibility, color, fill, slider, and touch.
9. HMI(software shall have a graphical (topology) view of servers by machine and cluster.
10. HMI software shall be capable of centralized deployment for management of project configuration for all nodes from a central location.
11. Runtime HMI software:
    a. HMI software shall be capable of adding future runtime licenses for future operator and plant manager workstations.
12. Development software:
    a. Install development licenses and software on the I/O Servers.

13. Thin Client License:
    a. Provide and install three (3) thin client lincenses on each of the three (3) workstations. Thin client license shall allow the operator to access and update HMI graphics, database and point tags on the I/O Servers.
14. Historian software:
    a. Provide, install and configure a Historian software on the Historical server with the following capabilities:
        1) 500 point tag count with the ability to increase tag count in future.
        2) Historian application shall provide with data capture, management and analytical capabilities to help generate improved decision-making.
        3) Historian shall be capable of providing point trending and the operator shall be able to add multiple trends to a single trend screen. Operator shall be able to adjust the trend time period from a few minutes to many months to analyze various parameter performance over time.
    b. Acceptable Historian products shall be (without exception):
        1) Wonderware Historian by Schneider Electric for Citect SCADA 2016 – 500 tags

C. Thin Client Licenses:
1. For each workstation provide, install and configure Remote Desktop Services Client Access Licenses (RDS CAL). Licenses shall be RDS per device CALs. Licenses shall be applicable and compatible with Microsoft Windows Server 2016.
2. All workstations shall be configured to connect to the I/O Server RD Session Host using RSD functionality (RDG/RDWeb, etc.).

D. OIT Software and Programming:
1. Schneider Electric Magelis OITs shall be programmed with Schneider Electric Vijeo Designer software version 6.2 or later. The latest stable release shall be provided.
2. Each OIT shall be configured for a stand-alone HMI solution that shall provide with an integrated operator interface to operate the associated equipment.
3. Systems Integrator shall develop screens and graphics for the OIT. Graphic screens shall have separate screens for setpoint entry and alarm management which shall be accessible to the operator but access shall be password protected. Operator shall be able to change any setpoints, view and acknowledge alarms at these OIT screens.
4. Any setpoint change or alarm acknowledgment performed at the OIT shall be automatically reflected at the Citect SCADA HMI node in the Admin Bldg and vice-versa.
5. The Systems Integrator and each equipment vendor shall be responsible for procuring or having in their possession a licensed copy of the OIT graphics development software. The Owner shall not pay towards the licensing of the software. The Owner shall not pay towards the licensing of the software.
6. The Systems Integrator shall provide a licenced copy of Schneider Electric Vijeo Designer software version 6.2 or later to the Owner during project startup and commissioning.

2.15 ACCESSORIES AND MAINTENANCE MATERIALS

A. Provide all accessories required to furnish a complete computer-based network for the control system to accomplish the requirements of the Drawings and Specifications.

B. Furnish Owner with the following extra materials:

None

PART 3 - EXECUTION

3.1 DEMONSTRATION

A. Demonstrate system in accordance with Specification Section 01 75 00.

3.2 INSTALLATION AND CHECKOUT

A. Provide installation and checkout in accordance with Specification Section 40 90 00.

END OF SECTION

SECTION 40 90 00

INSTRUMENTATION FOR PROCESS CONTROL: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for complete instrumentation system for process control.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 - Identification Devices.
   4. Division 26 - Electrical.
   5. Section 26 05 19 - Wire and Cable - 600 Volt and Below.
   6. Section 40 90 05 - Control Loop Descriptions.
   7. Section 40 91 10 – Primary Meters and Transmitters
   8. Section 40 94 43 – Programmable Logic Controller (PLC) Control System
   9. Section 40 96 52 – Configuration Requirements: Human Machine Interface (HMI) and Reports
   10. Section 40 97 00 – Control Auxiliaries
   11. Section 40 98 00 - Control Panels and Enclosures.
   12. Section 40 99 00 – Surge Protection Devices (SPD) for Instrumentation and Control Equipment

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Canadian Standards Association (CSA).
   2. FM Global (FM).
   3. The Instrumentation, Systems, and Automation Society (ISA):
      a. 7.0.01, Quality Standard for Instrument Air.
      b. S5.1, Instrumentation Symbols and Identification.
      c. S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.
      d. S5.4, Standard Instrument Loop Diagrams.
      e. S20, Standard Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   6. National Institute of Standards and Technology (NIST).
   7. Underwriters Laboratories, Inc. (UL):
      a. 913, Standard for Safety, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations.

B. General:
   1. The Instrumentation subcontractor, also referred to as the Systems Integrator in the Contract Documents, shall be a single entity for the project which shall be responsible for providing a complete and integrated control system including I&C procurement, programming, installation, factory and field testing and training.

2. All equipment, components and materials including but not limited to PLC control panels, local control stations, field instruments, shall be furnished by the Systems Integrator and shall be responsible for adequacy and performance of all items.
3. All software products delivered under this Contract shall be the manufacturers' latest revision at the time of procurement unless otherwise specified.
4. All hardware products delivered under this Contract shall be the manufacturers' latest proven design and model in that line of products at the time of procurement.
5. All firmware found in products shall be the latest and most up-to-date provided by the manufacturer at the time of procurement, or a version compatible with the operating system and associated software with which it interacts.
6. All equipment requiring users to log in using a password shall be configured with user/site-specific password(s) in coordination with the Owner. No system/product default passwords shall be permitted.
7. All equipment shall be configured in accordance with instructions provided by the manufacturer prior to installation and commissioning.

C. Qualifications:
1. The Systems Integrator shall have at least 10 years of continuous experience in designing, programming, implementing, supplying and supporting control systems for the water and wastewater industry. Experience shall include water and wastewater treatment plant control systems of comparable size and magnitude to the system described in the Contract Documents.
2. The Systems Integrator shall have in existence a permanent office facility with the ability to be on site within 2 days of request for support by the Owner. Systems Integrator shall demonstrate capability to respond by phone within 4 hours of request for support by Owner.
3. Systems Integrator shall demonstrate capability to provide remote support for plant's PLC and HMI network by remotely (from the Systems Integrator's office) logging in to the system for maintenance and troubleshooting.
4. The Systems Integrator shall designate a lead PLC and HMI programmer with at least 12 years of relevant experience, including 8 years in the water/wastewater industry. The Systems Integrator shall make every effort to retain the lead programmer for the entire duration of the project.
5. Other technical staff provided for this Contract shall have the qualifications and experience capable of designing, executing and supporting the PCS control system and associated components described in the Contract Documents and shall have been working with the firm for not less than 2 years from the date of bid advertisement.
6. The Systems Integrator shall not use outside consultants or manufacturers' representatives to satisfy the personnel requirements described in this Specification.
7. The Systems Integrator shall have a minimum of 10 years' experience configuring, programming and designing graphics for the HMI software described in the Contract Documents.
8. The Systems Integrator shall use a UL approved panel shop for panel fabrication.
9. Provide five (5) customer references, indicating contact name and telephone number, for systems similar to that being specified; provide references in close proximity if possible.
10. Provide documentation to illustrate that integrator maintains a qualified technical staff with experience in systems similar to that being specified, as well as facilities and trained staff to perform design and fabrication.
11. The Systems Integrator shall be certified by Schneider Electric for Citect SCADA and Modicon PLC programming and shall have applicable experience with the SCADA system(s) noted under Specification Section 40 62 16 2.15.B.1.

D. Systems Integrator Responsibility:
1. The Contractor shall retain the Systems Integrator to assume the responsibilities described below. However, execution of these specified duties by the Systems Integrator shall not relieve the Contractor of the ultimate responsibility for the complete and functional control system:

a. Design, fabrication, implementation and software programming and configuration to furnish a complete and functional Process Control System as described in the Contract Documents. Process Control System includes but not limited to PLC Control Panels, local control stations, cabinets, field instruments, HMI Servers, workstations, network cabinets, PLC software and associated programming of PLCs, network configuration, PLC communication, HMI software, graphics development and configuration and PLC and HMI database development and configuration.
b. Preparation, assembly and correction of all submittals for equipment supplied under Division 40 in accordance with the Contract Documents.
c. Interface of control system hardware and software with various packaged control systems that are furnished by other equipment suppliers, VFDs, control valve actuators and field instruments.
d. Field installation and supervision of the PLC Control Panels, local control stations and field instruments, panels, consoles, cabinets, server racks, network equipment and workstations.
e. Calibration and configuration of field instruments supplied by the Systems Integrator.
f. Training of Owner's operations and maintenance personnel.
g. Handling of all warranty obligations of the supplied control system.
h. Systems Integrator shall maintain two copies of the PLC program and HMI graphics configuration files at the Systems Integrators location for the duration of the warranty period. Systems Integrator shall document and update the program files when any changes are made to the program during the warranty period and turn over a copy of the files to the Owner after warranty expiration.

E. Software Ownership:
1. All PLC program logic and PLC tag database and SCADA HMI graphics and HMI tag databases developed by the Systems Integrator as part of this project shall become the property of the Owner after final acceptance by the Owner. The Systems Integrator shall not lock out any PLC or HMI code or tag database by means of a software key or password. If password protection is used the Systems Integrator shall provide the password(s) to the Owner at the beginning of the project.
2. The Systems Integrator shall turnover all PLC programs and databases and HMI graphics files and databases in their native formats and in pdf on a CD-ROM or DVD media to the Owner following final acceptance by the Owner.
3. The Systems Integrator shall provide a licensed copy of Schneider Electric Unity Pro programming software (latest release) licensed to the Owner. Systems Integrator shall install the licensed copy on an Engineering workstation designated by the Owner.
4. A copy of updates and revisions shall be provided by the Systems Integrator on a CD-ROM or DVD to the Owner for any revisions made by the Systems Integrator to the HMI and/or PLC project software. The Systems Integrator shall also promptly inform the Owner and Engineer of any PLC and/or HMI revisions or software updates by means of a submittal and email.

F. Miscellaneous:
1. Comply with electrical classifications and NEMA enclosure types shown on Drawings.

1.3 DEFINITIONS

A. Architecturally finished area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.

B. Non-architecturally Finished Area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.

C. Hazardous Areas: Class I, II or III areas as defined in NFPA 70.

D. Highly Corrosive and Corrosive Areas: Rooms or areas identified on the Drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or acidic agents, chemicals, chemical fumes or chemical mixtures.

E. Outdoor Area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.

F. Instrument Air Header: The segment of air supply piping and tubing which transports air from the compressed instrument air source through the branch isolation valve of any takeoff (branch) line.

G. Branch Line: The segment of air supply piping and tubing which transports air from the outlet of the air header branch isolation valve through an air user's isolation valve.

H. Intrinsically Safe Circuit: A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under test conditions as prescribed in UL 913.

I. Calibrate: To standardize a device so that it provides a specified response to known inputs.

1.4 SYSTEM DESCRIPTION

A. Control System Requirements:
   1. This Specification Section provides the general requirements for the instrument and control system.
   2. The instrument and control system consists of all primary elements, transmitters, switches, controllers, computers, recorders, indicators, panels, signal converters, signal boosters, amplifiers, special power supplies, special or shielded cable, special grounding or isolation, auxiliaries, software, wiring, and other devices required to provide complete control of the plant as specified in the Contract Documents.

B. All signals shall be directly linearly proportional to measured variable unless specifically noted otherwise.

C. Single Instrumentation Subcontractor:
   1. Furnish and coordinate instrumentation system through a single instrumentation subcontractor.
      a. The instrumentation subcontractor shall be responsible for functional operations of all systems, performance of control system engineering, supervision of installation, final connections, calibrations, preparation of Drawings and Operation and Maintenance Manuals, start-up, training, demonstration of substantial completion and all other aspects of the control system.
   2. Ensure coordination of instrumentation with other work to ensure that necessary wiring, conduits, contacts, relays, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, to control panels, and to receiving stations.

1.5 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Submittals shall be original printed material or clear unblemished photocopies of original printed material.
      a. Facsimile information is not acceptable.
   3. Limit the scope of each submittal to one (1) Specification Section.
      a. Each submittal must be submitted under the Specification Section containing requirements of submittal contents.
      b. Do not provide any submittals for Specification Section 40 90 00.

4. Product technical data including:
    a. Equipment catalog cut sheets.
    b. Instrument data sheets:
        1) ISA S20 or approved equal.
        2) Separate data sheet for each instrument.
    c. Materials of construction.
    d. Minimum and maximum flow ranges.
    e. Pressure loss curves.
    f. Physical limits of components including temperature and pressure limits.
    g. Size and weight.
    h. Electrical power requirements and wiring diagrams.
    i. NEMA rating of housings.
    j. Submittals shall be marked with arrows to show exact features to be provided.
5. Loop diagrams per ISA S5.4 as specified in Specification Section 40 98 00.
6. Comprehensive set of wiring diagrams as specified in Specification Section 40 98 00.
7. Panel fabrication drawings as specified in Specification Section 40 98 00.
8. PLC equipment drawings.
9. HMI graphics in full color, furnish electronic files on a CD or DVD media.
10. Nameplate layout drawings.
11. Drawings, systems, and other elements are represented schematically in accordance with ISA S5.1 and ISA S5.3.
    a. The nomenclature, tag numbers, equipment numbers, panel numbers, and related series identification contained in the Contract Documents shall be employed exclusively throughout submittals.
12. All Shop Drawings shall be modified with as-built information/corrections.
13. All panel and wiring drawings shall be provided in both hardcopy and softcopy.
    a. Furnish electronic files on CD-ROM or DVD-ROM media.
    b. Drawings in AUTO CAD format.
14. Provide a parameter setting summary sheet for each field configurable device.
15. Certifications:
    a. Documentation verifying that calibration equipment is certified with NIST traceability.
    b. Approvals from independent testing laboratories or approval agencies, such as UL, FM or CSA.
        1) Certification documentation is required for all equipment for which the specifications require independent agency approval.
16. Testing reports: Source quality control reports.

B. Operation and Maintenance Manuals:
1. See Specification Section 01 33 04 for requirements for:
    a. The mechanics and administration of the submittal process.
    b. The content of Operation and Maintenance Manuals.
    c. O&M manuals shall also include all items submitted as part of the shop drawings approval process.
    d. Include a list of spare parts as required by the Contract Documents.
2. Warranties: Provide copies of warranties and list of factory authorized service agents.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not remove shipping blocks, plugs, caps, and desiccant dryers installed to protect the instrumentation during shipment until the instruments are installed and permanent connections are made.

1.7 SITE CONDITIONS

A. Unless designated otherwise on the Drawings, area designations are as follows:
1. Outdoor area:
    a. Wet.

b. Corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.
c. Below grade vaults and manholes:
1) Subject to temporary submergence when specifically designated on the Drawings or Specifications.
2. Architecturally finished area:
a. Dry.
b. Noncorrosive unless designated otherwise on the Drawings or in the Specifications.
c. Nonhazardous unless designated otherwise on the Drawings or in the Specifications.
3. Non-architecturally finished area: As designated elsewhere on the Drawings or in the Specifications.

PART 2 - PRODUCTS

2.1 NEMA TYPE REQUIREMENTS

A. Provide enclosures/housing for control system components in accordance with the following:
1. Areas designated as wet and/or corrosive: NEMA Type 4X.
2. All outdoor panels: NEMA Type 4X.
3. Areas designated as Class I hazardous, Groups A, B, C, or D as defined in NFPA 70:
a. NEMA Type 7 unless all electrical components within enclosure utilize intrinsically safe circuitry.
1) Utilize intrinsically safe circuits to the maximum extent practical and as depicted in the Contract Documents.
4. Areas designated as Class II hazardous, Groups E, F, or G as defined in NFPA 70:
a. NEMA Type 9 unless all electrical components within enclosure utilize intrinsically safe circuitry.
1) Utilize intrinsically safe circuits to the maximum extent practical and as depicted in the Contract Documents.
5. Architecturally finished areas such as electrical rooms and control rooms designated as dry, noncorrosive, and nonhazardous: NEMA Type 12.
6. Areas designated to be subject to temporary submersion: NEMA 6P.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. System Operating Criteria:
1. Stability: After controls have taken corrective action, as result of a change in the controlled variable or a change in setpoint, oscillation of final control element shall not exceed two (2) cycles per minute or a magnitude of movement of 0.5 percent full travel.
2. Response: Any change in setpoint or change in controlled variable shall produce a corresponding corrective change in position of final control element and become stabilized within 30 seconds.
3. Agreement: Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
4. Repeatability: For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position final element.
5. Sensitivity: Controls shall respond to setpoint deviations and measured variable deviations within 1.0 percent of full scale.
6. Performance: All instruments and control devices shall perform in accordance with manufacturer's specifications.

2.3 ACCESSORIES

A. Provide identification devices for instrumentation system components in accordance with Specification Section 10 14 00.

B. Provide corrosion resistant spacers to maintain 1/4 IN separation between equipment and mounting surface in wet areas, on below grade walls and on walls of liquid containment or processing areas such as Clarifiers, Digesters, Reservoirs, etc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wherever feasible, use bottom entry for all conduit entry to instruments and junction boxes.

B. Install electrical components per Division 26.

C. Panel-Mounted Instruments:
   1. Mount and wire so removal or replacement may be accomplished without interruption of service to adjacent devices.
   2. Locate all devices mounted inside enclosures so terminals and adjustment devices are readily accessible without use of special tools and with terminal markings clearly visible.

D. See Specification Section 26 05 19.

3.2 FIELD QUALITY CONTROL

A. See Specification Section 01 75 00.

B. Maintain accurate daily log of all startup activities, calibration functions, and final setpoint adjustments.
   1. Documentation requirements include the utilization of the forms located at the end of this Specification Section.
      a. Loop Check-out Sheet.
      b. Instrument Certification Sheet.
      c. Final Control Element Certification Sheet.

C. In the event that instrument air is not available during calibration and testing, supply either filtered, dry, instrument quality air from a portable compressor or bottled, dry, instrument quality air.
   1. Do not, under any circumstances, apply hydrostatic test to any part of the air supply system or pneumatic control system.

D. Pneumatic Signal Tubing Testing:
   1. Before the leak test is begun, blow clean with dry air.
   2. Test signal tubing per ISA 7.0.01, except for tubing runs of less than 10 FT where simple soap bubble testing will suffice.
   3. If a leak is detected, repair the leak and repeat the leak test.
   4. After completion of the leak test, check each signal line for obstructions.
      a. If any are indicated, remove and retest.

E. Instrumentation Calibration:
   1. Verify that all instruments and control devices are calibrated to provide the performance required by the Contract Documents.
   2. Calibrate all field-mounted instruments, other than local pressure and temperature gages, after the device is mounted in place to assure proper installed operation.
   3. Calibrate in accordance with the manufacturer's specifications.
   4. Bench calibrate pressure and temperature gages.
      a. Field mount gage within seven (7) days of calibration.
   5. Check the calibration of each transmitter and gage across its specified range at 0, 25, 50, 75, and 100 percent.
      a. Check for both increasing and decreasing input signals to detect hysteresis.
   6. Replace any instrument which cannot be properly adjusted.

7. Stroke control valves with clean dry air to verify control action, positioner settings, and solenoid functions.
8. Calibration equipment shall be certified by an independent agency with traceability to NIST.
    a. Certification shall be up-to-date.
    b. Use of equipment with expired certifications shall not be permitted.
9. Calibration equipment shall be at least three (3) times more accurate as the device being calibrated.

F. Loop check-out requirements are as follows:
1. Check control signal generation, transmission, reception and response for all control loops under simulated operating conditions by imposing a signal on the loop at the instrument connections.
    a. Use actual signals where available.
    b. Closely observe controllers, indicators, transmitters, HMI displays, recorders, alarm and trip units, remote setpoints, ratio systems, and other control components.
        1) Verify that readings at all loop components are in agreement.
        2) Make corrections as required.
            a) Following any corrections, retest the loop as before.
2. Stroke all control valves, cylinders, drives and connecting linkages from the local control station and from the control room operator interface.
3. Check all interlocks to the maximum extent possible.
4. In addition to any other as-recorded documents, record all setpoint and calibration changes on all affected Contract Documents and turn over to the Owner.

G. Provide verification of system assembly, power, ground, and I/O tests.

H. Verify existence and measure adequacy of all grounds required for instrumentation and controls.

END OF SECTION

SECTION 40 90 05
CONTROL LOOP DESCRIPTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Instrumentation control loops.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   4. Section 40 94 43 – Programmable Logic Controller (PLC) Control System
   5. Section 40 97 00 – Control Auxiliaries
   6. Section 40 98 00 – Control Panels and Enclosures

1.2 QUALITY ASSURANCE

A. See Specification Section 40 90 00.

1.3 SYSTEM DESCRIPTION

A. The control loop descriptions provide the functional requirements of the control loops represented in the Contract Documents.
   1. Descriptions are provided as follows:
      a. Control system overview and general description.
      b. Major equipment to be controlled.
      c. Major field mounted instruments (does not include local gages).
      d. Manual control functions.
      e. Automatic control functions/interlocks.
      f. Major indications provided at local control panels and motor starters/VFD's.
      g. Remote indications and alarms.

B. The control loop descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions, but are rather intended to supplement and complement the Drawings and other Specification Sections.
   1. The control loop descriptions shall not be considered equal to a bill of materials.

C. Provide instrumentation hardware and software as necessary to perform control functions specified herein and shown on Drawings.

1.4 SUBMITTALS

A. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

B. See Specification Section 40 90 00.

C. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

D. Control Strategy for Record Documents:
   1. Obtain this Specification Section 40 90 05 in electronic format (Microsoft Word) from Engineer at beginning of Project.

2. Revise and update the file monthly during construction and start-up to reflect all changes that occur due to specific equipment and systems supplied on the Project.
    a. Show all revisions in 'track change' mode.
    b. Change Specification Section Title to read "Control Loop Descriptions - Contractor Record Document."
    c. Reference all changes by Request for Information (RFI) number or Change Proposal Request (CPR) number.
    d. Submit revised file monthly to Engineer for review.
3. Deliver the revised and updated file as a final control loop description Record Document in the Operation and Maintenance Manual described in Specification Section 01 33 04.
4. Provide both paper copy and electronic copy (on CD-ROM or DVD) of the Record Document control loop descriptions in the Operation and Maintenance Manual described in Specification Section 01 33 04.

PART 2 - PRODUCTS - (NOT APPLICABLE TO THIS SPECIFICATION SECTION)

PART 3 - EXECUTION

3.1 CONTROL LOOPS

A. Sludge Recirculation Pumps:
1. These pumps shall be equipped with a Local Control Station (LCS) for each pump. When the HOA selector switch on the LCS is placed in HAND position the pump shall start. When the HOA switch is placed in OFF position the pump shall be off. When the HOA switch is placed in the AUTO position the pump shall be controlled from the PLC (LCP-201) based on logic programmed in the PLC.
2. When the HOA selector switch at LCS is placed in AUTO position the pump shall be controlled from the plant PLC (LCP-201). A graphic selection for AUTO/MANUAL shall be provided on the HMI screen for the operator to select the pumps mode of operation.
3. When MANUAL mode is selected the operator shall be able to start and stop the pump from the pumps control popup. A control popup shall be provided for each pump.
4. When AUTO mode is selected the pump shall be started and stopped by the PLC logic. The PLC shall start SRP-01 when HX-101 is on, PLC shall start SRP-02 when HX-102 is on and PLC shall start SRP-03 when HX-103 is on.

B. Sludge Hot Water Recirculation Pumps:
1. These pumps shall be equipped with a Local Control Station (LCS) for each pump. When the HOA selector switch on the LCS is placed in HAND position the pump shall start. When the HOA switch is placed in OFF position the pump shall be off. When the HOA switch is placed in the AUTO position the pump shall be controlled from the PLC (LCP-201) based on logic programmed in the PLC.
2. When the HOA selector switch at LCS is placed in AUTO position the pump shall be controlled from the plant PLC (LCP-201). A graphic selection for AUTO/MANUAL shall be provided on the HMI screen for the operator to select the pumps mode of operation.
3. When MANUAL mode is selected the operator shall be able to start and stop the pump from the pumps control popup. A control popup shall be provided for each pump.
4. When AUTO mode is selected the pump shall be started and stopped by the PLC logic. The PLC shall start SHWRP-01 when HX-101 is on, PLC shall start SHWRP-02 when HX-102 is on and PLC shall start SHWRP-03 when HX-103 is on.

C. A separate alarm summary screen shall be created on each OIT to display all active and acknowledged alarms. Active alarms shall be displayed with red color background. Once an alarm has been acknowledged and cleared by the PLC the alarm shall be removed from the alarm summary screen. A graphic pushbutton shall be available on each screen on the OIT to enable the operator to navigate to the alarm summary screen and a separate graphic pushbutton shall be available on each screen to enable the operator to navigate to the main screen.

A main screen shall be provided on each OIT that shall display all the components on that process building.

D. All setpoints shall be operator adjustable. All setpoints shall be provided with a deadband of +/-5% to avoid setpoint “chatter” which may cause final devices to turn on and off when the associated process variable hovers around the setpoint value.

3.2 HMI/OIT SOFTWARE REQUIREMENTS

A. This Section lists the requirements for programming the Allen Bradley PanelView Plus 6 HMI screens at the Solids Handling Bldg., Blower Bldg. and the Primary Sludge Pump Room Bldg.

B. Digester Building:
   1. The Digester Building Local Control Panel OIT located on the Digester PLC Control Panel shall display all I/O points as shown on the Contract Documents for monitoring and controls.

C. All active alarms shall be displayed on a stock ticker styled ribbon running continuously on the top of each graphic screen.

D. All setpoints shall be operator adjustable. All setpoints shall be provided with a deadband of +/-5% to avoid setpoint “chatter” which may cause final devices to turn on and off when the associated process variable hovers around the setpoint value.

E. The Contractor shall submit color copies of all OIT screens to the Engineer and Owner. All comments from the Engineer and Owner shall be addressed prior to factory testing. The Contractor shall submit confirmation of all comments and final OIT screens to the Owner and Engineer after successful completion of the factory test.

END OF SECTION

BIOGAS COGENERATION SYSTEM

FUNCTIONAL DESCRIPTION

3.1 PROCESS OVERVIEW:

A. The Biogas Cogeneration System consists of the following major equipment:
   1. Gas treatment system
   2. Cogeneration Engines
   3. Heat Recovery System
   4. Waste Heat System
   5. Waste Gas Burner

B. Biogas produced by the Anaerobic Digesters will be used in cogeneration engines to produce power and heat for plant operation. The biogas must first be treated by the treatment system to remove contaminants before being delivered as the fuel source for the engines.

C. The gas treatment system uses media to remove hydrogen sulfide, moisture, and siloxanes, then boosts the pressure of the biogas to meet the needs of the cogeneration engines.

D. The cogeneration engines are equipped with a heat recovery system which transfers heat from the engine lube oil, jacket, and exhaust to the hot water loop which heats the digesters.

E. The cogeneration system also includes a waste heat system which rejects heat to the atmosphere in order to prevent the engines from overheating when less heat is needed by the digesters.

F. The waste gas burner operates when biogas is produced in quantities greater than the engines can consume and storage has been filled. The waste gas burner prevents that digesters from exceeding operating pressure and venting biogas to the atmosphere.

3.2 EQUIPMENT:

A. The following equipment will be monitored or controlled through the PCS:
   1. Two cogeneration engines
      a. Engine No. 1
      b. Engine No. 2
   2. Two biogas storage level indicators
      a. Digester 1 gas storage level indicator
      b. Digester 2 gas storage level indicator
   3. Seven pressure transmitters
      a. Digester 1 header pressure
      b. Digester 2 header pressure
      c. H2S Scrubber inlet pressure
      d. Booster blower suction pressure
      e. Booster blower discharge pressure
      f. Siloxane scrubber outlet pressure
      g. Particulate filter outlet pressure
   4. Three temperature transmitters
      a. H2S scrubber inlet temperature
      b. Biogas wet gas temperature
      c. Dried biogas temperature
   5. Four Flow Meters
      a. Digester biogas flow meter
      b. Engine No. 1 biogas flow meter
      c. Engine No. 2 biogas flow meter
      d. Waste gas burner flow meter

3.3 OPERATION:

A. General:

1. Engine generators will operate continuously on biogas to generate power and heat.
2. The engines will parallel with the utility grid and only operate when there is grid power available. The engines will not be capable of starting or operating without utility power.
3. Each generator can be operated locally by switching the L-O-R selector to LOCAL or remotely from the PCS if the REMOTE position is selected.

B. Normal (PCS-AUTOMATIC) Operation:

1. Normal operation of the Cogeneration System
   a) BIOGAS LEVEL SIGNAL: The digester biogas storage level indicator will provide a continuous signal proportional to the digester biogas production. The total range of the biogas availability signal will be 4-20 mA with 4 mA indicating minimum gas production rate and 20 mA indicating maximum production rate. When the generator or generators are operating with automatic loading control, the cogeneration engines shall follow the external loading setpoint as described here. The loading shall follow the setpoint independent of the number of generators running since the setpoint will be adjusted in the external controls to accommodate the number of operating units on line.
   b) BIOGAS SUPPLY INCREASES: When the system is running, there will be a need for notification of need to add or drop a cogeneration engine as gas availability fluctuates. If gas availability is rising and the engine in operation is using available fuel at full load, or if the engine is approaching full load and there is an expectation that the next unit would be needed, then the generator control panel shall annunciate the need for the start of an additional engine. If the gas production is high, there is more gas than the currently operating cogeneration engines can consume and gas level in the digester storage tank will rise. When the controls cannot increase the cogeneration engine load further to consume the additional fuel, or if the fuel availability signal has been rising along with cogeneration engine loading and the cogeneration engine is approaching full load, there may be a need to add an additional cogeneration engine. The system logic shall include time delay functionality to avoid unnecessary messages suggesting cogeneration engine starts. The time delay shall include a logical auto reset in the event that the system conditions fall back below the cogeneration engine start logical parameter setting. Provide an adjustable time delay of 0.5 hours to 24 hours. Also provide displays related to sending a message suggesting adding a cogeneration engine. Provide displays at the cogeneration control panel and provide a status output for the Plant SCADA system to report high storage level and to relay the suggested cogeneration engine start message that an additional cogeneration engine is required.

c) BIOGAS SUPPLY DECREASES: If gas availability decreases to the point where one cogeneration engine could be dropped, then the cogeneration control panel shall annunciate the need to drop a cogeneration engine. The logical determination of this condition is to be included in the cogeneration control panel. The logical development of this control shall be similar to that for the "add a cogeneration engine" logic described above except that it shall operate in the reverse. The time delay and reset features similar to that described for the "add a cogeneration engine" logic shall be included. Also provide displays in the cogeneration control panel and provide a status output for the Plant SCADA system related to sending a message suggesting calling for reduction of one cogeneration engine. Provide displays at the cogeneration control panel and output status to Plant SCADA system to report all operating conditions.

d) LOW LOAD OPERATION: If at any time during the operation of the cogeneration engines, the controls require the on-line cogeneration engines to be loaded below their minimum recommended operating load, a cogeneration engine must be shut down. If the cogeneration engines continue to operate below minimum power for 0 to 4 hours (variable), provide the control function to automatically take the lead cogeneration engine or only operating cogeneration engine through a sequenced shutdown. Provide displays indicating that a cogeneration engine is shut down due to low gas availability. When a cogeneration engine is shut down due to low biogas fuel availability, provide displays at the cogeneration control panel and output status to the Plant SCADA system to report the change.

e) LOSS OF BIOGAS STORAGE LEVEL FUEL AVAILABILITY SIGNAL: Upon loss of the fuel availability signal from the plant external controls system (Plant SCADA) (with other SCADA system communication still intact), control shall transfer to the digester header pressure control strategy. The control strategy for pressure will be the same as with level, only the 4 – 20 mA signal will be from a pressure transducer instead of the tank level. Provide a display at the cogeneration control panel indicating that loss of biogas fuel availability signal occurred. Provide the equivalent signals to the Plant SCADA. If at any point in this configuration of operation, the gas availability signal is restored, an annunciation shall be initiated by the cogeneration control for indication at the same locations noted above.

e) LOSS OF ALL DIGESTER BIOGAS FUEL AVAILABILITY SIGNALS: Upon loss of level and pressure fuel availability signals from the plant external controls system (Plant SCADA) (with other SCADA system communication still intact), provide an automatic sequenced shutdown of the engine(s). Provide a display at the cogeneration control panel indicating that loss of biogas fuel availability signals occurred. Provide the equivalent signals to the Plant SCADA. If at any point in this configuration of operation, either gas availability signal is restored, an annunciation shall be initiated by the cogeneration control panel for indication at the same locations noted above.

f) EXCESS FUEL AVAILABILITY: If more gas is being produced than is being consumed, the fuel availability signal will rise. If all of the available cogeneration engines are already in operation, the PLC shall cause the operating cogeneration engines to be loaded to the maximum permissible level. The decision to flare will be programmed automatically by others outside the cogeneration system.

C. PCS-MANUAL Operation:

1. Normal operation of the Cogeneration System
    a. Each cogeneration engine can be set to operate at a set kW output. Operator must select an operating load for the engine or engines. If level in the gas storage or if header pressure falls during this operation, the engines will unload to maintain adequate system pressure.

D. LOCAL Mode of Operation:
    a. The cogeneration system shall not be permitted to operate in LOCAL mode.

3.4 INTERLOCKS:

A. The hard-wired interlocks associated with the Digester Recirculation System are described below.
    1. Digester 1 Header Pressure Low (PSL).
    2. Digester 2 Head Pressure Low (PSL).

B. The software interlocks associated with the Biogas Cogeneration System are described below.
    1. Biogas Pressure from the Gas Treatment System is too low.
    2. Dried Biogas Temperature is too high.

3.5 ALARMS AND CONTROLS:

A. Alarms: Alarms for failure of equipment and abnormal conditions are activated at the PCS. The alarms include:
    1. Any equipment L-O-R in LOCAL or OFF position.
    2. Biogas storage level LOW
    3. Biogas header pressure LOW
    4. Engine Generator Common ALARM or SHUTDOWN
    5. Booster Blower Suction Pressure Switch LOW
    6. Booster Blower Discharge Pressure Switch HIGH
    7. Biogas Flow LOW
    8. Hot Water System Temp HIGH
    9. Hot Water System Temp LOW
    10. Waste Gas Burner ON

B. Controls: Control functions for the equipment activated at the PCS include:
    1. PCS-AUTOMATIC; PCS-MANUAL selection.

3.6 GRAPHICAL DISPLAY:

A. The Digester Recirculation system graphical display at the PCS will include:
    1. Biogas Storage Cover Levels
    2. Biogas Flow to Engines
    3. Biogas Flow to Waste Gas Burner.
    4. Cogeneration System Running kW
    5. Cogeneration System Operating Hours
    6. Biogas Pressure, Inlet to Gas Treatment System
    7. Biogas Pressure, Discharge from Gas Treatment System
    8. Biogas Pressure Low Discharge Pressure Alarm
    9. Hot Water Supply Temperature
    10. Waste Heat System in operation

ANAEROBIC DIGESTER RECIRCULATION SYSTEM

FUNCTIONAL DESCRIPTION

3.7 PROCESS OVERVIEW:

A. The anaerobic digester recirculation system consists of the following major equipment:
   1. Sludge Recirculation Pumps
   2. Sludge Heat Exchangers (HE)

B. Primary Sludge, Thickened WAS, and Scum solids are fed to the Anaerobic Digesters. For the digestion process to be most effective and to reduce the risk of foaming and process upset, the digester must be kept at a constant temperature. Each tank is heated by means of recirculating solids through a heat exchanger.

C. Recirculation is achieved by means of a recirculation loop that draws solids (ADRS) from near the bottom center of the digester through a centrifugal pump into a spiral HE and back to the digester (ADRR).

D. Digester feed (ADF) joins ADRR after the heat exchanger. This prevents temperature fluctuations within the heat exchanger and helps prevent fouling of the heat exchanger that could occur from handling undigested solids. ADRR leaves the heat exchanger at a higher temperature than the digester and is at a significantly higher flow than ADF so the feed is effectively preheated and blended with digesting solids as it enters the primary digesters.

E. The recirculation system shall run continuously. Temperature control is achieved by varying the water flow and temperature as described in the Digester Heating System Functional Description.

F. If the recirculation system stops and digester temperatures change drastically (more than 1 degree C per day), the digestion process could become unstable and experience foaming or other problems. Ideally, temperature should not change more than 0.5 degrees C per day.

G. Each pump is paired with one HE and the system is configured for redundancy. If any single HE or any single pump is inoperable, the two digesters can still be heated. The swing pump and heat exchanger can serve Digester No. 1 or No. 2. The pumps and HEs serving No. 1 and No. 2 can also serve each other.

3.8 EQUIPMENT:

A. The following equipment will be monitored or controlled through the PCS:
   1. Three Sludge Recirculation Pumps
      a. Sludge Recirculation Pump No. 1
      b. Sludge Recirculation Pump No. 2
      c. Sludge Recirculation Pump No. 3
   2. Six Pressure Switches
      a. Digester Recirculation Pump No. 1 High Discharge Differential Pressure Switch (ADRR)
      b. Digester Recirculation Pump No. 1 Low Suction Pressure Switch (ADRS)
      c. Digester Recirculation Pump No. 2 High Discharge Differential Pressure Switch (ADRR)
      d. Digester Recirculation Pump No. 2 Low Suction Pressure Switch (ADRS)
      e. Digester Recirculation Pump No. 3 High Discharge Differential Pressure Switch (ADRR)
      f. Digester Recirculation Pump No. 3 Low Suction Pressure Switch (ADRS)

3.9 OPERATION:

A. General:
1. Recirculation pumps shall operate continuously in Digesters.
2. If recirculation and/or heating are interrupted at either Digester, the third recirculation system should be redirected to that Digester by manually switching valves to ensure proper heating of the digesters.
3. Each Recirculation pump can be operated locally by switching the L-O-R selector to LOCAL or remotely from the PCS if the REMOTE position is selected.

B. Normal (PCS-AUTOMATIC) Operation:
1. Normal operation of the Recirculation System
   a. Each Recirculation pump will RUN when the pump is placed in AUTO mode at the PCS screen and a graphic START pushbutton on the screen is pressed by the operator. A graphic selector switch "MANUAL/AUTO" shall be available at the screen for the operator to select the mode of operation. Once the pump has started the PCS shall run it continuously.

C. PCS-MANUAL Operation:
1. Normal operation of the Recirculation System
   a. Each Recirculation pump can be manually set to RUN or OFF in the PCS when the pump is placed in MANUAL mode at the PCS screen. Graphic pushbuttons for START and STOP shall be available at the PCS screen.

D. LOCAL Mode of Operation:
   b. If the L-O-R selector switch is set to LOCAL at the pump LCS, the pump will operate continuously.
   c. Only hardwired interlocks are available in the LOCAL mode.
   d. In LOCAL, the Recirculation Pump No. 3 will operate at the speed that is entered at the VFD keypad. Drive speed shall be adjustable from the VFD keypad.

E. If a Heat Exchanger becomes inoperable, manual valves may be operated to redirect flow through an adjacent pump/HE combination.

F. Each pump and HE is capable of providing flow into either digester and no valve position indicating limit switches are provided. (NOTE: If valves are incorrectly switched, the Recirculation could inadvertently be configured to transfer solids from one digester to another.)

G. When a pump must serve an alternative digester, the proper valves must be manually changed and the Digester No. must be selected by the operator in the PCS to ensure that control system utilizes the proper Digester Temperature to function as intended.

H. Table of recirculation pumps and the HE and digesters they can serve. This table shall be available at the PCS screen for the operator to view. The fields shall be operator changeable based on the manual valve configuration. The valves in this table shall be used by the PCS in the logic for interlocking the recirculation pump with the associated heat exchanger (see software interlock 2.a. in section D below).

Pump No.	Default HE	HEs Served	Default Digester No.	Digesters served
1	1	1	1	1
2	2	2	2	2
3	3	3	N/A	1 or 2

3.10 INTERLOCKS:

A. The hard-wired interlocks associated with the Digester Recirculation System are described below.
1. Pump suction pressure switch low (PSL).

2. Pump discharge differential pressure switch high (DPSH).

B. The software interlocks associated with the Digester Recirculation System are described below.
1. Hot water will not be sent to a HE unless solids are being pumped through (i.e. the HE is currently being served by an operating recirculation pump). To achieve this interlock the recirculation pump status shall be used in the associated HE logic to start the hot water pump(s) and also to open/close the hot water return valve.
2. Digester temperature (read from the HE inlet temperature sensor) will only be read once the pump selected for that digester has been operating (for at least 5 minutes)
3. Recirculation Pump will not run (via PCS) if the liquid level in the selected digester is below an operator-selected minimum level (level setpoint shall be operator adjustable at the PCS screen).
4. Recirculation Pump will not run (via PCS) if no digester or HE is selected or if the digester is not in service.

3.11 ALARMS AND CONTROLS:

A. Alarms: Alarms for failure of equipment and abnormal conditions are activated at the PCS. The alarms include:
1. Any equipment L-O-R in LOCAL or OFF position.
2. Recirculation Pump Motor FAIL
3. Suction Pressure Switch LOW
4. Discharge Differential Pressure Switch HIGH
5. Digester level LOW

B. Controls: Control functions for the equipment activated at the PCS include:
1. PCS-AUTOMATIC; PCS-MANUAL selection.
2. Recirculation Pump RUN/OFF

C. If manual valves are improperly configured, the recirculation system may cause unintended transfer to another tank. This will result in tank liquid levels to improperly vary and cause alarms (described in the Digester Transfer System).

3.12 GRAPHICAL DISPLAY:

A. The Digester Recirculation system graphical display at the PCS will include:
1. Digester Temperature.
2. Digester Recirculation System program status (PCS-AUTOMATIC; or PCS-MANUAL mode)
3. Any equipment L-O-R in LOCAL or OFF.
4. Elapsed run time meters for all motors.
5. Equipment run status – differentiate RUN, FAIL and OFF by color
6. Recirculation pump(s) operating (Recirculation Pump No. 1/ Recirculation Pump No.2/ Recirculation Pump No.3)
7. Digester (No. 1/No. 2) served by each Pump/HE
8. Recirculation Pump low suction pressure alarm
9. Recirculation Pump high differential discharge pressure alarm
10. Recirculation Pump No. 3 Operating Speed
11. Digester Level LOW alarm

DIGESTER HEATING SYSTEM

FUNCTIONAL DESCRIPTION

3.13 PROCESS OVERVIEW:

A. The digester heating system consists of the following major equipment:
   1. Cogeneration Engines
   2. Hot Water Boilers
   3. Hot Water Supply Pumps
   4. Hot Water Mixing Valve
   5. Pressure Independent Flow Control Valves
   6. Sludge Heat Exchangers
   7. Pressure Sustaining Valve

B. The digester heating system maintains the digester temperature between 95 and 100 degrees Fahrenheit. This is the optimum temperature range for mesophilic digestion. The primary source of heat will be cogeneration engines that use biogas to produce electricity and heat. The fuel source for the heat is primarily cleaned biogas with a natural gas backup. Hot Water Boilers will provide additional back up and peak heat needs during the coldest times of the year when the cogeneration engines cannot provide enough heat to maintain the heating requirements. Heat from engines is recovered from the engine lube oil, jacket water, and exhaust. Heat from the boilers is transferred from a fire tube hot water boiler which transfers the heat from the burning fuel to a bath of water. The hot water temperature leaving either the engines or the boilers is about 200 degrees Fahrenheit. On the hot water supply (HWS) a mixing valve returns HWR flow to the HWS flow upstream of the HWS pump suction as needed to reduce the HWS temperature to about 155 degrees Fahrenheit. The hot water supply (HWS) pumps draw the heated water from the boilers and pump it to the hot water side of the digester heat exchangers. There is one heat exchanger dedicated per digester, and one swing heat exchanger that can be used for either digester. For each heat exchanger, there is a flow control valve located just downstream of the hot water outlet.

3.14 EQUIPMENT:

A. The following equipment will be monitored or controlled through the PCS:
   1. Cogeneration Engines Heat Recovery System
      a. Temperature
      b. Pressure
      c. Biogas Flow (each Cogeneration Engine)
      d. Fuel Source (each Cogeneration Engine)
   2. Hot Water Boilers
      a. Temperature
      b. Pressure
      c. Biogas Flow (each Hot Water Boiler)
      d. Fuel Source (each Hot Water Boiler)
   3. Hot Water Supply Temperature
   4. Hot Supply Pump Suction Pressure
   5. Hot Water Supply Pump Discharge Pressure
   6. Differential Pressure across HWS and HWR
   7. Hot Water Supply Flow
   8. Hot Water Return Temperature (each HE)
   9. Hot Water Return Flow (each HE)
   10. Hot Water Return Pressure Independent Flow Control Valve positions (each HE)
   11. Hot Water Return Pressure
   12. Heat Exchanger Hot Water Inlet/Outlet Differential Pressure (each)
   13. Sludge Inlet Pressure (each HE)

14. Sludge Outlet Pressure (each HE)
15. Sludge Inlet Temperature (each HE)
16. Sludge Outlet Temperature (each HE)
17. Mixing Valve Position
18. Make up water flow (each boiler)
19. Boiler HWR motor operated valve position (each boiler)
20. Expansion Tank low level.

3.15 OPERATION:

A. General:

1. Operator Entered Values:

Value	units	Default Value	Password Protected?
Digester Temperature Set-point	Deg F	98	n
Hot Water Supply Temp. Set-point	Deg F	155	n
target HWS differential pressure	PSI	30	n

2. Input From Online Instruments:

Value	units		Analyzer
Digester 1 Sludge Temp.	Deg F		Temp RTD
Digester 2 Sludge Temp.	Deg F		Temp RTD
Sludge HE 1 HWR Outlet Temp.	Deg F		Temp RTD
Sludge HE 2 HWR Outlet Temp.	Deg F		Temp RTD
Sludge HE 3 HWR Outlet Temp.	Deg F		Temp RTD
Sludge HE 1 Sludge Outlet Temp.	Deg F		Temp RTD
Sludge HE 2 Sludge Outlet Temp.	Deg F		Temp RTD
Sludge HE 3 Sludge Outlet Temp.	Deg F		Temp RTD
Hot Water Supply Temp	Deg F		Temp RTD
HWS Pump Discharge Pressure.	PSIG		Pressure
Differential Pressure Across HWS and HWR	PSI		Diff. Press.
Digester 1 online	y/n		PCS
Digester 2 online	y/n		PCS
HWS Flow	GPM		Mag Flow

3. PCS Generated Values

Value	units		Analyzer
Target HE 1 sludge outlet temp	Deg F		
Target HE 2 sludge outlet temp	Deg F		
Target HE 3 sludge outlet temp	Deg F		
HE 1 HWR Flow Control Valve Flow	GPM		Integral Flow Meter
HE 2 HWR Flow Control Valve Flow	GPM		Integral Flow Meter
HE 3 HWR Flow Control Valve Flow	GPM		Integral Flow Meter

4. Sludge Heat Exchangers
   a. The flowing applies to each Digester and its associated Heat Exchanger.

b. PCS-AUTOMATIC

The operator enters a digester temperature setpoint for each digester.

If the digester temp is below the operator entered digester temperature setpoint, the PCS shall increase that digester's target HE sludge outlet temp. If the digester temp is above the operator entered digester temperature setpoint, the PCS shall decrease that digester's target HE sludge outlet temp.

A pressure independent flow control valve shall controls the flow rate to each heat exchanger. If the HE Sludge Outlet Temp is below the Target HEX Sludge Outlet Temp, the pcs shall call for the pressure independent flow control valve to increase the flow going through the HE. If the HE sludge outlet temp is above the target HEX sludge outlet temp, the pcs shall call the pressure independent flow control valve to decrease the flow going through the HE.

c. PCS-MANUAL

The operator shall be able to set the pressure independent flow control valve flow setting individually for each heat exchanger. The position shall be displayed as a percentage of fully open.

d. HAND

The operator shall be able to set the pressure independent flow control valve setting locally.

5. Hot Water Supply Pumps

PCS-AUTOMATIC

There shall be a HWS pump selection matrix where the operator selects lead and lag HWS pumps. There can only be 1 pump selected lead and each lag position. The pumps shall run as needed to maintain the HWS Pump discharge header pressure at the target HWS differential pressure. The target HWS differential pressure is manually adjustable at the PCS between 5-40 psi. The HWS differential pressure shall be able to be reset to a default of 30 psi.

When all pumps are off the PCS shall alternate the lead/lag designations by making the Lag pump as Lead and the Lead pump as Lag for the next cycle.

a. PCS-MANUAL

The operator can individually adjust the speed for each pump.

b. HAND

The operator can adjust the speed of each pump at it's corresponding VFD.

6. Mixing Valve

a. PCS-AUTOMATIC

The PCS shall modulate the mixing valve as necessary to maintain the HWS Temp. within 1 degree of the Hot Water Supply Temp Set-point. The mixing valve blends the cooler HWR flow with the hot boiler water to maintain the HWS flow at the set point.

b. PCS-MANUAL

The operator manually set the mixing valve position via the PCS

c. HAND

The operator locally adjusts the position of the mixing valve.

7. Cogeneration Heat Recovery Equipment

a. PCS-AUTOMATIC

The heat recovery equipment is controlled by the cogeneration engine system. Engines will provide heat into the hot water system as first priority. If the engines are in operation and the hot water supply temperature drops below 155 degrees F. the PCS shall alert the operator to bring a hot water boiler online. If the engines are in operation and the heat loop exceeds 165 degrees F, the cogeneration system waste heat system will operate.

b. PCS-MANUAL

The operator will adjust the running load of the cogeneration engines to a specific kW output. The heat rejected by the engines to the hot water system will be a function of the running load of the engines.

c. HAND

d. The operator will manually adjust cogeneration system operation to maintain hot water temperature, within the limits of power generation and engine turndown capabilities.

8. Hot Water Boilers

a. PCS-AUTOMATIC

The hot water boilers are only controlled manually. If only one hot water boiler is in operation and the hot water boiler temperature drops below 190 degrees F. the PCS shall alert the operator to bring a second hot water boiler online.

b. PCS-MANUAL

There shall be a hot water boiler selection matrix that resembles the following:

	Hot Water boiler 1	Hot Water boiler 2
Online	X	
Standby		X

When a boiler is selected to be online the motor operated valve on its associated HWR line shall open. When a boiler is selected to be offline the motor operated valve on its associated HWR line shall close.

c. HAND

The operator enters the boiler water temperature set point locally at the boiler control panel.

3.16 INTERLOCKS:

A. Hot water will not be sent to a HE unless sludge is being pumped through (the HE is currently being served by an operating digester recirculation pump)

B. Digester temperature (read from the HE inlet temperature sensor) will only be read once the recirculation pump selected for that digester (and HE) has been operating (for at least 5 minutes). Prior to that that, the last known digester temperature shall be assumed.

3.17 ALARMS AND CONTROLS:

A. Pump fail for hot water pumps.

B. High discharge pressure for hot water pumps.

C. Cogeneration System common alarm

D. Boiler common alarm

E. Pressure independent flow control valve actuator common alarm for pressure independent flow control valve valves.

F. Mixing valve actuator common alarm.

G. Hot Water Temp. High (205 deg. F)

H. Hot Water Temp. Low (185 deg. F)

I. Hot Water Return Temp. Low (use boiler manufacturer recommendation)

J. Expansion Tank Low Level

K. HWS pressure high (100 psi)

L. Boiler pressure high (85 psi)

M. HWS pumps running at 100%

N. Hot water boiler pilot light out for hot water boilers 1 and 2.

3.18 GRAPHICAL DISPLAY:

A. The graphical display shall be graphically based on the P&IDs

B. Information shall be shown near its associated location on the P&ID

C. The following Information shall be displayed:
1. Cogeneration Heat Recovery System Supply Temp
2. Boiler Water Temp
3. Digester Gas flow
4. Natural Gas Flow
5. Hot Water Flow
6. Sludge Recirculation Flow
7. Hot Water Inlet Temp for each heat exchanger
8. Hot Water outlet temp for each heat exchanger
9. Hot water heat transferred for each heat exchanger (Btu/hr)
10. Sludge Inlet Temp for each heat exchanger
11. Sludge outlet temp for each heat exchanger
12. Sludge heat transferred for each heat exchanger (Btu/hr)

ANAEROBIC DIGESTER MIXING SYSTEM

FUNCTIONAL DESCRIPTION

3.19 PROCESS OVERVIEW:

A. The anaerobic digester mixing system consists of the following major equipment:
   1. Mixing Pumps

B. Combined Primary Sludge, Thickened WAS, and Scum is fed to the Anaerobic Digesters. To facilitate the digestion process by creating the proper conditions for the microorganisms and to prevent solids from settling, each tank is mixed. The mixing system is also designed to prevent excess foam accumulation in the digester.

C. Mixing is achieved by means of a chopper pump recirculation loop that draws solids (ADMS) from near the bottom center of the digester and sends solids (ADMR) to mixing nozzles mounted just above the floor of the digester. These mixing nozzles are oriented to cause the tank contents to rotate and actively mix the digester.

D. There are two nozzles mounted in the upper portion of the digester.
   1. Foam Suppression Nozzle: mounted just above the liquid surface and sprays in a fan pattern for foam suppression
   2. Scum Breaker Nozzle positioned to mix just below the liquid surface to prevent scum accumulation and ensure active mixing near the liquid surface.
   3. If the digester is operating at a lower level, these upper nozzles will have decreased flow.

E. In primary digesters, the mixing system should run continuously. Mixing intensity can be adjusted by the operators by controlling the chopper pump speed through VFD.

F. The digester transfer pipes (ADS) draw solids out of the tank from a location near the suction location of the ADMS. This ensure that the transfer system is able to draw from a low point in the tank to remove solids that may contain grit without getting plugged by large amounts of grit that may settle at the floor.

G. If the mixing system within a digester stops:
   1. Under certain conditions, the digester contents may expand due to entrained gas. This "Rapid Rise" scenario may cause the liquid level to increase and may adversely affect the normal operation of the digester overflow and gas withdrawal and relief systems.
   2. If feeding continues while mixing is not operating, undigested solids may accumulate in one portion of the digester. When mixing is restarted, the sudden spike in available food may cause digester instability and/or foaming conditions.

3.20 EQUIPMENT:

A. The following equipment will be monitored or controlled through the PCS:
   1. Three Digester Mixing Pumps
      a. Digester No. 1 mixing pump
      b. Digester No. 2 mixing pump
   2. Four Pressure Switches
      a. Digester No. 1 mixing pump suction pressure switch (ADMS)
      b. Digester No. 1 mixing pump discharge differential pressure switch (ADMR)
      c. Digester No. 2 mixing pump suction pressure switch (ADMS)
      d. Digester No. 2 mixing pump discharge differential pressure switch (ADMR)
   3. Two Motor Temperature Switches

3.21 OPERATION:

A. General:

1. Mixing pumps operate continuously in Digesters.
2. Mixing pump No. 1 and No. 2 are not configured to serve as redundant pumps to the other digester.
3. Each mixing pump can be operated locally or remotely from the PCS if the REMOTE position is selected.

B. Normal (PCS-AUTOMATIC) Operation:
   1. Normal operation of the Mixing System
      a. Each mixing pump will RUN at the operator-selected speed setpoint entered in the PCS. The speed setpoint shall be operator adjustable at the PCS screen.
      b. If Timer Function is enabled (typically for Secondary Digester), mixer will turn ON and OFF at the intervals selected in the PCS. A timer graphic shall be provided on the PCS screen for the operator to select the time period and also an enable/disable switch shall be provided on the screen for the operator to enable or disable the timer. Time period shall be operator adjustable at the PCS screen.
      c. Mixing speed may also be automatically controlled based on tank level. Mixing speed may be configured to increase and decrease to a Maximum or minimum level over a certain tank level range.

C. PCS-MANUAL Operation:
   1. Normal operation of the Mixing System
      a. Each mixing pump can be manually set to RUN or OFF in the PCS.
      b. When switched to PCS-MANUAL, the pump will continue operate at the same speed. This speed can be adjusted by an operator.
      c. Timer Function is not available in PCS-MANUAL mode.

D. LOCAL Mode of Operation:
   1. If the L-O-R selector switch is set to LOCAL, the pump will start to facilitate testing and operation at the pump
      a. In LOCAL, the pump will operate at the speed that is entered at the VFD keypad. Drive speed shall be adjustable from the VFD keypad.

E. Rapid Rise and Foaming:
   1. If a mixing pump fails or is stopped there is potential for rapid rise and/or foaming.
   2. Rapid Rise can begin immediately so mixing should be restored as soon as possible. The primary digester mixing pump fault will be a high priority alarm at the PCS alarms summary.
   3. If Rapid Rise is determined to be a problem, prior to scheduled mixing pump maintenance, feed should be gradually reduced if possible to reduce gas production and activity within the digester before shutting the mixer down. Care should be taken to avoid overloading the other digester and any changes in feed should be made gradually.
   4. If mixing is stopped in any Digester for more than approximately 3 hours, mixing and feed should be gradually increased back to normal levels to avoid foaming or digester upset. If mixing is stopped in any Digester for more than 3 hours, PCS shall not allow the operator to put that digester mixing pump in PCS-AUTO mode for a period of 1 hour (operator adjustable time) to allow the operator to run in PCS-MANUAL mode to avoid foaming, a rapid rise in level or surge in gas production.

3.22 INTERLOCKS:

A. The hard-wired interlocks associated with the Digester Mixing System are described below.
   1. Mixing pump motor high temperature switches, low suction pressure switches, and high discharge differential pressure switches hardwired to respective VFD.

B. The software interlocks associated with the Digester Mixing System are described below.
   1. Mixing Pump will not run (via PCS) if the corresponding digester is selected to be out of service.

2. Mixing Pump will not run (via PCS) if the liquid level in the corresponding digester is below an established minimum mixing level, based on the ADMS Piping configuration. Low level setpoint shall be operator adjustable.
3. A mixing pump failure for a particular digester shall automatically switch that digester's status in the PCS from "IN SERVICE" to "OUT OF SERVICE". This shall stop sludge feed to that digester.

3.23 ALARMS AND CONTROLS:

A. Alarms: Alarms for failure of equipment and abnormal conditions are activated at the PCS. The alarms include:
   1. Any equipment L-O-R in LOCAL or OFF position.
   2. Mixing Pump Motor FAIL
   3. Suction Pressure Switch LOW
   4. Discharge Differential Pressure Switch HIGH

B. Controls: Control functions for the equipment activated at the PCS include:
   1. PCS-AUTOMATIC; PCS-MANUAL selection.
   2. Mixing Pump RUN/OFF
   3. Mixing Pump Speed Setpoint
   4. Mixing Pump RUN/OFF Timer

3.24 GRAPHICAL DISPLAY:

A. The Digester Mixing system graphical display at the PCS will include:
   1. Digester Mixing System program status (PCS-AUTOMATIC; or PCS-MANUAL mode)
   2. Any equipment L-O-R in LOCAL or OFF.
   3. Elapsed run time meters for all motors.
   4. Equipment run status – differentiated by color RUN (red), FAIL (yellow) and OFF (green).
   5. Mixing pump(s) operating (Mixing Pump No. 1/ Mixing Pump No. 2)
   6. Digester served by each Mixing Pump (Digester No. 1/ Digester No.2)
   7. Mixing Pump operating speed
   8. Mixing Pump low suction pressure alarm
   9. Mixing Pump high discharge differential pressure alarm

ANAEROBIC DIGESTER SLUDGE TRANSFER PUMPING SYSTEM

FUNCTIONAL DESCRIPTION

3.25 PROCESS OVERVIEW:

A. The anaerobic digester Transfer Pumping System consists of the following major equipment:
   1. Digester Overflow Pipes
   2. Transfer Pumps
   3. Digester Level Sensors
   4. Digester Gas Pressure Sensors

B. Primary Sludge, Thickened Waste Activated Sludge, and Scum are fed to the Anaerobic Digesters. The Transfer Pumping System moves Anaerobic Digested Sludge (ADS) to land application or compost facility storage tanks.

C. The Transfer Pumping System performs the following:
   1. In Composting Mode
      a. Transfers solids from the Digesters to the Compost Facility sludge drying beds
   2. In Land Application Mode
      a. Transfers solids from the Digesters to the Land Application storage tank.

D. In the Digesters, the liquid level will be maintained by monitoring the liquid level in each tank and operating the appropriate transfer pump.

3.26 EQUIPMENT:

1. Two Digester Transfer Pumps
   a. Digester Transfer Pump No. 1
   b. Digester Transfer Pump No. 2

2. Two Digester Level indicators
   a. Digester No. 1 Level (Pressure)
   b. Digester No. 2 Level (Pressure)

3. Two Digester Pressure indicators (Note: Gas pressure must be subtracted from the pressure-based level measurement to provide accurate values.
   a. Digester No. 1 Gas Pressure
   b. Digester No. 2 Gas Pressure

4. Two Adjustable High Pressure Switches
   a. Transfer Pump No. 1 High Pressure
   b. Transfer Pump No. 2 High Pressure

5. Two Pump Stator High Temperature switches
   a. Transfer Pump No. 1 temperature switch
   b. Transfer Pump No. 2 temperature switch

3.27 OPERATION:

A. General Description
   1. Under normal conditions, the transfer from primary digesters to drying beds or storage tanks pumped by the transfer pumps.

B. Level Controls
   1. Level in each tank is sensed via Pressure-based level sensors.

2. Gas pressure is also measured to allow for an accurate representation of tank level by subtracting the gas pressure value from the pressure-based level sensor reading.
3. The pressure sensor will serve as a reference to detect abnormal conditions (foaming and Rapid Rise).
4. High and overflow liquid levels setpoints shall be set in accordance with the elevations of the respective overflow lines. An alarm should correspond to flow through that line.
5. Low liquid level setpoints should be set to indicate a condition where the digester volume drops to an unexpected level or to a point that would reduce the HRT below 15 days.

C. Overflow Operation
1. There are two gravity overflow systems in the Digesters:
a. Normal Overflow- maintains normal liquid level in the tank when not being pumped.
b. Emergency Overflow - If the Normal Overflow becomes obstructed or is isolated and Pumped withdrawal does not occur, the tank liquid level may rise and flow through the Emergency Overflow. When Emergency liquid level is reached, the "Emergency Liquid Level" Alarm will be activated. The emergency overflow pipe is normally filled with gas and has a glycol/water trap with a sight glass to ensure there is adequate liquid to maintain a seal. In the event of an overflow, the digester contents would flow into the sludge drying basin containment area.
2. Normal and High Overflows do not operate unless transfer pumping is offline.

D. Transfer Pump Operation
1. In order to draw off solids (and grit) from lower areas of the Digesters, Transfer Pumps will operate daily at full speed for an operator-selected time period (Note: This should not exceed 6 hours so as not to draw the digester down much below normal operating elevation and cause low liquid level alarms.)
2. Transfer from Digester Compost Facility or Land Application.
a. Pump operation and speed will be controlled by:
1) Level in land application storage tank
2) Level in Compost Facility drying beds
3) Level in Digester

E. Normal (PCS-AUTOMATIC) Pump Operation
1. Normal operation of the Pump Transfer Pumping System
a. Pumping from Digesters for grit removal
1) Each primary transfer pump will RUN for a set period of time each day (Adjustable from 0-24 hours, initial setpoint of 6 hours)
b. Pumping from Primary Digesters
1) Transfer pump will RUN automatically at a speed to maintain the level in the Digesters.

F. PCS-MANUAL Operation
1. Manual operation of the Transfer Pumping System
a. Each Transfer pump can be manually set to RUN or OFF in the PCS.
b. Pump will run at an operator-set speed in the PCS.

G. LOCAL Mode of Operation
e. The Digester feed pumps will operate continuously when the L-O-R selector switch is placed in the LOCAL position. The pump speed is adjusted manually at the VFD.
f. Only the hardwired interlocks are active in the LOCAL mode.

H. Emergency (Rapid Rise)
1. If a digester liquid level increases suddenly (i.e. faster than the maximum feed pump flow, >4" per hour) according to the sensors, it is likely that a Rapid Rise event has started. This would typically correspond to a loss of mixing in the digesters.
2. In this condition, a "Rapid Rise/Foam Conditions Detected" ALARM will activate.
3. If it is determined that Rapid Rise is a risk:
a. Mixing operation should be confirmed and the Mixing Pump VFD set to 100%.

b. Transfer Pumps and or Transfer Valves can be manually operated to lower the liquid level in this digester by transferring solids to the compost facility or land application storage tank.

c. A Rapid Rise event may also cause significant flow through any of the overflow pipes (above)

I. Emergency (Foaming)

1. Excessive Foam on the surface of the digester will have a similar effect to Rapid Rise. If the mixing system is functioning and at full speed, the issue is more likely Foam.
2. Chemical defoamant should be kept on hand and added manually to the tank surface in an emergency (if other control methods fail to control the foam).

J. Digester Drain/Fill

1. Once manual valves are adjusted appropriately, the Transfer Pumping System can be operated in PCS-MANUAL or LOCAL mode to operate two transfer pumps simultaneously in order to increase flow.

3.28 INTERLOCKS:

A. The hard-wired interlocks associated with the Digester Transfer Pumping System are described below.

1. Pump Stator High Temperature Switch will cause the Digester Transfer pump to shut down if RUN DRY conditions are detected.
2. Digester Transfer Pump HIGH discharge pressure, after a time delay (set per pump manufacturer's recommendations), will cause the Digester Transfer pump to shut down.

B. The software interlocks associated with the Digester Transfer Pumping System are described below.

1. Transfer Pump will not be allowed to start if the liquid level in the digester is below an operator-set minimum level.
2. Transfer Pump will not be allowed to start if the liquid level in the destination tank (compost sludge drying bed or land application storage tank) is above the maximum levels, as reported by the PCS.
3. If there is indication that Rapid Rise is occurring (from the level sensors), feed to the affected digester will stop automatically. (Additional operational steps are discussed in "Rapid Rise", above.)

3.29 ALARMS AND CONTROLS:

A. Alarms: Alarms for failure of equipment and abnormal conditions are activated at the PCS. The alarms include:

1. Any equipment L-O-R in LOCAL or OFF position.
2. Transfer Pump Motor FAIL (for Transfer Pump No. 1/ Transfer Pump No.2)
3. Pump Stator High Temperature Switch RUN DRY (for Transfer Pump No. 1/ Transfer Pump No.2)
4. Discharge Pressure Switch HIGH (for Transfer Pump No. 1/ Transfer Pump No.2)
5. Digester High Liquid Level (Digester No. 1, Digester No. 2)
6. Digester Low Liquid Level (Digester No. 1, Digester No. 2)
7. Emergency Overflow Liquid Level (Digester No. 1, Digester No. 2)
8. Rapid Rise/Foam Conditions Detected (Digester No. 1, Digester No. 2)
9. Transfer Stopped – Compost Facility Drying Beds HIGH
10. Transfer Stopped – Land Application Storage Tank FULL
11. Level Indicator Error (Digester No. 1, Digester No. 2)

B. Controls: Control functions for the equipment activated at the PCS include:

1. PCS-AUTOMATIC; PCS-MANUAL selection.
2. Transfer Pump RUN/OFF
3. Transfer Pump Speed Setpoint (for Transfer Pump No. 1/ Transfer Pump No.2)

3.30 GRAPHICAL DISPLAY:

A. The Digester Transfer Pumping System graphical display at the PCS will include:
  1. Digester Transfer Pumping System program status (PCS-AUTOMATIC; or PCS-MANUAL mode)
  2. Digester System Delivery Mode (Compost Facility, Land Application)
  3. Liquid Level for Each Digester (Digester No. 1, Digester No. 2)
  4. Digester Gas Pressure (Digester No. 1, Digester No. 2)
  5. Any equipment L-O-R in LOCAL or OFF.
  6. Elapsed run time meters for all motors.
  7. Equipment run status – differentiate RUN, FAIL and OFF by color.
  8. Transfer pump(s) operating (Transfer Pump No. 1/ Transfer Pump No. 2)
  9. Transfer Pump operating speed
  10. Transfer Pump Stator High Temperature RUN DRY Alarm
  11. Transfer Pump high discharge pressure alarm

Customer: City of Santa Fe
Project: Cogen

Instrument List

Equipment Designation	Instrument Number	Instrument Tag	Description	P&ID No.	Range Low_Limit	Range High_Limit	Setpoint	Engr_Units	Furnished by	Power
FIT	101	FIT-101	CV-101 Flow Transmitter	06Y-01	0	500	-	gpm	Contractor	2-wire
FIT	102	FIT-102	CV-102 Flow Transmitter	06Y-01	0	500	-	gpm	Contractor	2-wire
PSH	101	PSH-101	Sludge Transfer Pump No. 1 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	101	FSL-101	Sludge Transfer Pump No. 1 Low Flow Switch	06Y-01	0	250	100	gpm	Contractor	-
PSH	102	PSH-102	Sludge Transfer Pump No. 2 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	102	FSL-102	Sludge Transfer Pump No. 2 Low Flow Switch	06Y-01	0	300	100	gpm	Contractor	-
PSH	101	PSH-101	Sludge Recirc. Pump No. 1 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	101	FSL-101	Sludge Recirc. Pump No. 1 Low Flow Switch	06Y-01	0	400	150	gpm	Contractor	-
PSH	102	PSH-102	Sludge Recirc. Pump No. 2 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	102	FSL-102	Sludge Recirc. Pump No. 2 Low Flow Switch	06Y-01	0	400	150	gpm	Contractor	-
PSH	103	PSH-103	Sludge Recirc. Pump No. 3 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	103	FSL-103	Sludge Recirc. Pump No. 3 Low Flow Switch	06Y-01	0	400	150	gpm	Contractor	-
PSH	101	PSH-101	Digester Mixing Chopper Pump No. 1 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	101	FSL-101	Digester Mixing Chopper Pump No. 1 Low Flow Switch	06Y-01	0	2500	1000	gpm	Contractor	-
PSH	102	PSH-102	Digester Mixing Chopper Pump No. 2 High Pressure Switch	06Y-01	0	90	40	psi	Contractor	-
FSL	102	FSL-102	Digester Mixing Chopper Pump No. 2 Low Flow Switch	06Y-01	0	2500	1000	gpm	Contractor	-
FIT	201	FIT-201	Flow Transmitter	06Y-01	0	400	-	gpm	Contractor	2-wire
FIT	202	FIT-202	Flow Transmitter	06Y-01	0	400	-	gpm	Contractor	2-wire
TIT	101	TIT-101	Sludge Heat Exchanger No. 1 Temperature Trasmitter	06Y-01	0	250	-	degF	Contractor	2-wire
TIT	102	TIT-102	Sludge Heat Exchanger No. 2 Temperature Trasmitter	06Y-01	0	250	-	degF	Contractor	2-wire
TIT	103	TIT-103	Sludge Heat Exchanger No. 3 Temperature Trasmitter	06Y-01	0	250	-	degF	Contractor	2-wire
LIT	101	LIT-101	West Digester Level Transmitter	06Y-02	0	50	-	ft	Contractor	120VAC
LIT	102	LIT-102	East Digester Level Transmitter	06Y-02	0	50	-	ft	Contractor	120VAC
TIT	401	TIT-401	Sludge Heat Exchanger Hot Water Supply Temperature Gauge	06Y-02	0	250	-	degF	Contractor	2-wire
TIT	402	TIT-402	Sludge Heat Exchanger Hot Water Return Temperature Gauge	06Y-02	0	250	-	degF	Contractor	2-wire
TI	101	TI-101	Hot Water Boiler No. 1 Temperature Indicator	06Y-02	0	250	-	degF	Contractor	2-wire
TI	102	TI-102	Hot Water Boiler No. 2 Temperature Indicator	06Y-02	0	250	-	degF	Contractor	2-wire
FIT	103	FIT-103	West Digester Flow Transmitter	06Y-02	0	300	-	cfm	Contractor	2-wire
FIT	104	FIT-104	East Digester Flow Transmitter	06Y-02	0	300	-	cfm	Contractor	2-wire
TIT	401	TIT-401	Hot Water Pump No. 2 Discharge Temperature Transmitter	06Y-02	0	250	-	degF	Contractor	2-wire
TIT	402	TIT-402	Sludge Heat Exchangers Discharge Temperature Transmitter	06Y-02	0	250	-	degF	Contractor	2-wire
TIT	403	TIT-403	CHP Engines Discharge Temperature Transmitter	06Y-02	0	250	-	degF	Contractor	2-wire
TIT	404	TIT-404	Hot Water Boiler Discharge Temperature Transmitter	06Y-02	0	250	-	degF	Contractor	2-wire
PIT	601	PIT-601	Hydrogen Sulfide Removal Vessel Pressure Transmitter	06Y-03	-5	20	-	inches w.c.	Gas Treatment Supplier	2-wire
LSH	601	LSH-601	Particulate Filter No. 4 High Level Switch	06Y-03	0	20	5	ft	Gas Treatment Supplier	-
PIT	602	PIT-602	Particulate Filter No. 4 High Pressure Transmitter	06Y-03	-5	20	-	inches w.c.	Gas Treatment Supplier	2-wire
LSH	602	LSH-602	Particulate Filter No. 6 High Level Switch	06Y-03	0	20	5	ft	Gas Treatment Supplier	-
TIT	601	TIT-601	Gas Booster Blower No. 1 Temperature Gauge	06Y-03	0	300	-	degF	Gas Treatment Supplier	2-wire
PIT	603	PIT-603	Gas Booster Blower No. 1 Pressure Gauge	06Y-03	0	10	-	psi	Gas Treatment Supplier	2-wire
TIT	602	TIT-602	Moisture Separator Temperature Gauge	06Y-03	0	200	-	degF	Gas Treatment Supplier	2-wire
PIT	604	PIT-604	Moisture Separator Pressure Gauge	06Y-03	0	10	-	psi	Gas Treatment Supplier	2-wire
TIT	603	TIT-603	Chiller Temperature Gauge	06Y-03	0	100	-	degF	Gas Treatment Supplier	2-wire
PIT	605	PIT-605	Chiller Pressure Gauge	06Y-03	0	100	-	psi	Gas Treatment Supplier	2-wire
PIT	606	PIT-606	Siloxane Removal Vessel Pressure Transmitter	06Y-03	0	10	-	psi	Gas Treatment Supplier	2-wire
FIT	801	FIT-801	Engine Generator No. 1 Flow Transmitter	06Y-03	0	200	-	cfm	Contractor	2-wire
FIT	802	FIT-802	Engine Generator No. 2 Flow Transmitter	06Y-03	0	200	-	cfm	Contractor	2-wire

SECTION 40 91 10

PRIMARY METERS AND TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Flow components.
   2. Pressure components.
   3. Level components.
   4. Temperature components.
   5. Pipe, tubing and fittings.
   6. Instrument valves.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   4. Section 40 90 05 - Control Loop Descriptions.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Gas Association (AGA):
      a. Gas Measurement Committee Report #3.
   2. American Iron and Steel Institute (AISI).
   3. American National Standards Institute (ANSI).
   4. American Society of Mechanical Engineers (ASME):
      a. B16.5, Pipe Flanges and Flanged Fittings.
      b. B31.1, Power Piping.
      c. PTC 19.3, Instruments and Apparatus, Part 3 Temperature Measurement.
      d. PTC 19.5, Application of Fluid Meters, Part 2.
      e. Section II, Part A SA-182, Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   5. ASTM International (ASTM):
      a. A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
      b. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
      c. A276, Standard Specification for Stainless Steel Bars and Shapes.
      d. B75, Standard Specification for Seamless Copper Tube.
      e. B124, Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes.
      f. B283, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).
      g. B453, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Rod, Bar, and Shapes.
   6. Federal Communications Commission (FCC)
      a. 47 CFR 15, Radio Frequency Devices.
   7. Instrumentation, Systems, and Automation Society (ISA):
      a. MC96.1, Temperature Measurement Thermocouples.
   8. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SYSTEM DESCRIPTION

A. The instruments specified in this Specification Section are the primary element components for the control loops shown on the "Y" series Drawings and specified in Specification Section 40 90 05.
   1. These instruments are integrated with other control system components specified under Specification Section 40 90 00 series to produce the functional control defined in the Contract Documents.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 90 00.
   3. ISA S20 data sheets showing instrument tag numbers.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the Articles describing the elements are acceptable.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 FLOW COMPONENTS

A. Magnetic Flow Meters:
   1. Acceptable manufacturers:
      a. ABB WaterMaster
      b. Rosemount 8705
      c. Krohne Optiflux
   2. Design and fabrication:
      a. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate.
      b. High input impedance pre-amplifiers.
         1) Minimum impedance: 10^{10} ohms.
      c. Provide flanged end connections per ASME B16.5 rated for piping system operating and test conditions.
      d. Grounding requirements:
         1) Nonmetallic or lined pipe:
            a) Inlet and outlet grounding rings of same material as electrode.
         2) Conductive piping:
            a) Conductive path between the meter and the piping flanges.
      e. Provide cable between magnetic flow meter and transmitter.
      f. Pulsed DC magnetic field excitation.
      g. Automatic zero.
      h. Adjustable low flow cutoff.
      i. Minimum signal lock (empty tube zero) to prevent false measurement when tube is empty.
      j. Inaccuracy:
         1) Above 10 percent of range: +/-1.0 percent of rate.

2) Below 10 percent of range: +/-0.1 percent of range setting.
3) Add +0.1 percent of range to above inaccuracies for analog outputs.

k. 4-20 mA DC isolated output into maximum 800 ohms.
l. Power supply: 120 V +/-10 percent, 60 Hz.
m. Indication of flow rate and totalized flow at transmitter.
n. Meter operable as specified in liquids with 5.0 micro mho/cm or more conductivity.
o. Transmitter electronics shall use microprocessor based architecture and be configured using parameters.

3. Schedule: See Contract Drawings and Instrument List 40 91 10A

B. Thermal Dispersion Mass Flowmeters:

1. Acceptable manufacturer:
   a. Fluid Components, Inc. Model ST51/51A
   b. Magnetrol Thermatel TA2
2. Materials:
   a. All wetted surfaces: 300 series stainless steel.
3. Design and fabrication:
   a. Sensor assembly of 300 series stainless steel thermowells with precisely matched RTDs and a heating element.
   b. Single-point insertion type
   c. Shall meet Class 1 Division 1 Groups B, C, D explosion-proof ratings. Submit manufacturer furnished certificates to certify installation in Class 1 Div 1 areas.
   d. Turndown ratio: 10:1 to 100:1.
   e. Accuracy: +/-0.75 percent of reading down to +/-0.5 percent of full scale
   f. Repeatability: +/-0.5 percent of reading.
   g. Operating temperature:
      1) Sensor: -40 to 350 DegF.
      2) Transmitter: 0-150 DegF.
   h. Process connection: 3/4 IN NPT
   i. Calibration shall be performed on NIST traceable flow stands and equipment.
   j. Field adjustable insertion length.
   k. Microprocessor based electronics with field adjustable instrument performance parameters and build-in testing and diagnostics and nonvolatile memory.
   l. Provide digital LCD display at transmitter.
   m. 4-20 mA DC, 600 ohm process output.
   n. 115 Vac, 60 Hz power.
   o. Outputs: Two analog 4-20mA outputs HART, user assignable.
   p. Provide with suitable length of cable between sensor and transmitter.
   q. Supply one (1) programmer to allow reconfiguration of process parameters.
4. Schedule: See Contract Drawings and Instrument List 40 91 10A

TAG NUMBER	SERVICE	FLOW RANGE (SCFM)	METER SIZE (IN)
FIT-101	West Digester Gas Flow	0-250	Insertion
FIT-102	East Digester Gas Flow	0-250	Insertion

TAG NUMBER	INSERTION LENGTH (INCHES)	SENSOR MATERIAL	INTEGRAL, FIELD OR PANEL-MOUNTED TRANSMITTER
FIT-101	Per pipe size	316 Stainless Steel	Field
FIT-102	Per pipe size	316 Stainless Steel	Field

2.3 PRESSURE COMPONENTS

A. Pressure Transmitters:
1. Acceptable manufacturers:
   a. Rosemount, Model 3051.
   b. Foxboro, I/A series.
   c. Honeywell SmartLine ST700
2. Materials:
   a. Isolating diaphragm: Hastelloy C
   b. Process flanges and adapters: 316 stainless steel.
   c. Housing: Aluminum.
   d. Vent/drain valve: 316 stainless steel.
   e. Fill fluid:
      1) Utilize halocarbon fill for process applications involving strong oxidizing agents.
         a) Agents include but are not limited to: Cl2, KMN04, FeCl, Na0H, and Na0Cl.
      2) Utilize manufacturer's standard fill for other applications.
         a) Ensure fill is suitable for application temperatures.
3. Design and fabrication:
   a. Smart transmitters utilizing microprocessor based electronics.
   b. Output: 4-20 mA DC proportional to pressure.
   c. Nonvolatile EEPROM memory.
   d. Power supply: 24 Vdc.
   e. Adjustable zero and span.
   f. Temperature limits: -20 to 180 DegF.
      1) -4 to 175 DegF for LCD indicators.
   g. Overpressure limits: Withstand 150 percent of stated maximum service pressure without damage.
   h. Humidity limits: 0 to 100 percent relative humidity.
   i. Damping: Adjustable between 0 and 32 seconds.
   j. Inaccuracy (includes effects of linearity, repeatability and hysteresis): +/-0.10 percent of calibrated span for 15:1 rangeability.
   k. Stability: +/-0.2 percent of upper range limit for 12 months.
   l. Temperature effect:
      1) Total effect including span and zero errors: +/-0.2 percent of upper range limit per 100 DegF for minimum 15:1 rangeability.
   m. Minimum 1/2 IN pressure connection.
   n. Equip with test jacks or accessible terminals for testing output.
   o. Equip with isolation valve and test connections with isolation valves and/or plugs.
4. Schedule: See Contract Drawings and Instrument List 40 91 10A

A. Differential Pressure Transmitters:
1. Acceptable manufacturers:
   a. Rosemount, Model 3051C, without exceptions (Measurement type D – differential)
2. Design and fabrication:
   a. Smart transmitter utilizing microprocessor based electronics.
   b. Housing material: Stainless Steel
   c. Output: 4-20 mA DC proportional to:
      1) Non-flow applications: Differential pressure.
      2) Flow applications: Square root of the differential pressure.
   d. Nonvolatile EEPROM memory.
   e. Power supply: 24 Vdc.
   f. Rated for Class 1 Division 1 explosion-proof application. Submit manufacturer supplied certificate for Class I Division 1 explosion-proof (XP) installation. Provide Rosemount certification for code E5.
   g. Adjustable zero and span.
   h. Temperature limits: -20 to 180 DegF.
      1) -4 to 175 DegF for LCD indicators.

i. Overpressure limits:
   1) Withstand body rated pressure on either side without damage or loss of calibration.
   2) Withstand 150 percent of stated maximum service pressure without damage.
j. Humidity limits: 0 to 100 percent relative humidity.
k. Damping: Adjustable between 0 and 32 seconds.
l. Inaccuracy (includes effects of linearity, repeatability and hysteresis): +/-0.10 percent of calibrated span for 15:1 rangeability.
m. Stability: +/-0.2 percent of upper range limit for 12 months.
n. Temperature effect:
   1) Total effect including span and zero errors: +/-0.2 percent of upper range limit per 100 DegF for minimum 15:1 rangeability.
o. Minimum 1/2 IN pressure connection.
p. Equip with test jacks or accessible terminals for testing output.
q. Equip with a three-valve manifold as follows:
   1) Two (2) transmitter isolating valves.
   2) One (1) transmitter equalizing valve.
r. Provide with test connections with isolation valves and/or plugs.

3. Schedule:

TAG NUMBER	SERVICE	SPAN
LIT-101	West Digester Level	0-20 ft
LIT-102	East Digester Level	0-20 ft

B. Pressure Switches:
1. Acceptable manufacturers:
   a. Mercoid.
   b. Ashcroft B series
2. Materials:
   a. Wetted switch elements: 316 stainless steel.
   b. Diaphragm seal housing: 316 stainless steel.
   c. Pressure snubber:
      1) Filter disc: 316 stainless steel.
      2) Housing: 316 stainless steel.
3. Accessories:
   a. Provide ball valve to isolate pressure switch from source.
   b. Utilize pressure snubbers with porous metal discs to provide pulsation dampening on pressure switch as shown on schedule.
   c. On applications where a pressure switch and a pressure gage are used at the same location, it is permissible to utilize one (1) pulsation dampener and diaphragm seal to isolate both elements from the process fluid.
   d.
4. Design and fabrication:
   a. Utilize hermetically sealed mercury contact switches.
   b. Two (2) SPDT contacts rated:
      1) 1 amp inductive at 125 Vdc.
      2) 5 amp inductive at 120 Vac.
   c. Switch set points:
      1) Above 1,000 psi:
         a) Between 30 and 35 percent of switch rated working range.
         b) Operating pressure range not to exceed 35 percent of switch rated working pressure.
      2) Below 1,000 psi:
         a) Set points between 30 and 70 percent of switch rated working range.
         b) Operating pressure not to exceed 75 percent of switch rated working range.

d. Accuracy: Better than 1 percent of full scale.
e. Process connection: Minimum of 1/4 IN.

A. Pressure Gage:
1. Acceptable manufacturers:
a. Ashcroft 1279 Duragauge Plus
b. Ametek
2. Materials:
a. Bourdon tube, socket, connecting tube: 316 stainless steel or monel.
b. Case: Phenolic.
c. Pressure snubber:
1) Filter disc: 316 stainless steel
2) Housing: 316 stainless steel
3. Accessories:
a. Provide valve at point of connection to equipment and at panel if panel mounted.
b. Utilize pressure snubbers with porous metal discs to provide pulsation dampening on gage applications as shown on schedule.
c. Provide 1/2 IN stainless steel antisiphon pigtail inlet connection for hot water and steam applications.
4. Design and fabrication:
a. All components suitable for service at:
1) 250 DegF.
2) The maximum process temperature to which the gage is to be exposed.
b. Dry gauge – no liquid fill.
c. Shatter-proof glass window.
d. Provide viewer protection from element rupture.
e. Calibrate gages at jobsite for pressure and temperature in accordance with manufacturer's instructions.
f. Unless otherwise required by codes, provide stem mounted or flush mounted, as required, with 4 ½” dial diameter and ½” process connection.
g. Equip with white faces, black numerals and black pointers.
h. Gage tapping position to be clear of equipment functions and movements, and protected from maintenance and operation of equipment.
1) Gage to be readable from an accessible standing position.
i. Gage accuracy: 1 percent of full range.
j. Select gage range so that:
1) The normal operating value is in the middle third of the dial.
2) Maximum operating pressure does not exceed 75 percent of the full scale range.

A. Diaphragm Seal:
1. Acceptable manufacturers:
a. Ashcroft Type 201
b. Ametek
c. Red Valve Series 742
2. Materials:
a. Lower housing: 316 stainless steel.
b. Diaphragm material: 316 stainless steel.
3. Design and fabrication:
a. Isolates instrument from process fluids which are corrosive or contain solids.
b. Upper housing with bleed screw.
c. Lower housing with flushing connection/flushing port.
d. Diaphragm welded to top housing.
e. Fill fluid:
1) Silicone oil.
2) Ensure fill is suitable for application temperatures.
f. Process connections:
1) Instrument: 1/2 IN NPT

2) Process: 0.5 IN female NPT.
3) PVC pipe applications: Use a socket weld connection.
4. Installed where specified or shown on Drawings.
5. Rated up to 2500 psi.

B. In-Line Isolation Sleeve (Annular Seal):
1. Acceptable manufacturers:
a. Red Valve Series 40
2. Materials:
a. Body: 316 stainless steel
b. Flanges: 316 stainless steel
c. Flexible liner: Buna-N
3. Design and fabrication:
a. Provide full 360 degree annular pressure sensor with flexible in-line sleeve.
b. Sensor shall not restrict the process flow (non-intrusive).
c. Seal shall have ANSI Class 150 flanges.
1) Line size as shown on the Drawings.
d. Instrument connection: 0.25 IN female NPT.
e. Fill fluid:
1) Utilize halocarbon fill for process applications involving strong oxidizing agents.
a) Agents include but are not limited to: Cl_2, $KMNO_4$, FeCl, NaOH, and NaOCl.
2) Utilize manufacturer's standard fill for other applications.
a) Ensure fill is suitable for application temperatures.
f. Pressure rating: To meet requirements of schedule.

2.4 LEVEL COMPONENTS

A. Float type level switches:
1. Acceptable manufacturers:
a. ITT Flygt/ENM-10
2. Design and fabrication:
a. Type: Mechanical micro switch in plastic casing
b. Material: Polypropylene encapsulated ball with PVC sheared cable
c. Construction: Welded and screwed plastic components. No adhesives allowed.
d. Cable length: 30 ft minimum (cut cable to suit in field)
e. Temperature rating: 32 to 140 degF
f. Switch electrical rating: 250VAC, 10A resistive, 4A inductive SPDT snap acting. Mercury switches shall not be accepted.
g. Specific gravity range: 0.95 to 1.10

B. Ultrasonic Level Sensor and Transmitter:
1. Acceptable manufacturers:
a. Siemens Milltronics Hydroranger 200
b. Rosemount 3105 with 3490 controller unit
c. ABB Model LST400
2. Materials:
a. Sensor wetted parts: PVC, polypropylene, KYNAR or polyvinylidene fluoride (PVDF).
3. Design and fabrication:
a. Sensor:
1) Emits ultrasonic sound.
2) Detects return echo reflected from surface and converts it to electrical energy proportional to level.
b. Temperature compensated.
c. Capable of being configured to ignore false targets.
d. Operating temperature: -4 to 140 DegF.

e. Humidity: 95 percent non-condensing.
f. Transmitter:
1) Capable of producing output signal proportional to level of 4-20 mA DC into 500 ohm load.
2) NEMA 4X housing
3) Power supply: 120 Vac (+/-10 percent), 60 Hz.
4) Inaccuracy: 0.25 percent of range or 0.24 IN, whichever is greater.
5) Resolution: 0.1 percent of span or 0.08 IN, whichever is greater.
6) Display: Menu-driven LCD scalable to engineering units with selectable decimal point.
7) Temperature: -5 to 122 DegF.
8) Humidity: 95 percent noncondensing.
9) Memory: EEPROM (non-volatile).
10) Keypad programmer.
11) Provide sunshield for transmitter housing.
g. Furnish manufacturer supplied stainless steel tag engraved with Owners instrument tag number and description.
4. Schedule: See Contract Drawings and Instrument List 40 91 10A

2.5 TEMPERATURE COMPONENTS

A. RTD's:
1. Acceptable manufacturers:
a. Rosemount.
b. Foxboro.
2. Materials:
a. Sensor: Platinum.
b. Sheath:
1) 900 DegF maximum: Type 316 stainless steel.
2) 1200 DegF maximum: Inconel.
c. Insulation: Ceramic or metallic oxide.
3. Design and fabrication:
a. 100 ohms at 0 DegC.
b. Spring loaded.
c. Lead wire compensation: Three- or four-wire.
d. Accuracy: +0.5 DegF or +0.5 percent of measured temperature, whichever is greater.
e. Sheath diameter: 1/4 IN (6.0 mm).

B. Thermowells:
1. Acceptable manufacturers:
a. Rosemount.
b. Foxboro.
2. Materials:
a. Well: ASTM A182, F316 stainless steel.
b. Head: Cast iron.
3. Design and fabrication:
a. Constructed in accordance with ASME PTC 19.3, Part 3, Chapter 1, Paragraphs 8-19.
b. Lagging extension sufficient to provide wrench clearance above lagging.
c. Seal welded on applications where process pressure exceeds 450 psi.
d. Test thermowells shall be supplied with watertight cap and chain.

C. Temperature Transmitters:
1. Acceptable manufacturers:
a. Emerson Rosemount, Model 3144P.

2. Materials:

a. Housing: Stainless Steel.

3. Design and fabrication:
   a. Smart transmitter utilizing microprocessor based electronics.
   b. LCD display.
   c. Rated for Class 1 Division 1 explosion-proof application. Submit manufacturer supplied certificate for Class I Division 1 explosion-proof (XP) installation.
   d. Transmitter inaccuracy shall be in accordance with the following:
      1) 100 ohm platinum RTD input: +/-[0.25 DegF +0.02 percent of span] or +/-[0.2 DegF +0.025 percent of span] or +/-[0.09 DegF +0.05 percent of span], whichever is greater.
   e. Stability:
      1) Any of the following drift limits are acceptable:
         a) Greater of: 0.1 percent of reading or 0.1 DegC per 12 months.
         b) 0.05 percent of input reading plus 0.043 percent of span per 12 months.
         c) 0.05 percent of maximum span per 12 months.
   f. Ambient temperature effects (including digital, D/A conversion, and cold junction effects):
      1) Any of the following effects per 50 DegF change are acceptable:
         a) One-half reference inaccuracy plus 0.18 DegF.
         b) Effects in accordance with the following inputs:
            (1) 100 platinum RTD input: +/-[0.08 DegC +0.025 percent of (reading +200) +0.025 percent of span +0.02 percent of (reading - lower range value)].
   g. Ambient temperature limits:
      1) -40 to 185 DegF.
      2) Integral LCD meter: -4 to 158 DegF.
   h. Output: 4-20 mA/HART enabled DC signal linearly proportional to temperature.
   i. Power supply: 24 Vdc.
   j. Adjustable span.
   k. Adjustable zero.

2.6 PIPE, TUBING, AND FITTINGS

A. Acceptable Manufacturers:
   1. Tube fittings:
      a. Parker CPI.
      b. Swagelok.

B. Instrument Tubing and Fittings:
   1. Material:
      a. Tubing: ASTM A269, Grade TP 316 stainless steel.
      b. Straight fittings: 316 stainless steel per ASME SA-479 or ASTM A276.
      c. Shaped bodies: ASME SA-182 F316 stainless steel.
   2. Design and fabrication:
      a. Tubing:
         1) Seamless.
         2) Fully annealed.
         3) Maximum hardness: 80 Rb.
         4) Free from surface scratches and imperfections.
         5) Diameter: 1/2 IN OD unless specified otherwise.
         6) Wall thickness:
            a) Meet requirements of ASME B31.1, Paragraph 122.3.
            b) Minimum 0.049 IN for 1/2 IN OD tubing.
      b. Fittings:
         1) Flareless.

2) Compression type.

C. Instrument Piping:
1. For applications where the instrument is supported solely by the sensing line, (e.g., pressure gauge directly mounted to process line) utilize piping as specified below.
a. Diameter: 1/2 IN unless specified otherwise.
b. Schedule 80.
c. 316 stainless steel.

2.7 INSTRUMENT VALVES

A. Process instrument multi-valve manifolds, isolation, vent and blow-down valves:
1. Acceptable manufacturers:
a. Whitey Co.
b. Anderson-Greenwood USA, Inc.
2. Materials:
a. Packing:
1) 450 DegF and above: Graphite.
2) Below 450 DegF: Graphite or Teflon.
b. Body: 316 stainless steel per ASTM A479.
c. Stem: 316 stainless steel per ASTM A276.
d. Ball: 316 stainless steel per ASTM A276.
e. Support rings: 316 stainless steel per ASTM A276.
f. Seats:
1) Metal:
a) 316 stainless steel per ASTM A276.
2) Soft:
a) Teflon, Delrin.
b) Only utilized on applications where manufacturer's temperature and pressure ratings exceed process design conditions.
3. Design and fabrication:
a. Either of the following:
1) Ball valve with 1/4 turn activation.
2) Free-swiveling ball stem.
b. Provide body wall thickness sufficient for process design conditions per ASME B31.1.
c. Temperature: Manufacturer's temperature rating for all components shall exceed process design conditions.

2.8 ACCESSORIES

A. Furnish all mounting brackets, hardware and appurtenances required for mounting primary elements and transmitters.
1. Materials, unless otherwise specified, shall be as follows:
a. Bolts, nuts, washers, expansion anchors: 316 stainless steel.
b. Mounting brackets:
1) Standard: 316 stainless steel.
2) Highly corrosive areas: Aluminum.
c. Mounting plates, angles:
1) Standard: Carbon steel.
2) Corrosive areas: 316 stainless steel.
d. Instrument pipe stands:
1) Standard: Hot-dip galvanized 2 IN schedule 40, ASTM A106, Grade B carbon steel.
2) Corrosive areas: 316 stainless steel.

B. Tubing Support Angles and Brackets:
1. Any of the following materials are acceptable:
a. Aluminum support with dielectric material between support and tubing.

b. Type 316 stainless steel.
c. Fiberglass.

C. Tubing Tray or Channel:
1. Aluminum.
2. Provide dielectric material between tray or channel and tubing.

D. Provide handheld communicator compatible with all intelligent transmitters furnished.
1. Hand held communicator shall provide capability to check calibration, change transmitter range, and provide diagnostics.
2. If these features are provided with the intelligent transmitter, the hand held communicator is not required.

E. Cable lengths between sensors and transmitters shall be continuous (without splices) and as required to accommodate locations as shown on Drawings.

F. All field mounted instruments shall be furnished with a hinged sunshield cover. See Contract Drawing 07Y-12 for sunshield detail.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install instrument mounting pipe stands level and plumb.

C. Instrument Valves:
1. Orient stems for proper operation.
2. Install arrays orderly and neat in appearance with true horizontal and vertical lines.
3. Provide a minimum of 2 IN clearance between valve handle turning radii where there are multiple valve handles appearing in a straight line.
4. Valves shall have bonnets and any soft seals removed during welding or soldering into the line.
   a. When cool, reassemble the valves.
5. Support each valve individually.
   a. The tubing system does not qualify as support for the valve.

D. Locate instrument piping and tubing so as to be free of vibration and interference with other piping, conduit, or equipment.

E. Keep foreign matter out of the system.

F. Remove all oil on piping and tubing with solvent before piping and tubing installation.

G. Plug all open ends and connections to keep out contaminants.

H. Tubing Installation:
1. General:
   a. Install such that tube shows no sign of crumpling, bends of too short a radius, or flattening, etc.
   b. Make tube runs straight and parallel or perpendicular to the floor, equipment and piping runs.
   c. For liquid and steam applications, slope continuously from the process to the instrument with a minimum slope of 0.50 IN per foot.
   d. For gas and air applications, slope continuously from the instrument to the process with a minimum slope of 0.50 IN per foot.
   e. If the sensing line cannot be continuously sloped, install high point vents and low point drains.
   f. Keep instrument tubing clean during all phases of work.
   g. Blow out with clean, dry, oil-free air immediately before final assembly.

h. Cut by sawing only and debur.

2. Bending:
   a. Make each bend with tube bender of the correct size for the tube.
   b. Make all bends smooth and continuous.
   c. Rebending is not permitted.
   d. Make bends true to angle and radius.
   e. Maintain a true circular cross section of tubing without buckling or undue stretch of tube wall.
   f. Allowable tolerance for flattening out of tubing bends: Maximum of 8 percent of the OD for stainless steel tubing.
   g. Minimum bending radius for stainless steel tubing:

TUBE OD, INCHES	MINIMUM BENDING RADIUS, INCHES
1/4	9/16
3/8	15/16
1/2	1-1/2

   h. Minimum bending radius for type L, hard (drawn) copper:

TUBE OD, INCHES	MINIMUM BENDING RADIUS, INCHES
3/8	1-3/4
1/2	2-1/2

3. Tubing support:
   a. Intermittently support by clamping to support angle.
   b. Install supports to be self-draining, supported by hangers, or cantilevered from walls or structural beams.
   c. Support at 5 FT-0 IN maximum spans for horizontal or vertical runs.
   d. Use tubing trays in areas where spans between supports are greater than 5 FT and for all signal tubing support.
   e. Support each tubing tray at 10 FT maximum spans.
   f. Align tubing in orderly rows and retain in the tray by bolted clips.
      1) The use of spring or speed clips is not acceptable.
   g. Maintain order of the tubing throughout the length of the tray.
   h. Locate angle, channel and tray installation to protect tubing from spills and mechanical damage.
   i. Locate support members to clear all piping, conduit, equipment, hatchways, monorails, and personnel access ways and allow access for equipment operation and maintenance.
   j. Support trays to prevent torsion, sway or sag.
   k. Permanently attach supports to building steel or other permanent structural members.
   l. Arrange supports and trays so that they do not become a trough or trap.
4. Routing and orientation:
   a. Route to maintain a minimum headroom clearance of 8 FT.
   b. Locate and orient valves and specialties so that they are accessible for operation and maintenance from the operating floor.
      1) Do not route through or over equipment removal areas, below monorails or cranes nor above or below hatches.
5. Expansion and vibration provisions:
   a. Provide horizontal expansion loops at the process connections.
   b. Route tubing parallel to relative motion through sleeved supports that allow linear tube movement.
   c. Cold springing of tubing to compensate for thermal expansion is prohibited.

d. Utilize flexible hoses to connect pneumatic tubing to air users which may move or vibrate.
6. Use Tite-Seal or acceptable alternate.
7. Use of lead base pipe dope or Teflon tape is not acceptable.
8. Do not apply Tite-Seal to tubing threads of compression fittings.

I. Capillary Tubing:
1. Route capillary tubing in tubing tray.
2. Install capillary tubing with a 2 IN minimum bend radius which does not kink or pinch the capillaries.
3. Do not cut or disconnect at any point.
4. Coil excess capillary tubing and secure at the instrument.

J. Instrument Mounting:
1. Mount all instruments where they will be accessible from fixed ladders, platforms, or grade.
2. Mount all local indicating instruments with face forward toward the normal operating area, within reading distance, and in the line of sight.
3. Mount instruments level, plumb, and support rigidly.
4. Mount to provide:
   a. Protection from heat, shock, and vibrations.
   b. Accessibility for maintenance.
   c. Freedom from interference with piping, conduit and equipment.

3.2 TRAINING

A. Provide on-site training in accordance with Specification Section 01 75 00.

END OF SECTION

I/O List

SignalType	Equipment Number	Modifier	I/O Tag	P&ID	I/O Type	I/O Interface	PLC Tag	User Description
HY	101	A	HY101A	06Y-01	DO	Hardwired	PLC-201	West Digester Intake Valve Open Command
HY	101	B	HY101B	06Y-01	DO	Hardwired	PLC-201	West Digester Intake Valve Close Command
YI	101	A	YI101A	06Y-01	DI	Hardwired	PLC-201	West Digester Intake Valve Open
YI	101	B	YI101B	06Y-01	DI	Hardwired	PLC-201	West Digester Intake Valve Closed
YI	101	C	YI101C	06Y-01	DI	Hardwired	PLC-201	West Digester Intake Valve In Remote
HY	102	A	HY102A	06Y-01	DO	Hardwired	PLC-201	East Digester Intake Valve Open Command
HY	102	B	HY102B	06Y-01	DO	Hardwired	PLC-201	East Digester Intake Valve Close Command
YI	102	A	YI102A	06Y-01	DI	Hardwired	PLC-201	East Digester Intake Valve Open
YI	102	B	YI102B	06Y-01	DI	Hardwired	PLC-201	East Digester Intake Valve Closed
YI	102	C	YI102C	06Y-01	DI	Hardwired	PLC-201	East Digester Intake Valve In Remote
HY	G101		HYG101	06Y-01	DO	Hardwired	PLC-201	Grinder No. 1 Start Command
YI	G101	A	YIG101A	06Y-01	DI	Hardwired	PLC-201	Grinder No. 1 Running
YI	G101	B	YIG101B	06Y-01	DI	Hardwired	PLC-201	Grinder No. 1 in Auto
YA	G101		YAG101	06Y-01	DI	Hardwired	PLC-201	Grinder No. 1 Fault
HY	G102		HYG102	06Y-01	DO	Hardwired	PLC-201	Grinder No. 2 Start Command
YI	G102	A	YIG102A	06Y-01	DI	Hardwired	PLC-201	Grinder No. 2 Running
YI	G102	B	YIG102B	06Y-01	DI	Hardwired	PLC-201	Grinder No. 2 in Auto
YA	G102		YAG102	06Y-01	DI	Hardwired	PLC-201	Grinder No. 2 Fault
HY	201		HY201	06Y-01	DO	Hardwired	PLC-201	Sludge Recirc Pump No. 1 Start Command
YI	201	A	YI201A	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 1 Running
YI	201	B	YI201B	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 1 in Auto
YA	201		YA201	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 1 Fault
HY	202		HY202	06Y-01	DO	Hardwired	PLC-201	Sludge Recirc Pump No. 2 Start Command
YI	202	A	YI202A	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 2 Running
YI	202	B	YI202B	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 2 in Auto
YA	202		YA202	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 2 Fault
HY	203		HY203	06Y-01	DO	Hardwired	PLC-201	Sludge Recirc Pump No. 3 Start Command
YI	203	A	YI203A	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 3 Running
YI	203	B	YI203B	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 3 in Auto
YA	203		YA203	06Y-01	DI	Hardwired	PLC-201	Sludge Recirc Pump No. 3 Fault

I/O List

SignalType	Equipment Number	Modifier	I/O Tag	P&ID	I/O Type	I/O Interface	PLC Tag	User Description
HY	204		HY204	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Start Command
YI	204	A	YI204A	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Running
YI	204	B	YI204B	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 in Auto
YA	204		YA204	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Fault
HY	205		HY205	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Start Command
YI	205	A	YI205A	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Running
YI	205	B	YI205B	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 in Auto
YA	205		YA205	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Fault
HY	206		HY206	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Start Command
YI	206	A	YI206A	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Running
YI	206	B	YI206B	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 in Auto
YA	206		YA206	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Fault
HY	207	A	HY207A	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Inlet Valve Open Command
HY	207	B	HY207B	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Inlet Valve Close Command
YI	207	A	YI207A	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Inlet Valve Open
YI	207	B	YI207B	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Inlet Valve Closed
YA	207		YA207	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 1 Inlet Valve Fault
HY	208	A	HY208A	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Inlet Valve Open Command
HY	208	B	HY208B	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Inlet Valve Close Command
YI	208	A	YI208A	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Inlet Valve Open
YI	208	B	YI208B	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Inlet Valve Closed
YA	208		YA208	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 2 Inlet Valve Fault
HY	209	A	HY209A	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Inlet Valve Open Command
HY	209	B	HY209B	06Y-01	DO	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Inlet Valve Close Command
YI	209	A	YI209A	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Inlet Valve Open
YI	209	B	YI209B	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Inlet Valve Closed
YA	209		YA209	06Y-01	DI	Hardwired	PLC-201	Sludge Hot Water Recirc Pump No. 3 Inlet Valve Fault
HY	101		HY101	06Y-01	DO	Hardwired	PLC-201	Sludge Transfer Pump No. 1 Start Command
YI	101	A	YI101A	06Y-01	DI	Hardwired	PLC-201	Sludge Transfer Pump No. 1 Running
YI	101	B	YI101B	06Y-01	DI	Hardwired	PLC-201	Sludge Transfer Pump No. 1 in Auto

I/O List

					I/O			
SignalType	**Equipment Number**	**Modifier**	**I/O Tag**	**P&ID**	**Type**	**Interface**	**PLC Tag**	**User Description**
YA	101		YA101	06Y-01	DI	Hardwired	PLC-201	Sludge Transfer Pump No. 1 Fault
HY	102		HY102	06Y-01	DO	Hardwired	PLC-201	Sludge Transfer Pump No. 2 Start Command
YI	102	A	YI102A	06Y-01	DI	Hardwired	PLC-201	Sludge Transfer Pump No. 2 Running
YI	102	B	YI102B	06Y-01	DI	Hardwired	PLC-201	Sludge Transfer Pump No. 2 in Auto
YA	102		YA102	06Y-01	DI	Hardwired	PLC-201	Sludge Transfer Pump No. 2 Fault
FI	201		FI201	06Y-01	AI	Hardwired	PLC-201	Flow to Compost Facility
FI	202		FI202	06Y-01	AI	Hardwired	PLC-201	Flow to Land Application/Storage Tanks
FI	103		FI103	06Y-02	AI	Hardwired	PLC-201	West Digester Gas Flow
FI	104		FI104	06Y-02	AI	Hardwired	PLC-201	East Digester Gas Flow
LI	101		LI101	06Y-02	AI	Hardwired	PLC-201	West Digester Gas Level
LI	102		LI102	06Y-02	AI	Hardwired	PLC-201	East Digester Gas Level
YI	BRN		YIBRN	06Y-02	DI	Hardwired	PLC-201	Waste Gas Flare Burner On
YA	BRN		YABRN	06Y-02	DI	Hardwired	PLC-201	Waste Gas Flare Fault
HY	401		HY401	06Y-02	DO	Hardwired	PLC-201	Hot Water Pump No. 1 Start Command
YI	401	A	YI401A	06Y-02	DI	Hardwired	PLC-201	Hot Water Pump No. 1 Running
YI	401	B	YI401B	06Y-02	DI	Hardwired	PLC-201	Hot Water Pump No. 1 in Auto
YA	401		YA401	06Y-02	DI	Hardwired	PLC-201	Hot Water Pump No. 1 Fault
HY	402		HY402	06Y-02	DO	Hardwired	PLC-201	Hot Water Pump No. 2 Start Command
YI	402	A	YI402A	06Y-02	DI	Hardwired	PLC-201	Hot Water Pump No. 2 Running
YI	402	B	YI402B	06Y-02	DI	Hardwired	PLC-201	Hot Water Pump No. 2 in Auto
YA	402		YA402	06Y-02	DI	Hardwired	PLC-201	Hot Water Pump No. 2 Fault
AIT	101		AIT101	06Y-02	DI	Hardwired	PLC-201	Digester Gas Alarm
TI	401		TI401	06Y-02	AI	Hardwired	PLC-201	Hot Water Pump No. 1 Discharge Temp
TI	402		TI402	06Y-02	AI	Hardwired	PLC-201	Hot Water Pump No. 2 Discharge Temp
TI	403		TI403	06Y-02	AI	Hardwired	PLC-201	Hot Water Return from CHP EnginesTemperature
TI	404		TI404	06Y-02	AI	Hardwired	PLC-201	Hot Water Boilers Discharge Temperature
YI	601	A	YI601A	06Y-03	DI	Communication	PLC-201	Gas Conditioning System In Remote
YI	601	B	YI601B	06Y-03	DI	Communication	PLC-201	Gas Conditioning System Running
PI	601	A	PI601A	06Y-03	AI	Communication	PLC-201	H2S Removal Inlet Pressure
PI	601	B	PI601B	06Y-03	AI	Communication	PLC-201	Compressor Gas Suction Pressure

I/O List

SignalType	Equipment Number	Modifier	I/O Tag	P&ID	I/O Type	I/O Interface	PLC Tag	User Description
PI	601	C	PI601C	06Y-03	AI	Communication	PLC-201	Compressor Gas Discharge Pressure
TI	601	A	TI601A	06Y-03	AI	Communication	PLC-201	Compressor Gas Suction Temp
TI	601	B	TI601B	06Y-03	AI	Communication	PLC-201	Compressor Gas Discharge Temp
TI	601	C	TI601C	06Y-03	AI	Communication	PLC-201	Chiller Temp
YA	601		YA601	06Y-03	DI	Communication	PLC-201	Gas Conditioning System Common Alarm
HY	601		HY601	06Y-03	DO	Communication	PLC-201	Gas Conditioning System Permissive
LAH	601		LAH601	06Y-03	DI	Communication	PLC-201	Gas Conditioning System Condensate Drain High Level
FI	801		FI801	06Y-03	AI	Hardwired	PLC-201	Generator No. 1 Digester Gas Flow
FI	802		FI802	06Y-03	AI	Hardwired	PLC-201	Generator No. 2 Digester Gas Flow
YI	801	A	YI801A	06Y-03	DI	Communication	PLC-201	Generator No.1 Ready
YI	801	B	YI801B	06Y-03	DI	Communication	PLC-201	Generator No.1 Running
YA	801	A	YA801A	06Y-03	DI	Communication	PLC-201	Generator No.1 Shutdown Alarm
YA	801	B	YA801B	06Y-03	DI	Communication	PLC-201	Generator No.1 Warning Alarm
HY	801		HY801	06Y-03	DO	Communication	PLC-201	Generator No.1 Permissive
II	801		II801	06Y-03	AI	Communication	PLC-201	Generator No.1 Power Demand
YI	802	A	YI802A	06Y-03	DI	Communication	PLC-201	Generator No.1 Ready
YI	802	B	YI802B	06Y-03	DI	Communication	PLC-201	Generator No.2 Running
YA	802	A	YA802A	06Y-03	DI	Communication	PLC-201	Generator No.2 Shutdown Alarm
YA	802	B	YA802B	06Y-03	DI	Communication	PLC-201	Generator No.2 Warning Alarm
HY	802		HY802	06Y-03	DO	Communication	PLC-201	Generator No.2 Permissive
II	802		II802	06Y-03	AI	Communication	PLC-201	Generator No.2 Power Demand

SECTION 40 94 43

PROGRAMMABLE LOGIC CONTROLLER (PLC) CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Programmable logic controller (PLC) control system(s), including software, programming, and training.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 Identification Devices.
   4. Section 40 05 05 - Equipment: Basic Requirements.
   5. Section 40 62 16 – Control Network and Human Machine Interface (HMI) System
   6. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   7. Section 40 90 05 - Control Loop Descriptions.
   8. Section 40 98 00 - Control Panels and Enclosures.
   9. Section 26 05 19 - Wire and Cable - 600 Volt and Below.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C37.90.2, Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
      b. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   2. National Electrical Manufacturers Association (NEMA):
      a. ICS 1, General Standards for Industrial Control and Systems.

B. Qualifications:
   1. Installation supervisor shall have had experience in overseeing installation and startup of at least three (3) similar installations.
   2. Programmer(s) shall have had experience in programming PLCs for at least two (2) projects of similar size and complexity.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 90 00.
   3. Product technical data including:
      a. Annotated hard copies of PLC software programs.
         1) Submit program for logic in ladder diagram format as used for the specific PLC system.
         2) Annotate program listing to include the following:
            a) Written description of each rung's function.
            b) Reference to control loop number for each rung where applicable.
            c) Reference to instrumentation tag number of I/O devices for each rung where applicable.
         3) Provide written descriptions completely defining all function blocks used in program.
         4) Provide list of all addresses referenced in logic diagram with description of data associated with each address.

b. Results of factory testing procedures.
c. Drawings containing the following information to be submitted as part of Specification Section 40 98 00 submittals:
1) Arrangement drawings for PLC system components.
2) Panel and enclosure plans, sections and details.
3) Access opening locations and required clearances for each panel and enclosure.
4) Enclosure internal wiring and terminal blocks.
d. Catalog cut sheets containing information on PLC components to be submitted as part of this Specification Section submittals.
4. Certifications:
a. Qualifications of installation supervisor.
b. Qualifications of programmer(s).

B. Contract Closeout Information:
1. Operation and Maintenance Data:
a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
2. Submit maintenance procedures available to Owner.
a. Include the location and phone numbers of service centers (including 24 HR "hot lines").
b. Provide specific information including operation and maintenance requirements, programming assistance, troubleshooting guide, parts ordering, field service personnel requests, and service contracts.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Schneider Electric Modicon M340 or M580 Automation Platform

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. See Section 40 90 00.

B. The PLC system shall accomplish the control requirements of the loop descriptions, Drawings, and Specifications.

C. PLC programming shall be documented and factory tested.

D. The PLC system shall operate in ambient conditions of 32 to 140 DegF temperature and 5 to 95 percent relative humidity without the need for purging or air conditioning.

E. Environmental Controls:
1. Furnish circulation fans in solid state control system enclosures.
2. Over-temperature switches shall be utilized to provide special cooling if required to maintain operating temperatures within the manufacturer's specified range.
3. Air conditioning applications shall include means of preventing moisture condensation.

F. Where the PLC is utilized to control multiple trains of equipment and where the equipment in each train operates as a unit relatively independent of other equipment trains (e.g., facility with multiple boiler units or filter trains), the PLC components (I/O modules, power supplies, etc.) shall be assigned so that the failure of any one (1) component does not affect equipment on all trains.
1. I/O modules shall be segregated on a train basis unless required otherwise for safety reasons.

2. Where several equipment units operate in parallel, but are not considered assigned to a particular equipment train (e.g., multiple raw water pumps or chemical feed pumps all discharging into a common system), the PLC I/O modules associated with each equipment unit shall be assigned so that the failure of any one (1) I/O module does not affect all of the parallel operating equipment units.

G. All PLC control system components shall be capable of meeting or exceeding electromagnetic interference tests per IEEE C37.90.2.

H. Incorporate the following minimum safety measures:
1. Watchdog function to monitor:
    a. Internal processor clock failure.
    b. Processor memory failure.
    c. Loss of communication between processor and I/O modules.
    d. Processor ceases to execute logic program.
2. Safety function wiring: Emergency shutdown switches shall not be wired into the controller.
3. Safe wiring:
    a. Unless otherwise specified, activation of alarms and stopping of equipment shall result from the de-energization of control circuits, rather than the energization of control circuits.
    b. Low voltage control signal wires:
        1) Place in conduit segregated for that purpose only.
        2) Twisted shielded wire pair.
        3) Not located in the same conduit or bundle with power wiring.
4. Initial safety conditions:
    a. Utilize program module to dictate output states in a known and safe manner prior to running of control program.
    b. Utilize program each time PLC is re-initiated and the control program activated.
5. Monitoring of internal faults and display:
    a. Internal PLC system status and faults shall be monitored and displayed.
        1) Monitored items shall include:
            a) Memory ok/loss of memory.
            b) Processor ok/processor fault.
            c) Scan time overrun.
6. Control of programs: Protect access to PLC program loading with password protection or with locked, key operated selector switches.
7. Design PLC system with high noise immunity to prevent occurrence of false logic signals resulting from switching transients, relay and circuit breaker noise or conducted and radiated radio frequency interference.
8. Operator intervention:
    a. Logic system failure shall not preclude proper operator intervention.
    b. Safety shutdown of equipment or a system shall require manual operator intervention before the equipment or system operation may be reestablished.

2.3 COMPONENTS

A. PLC System Central Processor Unit (CPU):
1. CPU shall provide communications with other control systems and man-machine interfaces as specified.
2. Acceptable CPU models:
    a. Schneider Electric M340 controller BMXP3420102 processor module
    b. Schneider Electric M580 controller BMEP582040 processor module

3. Memory:
    a. Battery-backed RAM.
    b. EEPROM program back-up:
        1) Automatically download to RAM in the event RAM is corrupted.

4. Memory battery backup shall be capable of 60 days memory retention with fresh battery.
   a. Provide visual indication of battery status and alarm low battery voltage.
   b. Memory battery backup shall be capable of 14 days memory retention after the "Battery Low" indicating LED is on.
5. Plug-in card design to allow quick field replacement of faulty devices.
   a. Provide unit designed for field replacement and expansion of memory without requiring rewiring or use of special tools.
6. 20 percent minimum spare useable memory capacity after all required programming is in place and operating.
7. Capable of executing all control functions required by the Specifications and Drawings.
8. Built-in three-mode (proportional-integral-derivative) control capabilities.
   a. As directly selectable algorithms requiring no user knowledge of programming languages.
9. On-line reconfigurable.
10. Lighted status indicators for "RUN" and "FAILURE."
11. Capable of Modbus TCP communication.
12. Capable of manual or automatic control mode transfer from the operating console stations or from within the control strategy.
   a. Transfer shall be bumpless and balanceless.

B. Input/output (I/O) Modules:
1. Provide plug-in modular-type I/O racks with cables to connect to all other required PLC system components.
2. Provide I/O system with:
   a. I/O solid state boards with status lights indicating I/O status.
   b. Electric isolation between logic and field device.
   c. Capability of withstanding low energy common mode transient to 1000 V without failure.
   d. Incorporate noise suppression design.
   e. Capable of meeting or exceeding electrical noise tests, NEMA ICS 1-109.60-109.66.
   f. Capable of being removed and inserted into the I/O rack under power, without affecting any other I/O modules in the rack.
   g. Install 20 percent spare I/O modules.
3. Input/output connection requirements:
   a. Make connections to I/O subsystem by terminating all field wiring on terminal blocks within the I/O enclosure.
   b. Prewire I/O modules to terminal blocks.
   c. Provide terminal blocks with continuous marking strip.
   d. Size terminals to accommodate all active data base points and spares.
   e. Provide terminals for individual termination of each signal shield.
   f. Field wiring shall not be disturbed when removing or replacing an I/O module.
4. Discrete I/O modules:
   a. Interface to ON/OFF devices.
   b. I/O status indicator on module front.
   c. Voltage rating to match circuit voltage.
   d. Output module current rating:
      1) Match maximum circuit current draw.
      2) Minimum 1.0 continuous A/point for 120 Vac applications.
   e. Isolated modules for applications where one (1) module interfaces with devices utilizing different sources of power.
   f. Acceptable discrete I/O module models:
      1) M340 or M580 16-channel discrete input modules and 16-channel discrete output modules
5. Discrete outputs shall be fused:
   a. Provide one (1) fuse per common or per isolated output.
   b. Provide blown fuse indication.

c. External fusing shall be provided if output module does not possess internal fusing.
d. Fuses provided external to output model shall:
    1) Be in accordance with module manufacturer's specifications.
    2) Be installed at terminal block.

6. Analog I/O modules:
    a. Input modules to accept signals indicated on Drawings or Specifications.
    b. Minimum 12 bit resolution.
    c. I/O chassis supplied power for powering connected field devices.
    d. Differential inputs and outputs.
    e. User configurable for desired fault-response state.
    f. Provide output signals as indicated on Drawings and Specifications.
    g. Individual D/A converter for each output module.
    h. Individual A/D converter for each input module.
    i. Acceptable analog I/O module models:
        1) M340 or M580 8-channel analog input modules and 8-channel analog output modules

C. Power Supply Units:
1. Provide regulated power units:
    a. Designed to operate with PLC system and shall provide power to:
        1) All components of PLC system.
        2) All two-wire field instruments.
        3) Other devices as indicated on Drawings or Specifications.
    b. Capable of supplying PLC system when all of the specified spare capacity is utilized.
    c. Each power supply shall be sized such that it will carry no more than 75 percent of capacity under normal loads.
2. Acceptable power supply modules:
    a. Modicon M340 BMXCPS 3500 power supply module
    b. Modicon M580 BMXCPS power supply module
3. Electrical service to PLC system is 105 to 125 V, 60 Hz, +1 percent, 1 PH power.
4. Separate AC circuit breakers shall be provided for each power supply.
5. If the PLC system is field expandable beyond the specified spare capacity, and if such expansion requires power supply modification, note such requirements in the submittals and allow room for power supply modification in the PLC system enclosure.
6. Capable of meeting or exceeding electrical noise tests, NEMA ICS 1-109.60-109.66.
7. Power distribution:
    a. Immune to transients and surges resultant from noisy environment.
    b. Shall provide constant voltage level DC distribution to all devices.
8. Provide uninterruptible power supply (UPS) to sustain full power to UPS powered loads listed below for a minimum of 60 minutes following loss of primary power and to ensure that the transient power surges and dips do not affect the operation of the PLC system. UPS shall be sized for 150% of panel load.
    a. UPS powered loads:
        1) All rack mounted PLC components.
        2) Local operator consoles.
        3) All power supplies furnished with the PLC and associated loads.
    b. Input:
        1) 120 Vac +10 percent.
        2) 60 Hz.
        3) Line fuse protection.
    c. Output:
        1) 120 Vac.
        2) 60 Hz.
        3) Short circuit protected.
        4) Instantaneous transfer time.

d. IEEE C62.41 Class A voltage surges of 6000 V attenuated to less than 50 V on the output.
e. Battery: Maintenance free lead acid.

D. PLC System Enclosure:
1. In accordance with Section 40 98 00.
2. Component placement:
a. Mount all controller components vertically within the enclosure to allow maximum convection cooling.
b. Either install power supplies above all other equipment with at least 10 IN of clearance between the power supply and the enclosure top, or adjacent to other components, but with sufficient spacing for circulation of cooling air.
c. Do not place I/O racks directly above the CPU or power supply.
d. Locate incoming line devices (isolation or constant voltage transformers, local power disconnects, surge suppressors, etc.) so as to keep power wire runs within an enclosure as short as possible.
e. If items such as magnetic starters, contactors, relays, and other electromagnetic devices must be located within the same enclosure as the PLC system components, place a barrier with at least 6 IN of separation between the magnetic area and the control area.
f. Place circulating fans close to major heat generating devices.
g. Segregate input/output modules into groups of identical type.
3. Wiring and grounding to be in accordance with Section 40 98 00.
4. Termination requirements:
a. In accordance with Section 40 98 00.
b. Make connections to I/O subsystem by terminating all field wiring on terminal blocks within the enclosure.
c. Prewire I/O modules to terminal blocks.
d. Size terminals to accommodate all active database points and spares.
e. Provide terminals for individual termination of each signal shield.
f. Field wiring shall not be disturbed when removing or replacing an I/O module.

E. PLC System Software and Programming:
1. Provide all hardware and programming required to provide communication between the PLC and the man-machine interface.
2. Acceptable PLC programming software shall be:
a. Schneider Electric Unity Pro (latest version).
3. Provide programming to accomplish all control and monitoring requirements of the Drawings and Specifications.
4. Provide two (2) copies of control logic program on 3-1/2 IN disks or on CD.
5. IBM compatible software.
6. Full documentation capability.
a. Provide description for each rung.
7. On/off line programming.
8. Offline simulation prior to download.
9. Two-step commands requiring operator verification prior to deletion of any programming.
10. The system integrator shall be responsible for purchasing all development licenses and accessories for the PLC programming software (Unity Pro) at no additional cost to the Owner.
11. The systems integrator shall turn over the software development license to the City prior to project startup and commissioning.

2.4 ACCESSORIES

A. Provide all accessories required to furnish a complete PLC control system to accomplish the requirements of the Drawings and Specifications.

2.5 SOURCE QUALITY CONTROL

A. Provide a performance test after factory completion and prior to shipment.

1. Conduct a test where the system is operated continuously and checked for correct operation including loop controls, displays, printing, keyboard functions, alarm responses, and on/off sequencing control.
2. Conduct testing with dummy I/Os to verify each control loop operation.
3. Allow for Owner and Engineer representatives to witness testing program.
   a. Provide minimum of 15 days notice prior to testing.
4. Do not ship prior to successful completion of this testing program.

2.6 MAINTENANCE MATERIALS

A. Furnish Owner with the following extra materials:
   1. One (1) spare I/O card of each card type for every 10 cards or fraction thereof installed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install PLC control system in accordance with manufacturer's written instructions.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of equipment manufacturer's field service representative(s) to:
   1. Inspect equipment covered by these Specifications.
   2. Supervise adjustments and installation checks.
   3. Maintain and submit an accurate daily or weekly log of all commissioning functions.
      a. All commissioning functions may be witnessed by the Engineer.
      b. All reports shall be cosigned by the Contractor and the Engineer if witnessed.
   4. Conduct startup of equipment and perform operational checks.
   5. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.

3.3 DEMONSTRATION

A. Demonstrate system in accordance with Section 01 75 00.

B. On-Site Training:
   1. Provide employee of the manufacturer or certified representative extensive training of system operation and maintenance covering all topics under 3.3.B.1.a at the Project site after the system has successfully undergone all field testing and acceptance procedures.
      a. As a minimum, training shall cover:
         1) Hardware overview.
         2) Software overview.
         3) Maintenance including replacement and reconfiguration of I/O modules
         4) Troubleshooting.
         5) Operation, e.g., changing set points, passwords, etc.

END OF SECTION

SECTION 40 96 52

CONFIGURATION REQUIREMENTS: HUMAN MACHINE INTERFACE (HMI) AND REPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Configuration requirements for HMI and reports which includes but is not necessarily limited to.
      a. Specific software functional descriptions.
      b. Graphics requirements.
      c. HMI functionality requirements.
      d. Plant overview screens.
      e. Process overview screens.
      f. Detail displays.
      g. Trend displays.
      h. PLC hardware/HMI status screen.
      i. Alarm monitoring.
      j. Report generation.
      k. Configuration standards and conventions.
      l. Graphic configuration and database design review meetings (workshops).
      m. Report configuration review meetings (workshops).
      n. Coordination.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 40 62 16 – Computer Network and Human Machine Interface (HMI) System.
   4. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   5. Section 40 90 05 – Functional Descriptions
   6. Section 40 94 43 – Programable Logic Controller (PLC) Control System

1.2 QUALITY ASSURANCE

A. Qualifications:
   1. Refer to Section 40 90 00 for Systems Integrator qualifications.

1.3 DEFINITIONS

A. HMI: Human Machine Interface.

B. I/O: Input/Output.

C. OLE: Object Linking and Embedding, a document standard developed by Microsoft that enables the creation of an object with one application and the linking or embedding of the object in a second application.

D. OPC: "OLE for Process Control"; a software standard utilizing a client/server model that makes interoperability possible between automation/control applications and field systems/devices.

E. PC: Personal Computer.

F. PLC: Programmable Logic Controller.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 90 00.
   3. Software Configuration Standards and Conventions document.
   4. Graphic screen displays; provide in actual colors utilized.
   5. Sample reports.
   6. Certifications:
      a. Qualifications of programmer(s) including resumes.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
   2. Software Configuration Standards and Conventions - final version.

C. Informational Submittals:
   1. Results of factory testing procedures.
   2. Proposed training agendas and schedule.

1.5 GENERAL FUNCTIONAL REQUIREMENTS

A. Software Functional Requirements:
   1. General functional requirements for system configuration are indicated on the Drawings and described in the Specifications.
   2. The information presented herein and indicated on the Drawings illustrates the general functional intent of the system and may not be sufficient to fully configure the system.
   3. The Systems Integrator shall propose example HMI graphic styles as part of an initial submittal to develop final HMI graphics, including but not limited to, colors, symbols and text, system overview screen(s), navigation style, alarm summary screen, control popups and equipment control graphic boxes.
   4. Systems Integrator shall incorporate high performance HMI elements in developing graphics.
   5. Systems Integrator shall apply ISA101 concepts to developing HMI graphics.
   6. It shall be the responsibility of the Contractor and Systems Integrator to coorindate with the Plant manager and operators to understand the Plant’s expected HMI requirements.

B. Available Process Values:
   1. All process alarm, equipment status, and process variable values shall be available at any HMI.
   2. If communications to a particular I/O point has failed for any reason, then wherever that data is displayed, the software shall post a visual indication that the point is not valid.

C. Provide comprehensive on-line help for all development functions.

D. Manual Entry of Data:
   1. All PC-based HMIs must allow manual entry of surrogate data and other variables, which must then be available for display and use in reports.
      a. Operator-entered commands from any of the operator workstations must be logged by the computer servers.

E. System Failure:
   1. Failure of any PLC, remote I/O hardware, or network communication link must be individually alarmed at HMIs.
   2. Unless otherwise specified, each alarm must be specific to a single point of failure.

F. Software licensing shall allow a minimum of 6 plant HMIs to be active simultaneously.

G. All process related functions, calculations, timers, and numeric manipulations, shall be accomplished in the PLC hardware and not in the HMI.
   1. The HMI shall function as a monitoring system, not as a process controller.
   2. The HMI shall transfer data to the PLC system and the PLC system shall perform all control algorithms.

1.6 SECURITY

A. Fully integrate security into the SCADA system to allow only users with appropriate security levels access to individual parts of the system.

PART 2 - PRODUCTS

2.1 SPECIFIC SOFTWARE FUNCTIONAL DESCRIPTIONS

A. Specific functional requirements for various software control blocks within the computer system are as follows.

B. Descriptions are general and are not intended to fully indicate the complete functionality of the system.
   1. Monitoring of process values:
      a. Process values derived from analog process variable signals must be historically archived.
         1) Store all historical data with time and date of occurrence.
         2) Make values available for use in reports.
         3) Assign high and low alarms to process values as defined below and otherwise deemed appropriate.
      b. Provide capability for computer server(s) to retrieve real-time values from the PLC system at adjustable time periods.
      c. Alarm limits:
         1) Set per direction from the Owner.
         2) An operator having proper security authorization must be able to enable, disable, and adjust the setpoint of any individual alarm.

C. Utilize graphic screen displays at the HMI(s) to provide monitoring and control functionality.
   1. Hierarchy of HMI screens is in descending order as follows:
      a. Plant overview screen(s).
      b. Process overview screens.
      c. Process screens.
      d. Pop-up/control screens.

D. HMI operator interface functionality shall include:
   1. Indication of process variables.
   2. Configuration of control loop parameters (e.g., setpoints, gains, etc.).
   3. Adjustment of controller output.
   4. Display of real time and historical process trends.
   5. Selector switch and pushbutton station controls.
   6. System and process status indicators.
   7. Graphic representation of plant operations with interactive status and measurement symbols.
   8. Annunciation.

E. Graphics:
   1. Utilize dynamic variables with unique tags per graphic.
   2. Dragging the mouse over designated process areas of screen shall allow the operator to select predetermined processes or equipment and drill down to site-specific detail screens.
   3. Critical "overview" information such as tank levels, flows and pressures shall be indicated through data fields or animation effects such as level fills or color change.
   4. All monitored and or controlled process equipment shall be animated or color-highlighted to indicate status changes.

a. For example, a pump "running" condition shall be signified by the pump color changing to bright red.
5. Tank and vessel levels shall be indicated with a tabular data field and by graphic "fill" simulating a rising or falling level within the tank or vessel.
6. Provide the ability to "drill down" to detail screens or graphics.
   a. Clicking on a device or process area shall generate a detail graphic or pop-up window to access specific data or control functions.
   b. All operator adjustments (e.g., set point adjustment, mode selection) shall be accomplished via a pop-up display, and shall not be allowed on the process screen.
7. Standard symbol library:
   a. User defined.
   b. Must not require software programming.
8. Single keystroke access from graphic to group display or other custom graphic displays.
9. Capable of being edited by moving, copying, or grouping user defined areas of screen.
10. Utilize a navigation bar.
   a. Navigation bar utilized on every screen.
   b. Navigation bar to include navigation functions, active alarm notification, security functions, current date/time display, "PRINT SCREEN" pushbutton, and other functions as required and as agreed upon at the Screen Configuration Review Meetings.

F. Plant Overview Screens:
1. As a minimum, provide Plant Overview screens as listed below.
   a. This list is meant to serve as an initial guide; final determination of overview screen requirements will be made during the Configuration Conferences.

G. Process Overview Screens:
1. As a minimum, provide screens as listed below.
   a. This list is meant to serve as an initial guide; final determination of process and equipment screen requirements will be made during the Configuration Conferences.
2. At a process overview screen, the operator shall be able to select a specific process screen for monitoring/control purposes.
   a. Monitoring and control functions available at the selected process screen include but are not limited to the following:
      1) Select individual equipment items for monitoring and control.
      2) Select a control loop or point for control action.
      3) Change control mode of loop selected (manual, automatic, cascade).
      4) Change setpoint.
      5) Issue commands to start/stop and open/close two-state equipment.
      6) For manual loading output stations, the operator shall be able to manipulate analog output values.
      7) Select a loop and initiate further display, such as the detail display, trend, or hourly averaging.
      8) Display and change ratio and bias values.
      9) Control field equipment such as motor-operated valves and switches.

H. Detail Display:
1. Provide separate display for each point.
   a. Representations of each analog and digital point shall be single user configured faceplate.
   b. Display shall include alphanumeric representations of all variables and parameters for single loops including but not limited to:
      1) Alarm points.
      2) Limits.
      3) Constants.
      4) Interconnections to other loops.
      5) Calculating functions.

I. Trend Displays:

1. Real time historical trend displays.
2. Real time on-line trend displays.
3. Capable of displaying multiple points per display.
4. Operator shall be able to select any desired sample time interval.
5. Provide flexibility and easy access to real time and historical trend information for any variable TAG defined within the SCADA application.
    a. As a minimum, provide the following:
        1) Provide capability for the user to define trend scenarios.
        2) Provide a button to open a dialog window to select multiple variable TAGS and save them as a trend scenario for future use.
        3) Provide a pull-down menu to allow the user to open saved trend scenarios.
        4) Provide a button to allow the user to select real-time or historical trends.
        5) Provide a button to save displayed trend info to a file for export to external software applications (such as Microsoft Excel).
        6) Provide a Print Trend button to allow user to print current trend.
6. Utilize Historical Data Server(s) to collect and manage data.

J. PLC Hardware/HMI Status Screen:
1. Provide a status screen to depict status conditions and diagnostic information for all major networked equipment.
2. Depict communication status for all networked communicating devices, such as PLC processors, Ethernet switches, PCs, and radios.

K. Alarm Monitoring:
1. Provide standard alarm screen functionality to ensure flexibility and quick access to live alarms, alarm history and alarm grouping parameters.
    a. As a minimum, include the following features and functionality:
        1) An Alarm Screen header bar to head all alarm pages and reside below the Navigation Bar.
        2) Buttons to dynamically switch between Alarm Summary and Alarm History.
        3) A menu to allow user to select and open historical alarm archives.
            a) Utilize a time-date stamp file structure.
        4) Pull-down menu bar to select operator configured alarm groups.
        5) Capability to sort alarms by priority and to define priority for all system alarms.
        6) Capability to filter or group alarms.
2. Analog alarms:
    a. The SCADA software shall monitor analog and discrete variables and calculated conditions, and determine if the variable is in an alarm condition.
    b. For each Analog Tag, an alarm for each of the following conditions shall be assignable:
        1) Low-low.
        2) Low.
        3) High.
        4) High-high.
        5) Deviation low.
        6) Deviation high.
        7) Rate of change.
    c. Provide adjustable dead bands and delay timers for all analog alarms.
3. Present alarms in order of:
    a. Priority.
    b. Time of occurrence.
    c. Non-acknowledged presented ahead of acknowledged.
4. Utilize single keystroke or pushbutton to:
    a. Acknowledge alarms.
5. Alarm list presented to operator shall include:
    a. Time of occurrence.
    b. Time of acknowledgement.
    c. Description.

d. Acknowledgement status.
6. Alarm list printed by either of the following:
   a. On command.
   b. Periodically.
7. Audible alarming capability for user selected alarms.

L. Report Generation:
1. Base bid on the generation of the following reports:
   a. Minimum of 8 formatted reports.
      1) Report form and content shall be determined at the Report Configuration Review Meetings.
      2) Each report shall contain daily, weekly, and monthly average calculated values.
      3) Each report shall contain between 15 and 30 measured parameters.
   b. List of all entries initiated by operator including the following:
      1) Console key changes.
      2) Beginning and final values of setpoint and output changes.
      3) Mode changes (i.e., auto to manual).
      4) Time change was made.
   c. Event list:
      1) Description of selected events.
      2) Time of event.
2. Custom report capabilities:
   a. User configurable.
   b. Contain selected information from any log, event, or alarm list.
   c. Capable of producing custom log report for periodic and on-demand printing of a list of process or calculated variables.
   d. Reports shall not require software programming by the user to setup.
3. Control of programs:
   a. Protect access to configuration via password protection.

PART 3 - EXECUTION

3.1 CONFIGURATION REQUIREMENTS

A. Provide all programming and configuration required for all HMIs furnished under this Contract:

3.2 CONFIGURATION STANDARDS AND CONVENTIONS

A. Prepare and submit a "Software Configuration Standards and Conventions."
1. Submit for review and approval prior to commencing with software configuration.
2. Describe and define such items as:
   a. Proposed graphic display process colors/representations.
   b. Color standards for "ON," "OFF," and "ALARM" conditions.
   c. Font type and size.
   d. Alarm handling conventions.
   e. Methods for navigation between displays.
   f. Address usage/naming conventions.
   g. Security setup.
3. Prior to submitting the initial draft document, the Contractor must meet with the Owner to review any of the Owner's existing standards and conventions.
4. In addition to submitting the initial document for review, submit an updated version of the document as part of the Operation and Maintenance Manuals.
   a. Revise this document to include any additional standards that are established throughout the configuration process.

B. It is the intent of these specifications to provide the end user with state-of-the-art functionality.
1. Minimum standards are as follows:
   a. Depict the actual process equipment configuration as accurately as possible.

2. All overview and site-specific screens shall incorporate a "navigational header bar" similar in function and appearance to *Microsoft Internet Explorer.*
    a. The intention of this Specification is to provide a familiar, user-friendly navigation throughout the graphical displays.

3.3 GRAPHIC AND REPORT CONFIGURATION

A. Proposed graphic screens and report formats must be reviewed with the Owner throughout the configuration process.

3.4 COORDINATION

A. Coordinate as required with other contractors and vendors to seamlessly integrate all HMI monitoring and control functions.
    1. To the greatest extent possible, integrate graphics presentation for all systems into screens utilizing one common HMI software.

B. Examples of systems that utilize separate application software packages and thus require coordination include, but are not necessarily limited to:
    1. Generator Controls.
    2. Digital Metering Package.

3.5 FIELD QUALITY CONTROL

A. Systems Integrator shall perform the following tasks during start-up:
    1. Inspect equipment covered by this Specification Section.
    2. Supervise adjustments and installation checks.
    3. Maintain and submit an accurate daily or weekly log of all commissioning functions.
        a. All commissioning functions may be witnessed by the Engineer.
        b. All reports shall be cosigned by the Contractor and the Engineer if witnessed.
    4. Conduct startup of equipment and perform operational checks.
    5. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.

3.6 DEMONSTRATION

A. Demonstrate system in accordance with Specification Section 01 75 00.

B. On-Site Training:
    1. Provide employee of the manufacturer or certified representative to provide two (2) hours of operation and maintenance training at the Project site after the system has successfully undergone all field testing and acceptance procedures.
        a. As a minimum, training shall cover:
            1) Hardware overview.
            2) Software overview.
            3) Maintenance.
            4) Trouble shooting.
            5) Operation, e.g., changing set points, passwords, etc.

END OF SECTION

SECTION 40 97 00
CONTROL AUXILIARIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pilot devices:
      a. Selector switches.
      b. Pushbuttons.
      c. Indicating lights.
   2. Relays/timers:
      a. Control relays.
      b. Signal-level switching relays.
      c. Time delay relays.
   3. Termination equipment:
      a. Terminal blocks.
      b. Fuse holders.
   4. Power supplies:
      a. Redundant 24VDC power supplies.
   5. Beacons (Strobe Lights)

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   4. Section 26 43 13 - Low Voltage Surge Protective Devices (SPD).

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. The Instrumentation, Systems, and Automation Society (ISA):
      a. S18.1, Annunciator Sequences and Specifications.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   3. Underwriters Laboratories, Inc. (UL).

B. Miscellaneous:
   1. Assure units comply with electrical area classifications and NEMA enclosure type shown on Drawings.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 90 00.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the applicable Articles below are acceptable.

B. Provide similar components from the same manufacturer for uniformity of appearance, operations, and maintenance.

C. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 PILOT DEVICES

A. Selector Switches:
   1. Acceptable manufacturers:
      a. Eaton.
      b. Allen-Bradley.
   2. Design and fabrication:
      a. Heavy-duty type.
      b. Oiltight, NEMA 4X.
      c. Rotary cam units conforming to NEMA ICS 2-216.22.
      d. Mounting hole: 30.5 mm.
      e. Supply switches having number of positions required with contact blocks to fulfill functions shown and specified.
      f. UL listed.
      g. Maintained contact type.
      h. Knob type operators.
      i. Black colored operators.
      j. Designed with cam and contact block with approximate area of 2 IN SQ.
      k. Legend plate marked per Contract Documents.
      l. Contact block requirements:
         1) Dry and indoor locations: Standard contact blocks rated for 10 A continuous current.
         2) Wet or outside locations: Hermetically sealed contact blocks.
         3) Manufacturer furnished legend plate engraved per Contract Documents.

B. Pushbuttons:
   1. Acceptable manufacturers:
      a. Eaton.
      b. Allen-Bradley.
   2. Materials:
      a. Backing diaphragm: Buna-N.
   3. Design and fabrication:
      a. Heavy-duty.
      b. Oiltight, NEMA 4X.
      c. Conforming to NEMA ICS 2-216.22.
      d. Mounting hole: 30.5 mm.
      e. Diaphragm backed.
      f. UL listed.
      g. Emergency stop pushbuttons to have mushroom head operator and maintained contact.
      h. Non-illuminated type:
         1) Momentary contact with necessary contact blocks.
         2) Molded, solid color melamine buttons.
         3) Standard flush with full shroud.
         4) Black colored buttons for START or ON and black color for STOP or OFF.
         5) Appropriate contact blocks to fulfill functions shown or specified.
      i. Contact block requirements:

1) Dry and indoor locations: Standard contact blocks rated for 10 A continuous current.
2) Wet or outside locations: Hermetically sealed contact blocks.
3) Manufacturer furnished legend plate engraved per Contract Documents.

C. Indicating Lights:
1. Acceptable manufacturers:
a. Eaton.
b. Allen-Bradley.
2. Design and fabrication:
a. Heavy duty.
b. Oiltight, NEMA 4X.
c. Type allowing replacement of bulb without removal from control panel.
d. Transformer type LED. Incandescent lights shall not be acceptable.
e. UL listed.
f. Nominal 2 IN SQ face.
g. Mounting hole: 30.5 mm.
h. Push-to-test indicating lights.
i. Glass lens.
j. Color code lights as follows:
1) Green:OFF or stopped; valve closed.
2) Amber: FAIL.
3) Red: ON or running; valve open.
4) Manufacturer furnished legend plate engraved for each light.

2.3 RELAYS/TIMERS

A. Control Relays:
1. Acceptable manufacturers:
a. Idec.
b. Potter & Brumsfield.
c. Allen-Bradley.
2. Design and fabrication:
a. Plug-in general purpose relay.
b. Blade connector type.
c. Switching capacity: 10 A.
d. Contact material: Silver cadmium oxide.
e. 4PDT contacts.
f. Coil voltage: 120 Vac or 24 Vdc.
g. Relay sockets are DIN rail mounted.
h. Internal neon or LED indicator is lit when coil is energized.
i. Clear polycarbonate dust cover with clip fastener.
j. Check button.
k. Temperature rise:
1) Coil: 85 DegF max.
2) Contact: 65 DegF max.
l. Insulation resistance: 100 Meg min.
m. Frequency response: 1800 operations/hour.
n. Operating temperature: -20 to +150 DegF.
o. Life expectancy:
1) Electrical: 500,000 operations or more.
2) Mechanical: 50,000,000 operations or more.
p. UL listed or recognized.

B. Signal-Level Switching Relays:
1. Acceptable manufacturers:
a. Idec.

b. Potter & Brumsfield.
2. Design fabrication:
a. Minimum one DPDT gold-flashed, bifurcated contact.
b. Hermetically sealed.
c. Rated at 3 A resistive at 120 Vac or 24 Vdc.

C. Time Delay Relays:
1. Acceptable manufacturers:
a. Eagle Signal Controls.
b. Idec.
2. Design and fabrication:
a. Melt design test and performance requirements of NEMA ICS 2-218.
b. Heavy-duty.
c. Solid-state construction.
d. 4PDT contacts.
e. External adjusting dial.
f. Auxiliary relays as required to perform functions specified or shown on Drawings.
g. Operates on 117 Vac (±10 percent) power source.
h. Contact rating: A150 per NEMA ICS 2-125.
i. Furnish with "on" and "timing out" indicators.

2.4 TERMINATION EQUIPMENT

A. Terminal Blocks:
1. Acceptable manufacturers:
a. Phoenix Contact Model UT-4 or UT-6
b. Allen-Bradley.
2. Design and fabrication:
a. Modular type with screw compression clamp.
b. Screws: Stainless steel.
c. Feed-through design.
d. Current bar: Nickel-plated copper allow.
e. Thermoplastic insulation rated for -40 to +90 DegC.
f. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
g. Install end sections and end stops at each end of terminal strip.
h. Install machine-printed terminal markers on both sides of block.
i. Spacing: 6 mm.
j. Wire size: 22-12 AWG.
k. Rated voltage: 600 V.
l. Din rail mounting.
m. UL listed.
3. Standard-type block:
a. Rated current: 30 A.
b. Color: Gray body.
4. Bladed-type block:
a. Terminal block with knife blade disconnect which connects or isolated the two (2) sides of the block.
b. Rated current: 10 A.
c. Color:
1) Panel control voltage leaves enclosure - normal: Gray body, orange switch.
2) Foreign voltage entering enclosure: Orange body, orange switch.
5. Grounded-type block:
a. Electrically grounded to mounting rail.
b. Use to terminal ground wires and analog cable shields.
c. Color: Green and yellow body.

B. Fuse Holders:

1. Acceptable manufacturers:
    a. Phoenix Contact.
    b. Allen-Bradley.
2. Design and fabrication:
    a. Modular-type with screw compression clamp.
    b. Screws: Stainless steel.
    c. Current bar: Nickel-plated copper alloy.
    d. Thermoplastic insulation rated for -40 to +105 DegC.
    e. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
    f. Blocks can be ganged for multi-pole operation.
    g. Install end sections and end stops at each end of terminal strip.
    h. Install machine-printed terminal markers on both sides of block.
    i. Spacing: 9.1 mm.
    j. Wire size: 30-12 AWG.
    k. Rated voltage: 300 V.
    l. Rated current: 12 A.
    m. Fuse size: 1/4 x 1-1/4.
    n. Blown fuse indication.
    o. DIN rail mounting.
    p. UL listed.

2.5 POWER SUPPLIES

A. Redundant DC Power Supplies:
1. Acceptable manufacturers:
    a. Sola Hevi-Duty.
    b. Phoenix Contact.
2. Design and fabrication:
    a. Converts 120 Vac input to DC power at required voltage.
    b. All 24VDC power supplies shall be redundant and supplied with a redundancy (diode) module to automatically switchover to standby module if the primary module fails. Switchover shall be instantaneous without loss of 24VDC feed.
    c. DIN rail mount with enclosure (i.e., not open frame).
    d. Switching type.
    e. AC input: 120 Vac +/-15 percent, nominal 60 Hz.
    f. Efficiency: Minimum 86 percent.
    g. Rated mean time between failure (MTBF): 500,000 HRS.
    h. Voltage regulation:
        1) Static: Less than 1.0 percent V_{out}.
        2) Dynamic: +/-2 percent V_{out} overall.
    i. Output ripple/noise: Less than 100 mV peak to peak (20 MHz).
    j. Overload, short circuit and open circuit protection.
    k. Temperature rating: 0 to 60 DegC full rated, derated linearly to 50 percent at 70 DegC.
    l. Humidity rating: Up to 90 percent, non-condensing.
    m. LED status indication for DC power.

2.6 BEACONS (STROBE LIGHTS)

A. Beacons:
1. Acceptable manufacturers:
    a. Edwards Signaling Model 125 Class
    b. Federal Signal Pulsator 551 Plus model.
2. Design and fabrication:
    a. NEMA 4X rated housing.
    b. 120VAC power supply.
    c. High profile, polycarbonate base flashing strobe light

d. Rated for outdoor applications.
e. Amber colored lens. Lens shall be easily field replaceable.
f. Conduit mounting on ½” NPT threaded conduit. Manufacturer to furnish all required mounting accessories.
g. Protective wire guard.
h. Operating temperature: -31 degF to 150 degF.
i. UL listed.

PART 3 - EXECUTION

3.1 INSTALLATION

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

END OF SECTION

40 98 00 A Control Panel Schedule

Panel Tag	Description	Drawing	Location	NEMA Rating	Supplied By
LCS-101	Sludge Transfer Pump No. 1 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCS-102	Sludge Transfer Pump No. 2 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCS-201	Sludge Recirc Pump No. 1 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCS-202	Sludge Recirc Pump No. 2 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCS-203	Sludge Recirc Pump No. 3 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCS-301	Digester Mixing Chopper Pump 1 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCS-302	Digester Mixing Chopper Pump 2 LCS	06Y-01	Equipment Bldg	NEMA 4X 304SS	Systems Integrator
LCP-G-101	Grinder No. 1 LCP	06Y-01	Equipment Bldg	NEMA 4X 304SS	Equipment Manufacturer
LCP-G-102	Grinder No. 2 LCP	06Y-01	Equipment Bldg	NEMA 4X 304SS	Equipment Manufacturer
LCP-BLR1	Boiler 1 LCP	06Y-02	Equipment Bldg	NEMA 4X 304SS	Equipment Manufacturer
LCP-BLR2	Boiler 2 LCP	06Y-02	Equipment Bldg	NEMA 4X 304SS	Equipment Manufacturer
LCP-BRN	Waste Gas Burner LCP	06Y-02	Field	NEMA 4X 316SS	Equipment Manufacturer
LCP-100	Admin Bldg LCP	06Y-06	Admin Bldg Control Room	NEMA 12	Systems Integrator
LCP-201	Digester Bldg LCP	06Y-05	Digester Bldg Equipment Room	NEMA 12	Systems Integrator
NIP-100	Network Interface Panel	06Y-05	Server Room	-	Systems Integrator
LCP-601	Gas Conditioning System Local Control Panel	06Y-03	Cogen	NEMA 4X 316SS	Equipment Manufacturer
LCP-801	Generator Master Control Panel	06Y-03	Cogen	NEMA 4X 316SS	Equipment Manufacturer

SECTION 40 98 00

CONTROL PANELS AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Requirements for control panels and enclosures utilized as follows:
      a. Unless noted otherwise, all control panels and enclosures housing control components that are specified in Specification Section 40 91 10, Specification Section 40 97 00, Specification Section 40 99 00 or Specification Section 40 94 43.

B. This Section is only applicable to panels housing Division 26 specified equipment (e.g., motor starters, lighting controls, etc.) when so stated in the applicable Division 26 Specification Section.

C. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 - Identification Devices.
   4. Division 41, 43, 44, 46 – Various Equipment.
   5. Division 26 - Electrical.
   6. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   7. Section 40 91 10 - Primary Meters and Transmitters.
   8. Section 40 97 00 - Control Auxiliaries.
   9. Section 40 99 00 - Surge Protection Devices (SPD) for Instrumentation and Control Equipment.
   10. Section 40 94 43 - Programmable Logic Controller (PLC) Control System.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. ASTM International (ASTM):
      a. B75, Standard Specification for Seamless Copper Tube.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ICS 4, Industrial Control and Systems: Terminal Blocks.
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC):
         1) Article 409, Industrial Control Panels.
   5. Underwriters Laboratories, Inc. (UL):
      a. 508A, Standard for Safety Industrial Control Panels.

B. Miscellaneous:
   1. Approved supplier of Industrial Control Panels under provisions of UL 508A.
      a. Entire assembly shall be affixed with a UL 508A label "Listed Enclosed Industrial Control Panel" prior to shipment to the jobsite.
      b. Control panel(s) without an affixed UL 508A label shall be rejected and sent back to the Contractor’s factory.

1.3 DEFINITIONS

A. The term "panel" refers to control panels or enclosures listed in the schedule included in this Specification Section.

B. Foreign Voltages: Voltages that may be present in circuits when the panel main power is disconnected.

C. Intrinsically Safe:
   1. A device, instrument or component that will not produce sparks or thermal effects under normal or abnormal conditions that will ignite a specified gas mixture.
   2. Designed such that electrical and thermal energy limits inherently are at levels incapable of causing ignition.

D. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.

E. Instrumentation Cable:
   1. Multiple conductor, insulated, twisted or untwisted, with outer sheath.
   2. Instrumentation cable is typically either TSP (twisted-shielded pair) or TST (twisted-shielded triad), and is used for the transmission of low current or low voltage signals.

F. Ground Fault Circuit Interrupter (GFCI): A type of device (e.g., circuit breaker or receptacle) which detects an abnormal current flow to ground and opens the circuit preventing a hazardous situation.

G. Programmable Logic Controller (PLC): A specialized industrial computer using programmed, custom instructions to provide automated monitoring and control functions by interfacing software control strategies to input/output devices.

H. Remote Terminal Unit (RTU): An industrial data collection device designed for location at a remote site, that communicates data to a host system by using telemetry such as radio, dial-up telephone, or leased lines.

I. Input/Output (I/O): Hardware for the moving of control signals into and/or out of a PLC or RTU.

J. Supervisory Control and Data Acquisition (SCADA): Used in process control applications, where programmable logic controllers (PLCs) perform control functions but are monitored and supervised by computer workstations.

K. Highway Addressable Remote Transducer (HART): An open, master-slave protocol for bus addressable field instruments.

L. Digital Signal Cable: Used for the transmission of digital communication signals between computers, PLCs, RTUs, etc.

M. Uninterruptible Power Supply (UPS): A backup power unit that provides continuous power when the normal power supply is interrupted.

N. Loop Calibrator: Portable testing and measurement tool capable of accurately generating and measuring 4-20ma DC analog signals.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 90 00.
   3. Prepared with computer aided design (CAD) software.
   4. Printed on 11 by 17 IN sheets.
   5. Drawings shall include a title block containing the following:
      a. Plant or facility name where panel(s) are to be installed.
      b. Drawing title.
      c. Drawing number.
      d. Revision list with revision number and date
      e. Drawing date.

f. Drawing scale.
g. Manufacturer name, address, and telephone number.

6. Cover sheet for each drawing set shall indicate the following:
   a. Plant or facility name.
   b. Project name.
   c. Submittal description.
   d. Revision number.
   e. Issue date.
7. Table of contents sheet(s) shall indicate the following for each drawing in the set:
   a. Drawing number.
   b. Drawing title.
   c. Sheet number.
8. Legend and abbreviation sheet shall indicate the following:
   a. Description of symbols and abbreviations used.
   b. Panel construction notes including enclosure NEMA rating, finish type and color, wire type, wire color strategy, conductor sizes, and wire labeling strategy.
   c. Confirmation that the panel(s) are to be affixed with a UL 508A label prior to shipment from the factory.
9. Bill of Material for each panel shall include the following component information:
   a. Instrument tag number.
   b. Quantity.
   c. Functional name or description.
   d. Manufacturer.
   e. Complete model number.
   f. Size or rating.
10. Panel exterior layout drawings to scale and shall indicate the following:
    a. Panel materials of construction, dimensions, and total assembled weight.
    b. Panel access openings.
    c. Conduit access locations.
    d. Front panel device layout.
    e. Nameplate schedule:
       1) Nameplate location.
       2) Legend which indicates text, letter height and color, and background color.
11. Panel interior layout drawings shall be drawn to scale and shall indicate the following:
    a. Sub-panel or mounting pan dimensions.
    b. Interior device layouts.
    c. PLC/RTU general arrangement layouts.
    d. Wire-way locations, purpose, and dimensions.
    e. Terminal strip designations.
    f. Location of external wiring and/or piping connections.
    g. Location of lighting fixtures, switches and receptacles.
12. Wiring diagrams shall consist of the following:
    a. Panel power distribution diagrams.
    b. Control and instrumentation wiring diagrams.
    c. PLC/RTU I/O information:
       1) Model number of I/O module.
       2) Description of I/O module type and function.
       3) Rack and slot number.
       4) Terminal number on module.
       5) Point or channel number.
       6) Programmed point addresses.
       7) Signal function and type.
    d. Wiring diagrams shall identify each wire as it is to be labeled.

B. Manufacturer catalog cut sheets for enclosure, finish, panel devices, control auxiliaries, and accessories.

C. Electrical load calculations for each panel:
   1. Total connected load.
   2. Peak electrical demand for each panel.

D. Climate control calculations for each panel.
   1. Verify that sufficient dissipation and/or generation of heat is provided to maintain interior panel temperatures within the rated operating temperatures of panel components.

E. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.
   2. See Specification Section 40 90 00.

F. Informational Submittals:
   1. Record Drawings:
      a. Updated panel drawings delivered with the panel(s) from the Contractor's factory.
      b. Drawings shall be enclosed in transparent plastic and firmly secured within each panel.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Enclosures:
      a. Hoffman Engineering Co.
      b. Rittal.
      c. Hammond Manufacturing.
   2. Panel heaters:
      a. Hoffman Enclosures, Inc.
      b. Rittal.
      c. Hammond Manufacturing.
   3. Heat exchangers and air conditioners:
      a. Hoffman Enclosures, Inc.
      b. Rittal.
      c. Hammond Manufacturing.
      d. Ice Qube Inc.
   4. Cooling fans and exhaust packages:
      a. Hoffman Enclosures, Inc.
      b. Rittal.
   5. Internal corrosion inhibitors:
      a. Hoffman Enclosures, Inc.; Model A-HCI.
      b. Northern Technologies International Corporation (NTIC); Model Zerust VC.
      c. Cortec Corporation; Model VpCl Emitting Systems.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 ACCESSORIES

A. Panel Nameplates and Identification:
   1. See Section 10 14 00.

2.3 FABRICATION

A. General:
   1. Fabricate panels with instrument arrangements and dimensions identified in the Contract Documents.

2. Provide panel(s) with the required enclosure rating per NEMA 250 to meet classifications identified in the Contract Documents.
3. Devices installed in panel openings shall have a NEMA enclosure rating at least equal to the panel enclosure rating.
    a. Devices that cannot be obtained with an adequate NEMA rating shall be installed behind a transparent viewing window.
    b. The window shall maintain the required NEMA rating of the enclosure.
4. Panel(s) shall be completely assembled at the Contractor's factory.
    a. No fabrication other than correction of minor defects or minor transit damage shall be performed on panels at the jobsite.
5. Painting:
    a. Panels fabricated from steel shall have their internal and external surfaces prepared, cleaned, primed, and painted.
        1) Mechanically abrade all surfaces to remove rust, scale, and surface imperfections.
        2) Provide final surface treatment with 120 grit abrasives or finer, followed by spot putty to fill all voids.
        3) Utilize solvent or chemical methods to clean panel surfaces.
        4) Apply surface conversion of zinc phosphate prior to painting to improve paint adhesion and to increase corrosion resistance.
        5) Electrostatically apply polyester urethane powder coating to all inside and outside surfaces.
        6) Bake powder coating at high temperatures to bond coating to enclosure surface.
            a) Panel interior shall be white with semi-gloss finish.
            b) Panel exterior shall be ANSI #61 gray with flat finish.
        7) Application of alkyd liquid enamel coating shall be allowed in lieu of polyester urethane powder for wall mounted NEMA 1 or NEMA 12 rated panels.
    b. Panels fabricated from stainless steel, aluminum, or fiberglass shall not be painted.
6. Finish opening edges of panel cutouts to smooth and true surface conditions.
    a. Panels fabricated from steel shall have the opening edges finished with the panel exterior paint.
7. Panel shall meet all requirements of UL 508A.
    a. If more than one (1) disconnect switch is required to disconnect all power within a panel or enclosure, provide a cautionary marking with the word "CAUTION" and the following or equivalent, "Risk of Electric Shock-More than one (1) disconnect switch required to de-energize the equipment before servicing."
8. Provide control panel in accordance with NFPA 70, Article 409.
    a. In the event of any conflict between NFPA 70, Article 409 and UL 508A, the more stringent requirement shall apply.

B. Free-Standing Panels:
1. Welded construction.
2. Completely enclosed, self-supporting, and gasketed dusttight.
3. Rolled lip around all sides of enclosure door opening.
4. Seams and corners welded and ground smooth to touch and smooth in visual appearance.
5. Full height, fully gasketed flush pan doors.
6. Full length piano hinges rated for 1.5 times door plus instrument weight.
7. Doors with keyed alike locking handles and three-point catch.
8. Appropriate conduit, wiring, and instrument openings shall be provided.
9. Lifting eyebolts to allow simple, safe rigging and lifting of panel during installation.

C. Wall Mounted Panels:
1. Seams continuously welded and ground smooth.
2. Rolled lip around all sides of enclosure door opening.
3. Gasketed dust tight.
4. Three-point latching mechanism operated by oil tight key-locking handle.
5. Key doors alike.
6. Continuous heavy GA hinge pin on doors.

a. Hinges rated for 1.5 times door plus instrument weight.
7. Front full opening door.
8. Brackets for wall mounting.

D. Internal Panel Wiring:
1. Panel wire duct shall be installed between each row of components, and adjacent to each terminal strip.
    a. Route wiring within the panel in wire-duct neatly tied and bundled with tie wraps.
    b. Follow wire-duct manufacturer's recommended fill limits.
    c. Wire-duct shall have removable snap-on covers and perforated walls for easy wire entrance.
    d. Wire-duct shall be constructed of nonmetallic materials with rating in excess of the maximum voltage carried therein.
2. Wiring shall be installed such that if wires are removed from one (1) device, source of power will not be disrupted to other devices.
3. Splicing and tapping of wires permitted only at terminal blocks.
4. Wire bunches to doors shall be secured at each end so that bending or twisting will be around longitudinal axis of wire.
    a. Protect bend area with sleeve.
5. Arrange wiring neatly, cut to proper length, with surplus wire removed.
    a. Arrange wiring with sufficient clearance.
    b. Provide abrasion protection for wire bundles that pass through openings or across edges of sheet metal.
6. AC circuits shall be routed separate from analog signal cables and digital signal cables.
    a. Separate by at least 6 IN, except at unavoidable crossover points and at device terminations.
7. Provide at least 6 IN of separation between intrinsically safe devices and circuits and non-intrinsically safe devices and circuits.
8. Wiring to pilot devices or rotary switches shall be individually bundled and installed with a "flexible loop" of sufficient length to permit the component to be removed from panel for maintenance without removing terminations.
9. Conductors for AC and DC circuits shall be type MTW stranded copper listed for operation with 600 V at 90 DegC.
    a. Conductor size shall be as required for load and 16 AWG minimum.
    b. Internal panel wiring color code:
        1) AC circuits:
            a) Power wiring: Black.
            b) Control interconnections: Yellow.
            c) Neutral: White.
            d) Ground: Green.
        2) Low voltage DC circuits:
            a) Power wiring: Blue.
            b) Control interconnections: Violet.
        3) Foreign voltage circuits: Pink.
        4) Annunciator circuits: Red.
        5) Intrinsically safe circuits: Orange.
10. Analog signal cables shall be of 600 V insulation, stranded copper, twisted-shielded pairs.
    a. Conductor size: 18 AWG minimum.
    b. Terminate shield drain conductors to ground only at one (1) end of the cable.
11. High precision 250 ohm resistors with 0.25 percent accuracy shall be used where 4-20 mA DC analog signals are converted to 1-5 VDC signals.
    a. Resistors located at terminal strips.
    b. Resistors terminated using individual terminal blocks and with no other conductors.
    c. Resistor leads shall be un-insulated and of sufficient length to allow test or calibration equipment (e.g., HART communicator, loop calibrator) to be properly attached to the circuit with clamped test leads.

12. Analog signals for devices in separate enclosures shall not be wired in series.
    a. Loop isolators shall be used where analog signals are transmitted between control enclosures.
13. Wire and cable identification:
    a. Wire and cables numbered and tagged at each termination.
    b. Wire tags:
        1) Slip-on, PVC wire sleeves with legible, machine-printed markings.
        2) Adhesive, snap-on, or adhesive type labels are not acceptable.
    c. Markings as identified in the Shop Drawings.

E. Grounding Requirements:
1. Equipment grounding conductors shall be separated from incoming power conductors at the point of entry.
2. Minimize grounding conductor length within the enclosure by locating the ground reference point as close as practical to the incoming power point of entry.
3. Bond electrical racks, chassis and machine elements to a central ground bus.
    a. Nonconductive materials, such as paint, shall be removed from the area where the equipment contacts the enclosure.
4. Bond the enclosure to the ground bus.
    a. It is imperative that good electrical connections are made at the point of contact between the ground bus and enclosure.
5. Panel-mounted devices shall be bonded to the panel enclosure or the panel grounding system by means of locknuts or pressure mounting methods.
6. Sub-panels and doors shall be bonded to ground.

F. Termination Requirements:
1. Wiring to circuits external to the panel connected to interposing terminal blocks.
2. Terminal blocks rigidly mounted on DIN rail mounting channels.
3. Terminal strips located to provide adequate space for entrance and termination of the field conductors.
4. One (1) side of each strip of terminal blocks reserved exclusively for the termination of field conductors.
5. Terminal block markings:
    a. Marking shall be the same as associated wire marking.
    b. Legible, machine-printed markings.
    c. Markings as identified in the shop drawings.
6. Terminal block mechanical characteristics, and electrical characteristics shall be in accordance with NEMA ICS 4.
7. Terminal blocks with continuous marking strips.
    a. Each terminal block shall be identified with machine printed labels.
8. Terminals shall facilitate wire sizes as follows:
    a. 120 VAC applications: Conductor size 12 AWG minimum.
    b. Other: Conductor size 14 AWG minimum.
9. Analog signal cable shield drain conductors shall be individually terminated.
10. Install minimum of 20 percent spare terminals.
11. Bladed, knife switch, isolating type terminal blocks where control voltages enter or leave the panel.
12. Fused terminal blocks shall be used in the following circuits:
    a. Control voltage is used to energize a solenoid valve.
    b. DC power is connected to 2-wire, loop-powered instruments.
13. Fused terminal blocks shall be provided with blown fuse indicators.
14. When control circuits require more than one (1) field conductor connected to a single wiring point, a sufficient number of terminal points shall be connected internally to allow termination of only one (1) field conductor per terminal block.
15. DIN rail mounting channels shall be installed along full length of the terminal strip areas to facilitate future expansion.

16. Connections to devices with screw type terminals shall be made using spade-tongue, insulated, compression terminators.

G. Component Mounting and Placement:
   1. Components shall be installed per manufacturer instructions.
   2. Control relays and other control auxiliaries shall be mounted on DIN rail mounting channels where practical.
   3. Front panel devices shall be mounted within a range of 40 to 70 IN above the finished floor, unless otherwise shown in the Contract Documents.
   4. PLC/RTU and I/O rack installation:
      a. Located such that the LED indicators and switches are readily visible with the panel door open.
      b. Located such that repair and/or replacement of component can be accomplished without the need to remove wire terminations or other installed components.
   5. Locate power supplies with sufficient spacing for circulation of air.
   6. Where components such as magnetic starters, contactors, relays, and other electromagnetic devices are installed within the same enclosure as the PLC/RTU system components, provide a barrier of at least 6 IN of separation between the "power area containing the electromagnetic devices" and the "control area".
   7. Components mounted in the panel interior shall be fastened to an interior sub-panel using machine screws.
      a. Fastening devices shall not project through the outer surface of the panel enclosure.
   8. Excess mounting space of at least 20 percent for component types listed below to facilitate future expansion:
      a. Fuse holders.
      b. Circuit breakers.
      c. Control relays.
      d. Time delay relays.
      e. Intrinsically safe barriers and relays.
   9. Components installed on sub-panels shall be provides with a minimum spacing between component and wire duct of 1 IN.
      a. Minimum of 2 IN separation between terminal strips and wire ducts.

H. Power Distribution:
   1. Main incoming power circuits shall be protected with a thermal magnetic circuit breaker.
      a. Limit load to maximum of 80 percent of circuit breaker rating.
   2. Component types listed below shall be individually fused so that they may be individually de-energized for maintenance:
      a. PLC/RTU power supply modules.
      b. Recorders.
   3. Each control panel with PLC/RTU components shall be furnished with power protection in the form of a double conversion UPS.
   4. Equip each panel with necessary power supplies with ratings required for installed equipment and with minimum 25 percent spare capacity.
   5. Constant voltage transformers, balancing potentiometers, and rectifiers as necessary for specific instrument requirements.

I. Internal Panel Lighting and Service Receptacles:
   1. Panels less than or equal to 4 FT wide:
      a. One (1) electrical GFCI duplex receptacle.
      b. One (1) compact fluorescent light fixture with manual switch(es).
   2. Panels or panel faces greater than 4 FT wide:
      a. One (1) duplex electrical GFCI receptacle per 6 FT of length.
      b. Continuous fluorescent lighting strip with manual switches.

J. Environmental Controls:
   1. Indoor panels located in a designated electrical room or control room:

a. Thermostat controlled cooling fans with exhaust louvers if required to maintain temperature inside panel(s) below the maximum operating temperature rating of the internal components.
b. Internal corrosion inhibitors.

2. Indoor panels not located within a designated electrical room or control room:
a. Thermostat controlled heaters to maintain temperature approximately 10 DegF above ambient for condensation prevention inside the panels.
b. Automatically controlled, closed-loop heat exchangers or closed-loop air conditioners where required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the panel(s).
c. Internal corrosion inhibitors.

3. Outdoor panels:
a. Outdoor temperature range of 0 DegF through 120 DegF.
b. Thermostat controlled heaters to maintain temperature approximately 10 DegF above ambient for condensation prevention inside the panels.
c. Outdoor temperature range of 0 DegF through 120 DegF.
d. Thermostat controlled closed-loop heat exchangers or closed-loop air conditioners if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the panel.
e. Internal corrosion inhibitors.

4. Environmental control components:
a. Panel heaters:
1) Thermostat controlled.
2) Fan driven.
3) Components mounted in an anodized aluminum housing.
4) Designed for sub-panel mounting.
5) Powered from 120 Vac and protected with a dedicated circuit breaker.
b. Cooling fans and exhaust packages:
1) Cooling fan with louver or grill and replaceable filter.
2) Designed to be mounted within a panel cutout to provide positive airflow through the panel.
3) Cooling fan and exhaust louvers shall be designed and listed to maintain a NEMA 12 enclosure rating.
4) Fitted with replaceable, high-density foam or synthetic fiber.
5) Cooling fan controlled with a separately mounted thermostat with bi-metal sensor and adjustable dial for temperature setting.
6) Powered from 120 Vac and protected with a dedicated circuit breaker.
c. Heat exchangers and air conditioners:
1) Dual-loop design to isolate panel interior air from exterior air.
2) Thermostat controlled.
3) Operate from 120 Vac and protected with a dedicated circuit breaker.
d. Internal corrosion inhibitors:
1) Contains chemical which vaporizes and condenses on surfaces in the enclosure.
2) Inhibitor shall be applied in accordance with manufacturer instructions for the enclosure volume.
3) Inhibitor shall be applied in the panel(s) prior to shipment from the Contractor's factory.

2.4 MAINTENANCE MATERIALS

A. Extra Materials:
1. Quantity of 25 percent replacement lamps for each type installed (minimum of 12 of each type).
2. Minimum 12 replacement filters for each type installed.
3. One (1) quart of exterior finish touch-up paint.
4. One (1) complete set of replacement corrosion inhibitors in sealed packages for each panel.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Scope: Inspect and test entire panel assembly to verify readiness for shipment.

B. Location: Contractor's factory.

C. Factory Tests:
   1. Tests shall be fully documented and signed by the Contractor's factory supervisor.
   2. The panel shop shall fully test the control panel for correct wiring.
      a. Each I/O point shall be checked by measuring or connecting circuits at the field terminal blocks.
   3. Burn-in test: Panel(s) shall be fully energized for a minimum period of 48 HRS.
   4. A PLC Central Processing Unit (CPU) shall be obtained and connected to the panel(s) if necessary for testing purposes.
   5. Testing equipment (such as digital multi-meters, analog loop calibrators, and laptop computers with PLC programming software) shall be used as required for testing.
   6. The following functions shall be tested as a minimum:
      a. Demonstrate functions of the panel(s) required by the Contract Documents.
      b. Correctness of wiring from all panel field terminals to all I/O points and to all panel components.
      c. Simulate and test each discrete signal at the field terminal strips.
      d. Simulate and test each analog signal using loop calibrators.
      e. Correct operation of communications between PLC system Central Processing Units (CPUs) and Remote I/O bases.
      f. Correct operation of single-loop controllers (including digital communication to microprocessor based devices).
      g. Correct operation of all digital communication devices.
      h. Demonstrate online and offline diagnostic tests and procedures.
      i. The Contractor shall notify the Engineer in writing a minimum of 15 calendar days prior to the Factory Tests.
         1) Engineer has the option to witness all required tests.
   7. Make following documentation available to the Engineer at test site during the tests:
      a. Contract Documents.
      b. Factory Demonstration Testing procedures.
      c. List of equipment to be testing including make, model, and serial number.
      d. Shop Drawing submittal data for equipment being tested.
   8. Deficiencies shall be corrected prior to shipment from the Contractor's factory.

3.2 INSTALLATION

A. Install free-standing panels on 4 IN high concrete housekeeping pads.

B. Anchor panels in a manner to prevent the enclosure from racking, which may cause the access doors to become misaligned.

C. Obtain approved panel layouts prior to installation of conduits.

D. Install products in accordance with manufacturer's instructions.

END OF SECTION

SECTION 40 99 00

SURGE PROTECTION DEVICES (SPD) FOR INSTRUMENTATION AND CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Type IC1 SPD - Dedicated 120 Vac circuit, series connection, control panel mounted.
   2. Type IC3 SPD - Discrete 120 Vac control signal, control panel mounted.
   3. Type IC4 SPD - Analog instrumentation signal, field mounted.
   4. Type IC5 SPD - Analog instrumentation signal, control panel mounted.
   5. Type IC6 SPD - Combination 120 Vac circuit and analog signal, field mounted.
   6. Type IC7 SPD - Discrete low voltage control signal, control panel mounted.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. LS 1, Low Voltage Surge Protection Devices.
   3. Underwriters Laboratories, Inc. (UL):
      a. 497B, Standard for Safety Protectors for Data Communications and Fire-Alarm Circuits.
      b. 1283, Standard for Safety Electromagnetic Interference Filters.
      c. 1363, Standard for Safety Relocatable Power Taps.
      d. 1449, Standard for Safety Transient Voltage Surge Suppressors.

B. Qualifications:
   1. Provide devices for a manufacturer who has been regularly engaged in the development, design, testing, listing and manufacturing of SPDs of the types and ratings required for a period of 10 years or more and whose products have been in satisfactory use in similar service.
   2. Upon request, suppliers or manufacturers shall provide a list of not less than three (3) customer references showing satisfactory operation.

1.3 DEFINITIONS

A. Clamping Voltage: The voltage measured at the end of the 6 IN output leads of the SPD and from the zero voltage reference to the peak of the surge when the applied surge is induced at the 90 degree phase angle of the applied system frequency voltage.

B. Let-Through Voltage: The voltage measured at the end of the 6 IN output leads of the SPD and from the system peak voltage to the peak of the surge when the applied surge is induced at the 90 degree phase angle of the applied system frequency voltage.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the SPD device can operate and meet it specification within its rated temperature.

D. Maximum Surge Current:
   1. The maximum 8 x 20 microsecond surge current pulse the SPD device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 percent deviation of clamping voltage at a specified surge current.
   2. Listed by mode, since number and type of components in any SPD may vary by mode.

E. Protection Modes: This parameter identifies the modes for which the SPD has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

F. Surge Current per Phase:
   1. The per phase rating is the total surge current capacity connected to a given phase conductor.
   2. For example, a wye system surge current per phase would equal L-N plus L-G; a delta system surge current per phase would equal L-L plus L-G.
      a. The N-G mode is not included in the per phase calculation.

G. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for a 120 V system the L-N peak voltage is 170 V).

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. For named products, submit only a catalog cut sheet.
      a. For all other products, submit the data required below.
   3. See Specification Section 40 90 00.
   4. Product technical data for non-specified models:
      a. Manufacturer's experience.
      b. Standard catalog cut sheet.
      c. Electrical and mechanical drawing showing unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.
      d. Create a Product Data Sheet for each different model number of SPD provided.
         1) Data in the Product Data Sheet heading:
            a) SPD Type per PART 2 of the Specification.
            b) Manufacturer's Name.
            c) Product model number.
         2) Data in the Product Data Sheet body:
            a) Column one: Specified value/feature of every paragraph of PART 2 of the Specification.
            b) Column two: Manufacturer's certified value confirming the product meets the specified value/feature.
         3) Data in the Product Data Sheet closing:
            a) Signature of the manufacturer's official (printed and signed).
            b) Title of the official.
            c) Date of signature.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

1.5 WARRANTY

A. The manufacturer shall provide a minimum of a five (5) year Limited Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers' model numbers listed in the individual product paragraphs below are acceptable.

2.2 TYPE IC1 SPD

A. Approved Products:
   1. Eaton AGSHW CH-120N-15-XS.
   2. EDCO HSP121BT-1RU.
   3. MTL MA15/D/1/SI.
   4. Phoenix Contact SFP 1-20/120AC (2856702).

B. Standards: UL 1449.

C. Design:
   1. General:
      a. Mounted internally to control panels for point-of-use loads.
      b. MOV based or multi-stage hybrid solid state high performance suppression system.
      c. Designed for series connection.
      d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
      e. Field connection: Provide unit with external terminal screws for each phase, neutral and ground that will accept #14 through #12 conductors.
      f. Device monitoring: Long-life, solid state, externally visible indicators that monitors the on-line status of the units suppression filter system or power loss in any of the phases.
   2. Operating voltage: 120 Vac.
   3. Operating current: 15 A minimum.
   4. Operating frequency: 45 to 65 Hz.
   5. Modes of protection: All modes, L-N, L-G and N-G.
   6. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.
   7. Maximum surge current: 20,000A per phase, 10,000A per mode minimum.
   8. Minimum repetitive surge current capacity: 1000 impulses with no degradation of more than 10 percent deviation of the clamping voltage.
   9. Fusing: Optional integral unit level and/or component level short circuit and/or thermal overload protection.
      a. External protection as recommended by manufacturer.
   10. Maximum clamping voltages, dynamic test with voltages measured from the zero voltage reference and 90 degree phase angle:

		IEEE C62.41		
System Voltage	**Test Mode**	**B Comb. Wave**	**A Ring Wave**	**UL 1449**
L-N = 120 V	L-N	400 V	300 V	330 V
	L-G	500 V	400 V	400 V
	N-G	500 V	400 V	400 V

2.3 TYPE IC3 SPD

A. Approved Products:
   1. EDCO DRS-130RMS.
   2. MTL MA-15/D/1/SI.
   3. MTL SD-150X.
   4. Phoenix Contact PT 2x1VA-120AC-ST (2839185) with PT BE/FM (2839282) base for non-isolated wiring.
   5. Phoenix Contact PT-2 PE/S-120 AC-ST (2839334 with PT-BE/FM (2839282) base for isolated wiring.

B. Standards: UL 497B or UL 1449.

C. Design:
   1. General:
      a. Mounted internally to control panels for point-of-use loads.
      b. Multi-stage hybrid solid state high performance suppression system.
      c. Designed for series connection.
      d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
      e. Field connection: Provide unit with external terminal screws for each phase, neutral and ground that will accept #14 through #12 conductors.
      f. Device monitoring: Long-life, solid state, externally visible indicators that monitors the on-line status of the units suppression filter system or power loss in any of the phases.
   2. Operating voltage: 120 Vac.
   3. Operating current: 3 A minimum.
   4. Operating frequency: 45 to 65 Hz.
   5. Modes of protection: L-N; when ground conductor is present L-G and N-G.
   6. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.
   7. Maximum surge current: 6000 A per phase, 3000A per mode minimum.
   8. Minimum repetitive surge current capacity:
      a. The SPD shall meet one (1) of the following:
         1) 1000 occurrences of a 200A, 10x1000 microsecond waveform.
         2) 400 occurrences of a 500A, 10x1000 microsecond waveform.
         3) 100 occurrences of a 400A, 10x700 microsecond waveform.
         4) 100 occurrences of a 2000A, 8x20 microsecond waveform.
   9. Maximum clamping voltages, measured from the zero voltage reference:
      a. The SPD shall meet one (1) of the following:
         1) 400A, 10x700 microsecond waveform: 200 percent of system voltage.
         2) IEEE B3 combination wave: 250 percent of system voltage.
         3) IEEE B3 ring wave: 200 percent of system peak voltage.
         4) IEEE A3 ring wave: 200 percent of system peak voltage.
         5) Mode N-G clamping voltage may be 175 percent higher than the L-G levels.

2.4 TYPE IC4 SPD

A. Approved Products:
   1. Eaton DPIPE S0362.
   2. EDCO SS64-036-1, SS64-036-2, SS65-036-1 or SS65-036-2.
   3. MTL TP48-NDI.
   4. Phoenix Contact S-PT1-2PE-24DC (2818122).

B. Standards: None.

C. Design:
   1. General:
      a. For protection of field mounted equipment connected to 4-20mA analog signal loops.
      b. Mounted directly to an unused conduit entry on a process transmitter housing.
      c. Multi-stage hybrid solid state high performance suppression system.
      d. Designed for series connection.
      e. Enclosure: 1/2 IN to 3/4 IN stainless steel conduit pipe nipple.
   2. Operating voltage: 24 VDC or as indicated on the Drawings.
   3. Modes of protection: All modes, L-L and L-G.
   4. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.
   5. Maximum surge current: 10,000 A.
   6. Minimum repetitive surge current capacity:
      a. The SPD shall meet one (1) of the following:
         1) 1000 occurrences of a 200A, 10x1000 microsecond waveform.
         2) 400 occurrences of a 500A, 10x1000 microsecond waveform.
         3) 100 occurrences of a 400A, 10x700 microsecond waveform.

4) 100 occurrences of a 2000A, 8x20 microsecond waveform.
5) 10 occurrences of a 10,000A, 8x20 microsecond waveform.

7. Maximum clamping voltages, L-L:
   a. The SPD shall meet one (1) of the following:
      1) 400A, 10x700 microsecond waveform: 400 percent of system voltage.
      2) 10,000A, 8x20 microsecond waveform: 400 percent of system voltage.
      3) IEEE B3 combination wave: 250 percent of system voltage.
8. Maximum clamping voltages, L-G:
   a. The SPD shall meet one (1) of the following:
      1) 400A, 10x700 microsecond waveform: 200 percent of system voltage.
      2) 10,000A, 8x20 microsecond waveform: 200 percent of system voltage.
      3) IEEE B3 combination wave: 300 percent of system voltage.

2.5 TYPE IC5 SPD

A. Approved Products:
   1. Eaton DHW2P036.
   2. EDCO DRS-036 or PC642C-036 with PCB1B base.
   3. MTL SD32 or SD32X.
   4. Phoenix Contact PT 2x2-24DC-ST (2838228) with PT 2x2-BE (2838208) or PT 2x2+F-BE (2839224) base.

B. Standards: UL 497B.

C. Design:
   1. General:
      a. Mounted internally to control panels for protection of equipment connected to analog signal loops.
      b. Multi-stage hybrid solid state high performance suppression system.
      c. Designed for series connection.
      d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
      e. Field connection: The unit shall have external terminal screws for line and ground conductors.
   2. Operating voltage: 24 VDC or as indicated on the Drawings.
   3. Modes of protection: All modes, L-L and L-G.
   4. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.
   5. Maximum surge current: 10,000 A.
   6. Minimum repetitive surge current capacity:
      a. The SPD shall meet one (1) of the following:
         1) 1000 occurrences of a 200A, 10 x 1000 microsecond waveform.
         2) 400 occurrences of a 500A, 10 x 1000 microsecond waveform.
         3) 100 occurrences of a 400A, 10 x 700 microsecond waveform.
         4) 100 occurrences of a 2000A, 8 x 20 microsecond waveform.
         5) 10 occurrences of a 10,000A, 8 x 20 microsecond waveform.
   7. Maximum clamping voltages, L-L:
      a. The SPD shall meet one (1) of the following:
         1) 400A, 10x700 microsecond waveform: 400 percent of system voltage.
         2) 10,000A, 8x20 microsecond waveform: 400 percent of system voltage.
         3) IEEE B3 combination wave: 225 percent of system voltage.
   8. Maximum clamping voltages, L-G:
      a. The SPD shall meet one (1) of the following:
         1) 400A, 10x700 microsecond waveform: 200 percent of system voltage.
         2) 10,000A, 8x20 microsecond waveform: 200 percent of system voltage.
         3) IEEE B3 combination wave: 300 percent of system voltage.

2.6 TYPE IC6 SPD

A. Approved Products:

1. EDCO SLAC-12036.
2. MTL TPAC-4W.
3. Phoenix Contact BXT-N4X 4-Wire.

B. Product:
1. Field mounted for protection of field mounted equipment connected to 120V power and 4-20mA analog signal loops.
2. Type IC1 and Type IC5 SPDs mounted in a common enclosure.
3. Enclosure: Metallic or nonmetallic NEMA 4X.

2.7 TYPE IC7 SPD

A. Approved Products:
1. Eaton DDIN Series.
2. EDCO DRS Series.
3. MTL SD Series.
4. Phoenix Contact: PT Series.

B. Standards: UL 497B.

C. Design:
1. General:
   a. Mounted internally to control panels for protection of equipment connected to a discrete signal.
   b. Multi-stage hybrid solid state high performance suppression system.
   c. Designed for series connection.
   d. Enclosure: Metallic or plastic, flange or DIN rail mounting.
   e. Field connection: Provide unit with external terminal screws for line and ground conductors.
2. Operating voltage: 24 Vdc or 24 Vac or 120 Vac or as indicated on the Drawings.
3. Modes of protection: All modes:
   a. AC applications: L-N, L-G, N-G
   b. DC applications: Pos-Neg, Pos-Gnd, Neg-Gnd.
4. Maximum continuous operating voltage: Less than 130 percent of system peak voltage.
5. Maximum surge current: 10,000 A.
6. Minimum repetitive surge current capacity:
   a. The SPD shall meet one (1) of the following:
      1) 1000 occurrences of a 200A, 10 x 1000 microsecond waveform.
      2) 400 occurrences of a 500A, 10 x 1000 microsecond waveform.
      3) 100 occurrences of a 400A, 10 x 700 microsecond waveform.
      4) 100 occurrences of a 2000A, 8 x 20 microsecond waveform.
      5) 10 occurrences of a 10,000A, 8 x 20 microsecond waveform.
7. Maximum clamping voltages, L-L (Pos-Neg):
   a. The SPD shall meet one (1) of the following:
      1) 400A, 10x700 microsecond waveform: 400 percent of system voltage.
      2) 10,000A, 8x20 microsecond waveform: 400 percent of system voltage.
      3) IEEE B3 combination wave: 250 percent of system voltage.
8. Maximum clamping voltages, L-G:
   a. The SPD shall meet one (1) of the following:
      1) 400A, 10x700 microsecond waveform: 200 percent of system voltage.
      2) 10,000A, 8x20 microsecond waveform: 200 percent of system voltage.
      3) IEEE B3 combination wave: 300 percent of system voltage.

2.8 SOURCE QUALITY CONTROL

A. Performance tests to be performed or independently verified by a certified testing laboratory.

B. The SPD are to be tested as a complete SPD system including: Integral unit level and/or component level fusing.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Type IC1 SPD:
   1. Provide on the following applications:
      a. Incoming 120 V power to all control panels unless the 120 V power is sourced from an internal UPS.
      b. Line side of 120 V power terminals to equipment (e.g., PLCs, transmitters).
   2. Connected in series with the panel's or equipment’s branch circuit.
   3. Provide fuse protection as recommended by manufacturer.
   4. Flange mount or DIN rail mount in control panel.
   5. Connect all SPDs in the panel to the same grounding point.

C. Type IC3 SPD:
   1. Provide on the following applications:
      a. 120 V discrete PLC signals into a control panel from float switches, position switches, etc., where the device is mounted outdoors or in a remote building or structure from the control panel and where the control conductors are routed above grade or underground.
      b. 120 V discrete PLC signals into a control panel from float switches, position switches, etc., where both the device and control panel are mounted outdoors and the control conductors are routed above grade or underground.
   2. Connected in series with the equipment.
   3. Provide fuse protection as recommended by manufacturer.
   4. Flange mount or DIN rail mount in control panel.
   5. Connect all SPDs in the panel to the same grounding point.

D. Type IC4 SPD:
   1. Provide on the following applications:
      a. Loop powered transmitter (flow, level, etc.) where the transmitter is mounted outdoors or in a remote building or structure from the control panel and the signal conductors are routed above grade or underground.
      b. Loop powered transmitter (flow, level, etc.) where both the transmitter and control panel are mounted outdoors and the signal conductors are routed above grade or underground.
   2. Connect in series with the equipment.
   3. Attach to spare conduit entry of transmitter or inline of conduit at the transmitter.
   4. Bond transmitter to a grounded structure or provide a ground rod.
   5. Ground shield at control panel end.
   6. Verify SPDs series resistance and capacitance does not interfere with the transmitters signal.

E. Type IC5 SPD:
   1. Provide on the following applications:
      a. Incoming 4-20mA signals into a control panel from transmitters (flow, level, etc.) where the transmitter is mounted outdoors or in a remote building or structure from the control panel and the signal conductors are routed above grade or underground.
      b. Incoming 4-20mA signals into a control panel from transmitters (flow, level, etc.) where both the transmitter and control panel are mounted outdoors and the signal conductors are routed above grade or underground.
   2. Connect in series with the equipment.
   3. Flange mount or DIN rail mount in control panel.
   4. Connect all SPDs in the control panel to the same grounding point.
   5. Verify SPDs series resistance and capacitance does not interfere with the transmitters signal.

F. Type IC6 SPD:
   1. Provide on the following applications:

a. Outdoor field mounted transmitter (flow, level, etc.) that requires 120 V power and provides a 4-20mA signal to a control panel where the conductors are routed above grace or underground.
2. Connect in series with the equipment.
3. Mounted adjacent to equipment.
4. Bond transmitter to a grounded structure or provide a ground rod.
5. Ground shield at control panel end.
6. Verify SPDs series resistance and capacitance does not interfere with the transmitters signal.

G. Type IC7 SPD:
1. Provide on the following applications:
   a. Low voltage (e.g., 24 VAC, 24 VDC) discrete PLC signals into a control panel from float switches, position switches, etc., where the device is mounted outdoors or in a remote building or structure from the control panel and where the control conductors are routed above grade or underground.
   b. Low voltage (e.g., 24 VAC, 24 VDC) discrete PLC signals into a control panel from float switches, position switches, etc., where both the device and control panel are mounted outdoors and the control conductors are routed above grade or underground.
2. Connect in series with the equipment.
3. Flange mount or DIN rail mount in control panel.
4. Connect all SPDs in the control panel to the same grounding point.

END OF SECTION

SECTION 43 21 00

PUMPING EQUIPMENT: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pumping equipment.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 09 96 00 – High Performance Industrial Coatings.
   4. Section 40 05 05 - Equipment: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Hydraulic Institute (HI):
      a. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

B. Fully coordinate all mechanical seal systems specified to ensure pump and seal compatibility.

C. Pump/motor and VFD coordination: See Specification Section 40 05 05.

1.3 DEFINITIONS

A. The abbreviations are defined as follows:
   1. IPS: Iron Pipe Size.
   2. NPSHR: Net Positive Suction Head Required.
   3. TDH: Total Dynamic Head.
   4. TEFC: Totally Enclosed Fan Cooled.
   5. VFD: Variable Frequency Drive.

B. Pump Service Category: Pump or pumps having identical names (not tag numbers) used for specific pumping service.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 05 05.
   3. Product technical data including:
      a. Performance data and curves with flow (gpm), head (FT), horsepower, efficiency, NPSH requirements, submergence requirement.
      b. Pump accessory data.
      c. Bearing supports, shafting details and lubrication provisions.
         1) Bearing life calculations.
         2) Critical speed calculations.
      d. Solids passage information.
   4. Certifications:
      a. Certified pump performance curves as described in the SOURCE QUALITY CONTROL Article.
   5. Test reports:
      a. Factory hydrostatic test.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
   1. Certifications:
      a. Provide a written statement that manufacturer's equipment has been installed properly, started up and is ready for operation by Owner's personnel.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Pumps:
      a. See individual pump Specification Sections.
   2. Mechanical seals:
      a. Chesterton.
      b. Garlock.
      c. Or as noted in the individual pump Specification Sections.
   3. Seal water station:
      a. Chesterton.
      b. John Crane.
      c. AESSEAL.

2.2 CENTRIFUGAL PUMP DESIGN

A. Provide units with increasing head characteristics from the end run out portion of the curve to shut-off condition.

2.3 ACCESSORIES

A. See Specification Section 40 05 05.

B. Each Unit:
   1. Lifting eye bolts or lugs.
   2. Plugged gage cock connection at suction and discharge nozzles.
   3. Tapped and plugged openings for casing and bearing housing vents and drains.
   4. Fittings for properly adding flushing lubricant.
   5. Pressure relief fittings for grease lubrication.

C. Packing Seal:
   1. Provide packing unless mechanical seal is specified in narrow-scope pump sections.
   2. Minimum of five (5) rings graphite impregnated synthetic packing.
   3. Provide minimum 1/4 IN DIA supply tap and 1/2 IN DIA minimum drain tap.
   4. Provide split Teflon or bronze water seal ring.
   5. Adjustable split follower cast iron or bronze gland.

2.4 FABRICATION

A. Pump Support:
   1. Design base to support weight of drive, shafting and pump.
   2. Comply with HI vibration limitations.
   3. Mount horizontal pump, motor and coupling on single piece drip lip type baseplate.
   4. Mount vertical pumps on single piece pedestal baseplate.
   5. Fabricate to withstand all operating loads transmitted from the pump and drive.

2.5 SOURCE QUALITY CONTROL

A. Provide factory tests for all specified pumps:
  1. All units:
    a. Conduct tests in accordance with HI.
      1) Shut-off head and design condition: Positive unilateral performance tolerance meeting Grade 1U per HI 14.6.
    b. Hydrostatic test at 150 percent of shut-off head for a minimum of 5 minutes.
  2. Adjustable speed units:
    a. Head (FT) verses flow (gpm) pump curves:
      1) Maximum, minimum and two (2) equally spaced intermittent speeds.
      2) Efficiencies along each curve.
      3) Brake horsepower along each curve.
  3. Constant speed units:
    a. Head (FT) versus flow (gpm) pump curves:
      1) Efficiencies along curve.
      2) Brake horsepower along each curve.
  4. Results certified by a registered professional engineer.

B. Statically and dynamically balance each pump per HI standards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 40 05 05.

B. Floor or Pad-Mounted Units (Non-Submersible):
  1. Align vertically and horizontally level, wedge and plumb units to match piping interfaces.
  2. Assure no unnecessary stresses are transmitted to equipment flanges.
  3. Tighten flange bolts at uniform rate and manufacturer's recommended torque for uniform gasket compression.
  4. Support and match flange faces to uniform contact over entire face area prior to bolting pipe flange and equipment.
  5. Permit piping connecting to equipment to freely move in directions parallel to longitudinal centerline when and while bolts in connection flange are tightened.
  6. Grout equipment into place prior to final bolting of piping but not before initial fitting and alignment.
  7. Assemble connecting piping with gaskets in place and minimum of four (4) bolts per joint installed and tightened.
    a. Test alignment by loosening flange bolts to see if there is any change in relationship of piping flange with equipment connecting flange.
    b. Realign as necessary, install flange bolts and make equipment connection.
  8. Field paint units as defined in Specification Section 09 91 00.
  9. Provide pressure gage on discharge of all pumps and on suction and discharge of all non-submersible units.

C. Submersible Units:
  1. Assemble connecting piping with gaskets in place and minimum of four (4) bolts per joint installed and tightened.
    a. Test alignment by loosening flange bolts to see if there is any change in relationship of piping flange with equipment connecting flange.
    b. Realign as necessary, install flange bolts and make equipment connection.
  2. Field paint units as defined in Specification Section 09 91 00.
  3. Provide pressure gage on discharge of all pumps and on suction and discharge of all non-submersible units.

3.2 FIELD QUALITY CONTROL

A. Provide services of equipment manufacturer's field service representative(s) to:
   1. Inspect equipment covered by this Specification Section.
   2. Supervise pre-start adjustments and installation checks.
   3. Conduct initial startup of equipment and perform operational checks.
   4. Instruct Owner's personnel for the specified minimum number of hours at jobsite per Specification Section 01 75 00.

END OF SECTION

SECTION 43 23 58

PUMPING EQUIPMENT: POSITIVE DISPLACEMENT (LOBE)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Lobe pumps.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 43 21 00 - Pumping Equipment: Basic Requirements.
   4. Section 26 29 23 - Variable Frequency Drives: Low Voltage.

C. System Description
   1. Sludge Recirculation Pumps SRP-01, SRP-02 and SRP-03.
   2. Digested Sludge Transfer Pumps: STP-01 and STP-02.

D. Performance Requirements:
   1. Equipment shall be designed and selected for continuous duty pumping of concentrated solids derived from the treatment of wastewater. Where specified, pumps shall operate at variable speed and shall be capable of running dry, for a short period of time, without damage to the pump and or drive unit. Pumps shall be suitable for exposure to digested sludge containing grit, small particles of wood, metal, industrial solvents, greases, detergents, petroleum products, dissolved ammonia and hydrogen sulfide, and organic particles in concentrations as great as 8 percent as is typical of municipal wastewater. The pumped fluids are expected to range in temperatures between 45 degrees F and 100 degrees F, and the pH may vary between 6 and 9.
   2. The pumps, along with associated drive appurtenances, shall be mounted on a common fabricated steel adjustable baseplate for sheave drive adjustment. The baseplate shall be hot dip galvanized after fabrication.

1.2 QUALITY ASSURANCE

A. References
   1. Design, manufacturing, and assembly of elements of the equipment herein specified shall be in accordance with the standards of the below listed organizations. Where reference is made to a standard of one of the following or other organizations, the version of the standard in effect at the time of the bid opening shall apply.
      a. American Gear Manufacturing Association (AGMA)
      b. American Institute of Steel Construction (AISC)
      c. American Iron and Steel Institute (AISI)
      d. American Society of Mechanical Engineers (ASME)
      e. American National Standards Institute (ANSI)
      f. American Society for Testing Materials (ASTM)
      g. American Water Works Association (AWWA)
      h. American Welding Society (AWS)
      i. Anti-Friction Bearing MANUFACTURERS Association (AFBMA)
      j. Hydraulic Institute Standards
      k. Institute of Electrical and Electronics Engineers (IEEE)
      l. National Electrical Code (NEC)
      m. National Electrical MANUFACTURERS Association (NEMA)
      n. Occupational Safety and Health Administration (OSHA)
      o. Steel Structures Painting Council (SSPC)

p. Underwriters Laboratories, Inc. (UL)

B. Referenced Standards:
1. American Bearing Manufacturers Association (ABMA).
2. American Iron and Steel Institute (AISI):
a. Steel Products Manual.
3. ASTM International (ASTM):
a. A48, Standard Specification for Gray Iron Castings.
b. A536, Standard Specification for Ductile Iron Castings.
4. Society of Automotive Engineers (SAE).

1.3 SUBMITTALS

A. Shop Drawings.
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. See Specification Section 43 21 00.

B. Operation and Maintenance Manuals:
1. See Specification Section 01 33 04 for requirements.:

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, acceptable Manufacturers are listed in Section 01 61 05.
1. Gear Reducer:
a. U.S. Browning.
b. Reliance.
2. Mechanical adjustable speed drive:
a. SEW Euradrive "Varigear."
b. Reeves "Motodrive."

2.2 MATERIALS

A. Lobe Pumps:

Component	Material
Casting and casing cover plates	Grey Cast Iron ASTM A536, 230 to 260 Brinell hardness, 500 Brinell on end cover plate
Rotors	Cast iron core with Buna-N covering as specified
Shafts	Carbon steel, ASTM A293 60 mm Diameter
Shaft sleeve	Stellite coated stainless steel

1. Rotor case:
a. Ductile iron, ASTM A536.
b. Brinell hardness 220 or coated with 0.004-0.006 IN tungsten carbide.
2. Wear plates:
a. Steel, replaceable, hardened to 40 Rockwell C.
3. End cover:
a. SAE 285 C steel, hardened both sides to 55 Rockwell C.
4. Bearings:
a. Roller/ball, ABMA L-10 life 100,000 HRS.
5. Rotor:
a. Ductile iron ASTM A536 covered with urethane with durometer 80-90 hardness.
6. Shaft:
a. Steel, AISI 4140 or AISI 4340.

7. Shaft sleeve:
    a. Stainless steel - 440 C hardened to 45 Rockwell C.
8. Gears:
    a. Steel, AISI 8620.
9. Gear case:
    a. Cast iron ASTM A48.
10. Pump seal:
    a. Water lubricated with graphite impregnated Teflon packing.

2.3 EQUIPMENT

A. Provide sludge pumps meeting the following parameters:
1. Sludge Recirculation Pumps – Tag Numbers SRP-01, SRP-02 and SRP-03:
    a. Delivery capability:
        1) 250 gpm maximum.
    b. Total differential head:
        1) 30 psig maximum.
    c. Pump speed:1000 rpm maximum.
    d. Minimum displacement: 15 GAL per 100 revolutions.
    e. Driver: 7.5 HP maximum.
    f. Electric variable speed.
    g. Suction and discharge: 4 IN DIA.
    h. Material pumps: sludge at 3-5 percent solids.

2. Digested Sludge Transfer Pumps – Tag Numbers STP-01 and STP-02:
    a. Delivery capability:
        1) 250 gpm maximum.
        2) 125 gpm minimum.
    b. Total differential head:
        1) 30 psig maximum.
        2) 20 psig minimum.
    c. Pump speed: 350 rpm maximum.
    d. Minimum displacement: 33 GAL per 100 revolutions.
    e. Driver: 25 HP minimum.
    f. Electric variable speed
    g. Suction and discharge: 4 IN DIA.
    h. Material pumps: sludge at 3-5 percent solids.

2.4 ACCESSORIES

A. See Section 43 21 00.

B. Provide stainless steel belt guards.

C. Provide a 1 GAL calibration chamber on the suction port of each polymer pump.

2.5 FABRICATION

A. General:
    a. Pumps shall be capable of operation with lobe rotation in either direction.
    b. Pumps shall be capable to run dry for a short period of an indefinite time without damage. If pump cannot run dry, provide run dry protection for each pump.

B. Rotor Case:
1. Provide removable end cover which allows removal and replacement of rotors and reversible wear plates without disturbing shaft seals or packing, bearings or suction and discharge connections.
2. End cover shall have no intrusions inside case.
    a. Seal end cover with a Buna-N O-ring.

3. Tap and plug suction and discharge connections for minimum 1/2 IN DIA IPS connection.

C. Rotors:
1. Rotors shall utilize HiFlo four-tip rotors to be tri-lobe form.
2. Rotors shall be positioned to the shaft by replaceable hardened key ways, and secured to the shaft by internal/external expansion bolt and flush discs requiring no recesses in the end cover. Pumps utilizing lobe designs, with fewer than 4 tips will not be considered, due to the high potential for wear on the lobes, as a result of fewer sealing lines. Designs with replaceable lobe tips shall not be acceptable.
2. Rotors to be positioned on drive shafts using spline and locking assembly to provide precise and lasting rotor timing and allow rotor replacement without shaft re-timing.
3. Rotors shall be held in place on the shaft with locking rings with the ends sealed to prevent contact with the pumped liquid.

D. Rotor Shaft:
1. The shafts shall be of carbon steel ASTM A293 fitted with replaceable stainless steel sleeves where passing through the seal area. They shall be timed in their rotation by straight cut timing gears running in a separate oil chamber which also contains the ball and roller bearings for each shaft. Pumps requiring external re-timing in the event of blockage will not be considered. The shaft shall be a minimum of 60 mm in diameter where the rotors, bearings, and mechanical seals contact the shaft, to decrease the potential of torsional shaft fatigue. The use of step down, angular v-notch cut, or threaded, shafts will not be acceptable due to shaft fatigue and potential of breakage. The shaft sleeves where the mechanical seal rides, shall be removable through the front of the pump, when removing the cartridge mechanical seal, and without disturbing the surrounding piping. Maximum shaft deflection at operating pressure shall be .0034 inches.
2. Each rotor shaft shall be supported by a minimum of two (2) inboard bearings without bearings or guides in the end plate.
3. Shaft for sludge and scum pump shall have replaceable Stainless Steel shaft sleeves passing through the Seal area.

E. Gears:
1. Shaft shall be timed by straight cut or helical gears with zero backlash.
   a. Gears shall be keyed to the shafts.
2. Gears shall run in an oil filled gear and bearing housing.
   a. Provide fittings for adding and draining oil or other lubricants.
3. Provide oil seals on the shaft at the gear box.
4. Provide an oil reservoir(s) with level sight glass of adequate capacity and configuration to insure bearing lubrication at all pump speeds.

F. Shaft Seals:
1. Cartridge mechanical seals shall be provided of Blockring in Chrome Oxide / Duronite for each positive displacement pump. The seal shall include the mechanical seal faces, the seal holder and carrier, all applicable o'rings, the mechanical seal faces, and stainless steel shaft sleeve. The use of manual pre-load mechanical seals will not be accepted. A blocking chamber located behind the mechanical seal, and in front of the bearing housing lip seal shall be fitted into the cartridge seal of the pump to prevent contamination of the bearings on the event of a seal failure. This chamber shall be suitable for fill, from the top of the pump, and have an external pressurized oil bottle to review the status of the mechanical seals operation, mounted on the top of the pump, located in easy view of the operator. Pumps with open to air cavities located behind the mechanical seal housing, those that require water flush or quench, or those without oil bottles, will not be accepted, due to their potential for product spill failure on the surrounding areas of the pump, and the added maintenance and cost associated with mechanical seal water flushing systems.
2. Provide pumps that require only one (1) stuffing box or seal per shaft in the rotor case.
3. Provide a stuffing box with packing, split Teflon lantern ring, and adjustable gland for sludge pumps.
4. Polymer pumps seal shall be an externally mounted mechanical seal.

5. Provide seal water supply connection, a slinger between gland and gear box, and a drain from the seal area piped to discharge to the floor.

G. Baseplate:
1. Provide common cast iron or fabricated steel base plate for pump and drive train with drain piped to floor.

H. Drive Train:
1. All pumps shall include a factory-installed electric motor, gear reducer, V-belt connection or flexible coupling between the drive and pump.
2. The horsepower, torque and speed characteristics of each motor and drive shall be suitable for continuous operation for all loading conditions described without exceeding motor nameplate current or temperature rise.
   a. Gear boxes shall have a service factor of 2.0 minimum.
3. Motors shall be mounted above any gear boxes or other power transmission equipment.
4. Locally manually adjustable speed drives shall be mechanical sliding sheave belt drive type.
5. Remote adjustable speed drives shall be electric variable frequency type sized to provide required torque throughout pump operating range.
6. Variable frequency controller and pump motor with gear box shall be furnished by the pump manufacturer.
   a. See Specification Section 26 29 23 for VFD requirements.

2.6 SOURCE QUALITY CONTROL

A. See Section 43 21 00.
1. Hydrostatic test unit at 150 percent of maximum specified discharge pressure or at 150 psig, whichever is greater.

B. Each pump shall have factory run-in test prior to shipment.

2.7 MAINTENANCE MATERIALS

A. Provide the following spare parts per each pump size specified:
1. One (1) drive shaft, one (1) driven shaft.
2. Two (2) sets of rotors and gears.
3. Two (2) sets of mechanical seals.
4. Two (2) sets of bearing.
5. Two (2) sets of seals, gaskets and o-rings.
6. Two (2) sets of drive belts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 43 21 00.

B. Install products in accordance with manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

A. See Section 43 21 00.

B. See Section 01 75 00 for startup and training.

END OF SECTION

SECTION 46 24 23
SLUDGE GRINDERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. In-line mounted sludge grinders

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. A536, Standard Specification for Ductile Iron Castings.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Section 40 05 05.
   3. Net weight of grinder only.
   4. Net weight with baseplate and couplings.
   5. Capacity versus percent solids and horsepower.
   6. Rotative speed.

B. Contract Closeout Information:

C. Contract Closeout Information:
      a. Operation and Maintenance Data:
         1) See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. See Specification Section 01 61 05.

2.2 MATERIALS

A. Sludge Grinders, Equipment Tag Numbers (G-01 and G-02):
   1. Housing: Cast iron with coatings per Specification 09 96 00.
   2. Shafts: 4140 alloy steel, minimum tensile strength 180,000 psi.
   3. Cutting elements: 4130 alloy steel hardened to Rockwell "C" 43-48.
   4. Side rails: ASTM A536, ductile iron.

2.3 EQUIPMENT

A. Performance and Configuration Requirements:
   1. Grinders (G-01 and G-02):
      a. Capacity: 125 gpm at 2 - 3 percent solids.
      b. Pressure drop at specified capacity: 1 psi.
      c. Inlet/outlet size: 6 IN.

d. Motor size: 3 HP.
e. Operating pressure: 125 psig.
f. Drive shaft speed: 1750 rpm.

2.4 ACCESSORIES

A. See Section 40 05 05.

B. Controls:
1. Utilize solid state electronics.
2. Furnish "run-off-auto" selector switch with lockout provision.
3. Provide reversing starters with thermal magnetic overloads.
4. Furnish dry contacts for remote indication of grinder running in forward and reverse direction and alarm condition.
5. Use current switch to indicate jam and initiate reversing of grinder.
6. If overload (jam) occurs momentarily reverses to clear obstruction and returns to forward direction.
7. If second overload occurs, repeat action as for first overload.
8. If third overload occurs within 30 seconds, unit reverses, shuts down, and alarm bell and light come on.
9. Provide power on, forward, reverse and alarm indicating lights.
10. Provide fuse protection on all logic circuits.
11. Provide line transient protected to 1000 V.
12. Mount in wall-mounted enclosure rated for area classification.

2.5 FABRICATION

A. General:
1. Use double shaft design.
2. Fabricate to start under loaded conditions.
3. Furnish with 125 LB flanges.
4. Design for vertical or horizontal in-line mounting.
5. Design capability to operate continuously wet or dry.

B. Cutting Assembly:
1. Rotate driven shaft at approximately two-thirds the speed of the drive shaft.
2. Counter rotate shafts.
3. Equip with spacers and intermeshing five-tooth cutters.
4. Design cutters with two cutting edges on each tooth, reversible to lengthen life.
5. Entire grinder capable of reversing to utilize opposite sides of cutter teeth.
6. Furnish clean out and cover in casing.
7. Support shafts on each end by heavy duty sealed bearings.

C. Speed Reducer:
1. Planetary gear type.
2. Service factor (minimum): 1.9.
3. Load class: Heavy shock.
4. Grease filled.
5. Direct coupled to grinder drive shaft.

D. Seal Configuration:
1. Mechanical-type seal:
a. Reverse pressure principle.
b. Oversized bearings.
c. Tungsten-carbide.
d. Labyrinth shield.

E. Side Rails:
1. Provide concave inside profile of side rail to follow radial arc of cutters.

2. Provide clearance not to exceed 5/16 IN between major diameter of the cutter and concave arc of the side rail.

F. Couplings:
1. Provide two- and three-piece couplings.

2.6 MAINTENANCE MATERIALS

A. Extra Materials:
1. Furnish Owner the following total extra parts for a double shaft unit:
a. Cutting blades: Two sets.
b. Seals: Two sets.
c. Bearings: Two sets.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 40 05 05.

B. Vertically and horizontally align, level, and plumb units to match piping interfaces as shown on Drawings.

C. Exercise care in bolting flanged joints so that there is no restraining on the opposite end of pipe or fitting which would prevent uniform gasket pressure at connection or would cause unnecessary stresses to be transmitted to equipment flanges.

D. Tighten flange bolts at uniform rate for uniform gasket compression. Provide tightening torque in accordance with manufacturer's recommendations.

E. Support and match flange faces to uniform contact over their entire face area prior to installation of any bolt between the piping flange and equipment connecting flange.

F. Permit piping connecting to equipment to freely move in directions parallel to longitudinal centerline when and while bolts in connection flange are tightened.

G. Mount controller at locations shown on Drawings.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of equipment manufacturer's field service representative(s) to:
1. Inspect equipment covered by these Specifications.
2. Supervise pre-startup adjustments and installation checks.
3. Conduct initial startup of equipment and perform operational checks.
4. Provide Owner written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.
5. Instruct Owner' personnel per Section 01 75 00 at jobsite on operation and maintenance of the grinder equipment.

END OF SECTION

SECTION 46 33 13

POLYMER BLENDING UNIT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Polymer blend unit to be supplied by belt filter press manufacturer.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 – Procurement and Contracting Requirements.
   2. Division 1 – General Requirements.
   3. Section 40 05 05 – Equipment: Basic Requirements.
   4. Section 40 90 05 – Control Loop Descriptions
   5. Section 40 98 00 – Control Panels and Enclosures
   6. Section 46 76 21 – Belt Filter Press

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Anti-Friction Bearing Manufacturers Association (AFBMA).
   2. American Gear Manufacturers Association (AGMA).
   3. ASTM International (ASTM):
      a. A36, Steel, Sheet, Carbon, Cold-Rolled Commercial Quality.
      b. A123, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. Steel Structures Painting Council (SSPC):
      a. SP-10, Near-White Blast Cleaning.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 40 05 05.
   2. Complete fabrication, assembly, foundation, and installation drawings.
   3. Detailed specifications and data covering materials used, parts, devices, schematics wiring diagrams, and other accessories forming a part of the equipment furnished.
   4. Electrical connection diagrams and schematics identifying and describing all items required for operation of the equipment.
   5. Control panel layout drawings showing dimensions, conduit entry details, complete Bill of Material (BOM) including model numbers, tag numbers, quantity and manufacturer of all panel mounted components. All terminals, relays and circuit breakers shall be numbered. All drawings shall have a unique drawing number in their title block.
   6. Wiring diagrams shall have line numbers for each rung.
   7. Submittals shall bear individual page numbers.
   8. Certified, delivered cost per pound for polymer(s) to be used in performance test.
   9. Performance test protocol.

B. Operation and Maintenance Manuals:
   1. See Section 01 33 04

1.4 PROJECT/SITE CONDITIONS

A. Sludge Characteristics:
   1. See Section 46 76 21.

1.5 WARRANTY

A. The manufacturer shall warrant against any defects in material or workmanship to for a period of two (2) years from the date of substantial completion of the project.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   a. See Specification Section 01 61 05.

2.2 EQUIPMENT

A. Equipment Tag Numbers:
   1. Polymer Blending Unit: PB-03.

B. Materials:
   1. Materials shall be inert to system fluids.

C. Performance and Design Requirements:
   1. Neat polymer feed range: Determined by system supplier
   2. Dilution water feed range: Determined by system supplier
   3. Maximum water pressure: Determined by system supplier
   4. Mixer motor horsepower: Determined by system supplier
   5. Neat polymer pump:
      a. Variable Frequency Drive.
      b. Diaphragm type.
      c. Manual control or remote 4-20 mA signal.
      d. Manual adjustable stroke length.
      e. Solid-state solenoid actuated.
   6. Water regulators:
      a. Rotameter type.
      b. Sized for mixing water and dilution water volumes.
   7. Water flow sensor:
      a. Put unit on standby when water flow interrupted.
   8. Liquid polymer storage:
      a. Liquid polymer to be pre-mixed and stored in square configuration tote type polyethylene tanks.

2.3 FABRICATION

A. Provide automatic metering, mixing activation, and dilution of liquid polymer with water.

B. Single pass mixing and dilution.

C. Factory piped and wired.

D. Connections:
   1. Polymer: 1 IN NPT.

E. Controls:

F. Controls:

1. All power and controls required for operation of the polymer system, including variable frequency drives, shall be provided in a separate control panel The panel shall receive 120 volt, single phase, 60 Hz power from the 120Vac distribution panel.
2. LOCAL-AUTO switch:
    a. Local operation:
        1) Manual polymer pump speed adjustment.
        2) Manual mixer speed adjustment.
        3) Manual start/stop with interlocks for operating water supply solenoid valves.
    b. Auto operation:
        1) In AUTO mode, polymer system shall be controlled by the belt filter press control panel
        2) Discrete input: For start-stop of polymer system including water supply solenoid valves.
        3) 4-20 mA input: For speed control of neat polymer transfer pumps.
        4) Discrete output: For polymer pump running and polymer pump fail.
        5) 4-20mA output: For speed feedback of polymer pump.
3. Short circuit protection line fuse.
4. NEMA 4X enclosure.
5. Loss of flow sensor:
    a. Senses that water flow has been interrupted.
    b. Places polymer pump on standby.
    c. Restarts pump when flow restored.
6. All contacts required for proper interface to belt filter press control panel shall be provided.

G. Accessories:
1. Calibration kit:
    a. Graduated cylinder type.

H. Clamps, tubing, brackets and hardware for mounting to feeder.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 40 05 05.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of equipment manufacturer's field service representative(s) to:
1. Inspect equipment covered by these Specifications.
2. Supervise adjustments and installation checks.
3. Conduct startup of equipment and perform operational checks.
4. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.
5. Instruct Owner's personnel for 8 HRS at jobsite on operation and maintenance.

END OF SECTION

SECTION 46 73 00

ANAEROBIC DIGESTER EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for floating digester cover(s), gas equipment, mixing equipment, and boiler and heat exchanger equipment.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 09 96 00 - High Performance Industrial Coatings.
   4. Section 40 05 05 - Equipment: Basic Requirements.
   5. Section 46 73 16 - Digester Covers: Floating {Gasholder} Cover - Shell Type.
   6. Section 46 73 41 - Digester - Boiler and Heat Exchanger.
   7. Section 46 73 35 - Digester Gas Equipment.
   8. Section 46 73 34 - Digester Mixing System: External Pump Type.

1.2 QUALITY ASSURANCE

A. See Specification Section 45 05 05.

B. Reference Standards:
   1. American Welding Society (AWS):
      a. D1.1/D1.1M, Structural Welding Code - Steel.
   2. National Fire Protection Association (NFPA):
      a. 54, National Fuel Gas Code.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 05 05.
   3. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
      c. Equipment weights.
      d. Electrical and control diagrams.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Informational Submittals:
   1. Certifications:
      a. Manufacturers installation check letter.

PART 2 - PRODUCTS

2.1 DESIGN REQUIREMENTS

A. Electric Motor Operated Equipment:
   1. Class 1, Division 1 rated.

B. Materials suitable for exposure to and operation with digester gas having the following approximate volumetric composition:
   1. Methane (CH_4): 65 percent, ± 5 percent.
   2. Carbon Dioxide (CO_2): 30 percent, ± 5 percent.
   3. Hydrogen Sulfide (H_2S): 2 percent, ± 1 percent.
   4. Moisture: Saturated.

2.2 FABRICATION

A. Employ welding procedures and practices which comply with AWS D1.1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 01 61 03 and Specification Section 09 96 00 System Purge:
   1. Purge all digester gas piping, digester gas safety equipment, digester gas handling equipment, digester gas combustion equipment, digester gas storage equipment and the headspace beneath floating and fixed digester covers.
      a. Use nitrogen or carbon dioxide gas.
      b. Conform to NFPA 54, Part 4, Section 4.3.
   2. Provide all materials, inert gas, and labor for purging.
   3. Place into operation or valve off to prevent entrance of air to the system after completion of purging.

B. Employ welding procedures and practices which comply with AWS D1.1.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of authorized manufacturer's field service representative to:
   1. Inspect equipment to be installed by these Specifications.
   2. Supervise adjustments, perform modifications as necessary.
   3. Conduct start-up of equipment and perform operational checks.
   4. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.
   5. Instruct Owner's personnel Per Specification 01 75 00 for the specified minimum period on jobsite on operation and maintenance.

END OF SECTION

SECTION 46 73 16

DIGESTER COVERS: FLOATING {GASHOLDER} COVER - SHELL TYPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Specifications for shell-type floating digester cover.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 09 96 00 - High Performance Industrial Coatings.
   5. Section 46 73 00 - Digester Equipment: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Institute of Steel Construction (AISC):
      a. 325, Manual of Steel Construction.
   2. ASTM International (ASTM):
      a. A36, Standard Specification for Carbon Structural Steel.
   3. American Welding Society (AWS):
      a. A5.1/A5.1M, Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding.
      b. A5.5/A5.5M, Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding.
      c. A5.17/A5.17M, Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding.
      d. A5.18/A5.18M, Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding.
      e. A5.20/A5.20M, Specification for Carbon Steel Electrodes for Flux Cored Arc Welding.
      f. A5.23/A5.23M, Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding.

B. Qualifications:
   1. Manufacturer shall have a minimum of 10 units of 50 FT or greater diameter floating shell type covers in service for at least five (5) years.

1.3 DEFINITIONS

A. Effective Gas Storage Volume: Volume available within the floating gasholder cover for gas storage measured from the top of the ballast ring to 1 FT below the top of the skirt.

B. Roof Plate: The exterior plate of the floating cover.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 46 73 00.
   3. Documentation of qualifications including Owner contact name and telephone number.
   4. Design calculations showing relationship between weight, gas pressure and overpressure.
      a. Roof plate shall not be considered as structural member.
   5. Full details of interconnecting gas piping with cover in high, intermediate and low positions.
   6. Ballast and counterbalance weights, locations, and method of anchorage.

7. Verification that loading per corbel with design loads as specified in PART 2 of this Specification Section and with 2 IN of vacuum action on the cover does not exceed loading shown on the Drawings.

B. Operation and Maintenance Manuals.
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Informational Submittals:
   1. Cover leakage test report.
   2. Cover travel test report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. See Specification Section 01 61 05:

2.2 MATERIALS

A. Cover:
   1. Roof plates: Steel, ASTM A36.
   2. Channels and structural support elements: Steel, ASTM A36.
   3. Rim plates: Steel, ASTM A36.
   4. Bolts and nuts: 316 stainless steel.
   5. Welding electrodes:
      a. Shielded metal-arc: AWS A5.1/A5.1M or AWS A5.5/A5.5M, E70XX.
      b. Submerged-arc: AWS A5.17/A5.17M or AWS A5.23/A5.23M, F7X-EXXX.
      c. Gas metal-arc: AWS A5.18/A5.18M, E70S-X or E70U-1.
      d. Flux cored-arc: AWS A5.20/A5.20M, E70T-X (except 2, 3, 10, GS).

2.3 EQUIPMENT

A. Performance and Design Requirements:
   1. Floating cover (Anaerobic Digester No. 1 and No. 2):
      a. Tank inside diameter: 55 FT.
      b. Side wall:
         1) Total: 34 FT.
         2) Operating liquid depth:
            a) Maximum: 32 FT.
            b) Average: 30 FT.
            c) Minimum: 26 FT.
      c. Minimum effective gas storage volume at average operating liquid depth: 18,000 CF.
      d. Minimum freeboard (liquid level below the top of the skirt) at zero gas pressure in gas dome and cover in lowest position: 6 IN.
      e. Minimum pressure increase provided by submerged concrete ballast ring, inches of water column: 2 IN.
      f. Minimum ballast ring submergence at internal test pressure: 6 IN.
      g. Normal internal operating pressure, inches of water column: 6 IN.
      h. Internal test pressure, inches water column: 9 IN.
      i. Pressure relief valve setting, inches water column: 8 IN.
      j. Vacuum relief setting, inches water column: 2 IN.
   2. Typical digester gas characteristics and composition: See Specification Section 46 73 00.
   3. Design loading conditions (See Structural plans General Notes and design for the more stringent load requirement):
      a. Dead load:
         1) As calculated.
         2) Include insulation reference where appropriate.

b. Live and vacuum load: 35 LBS per square foot.
c. Wind load on projected area: 17 LBS per square foot.

2.4 ACCESSORIES

A. See Specification Section 40 05 05.

B. Vertical Guides and Appurtenances:
1. Guides to allow vertical cover travel without tipping, binding, or rotating.
2. Structural steel columns with top and bottom roller guide assemblies.
3. Bracing between columns and cover truss.
4. Stop plates at top of guides.

C. Rollers:
1. Lower rollers to have stainless steel lubrication lines located for convenient access, or be water lubricated.
2. Upper rollers to have accessible grease fittings.

D. Gas Collection Dome:
1. Locate at center of cover.
2. Equip with following:
   a. Bolt on cover.
   b. Gas take-off housing or pipe connection.
   c. Pressure/vacuum relief valve connection.

E. Combination Pressure-Vacuum Relief Valve:
1. See Specification 46 73 35.

F. Flexible Hose For Gas:
1. Uniroyal Cat #CH-6050.
2. Flexible hose of sizes noted on Drawings and constructed with the following:
   a. Cover: Black SBR rubber or neoprene.
   b. Carcass: Multiply high tensile rayon construction with spiralled spring steel.
   c. Inner tube: Buna-N liner tube.
   d. Unless otherwise noted on the Drawings, provide flexible hose with full-faced flanges constructed of duck and Buna-N materials.
      1) Fully insulated and cover with aluminum protective jacket all flexible hose exposed to the weather.

G. Manways:
1. Gastight.
2. Digester access: 48 IN DIA.
3. Number and location as shown on Drawings.

H. Sampling Wells:
1. Number and location as shown on Drawings.
2. Size: 8 IN DIA, extend to below liquid level.
3. Gastight.
4. Quick opening design.

I. Guardrails
1. Each cover shall be supplied with aluminum guardrail and toe plate by digester cover manufacturer.
2. Cover shall be manufactured and fabricated with sleeve to allow for installation of guard rail posts by standard methods.

J. Roof Access Ramp/Gang Plank
1. Each cover shall be supplied with a gang plank provided by digester cover manufacturer. Contractor shall coordinate the elevations of the platform on the roof of the digester building with the elevation of the gang plank on the digester wall for a smooth transition without any steps or gaps.

2. The gang plank shall provide access from the stationary aluminum platform to the floating cover, as shown on the Drawings. The gang plank construction shall conform to the specifications for Metal Fabrications. Gang plank shall provide clear 3-foot wide walkway that is a minimum of 16feet long. Gang plank shall be constructed of aluminum support beams and cross bracingand be designed for live load and design wind load conditions noted in the structural plans. Gang plank shall not deflect more than ¼" at midspan under a loading conditions noted in the structural plans.
3. Walking surface shall be aluminum grating securely anchored to the grating supports.
4. The gang plank shall be attached as shown on the plans with a robust hinged connection and shall have caster rollers on the cover end. All hardware and anchor bolts shall be stainless steel.
5. The gang plank shall have aluminum handrail on both sides with toe plate. The gang plank shall have a hinged aluminum cover plate spanning between the gang plank grating and the stationary aluminum platform grating. Cover plate shall be able to slide on top of the stationary aluminum platform as the gang plank pivots with the rise and fall of the digester cover.
6. Gang plank design calculations and drawings shall be signed and sealed by a Professional Engineer registered in the State of New Mexico.

2.5 FABRICATION

A. 1/4 IN minimum thickness for steel plate.

B. Structural steel designed to be self-supporting when resting on corbels with tank under 2 IN vacuum condition and specified design live and dead loads.

C. Assure maximum allowable stresses do not exceed limiting stress in AISC.

D. Weld in accordance with AWS standards.
  1. Welders: Qualified and certified in accordance with AWS requirements.
  2. Utilize full penetration welds on all abutting plates and members.
  3. Utilize two-sided, continuous fillet welds on plates and members that overlap.
  4. All shop and field welding to be shielded are welding and conform to standards of AWS.

E. Provide the following minimum number of radial beams: 24.

F. Fabricate with the following minimum number of top and bottom rollers and top roller guides:
  1. Shell design: 6.

G. Factory assemble and match-mark cover components as far as practical to verify that all mating parts can be easily field assembled.
  1. Factory assemble subassemblies in prefabricated unites as large as possible and still allow standard transportation methods to be used

H. Utilize ballast ring on bottom of rim plate.
  1. Attach on integral steel trough.
  2. Rigidly anchor ballast to prevent movement.
  3. Distribute for maximum cover stability.
  4. Design to provide 6 IN water seal when cover relief pressure is reached.

PART 3 - EXECUTION

3.1 ERECTION

A. See Specification Section 40 05 05 and Specification Section 46 73 00.

B. Painting:
  1. See Specification Section 09 96 00.
  2. Test cover before field paint applied.
  3. Walking surface:
     a. Form over entire cover surface.

b. Form by spreading coarse sand on last coat of paint.
c. Remove excess sand after paint has dried.
1) Do not allow sand to fall into tankage.

C. Connect all gas piping to cover.

D. Weld in accordance with AWS Standards.

3.2 FIELD QUALITY CONTROL

A. Cover Air Leakage Test:
1. Fill tank with plant effluent or water and trap air beneath the {ceiling} {roof} plates.
2. Pressurize attic space to 6 IN water column.
3. Check welded seams for leaks using soapsuds solution.
4. Reweld leaking areas and retest until no leaks are found.
5. Manufacturer's factory representative shall be present to document test results.

B. See Specification Section 01 75 00 for manufacturer's field service requirements.

3.3 DEMONSTRATION

A. See Specification Section 01 75 00.

B. Prestart-up Requirements:
1. Raise and lower each cover over its entire length of travel using a combination of air pressure and plant effluent.
2. Adjust all pressure and vacuum regulation devices to their proper setting and demonstrate by operation.
3. Verify and adjust, if necessary, waste gas burner and digester gas pressure and gas relief valves to meet the pressures specified.
4. Verify cover balance and adjust such that cover remains level 1/2 IN throughout the entire operating range.

END OF SECTION

SECTION 46 73 34
DIGESTER MIXING SYSTEM: EXTERNAL PUMP TYPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Digester mixing system, external pump type.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 09 96 00 – High Performance Industrial Coatings.
   5. Section 26 05 00 - Electrical: Basic Requirements.
   6. Section 46 73 00 - Digester Equipment: Basic Requirements.
   7. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
   8. Section 40 42 00 - Pipe, Duct and Equipment Insulation.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. Steel Products Manual.
   2. ASTM International (ASTM):
      a. A36, Standard Specification for Carbon Structural Steel.
      b. A48, Standard Specification for Gray Iron Castings.
      c. A276, Standard Specification for Stainless Steel Bars and Shapes.
   3. American Welding Society (AWS):
      a. D1.1, Structural Welding Code Steel.
   4. National Electric Manufacturers Association (NEMA):
      a. ICS 6, Enclosures for Industrial Controls and Systems.

1.3 SYSTEM DESCRIPTION

A. External pump-type digester mixing system shall be provided for Anaerobic Digesters as an integrated operating system. External Mixing Pumps MCP-01 and MCP-02.
   1. The mixing system as outlined for this project shall be the complete responsibility of the approved manufacturer listed. A complete system shall be provided including pumps, motors, nozzle assemblies and anchor bolts. The Contractor, unless otherwise required in this specification section, shall supply pump suction and discharge piping to nozzles, piping supports, as well as control panels, valves, gauges and other specialties. All performance and warranty requirements shall also be the responsibility of the approved manufacturer.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Section 43 21 00.
   2. Fabrication and/or layout drawings:
      a. Scaled (1/4 IN = 1 FT minimum) drawings illustrating proper orientation of mixing system components when cover is at high, low and intermediate positions. Identify elevations of key components including seal pipes, eductor tubes and diffusion assemblies.
      b. Drawings showing cover-mounted gas piping from cover to compressor. Detail all supporting framework.

3. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
    c. Detailed wiring schematics and instrumentation logic diagram for all electrical components.

B. Operation and Maintenance Manuals:
    1. See Section 01 33 04.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
    1. See Section 01 61 05.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Mixing equipment suitable to completely mix entire contents of digester. Complete mixing is defined as maintaining sludge concentration within +10 percent of average at all locations in digester and temperature variation no greater than +5 DegF. Approximate digester dimensions, contractor shall field verify:
    1. Diameter: 55 FT.
    2. Minimum side water depth: 27 FT 6 IN.
    3. Maximum side water depth: 32 FT.
    4. Conical section depth: 6FT.
    5. Mixing system: Complete mixing through range of cover and liquid travel and solids variations. Mixing system as follows:
        a. External pump mixing system.
        b. Recirculation flow rate: 1570 gpm.
        c. Minimum number of floor-mounted nozzles assemblies 2.

2.3 COMPONENTS

A. Mixing Assembly(ies):
    1. Multiple nozzle assembly(ies) including, pump, piping and regulating valves, and appurtenances required for proper operation.
    2. All components suitable for installation in a Class I, Division I, Group D area.

B. Piping and Fittings:
    1. Provide ductile iron suction and discharge pipe and fittings between exterior pump and internal nozzles.

2.4 NOZZLE CONSTRUCTION

A. Nozzles:
    1. Shall be ASTM A536 glass-lined cast ductile iron, with 1.0” minimum wall thickness or greater to protect against abrasive conditions, and a long straight taper length of at least 12 inches.

B. Assembly Fittings:
    1. Shall be ASTM S536 glass-lined cast ductile iron, with 150 lb. Flanged piping connection.
    2. The glass-lining shall have a minimum thickness of .010” and a minimum hardness of 73 C Rockwell.
    3. The lining shall be resistant to corrosion by most solution between pH-3 and pH-10 at 125°F.
    4. Pin-holes, crazing or fish scales, which expose the metal substrate, shall be limited to 0.01% of the total glass surface.

5. Visual appearance of the glass lining should be similar to bright and clean opaque window glass.

C. Testing procedures and acceptance criteria shall be provided for glass-lined assemblies as a part of the required submittal information.

D. Base: Shall be fabricated carbon steel, with 3/4" mounting holes for 5/8" anchor bolts.

E. Anchor bolts: Shall be 5/8" diameter, and of sufficient length to support thrust loads from nozzles. Construction shall be 316 stainless steel.

2.5 SERVICE CONDITIONS

A. The mixing system shall be sized for the following service conditions:
   1. GPM: 1,570
   2. HP: 30
   3. RPM: 1,750
   4. BHP: 27 maximum.

2.6 PUMP CONSTRUCTION

A. The Contractor shall furnish one centrifugal, horizontal chopper pump in location shown on drawings and all appurtenances as specified. The pump shall be specifically designed to pump and agitate waste solids at heavy consistencies. Materials shall be macerated and conditioned by the pump as an integral part of the pumping action. The pump must have demonstrated the ability to chop through, mix and pump high concentrations of solids such as plastics, heavy rags, grease and hair balls, wood, paper products and stringy materials without plugging, both in test and field applications.
   1. Casing, Back Pull-Out Adapter Plate and Wear Plate:
      a. The pump casing shall be of semi-concentric design, with the first half of the circumference being cylindrical beginning after the pump outlet, and the remaining circumference spiraling outward to the 150 LB flanged centerline discharge.
      b. Back pull-out adapter plate shall allow removal of pump components from above the casing, and allow external adjustment of impeller-to-cutter bar clearance.
      c. Wear plate shall be integral to the back pull-out plate, and shall include an internal cutter for stringy materials caught between the wear plate and the pump-out vanes on the back of the impeller.
      d. Casing and adapter plate shall be ductile cast iron with all water passages to be smooth, and free of blowholes and imperfections for good flow characteristics.
      e. Wear plate shall be heat treated steel plate.
   2. Impeller:
      a. Shall be semi-open type with pump out vanes to reduce seal area pressure.
      b. Chopping/maceration of materials shall be accomplished by the action of the cupped and sharpened leading edges of the impeller blades moving across the cutter bar at the intake openings, with a maximum set clearance between the impeller and cutter bar of .020"-.030"cold.
      c. Impeller shall be cast steel, heat treated to minimum Rockwell C 60 and dynamically balanced.
      d. The impeller shall be threaded to the shaft and shall have no axial adjustment and no set screws.
   3. Cutter Bar:
      a. Shall be recessed into the pump bowl, and shall extend diametrically across entire pump suction opening.
      b. Cutter bar shall be T1 plate steel heat treated to minimum Rockwell C 60.
   4. Upper Cutter:
      a. Shall be threaded into the back pull-out adapter plate above the impeller, designed to cut against the pump-out vanes and the impeller hub, reducing and removing stringy materials from the mechanical seal area.
      b. Upper cutter shall be cast steel, heat treated to minimum Rockwell C 60.

5. External Cutter:
    a. Shall cut against the outside surface of the cutter bar.
    b. External cutter shall be cast steel, heat treated to minimum Rockwell C 60.
6. Pump Shafting:
    a. The pump shaft and impeller shall be supported by ball bearings.
    b. All shafting shall be heat treated.
7. Bearings:
    a. Shaft thrust in both directions shall be taken up by two back-to-back mounted single-row angular contact ball bearings.
    b. Two back-to-back mounted single-row radial bearings shall also be provided.
    c. B10 bearing life shall be minimum 100,000 hours.
8. Bearing Housing:
    a. Shall be ductile cast iron, and machined with piloted bearing fits for concentricity of all components.
    b. Bearing housing shall be oil bath lubricated with ISO Gr. 46 turbine oil and a side-mounted site glass to provide a permanently lubricated assembly.
    c. Vitron® double lip seals riding on stainless steel shaft sleeves are to provide sealing at each end of the bearing housing.
9. Flushless 3-12” Pumps:
    a. Mechanical seal system specifically designed to require no seal flush through the elimination of the stuffing box:
        1) The mechanical seal shall be located immediately behind the impeller hub to minimize the depth of the stuffing box and maximize the flushing available from the impeller pumpout vanes.
        2) The seal shall be made of stainless steel and shall be a bolt-in, cartridge-type mechanical seal with Vitron® O-rings and silicon carbide faces for 3-6” pumps and tungsten carbide faces for 8-12” pumps.
        3) This cartridge seal shall be pre-assembled and pre-tested so that no seal settings or adjustments are required from the installer.
        4) Any springs used to push the seal faces together must be shielded from the fluid to be pumped.
        5) The cartridge shall also include a heat-treated 17-4 pH seal sleeve and a CF8M stainless steel seal gland.
        6) The mechanical seal faces shall be lubricated and cooled by a separate oil chamber.
        7) The area between the seal oil chamber and bearing oil chamber shall be vented and drained to prevent contamination of the bearing oil system by the separate seal oil system.
10. Shaft Coupling:
    a. Bearing housing and motor stool design is to provide accurate, self-aligning mounting for a C-flanged electric motor.
    b. Pump and motor coupling shall be T.B. Woods Sureflex Elastomeric type.
11. Stainless Steel Nameplates:
        1) Shall be attached to the pump and drive motor giving the manufacturer’s model and serial number, rated capacity, head, speed and all pertinent data.

2.7 MOTOR REQUIREMENTS

A. Drive motor shall be:
    1. 30 HP
    2. 1,750 RPM
    3. 480 Volts, 3 Phase, 60 hertz.
    4. Service factor: 1.15
    5. Foot and C-flange mounted
    6. TEFC Enclosure.

B. The motor shall be sized for all conditions.

C. See Section 40 05 05 and Specification Section 26 05 00, for additional motor requirements.

2.8 PAINTING AND COATINGS

A. See Section 09 96 00.
   1. Submerged units shall receive paint system #24, or fusion bonded epoxy coating. Surface preparation shall be in accordance with 09 96 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 01 61 03.

B. Piping:
   1. Install piping necessary to make equipment operable and function in accordance with drawings and manufacturer's recommendations.
   2. Insulate all piping exposed to ambient temperatures with 1-1/2 IN thick insulation, with jacket. See Section 40 42 00.

C. Anchorage:
   1. Anchor as required.
   2. All bolts, nuts, and washers necessary to install equipment and all necessary anchorage, fabricated from Type 316 stainless steel.

3.2 FIELD QUALITY CONTROL

A. See Specification Section 01 75 00 for manufacturer's field service requirements.

END OF SECTION

SECTION 46 73 35
DIGESTER GAS EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
  1. Digester gas equipment.

B. Related Sections include but are not necessarily limited to:
  1. Division 00 - Procurement and Contracting Requirements.
  2. Division 01 - General Requirements.
  3. Section 09 96 00 - High Performance Industrial Coatings.
  4. Section 10 14 00 - Identification Devices.
  5. Section 40 42 00 - Pipe, Duct and Equipment Insulation.
  6. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
  1. American Society of Mechanical Engineers (ASME):
     a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  2. ASTM International (ASTM):
     a. A182, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
     b. A351, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
  3. National Electrical Manufacturers Association (NEMA):
     a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings:
  1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
  2. Fabrication and/or layout drawings:
     a. Schematic drawing of gas system showing major components and corresponding initial pressure settings.
     b. Schematic to include tag numbers assigned to each component by Contract Documents.
  3. Product technical data:
     a. Acknowledgement that products submitted meet requirements of standards referenced.
     b. Manufacturer's installation instructions.
     c. Calibration constants and pressure settings for devices requiring settings.
        1) Calibrate settings using certified manometer.

B. Contract Closeout Information:
  1. Operation and Maintenance Data:
     a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

1.4 SYSTEM DESCRIPTION

A. The components described in this Section shall be supplied by one (1) manufacturer and when interconnected with piping constitute a complete digester gas control system.
  1. Each component is to be provided to integrate with other components for a complete operating system.
  2. Match the digester gas control system to all external devices using digester gas.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers listed below. Only the manufacturers listed are approved for this project, no alternate manufacturers will be considered.
   1. Varec.
   2. Groth.

2.2 MANUALLY OPERATED DRIP TRAPS

A. Design Criteria:

TAG #	CAPACITY	LOCATION
DT-01	6 quart	Gas safety room
DT-02	6 quart	Digester Equipment Building Boilers

B. Fabrication:
   1. Manually operated drip traps 1 IN NPT inlet and outlet connection and a 6 quart storage capacity.
   2. Rotating disc type drip traps with an air inlet port to permit free flow of condensate from bowl when draining.
   3. Gas cannot exit while draining or revolving operating handle.
   4. Cast aluminum unit with stainless steel shaft and springs.
   5. Working pressure: 5 psig.
   6. Pipe discharge from trap to nearest equipment or floor drain.

2.3 FOAM SEPARATORS

A. Design Criteria:

TAG #	SIZE INLET/OUTLET	GAS FLOW	LOSS (MAX)
FS-01	8 IN	15,000 scfh	0.2 IN WC
FS-02	8 IN	15,000 scfh	0.2 IN WC

B. The foam separator shall operate by means of a continuous spray wash of water. The biogas must rise vertically past an internal baffle located in the center of the unit. The foam separator shall be a cylindrical tank 24-in diameter. The tank shall be constructed with 1/4” thick, welded, 316L stainless steel. Each separator shall be provided with ANSI 150 FF flanged connections.

C. Each tank shall remain gas tight to maximum operating pressure of 18-in WC. Each tank shall be provided with a multiple spray system. The nozzles shall be 3/8” in 316 SS construction and rated for 40 psi pressure with 2 gpm water flow at 2 psi supply pressure. Nozzles shall be spaced on the pipe sections so as to completely cover the base area of the tank. Internal pipe sections shall be constructed of stainless steel.

D. Each tank shall be provided with float-operated high and low level switches with termination wiring in an explosion proof junction box.

E. A stainless steel bodied, double window, rotor type sight flow indicator shall be provided for the 4” operating overflow line of each separator.

2.4 ACCUMULATORS

A. Design Criteria: Condensate and sediment accumulators meeting the following:

TAG #	SIZE INLET/OUTLET	GAS FLOW	LOSS (MAX)
ST-01	8 IN	15,000 scfh	0.2 IN WC
ST-02	8 IN	15,000 scfh	0.2 IN WC

B. Fabrication:
1. Unit constructed from fabricated steel with flanged end connections.
    a. Minimum storage capacity: 6 GAL of sediment and 6 GAL of condensate.
    b. Tangential inlet nozzle to cause a circular motion of gas entering accumulator.
2. Piping connections shown on Drawings.
3. 1 IN NPT blowout connection, 1 IN NPT drip trap connection, and 3/8 IN NPT connections for sight glass.
    a. 1/2 IN Pyrex glass tube sight glass with two (2) isolating valves to permit cleaning.
    b. Guard rods to protect glass tube and drain cock on lower valve.
4. Removable top cover for interior access and an inspection pipe for content level measurements.

2.5 FLAME ARRESTERS

A. Design Criteria: Flame arresters meeting the following:

TAG #	INLET/OUTLET SIZE	MAXIMUM GAS FLOW	BASE PRESSURE	MAXIMUM PRESSURE LOSS
FA-001	8 IN	15,000 scfh	10 IN WC	0.5 IN WC
FA-002	8 IN	15,000 scfh	10 IN WC	0.5 IN WC

B. Fabrication:
1. Flame arresters with ASME B16.1, Class 125 flanged end connections and working pressure of 10 psig.
2. Aluminum housing.
3. Bank assembly:
    a. Aluminum material.
    b. Easy removal from housing for inspection and cleaning.
4. Net free area through bank assembly:
    a. Not less than four (4) times connection size.
    b. Construct grids of bank as individual corrugate stamped and rectangular shaped sheets.
    c. Arrange for individual removal.
    d. Horizontal or vertical configuration as indicated on Drawings.

2.6 PRESSURE RELIEF-FLAME TRAP ASSEMBLY

A. Design Criteria: Pressure relief flame trap assemblies meeting the following:

TAG #	INLET/OUTLET SIZE	MAXIMUM GAS FLOW	BASE PRESSURE	MAXIMUM PRESSURE LOSS
PR-901	8 IN	15,000 scfh	1.5 IN WC	10 IN WC

B. Fabrication:
1. ASME B16.1, Class 125 flanged end connections.
    a. Unit to include both a pressure relief section and a flame trap section.
2. Pressure relief portion:

a. Back pressure regulator valve actuated by a spring loaded diaphragm.
b. Include a spring barrel with a glass enclosed pointer and scale to indicate relief pressure setting.
c. Unit to permit setting adjustments without disassembling the diaphragm housing.
d. Cast aluminum unit with stainless moving parts and spring and synthetic rubber fiber reinforced diaphragm.
e. Setting range: 2 to 12 IN WC.
f. 1/2 IN NPT connections for gas pressure sensing tap and atmospheric vent.

3. Flame trap portion:
   a. Cast aluminum.
   b. Bank assembly: All aluminum construction.
   c. Easy removal for cleaning.
   d. Net free area through bank assembly: Minimum of four (4) times inlet connection size.
   e. Construct grids of bank individual corrugate stamped and rectangular shaped sheets.
   f. Arrange for individual removal.

C. Controls:
1. Interconnect (functionally) pressure relief regulator and flame trap by a thermal shut-off valve assembly which will automatically close the regulator by applying full upstream gas pressure on the top of the diaphragm housing in the event a fusible element is released due to gas temperature reaching 260 DegF at the flame trap outlet.
2. Fusible element replaceable without disassembling the valve.

D. Spare Parts for Each Size of Pressure Relief-Flame Trap Assembly:
1. Fusible elements: Four (4) each.
2. Diaphragm assembly: One (1) each.
3. Springs: One (1) set.

2.7 WASTE GAS BURNER

A. Design Criteria: Waste gas burner meeting the following:

TAG #	INLET SIZE	MAXIMUM GAS FLOW	PRESSURE LOSS	PILOT SUPPLY
B-001	6 IN	30,000 scfh	0.5 IN WC	0.5 IN WC

B. Fabrication:
1. Burner with ring type pilot that develops a flame curtain completely surrounding the gas nozzle.
   a. Baffles in the ignition chamber to direct digester gas through the curtain flame.
   b. Shutter-type air-gas mixture adjustment.
2. A pedestal, insulated internally, enclosing the pilot gas line and digester gas line.
   a. Base plate on pedestal suitable for mounting on concrete base support.
3. 1/2 IN NPT connection for pilot gas.
   a. Pilot observation and igniting port on ignition chamber.
4. Burner: Steel with heat resistant iron alloy ignition ring, cast iron cover and frame of pilot ignition port and stainless steel orifices of pilot gas supply.
5. Secondary stack:
   a. Integrally mounted to the burner.
   b. Schedule 10, Type 304 stainless steel pipe.
   c. Spacing suitable to sustain flame in high wind conditions.
6. Automatic, electric, pilot igniter for each burner.
   a. Igniter suitable for operation using 120 V, 1 PH, 60 Hz power supply.
7. Sense flame condition using an optical type flame sensor not in direct contact with the flame.

a. Sparking type ignition with replaceable electrodes.

8. Cables and other heat sensitive devices properly shielded and enclosed.

C. Controls:

1. In the automatic mode, unit will continually check for pilot flame.
2. Upon loss of flame, unit will automatically restrike the flame.
3. If a flame is not ignited, the unit continue to strike for a preset time period.
4. If, at the end of this time period flame is still not ignited, the unit will shut down and an alarm activated.

D. Spare Parts for Each Size of Burner:

1. Spark electrodes: Two (2) sets.
2. Optical sensor: One (1) each.

2.8 DUAL COMBINATION PRESSURE/VACUUM RELIEF VALVE AND FLAME ARRESTORS MOUNTED ON SAFETY SELECTOR VALVE

A. Acceptable Manufacturer:

1. Varec: 2 Series 5810B valves mounted on SSV valve.
2. Groth 2 Model 1200A/7618 valves mounted on 8800SDV valve.

B. Design and Fabrication:

1. Materials:
   a. Low copper cast aluminum valve body and stainless steel trim.
   b. Low copper cast aluminum flame arrestor housing with low copper aluminum extensible bank assembly flame and stainless steel sheets.
2. Pressure relief lead pallet weights for adjustment in increments of 1/4 IN water column.
3. ASME B16.1, Class 125 FF flanged connections.
4. Insulating jackets:
   a. Provide each assembly with insulated jacket to prevent freezing
   b. Suitable for a temperature range of -40 to 220 DegF.
   c. Insulated jacket constructed with silicone impregnated woven glass cloth lining with a 1 IN thick, 6 LB density fiber glass insulating material.
   d. Jacket to provide firm support to insulation preventing from shifting.
   e. Insulated jacket designed to provide uniform heat retention.

C. Schedule:

TAG #	INLET/OUTLET SIZE	MAXIMUM GAS FLOW	RELIEF PRESSURE	VACUUM PRESSURE	MAXIMUM PRESSURE DROP
PVRV 1	10 IN	15,000 scfh	11 IN WC	2 IN WC	0.5 IN WC
PVRV 2	10 IN	15,000 scfh	11 IN WC	2 IN WC	0.5 IN WC

2.9 BACK PRESSURE CHECK VALVE

A. Design Criteria: Back pressure relief valves meeting the following:

TAG #	INLET/OUTLET	GAS FLOW	MAXIMUM PRESSURE LOSS
CV-01	8 IN	30,000 scfh	0.8 IN WC

B. Fabrication:

1. Back pressure check valves of heavy cast aluminum construction with removable seat ring and stainless steel hinge pin.
2. Removable cover to provide access to seat ring and pallet.

3. ASME B16.1, Class 125 flanged connections.

2.10 MANOMETERS

A. Design Criteria: Manometers meeting the following:

TAG #	PRESSURE RANGE
PD-901	0-15 IN WC
B-902	0-3 psi

B. Fabrication:
  1. U-tube type manometers calibrated to read in inches and tenths of water column.
  2. Units with heavy wall annealed glass U-tube protected on three (3) sides by rigid steel channel body.
  3. Red mineral oil indicating fluid.
     a. Fluid specific gravity of 1.0 compared with water.
  4. Large bore U-tubes allowing for an essentially flat meniscus regardless of indicating fluid used.
     a. Easy removal of U-tube for cleaning or replacement without disturbing piping.
  5. Mount manometers on common stainless steel panel designed for wall mounting with edges extending to wall.
     a. Panel:
        1) Minimum 10 GA, Type 304 stainless steel.
        2) Stainless steel attachment hardware.
        3) Mount stainless steel isolation valves on panel and common atmospheric vent.

2.11 FLAME CHECKS

A. Design Criteria: Flame checks meeting the following:

TAG #	LOCATION	SIZE
FC-901	Manometer Vent	1/2 IN

B. Fabrication:
  1. Flame check with NPT end connections.
  2. Suitable for both digester gas and natural gas service.
  3. Design housing similar to pipe union to permit easy removal for inspection and cleaning.
  4. Construct union housing of cast aluminum.
  5. Provide element constructed of aluminum compressed woven wire.

2.12 COVER POSITION INDICATOR (GAGEHEAD TYPE)

A. Design Criteria: Gagehead type cover position indicators meeting the following:

B. Fabrication:
  1. Indicate cover position in feet, tenths and hundredths by counter located in gagehead.
     a. Counter movement: Simultaneous with cover movement.
     b. Calibrate counter to read zero when cover is resting on corbels.
     c. Protect counter by a tempered glass window built into the gagehead housing.
     d. Vent counter compartment to atmosphere.
  2. Power working mechanism of gagehead by a negator-type motor completely enclosed within a sealed, weatherproof housing meeting requirements for NEMA 4 rating.
     a. Actuate mechanism by combination perforated tape and 1/8 IN stainless steel cable connected directly to the digester cover.
     b. Enclose tape and cable in stainless steel pipe conduit and provide weatherproof enclosed sheave elbows and conduit.

3. Gagehead and elbow housing:
    a. Cast aluminum.
    b. Aluminum and stainless steel gagehead working mechanism and stainless steel sheaves in aluminum elbows.
    c. Conduit constructed from stainless steel.
4. Teflon or Oilite bearings for all moving parts and stainless steel shafts.
5. Accommodate electrical position transmitted for remote reading equipment without gagehead modification or removal from service.

C. Controls:
1. Position transmitter that converts movement in a proportional 4-20 mA DC signal.
2. Transmitter mounted in gagehead in a sealed enclosure meeting NEMA 4 requirements.
3. Transmitter suitable for operation using 120 V, 1 PH, 60 Hz power supply.
4. Place a desiccant in the transmitter housing after unit is installed.

D. Limit Switches:
1. Limit switches integrally mounted to gagehead.
2. Limit switches are totally enclosed NEMA 4 construction.
3. High limit switch to activate when top of cover is within 6 IN of the cover stop.
4. Lower limit switch to activate when cover is 6 IN above corbels.
5. Operation of limit switches is independent from position transmitter and suitable for 120 V, 1 PH, 60 Hz power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pipe insulation.

B. Insulate sludge and gas piping which is exposed to ambient conditions below 40 DegF.
1. Use minimum 2 IN thick insulation with aluminum jacket in compliance with Specification Section 40 42 00.

3.2 FIELD QUALITY CONTROL

1. Instruct Owner' personnel per Section 01 75 00 at jobsite on operation and maintenance of the grinder equipment.

END OF SECTION

SECTION 46 73 36

PACKAGED DIGESTER GAS TREATMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Furnishing a skid mounted digester gas moisture removal, treatment, and compression system.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. The Gas Handling and Treatment System shall be furnished by a single manufacturer or supplier to be responsible for proper selection of components, their manufacture and assembly and the proper functioning of the complete units.
   2. Each component of the Gas Handling and Treatment System shall be the standard product of a manufacturer regularly engaged in the production of this type of equipment. The component to be furnished shall be of proven quality and correct application to this work and shall be designed, constructed and installed in accordance with best practices and methods. Each component and ancillary equipment items furnished under this Section shall be new and unused, and the product of a manufacturer having a successful record of manufacturing and servicing the equipment.
   3. The Gas Handling and Treatment System shall be furnished by a vendor that is qualified and experienced in the packaging of digester gas treatment systems. The equipment vendor shall have at least 5 years of experience in the design, application, and supply of packaged systems and shall submit a list of equipment installations in North America as evidence of meeting the experience requirement.

B. Referenced Standards:
   1. ANSI:
      a. B16.5, Pipe Flanges and Flanged Fittings
   2. International Building Code

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Plans and elevations showing location and dimension of components.
   3. Details of connections, design elements, and relation to adjacent items.

B. Product Data:
   1. Acknowledgement that products submitted meet requirements of standards referenced.
   2. Manufacturer's installation instructions.
   3. Fabrication and/or layout drawings showing location of anchor bolts, location, size and connection method including specification designation for all external piping connections, dimensions and weights for all Gas Handling and Treatment System components.
   4. Descriptive literature, manufacturer catalog cut sheets, specifications, materials of construction for all Gas Handling and Treatment System components.

5. Detailed schematic and wiring diagrams showing piping and wiring connections with sizes required and location for the controls of all Gas Handling and Treatment System components.
6. Seismic calculations for all skids, tanks, and equipment.
7. Manufacturer's installation, operation and maintenance manuals, bulletins, and spare parts lists for all Gas Handling and Treatment System components.
8. Equipment list identifying all equipment, instruments, and ancillary components to be supplied by the Gas Handling and Treatment System vendor. For equipment, instruments, and ancillary components that will be shipped and pre-installed on a skid package, the equipment list shall identify the skid package that they will be pre-installed upon. Equipment, instruments, and ancillary components that are to be shipped loose, shall be identified as such.
9. Wiring diagram showing all electrical external connections.
10. PLC I/O list, and program listing.
11. Design Data
    a. Blower: Rotational speed at full load, frequency, voltage, number of phases, full load current, enclosure designation, NEMA code design letter, efficiency, horsepower rating, temperature rise, bearing life rating and method of lubrication.
    b. Hydrogen Sulfide Scrubber: Certified pressure drop calculations when the medium is 90 percent spent.
    c. Heat Exchanger: Inlet and outlet temperatures, flow rates, pressure drops, heat rejection, and heat transfer coefficients for both the shell and tube sides of the exchanger, and weight and volume of moisture condensed from gas stream.
    d. Moisture Separator: Volume of moisture removed from gas stream, pressure drop, design flow rate, maximum and minimum flow rate.
    e. Refrigeration System: Design heat rejection, flow rates, pressure drops, motor horsepower, assumed ambient temperature, unit efficiency.
    f. Siloxane Scrubber: Certified pressure drop calculations when the medium is 90 percent spent.
    g. Particulate Filter: Pressure drop when the filter is 90 percent utilized, removal efficiency
12. Certifications.
13. Test reports.
    a. A test report documenting the performance of all components included in the Gas Handling System. Documentation shall be based on shop testing of Gas Handling System on air prior to delivery on site. Flow, pressure, and temperature performance must meet design requirements and be approved by the Owner's Representative prior to acceptance.
14. Supplier Qualifications
    a. Qualifications for the Gas Handling System Supplier must be submitted prior to approval of the system by the Owner's Representative. The qualifications information must include at a minimum, reference project with contact information, firm financial statements or other proof of firm financial condition, number of personnel available for service and start up, and experience with digester gas or landfill gas applications.

C. Contract Closeout Information:
1. Operation and Maintenance Data:
    a. See Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

1.4 WARRANTY

A. The Gas Handling and Treatment System shall be provided with a one year warranty, effective following start-up, from the vendor in addition to manufacturer's warranties for individual components of the Gas Handling System. The warranty certificate shall be submitted in writing and signed by an officer of the Packager's firm, as part of the submittal package.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, only the following manufacturers are acceptable:
   1. Unison Solutions
   2. Engineer approved equal.

B. Submit request for substitution in accordance with Section 01 25 13.

2.2 SYSTEM REQUIREMENTS

A. Furnish all labor, materials, equipment and incidentals to manufacture and supply a skid mounted digester gas moisture removal, treatment, and compression system (the Gas Handling and Treatment System) for the Paseo Real Wastewater Treatment Plant in Santa Fe, New Mexico. The Gas Handling and Treatment System shall include at a minimum, two hydrogen sulfide scrubbers, one gas blower, a gas cooling heat exchanger with refrigeration system, moisture removal separator, two siloxane scrubber treatment vessels, one particulate filter, valves, piping and controls as specified herein. The specification indicates there are four skids for the system for the purposes of defining the elements needed for the system. The supplier shall determine the best means for packaging the system in terms of the number of actual skids that are shipped to the project site.

Item	Equipment No.
H2S Scrubber System	HS-1
H2S System Air Compressor	AC-1
Digester Gas Cooling Chiller Unit Pump	CGP-1
Digester Gas Cooling Chiller Unit	GCU-1
Digester Gas Cooling Heat Exchanger	HX-1
Digester Gas Moisture Separator	GD-1
Digester Gas Pressure Booster	PB-1
Siloxane Scrubber System	SS-1
Particulate Filter	PF-1

2.3 PERFORMANCE AND DESIGN REQUIREMENTS

A. Design Requirements and Operating Conditions
   1. Equipment shall be specifically designed and selected for continuous duty for moisture removal, treatment, and compression of digester gas. The approximate composition and characteristics of the digester gas at the inlet to the Gas Handling and Treatment System is indicated as follows:

Item	Value
Specific Gravity	0.7 to 0.9
Nitrogen	0 to 3 percent
Methane	55 to 65 percent
Carbon Dioxide	35 to 43 percent
Hydrogen Sulfide (average)	500 ppm
Hydrogen Sulfide (maximum)	2000 ppm
Siloxanes	40 mg/m^3 (total as Si)
Temperature	80 to 105 degrees Fahrenheit
Moisture	Saturated
Pressure	6 to 10 inches of water column

   2. Supports for all vessels and equipment shall be designed to meet the seismic requirements for Santa Fe, New Mexico.
   3. The system shall have a capacity of 120 scfm.

B. Performance Requirements

1. The Gas Handling and Treatment System shall treat and compress the gas to the following levels as measured at the discharge of the System:

Item	Value
Outlet Pressure (from the Gas Handling and Treatment System)	3.0 psig (minimum)
Hydrogen Sulfide	50 ppm (maximum)
Siloxane	0.1 mg/m^3 as Si per siloxane species D4, D5, and D6, 25% average reduction in L2, and 50% average reduction in L3.
Relative Humidity	50%
Particulate Removal	99 percent reduction of all particles 3 microns and larger
Discharge Temperature (maximum)	80 degrees Fahrenheit

C. Project / Site Requirements

1. All components of the Gas Handling and Treatment System will be located outdoors in an NEC classified Class 1, Division 1 area.

2.4 COMPONENTS

A. General

1. All components of the Gas Handling and Treatment System shall have firmly attached to each component a stainless steel nameplate. The nameplate shall have on it, as a minimum, the name of the manufacturer, the model number and the serial number. Drive motor nameplates shall have on them the name of the manufacturer, model number, serial number, volts, full load current, rated horsepower, service factor, full load rotational speed and temperature rating.

B. Hydrogen Sulfide Treatment Skid

1. The hydrogen sulfide treatment skid shall include two hydrogen sulfide scrubber vessels, air compressor, support frame, and interconnecting piping. The hydrogen sulfide skid shall connect to the digester gas system through a single 6-inch flanged inlet and a single 6-inch flanged outlet connection.
2. The hydrogen sulfide treatment skid shall be sized to limit pressure drop through the vessel and piping to no more than 4 inches of water column.
3. All equipment and instruments located within 5 feet of the digester gas process lines and the digester gas handling equipment shall be Listed and Labeled for use in NEC Class 1 Division 1 area.
4. Hydrogen Sulfide Scrubber Vessels
    a. The hydrogen sulfide scrubber vessels shall be designed for in situ air regeneration without requiring the removal of the hydrogen sulfide scrubber media.
    b. Hydrogen sulfide scrubber vessels shall be made of welded stainless steel according to API standards. The vessels shall be provided an opening large enough to permit inspection of the vessel and medium exchange.
    c. The hydrogen sulfide scrubber vessels shall be provided with a 1½-inch drain connection originating from the lowest point of the scrubber vessel. The 1½-inch drain shall be provided with a stainless steel ball valve.
    d. The hydrogen sulfide scrubber vessels shall be provided with a condensate collection pipe with a timer controlled electronically actuated drip trap. Electronics for the time and actuator shall be explosion proof and Listed and Labeled for operation in a Class 1 Division 1 classified area. The timer and drip trap solenoid shall be rated for 120VAC, single phase, power supply.
5. Air Compressor: An air compressor shall be provided to supply regeneration air to the hydrogen sulfide scrubbers. Air compressor shall be use 110 V single phase electrical power.
6. Hydrogen Sulfide Treatment Skid Piping.

a. All equipment provided on the hydrogen sulfide treatment skid shall be pre-piped and connected from the manufacturer. Piping and valving shall be as shown on drawings.
b. Digester gas piping shall be schedule 10, 304 stainless steel.
c. The digester gas piping shall include shall include digester gas sampling taps with shutoff valve upstream and downstream of the hydrogen sulfide scrubber system.
d. Air piping shall be pre-piped by the vendor of the Gas Handling and Treatment System and shall connect the air compressor to the digester gas piping upstream of the hydrogen sulfide scrubber vessels. Air piping shall be stainless steel.

7. Support Frame.
   a. The treatment vessels shall be supported on a stainless steel frame or powder coated carbon steel frame designed by a registered Professional Engineer in the State of New Mexico.
8. Accessories
   a. Provide a magnahelic type differential pressure gage on each vessel for the monitoring vessel gas pressure drop. The differential pressure gage shall be located to be easily viewed from ground level and shall be calibrated for differential pressure between 0 to 10 inches of water column.
   b. Provide stainless steel ANSI flanged valves on the inlet and outlet of each vessel.
   c. Provide two 110 V, single phase, electrical outlets on skid to power miscellaneous equipment. Outlets shall be rated for outdoor use with outdoor cover in compliance with National Electrical Code.
9. Iron Sponge Media
   a. The vessel shall be provided fully charged with hydrated ferric oxide (Iron Sponge) media.
   b. The hydrated ferric oxide media shall consist of wood chips impregnated with fifteen pounds of hydrated ferric oxide per cubic foot. Each scrubber shall be provided with enough Iron Sponge media to provide a 6 month bed life.

C. Digester Gas Moisture Removal and Compression Skid
1. The digester gas moisture removal and compression skid shall include one digester gas booster blower, a digester gas cooling heat exchanger, a digester gas moisture separator, all necessary drip traps, required instrumentation, a flow control valve, and interconnecting piping.
2. Interconnecting piping shall be pre-piped by the vendor.
3. The digester gas moisture removal and compression skid shall connect to the digester gas system through a single 6-inch inlet flanged connection and a single 4-inch outlet flanged connection.
4. All equipment and instruments located within 5 feet of the digester gas process lines and the digester gas handling equipment shall be Listed and Labeled for use in NEC Class 1 Division 1 area.
5. Digester Gas Cooling Heat Exchanger
   a. The heat exchanger shall be a digester gas to chilled glycol heat exchanger sized such that it cools the saturated digester gas from the inlet temperature plus the heat of compression down to 40 degrees Fahrenheit.
   b. The heat exchanger shall be sized such that moisture can flow freely from the heat exchanger without blocking or causing excessive pressure drop through the unit.
   c. Heat exchanger components in contact with the digester gas shall be 304 stainless steel.
6. Digester Gas Moisture Separator.
   a. The moisture separator shall remove 100% of all liquid particles that are 8 microns and larger when operating between 10% and 110% of design flowrate.
7. Digester Gas Pressure Booster Blower.
   a. The digester gas blower shall be a heavy duty blower designed for continuous service of compressing digester gas as specified herein.
   b. The booster blower shall be sized to boost 120 cfm of digester gas from atmospheric pressure to an acceptable pressure that will achieve 2 psig at the inlet of the engine fuel trains.

c. Digester gas blowers shall include miscellaneous accessories including gauges, switches, valves, discharge silencers, piping, controls, and wiring necessary for a complete installation.
d. The casing material shall be for digester gas service.
e. The shaft shall be sealed with a mechanical seal and shall not require oil lubrication.
f. Digester gas booster blowers shall not exceed 80 dbA at a three foot radius from the blower. Noise enclosures and inlet silencers may be provided as a mitigation method to achieve the 80 dbA requirement.
g. Digester gas booster blowers shall be VFD driven. Variable frequency drive shall be furnished and installed in by the General Contractor. The motor shall be inverter duty rated.

8. Booster Blower Inlet Filters
a. The inlet filters shall be constructed with a 304 stainless steel housing. The filter media shall provide 99 percent removal efficiency of droplets 3 microns and larger.
b. The coalescing package shall be provided with a drain connection, automatic drip traps operated on a timer, and visual level indicator. Electronics for the time and actuator shall be explosion proof and Listed and Labeled for operation in a Class 1 Division 1 classified area. Timer and drip trap solenoid shall be rated for 120VAC, single phase power supply.

9. Interconnecting Piping
a. All equipment provided on the digester gas moisture removal and compression skid shall be pre-piped and connected from the manufacturer.
b. Digester gas piping shall be schedule 10, 304 stainless steel upstream of the moisture separator. Piping downstream of the moisture separator shall be carbon steel.
c. The digester gas piping shall incorporate a recirculation bypass. A thermal mass flow meter shall be included to provide a signal that will allow for actuation of a motorized valve and prevent surge conditions in the booster blowers. Motorized valve shall be 460 VAC, 3 phase.
d. Interconnecting piping shall include digester gas pressure and temperature indication upstream and downstream of the digester gas cooling heat exchanger.
e. Pressure and Temperature transmitters shall be provided between the Digester Gas Moisture Separator and the recirculation bypass.
f. Isolation valves shall be provided to isolate the digester gas cooling heat exchanger, the digester gas moisture separator, and both digester gas pressure booster blowers.

D. Chiller System Skid
1. The chiller system skid shall include a refrigerant dryer/chiller and glycol pump to reduce the dew point of the digester gas and allow the removal of siloxanes.
2. The Gas Handling and Treatment vendor must coordinate the digester gas cooling heat exchanger and the refrigerant/dryer system to ensure that the equipment will meet the requirements for cooling the digester gas as described in Paragraph 2.03 E.
3. For sizing the coolant pump, the Gas Handling and Treatment vendor shall assume 40 ft of piping from the coolant supply and return between the digester gas cooling heat exchanger and the refrigerant/dryer system. Vendor shall account for headloss from any valves needed as part of the system.
4. The chiller package shall be provided with its own control system to control the chiller motor and chiller pump. Temperature indication of the glycol supply and return temperature shall be provided. The control panel for the chiller package shall be installed on the skid.

E. Siloxane Scrubber Skid
1. The siloxane scrubber skid shall include two siloxane scrubber vessels, support frame, and interconnecting piping.
2. Siloxane Scrubber Vessels
a. The siloxane scrubber vessels shall be a custom fabricated, high-performance device that is designed for maximum removal at low pressure drops.

b. Siloxane scrubber vessels shall have 150-pound ANSI B16.5 flanges for direct connections to gas piping. Siloxane scrubber vessels shall be fabricated from carbon steel.
c. Siloxane scrubber vessels shall be tapped and equipped with a 1-inch threaded and valved drain plug, three 3/4-inch or 1-inch threaded gage couplings and a ½-inch threaded and valved nitrogen purge connection. Two of the three couplings shall serve the differential pressure gage and shall be located upstream and downstream of the activated carbon. The other coupling shall be available for future connections downstream of the activated carbon. The nitrogen purge connection shall be located on the inlet piping of the tank, downstream of the isolation valve.
d. The nitrogen purge connections shall be equipped with self-closing, quick-connect couplings. The socket shall be provided with a Male NPT connection. The plug shall be provided with a hose clamp end connection.
e. Siloxane scrubber vessels shall be free standing units and shall have hinged 12 x 16 inch elliptical hand holes and access covers with easy-open swing bolts, toggle bolts, or similar latches. Gasket materials shall be Buna-N.
f. Siloxane scrubber vessels shall be equipped with retention screens. Screens shall be removable to accommodate vessel servicing.

3. Support Frame
   a. The treatment vessel shall be supported on a stainless steel or galvanized steel frame designed by a registered Professional Engineer in the State of New Mexico.
4. Interconnecting Piping
   a. All equipment provided on the siloxane scrubber skid shall be pre-piped and connected from the manufacturer and as shown on the drawings.
   b. Digester gas piping shall be schedule 10, carbon steel.
5. Accessories
   a. Provide a magnahelic type differential pressure gage for the monitoring vessel gas pressure drop. The differential pressure gage shall be located to be easily viewed from ground level and shall be calibrated for differential pressure between 0 to 5 psig.
   b. Provide ANSI flanged valves on the inlet and outlet of the vessel.
   c. Provide two 110 V electrical outlets on skid to power miscellaneous equipment. . Outlets shall be rated for outdoor use with outdoor cover in compliance with National Electrical Code
6. Siloxane Scrubber Media
   a. The vessel supplier shall provide the initial charge of virgin activated carbon, graphite molecular sieve, and/or silica molecular sieve for each vessel.
   b. Activated carbon shall have a hardness of greater than 98 percent, shall have a moisture content less than 3 percent, shall have a carbon tetrachloride (CCl_4) adsorption greater than 75 percent, and shall have a total ash level less than 10 percent. Nominal particle diameter shall be 2 mm.
   c. The scrubbers shall be provided with enough siloxane scrubber media to provide a 6 month bed life for each vessel.
   d. Siloxane scrubber media shall be easily removed and refilled into the siloxane scrubber vessels. Design of the siloxane scrubber skid should be such that all tools required for removal of media and refilling media can be easily operated without causing the disassembly of any part of the skid, other than hatches and opening on the scrubber vessels.
   e. All specialty tools and apparatus required for the removal and refilling of siloxane scrubber media shall be provided.

F. Particulate Filters
1. One particulate filter shall be provided to remove any remaining particulates immediately prior to sending the digester gas to the engine fuel train.
2. Particulate filter shall remove 99 percent of particles in excess of 3 microns.

G. Drive Motors

1. Drive motors shall be NEC Class 1, Group D, Division 1 explosion-proof, TEXP motors, such as Toshiba, US Motors. Motor shall be inverter duty rated for variable-frequency drive.
2. Drive motor horsepower rating shall be such that the motor will not be overloaded over the full range of operating conditions of the gas blower, not including the 1.15 Hp service factor as required herein.
3. The motor shall conform as follows:
   a. Maximum synchronous speed - 3600 rpm
   b. Slip 3 percent at full load
   c. Voltage 460 Volts
   d. Phases 3
   e. Frequency 60 Hz
   f. Mounting horizontally on blower skid or mounting frame
   g. Bearings ball type, anti friction, ABMA L 10 life 100,000 hours
   h. Bearing lubrication manufacturer's standard
   i. Service factor 1.15

H. Power and Control
1. General
   a. Supplier shall provide all motors and instruments as indicated herein.
   b. The supplier shall provide a fully functional control system to operate the Gas Handling and Treatment System. The control system shall provide signals to the engine system to allow it to modulate based on digester gas production.
   c. All power and control equipment shall be wired on skids to terminals for the General Contractor to connect to remote locations.
2. Electrical starters and variable frequency drive shall be provided by the General Contractor.
3. Pressure and Temperature gauges shall be supplied on all inlets and outlets of each skid.

I. Surface Preparation and Field Painting
1. All non-stainless steel surfaces shall be primed and painted in the shop as a part of the work under this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Supply of anchor bolts, temporary lift equipment, power, water, labor and all other incidentals required for proper installation of the equipment will be provided by the General Contractor.

B. Installation shall be in strict accordance with the Gas Handling and Treatment System vendor’s recommendations and instructions and the best practices of the trade. Anchor bolts shall be set in accordance with the manufacturer's installation drawings or template. Installation shall include connections required for cooling water, power and controls. Installation shall be completed by the General Contractor.

3.2 FIELD QUALITY CONTROL

A. Functional Test:
1. Prior to placing the equipment into operation all equipment described in this Section shall be inspected, in the presence of the Owner’s Representative and the Gas Handling and Treatment System vendor's representative, for proper connection, proper alignment, quiet operation and satisfactory performance by means of a functional test. The Gas Handling and Treatment System shall be operated under the full range of conditions that can be expected in this installation, including a simulation of low oil pressure and loss of cooling supply. During the functional test the mechanical elements shall be observed for excessive vibration and noise and for overheating. Furnish and install temporary electric metering equipment to allow observance of the power draw by the unit under the full range of operating conditions.

2. Upon completion of the functional tests, require the blower manufacturer to certify in writing that the installation is acceptable to the manufacturer and will not invalidate any warranty provided for the equipment.

B. Performance Test:

1. A performance test shall be conducted two months following beneficial use of the Gas Handling and Treatment System and again nine months after beneficial use of the Gas Handling and Treatment System to determine the level of digester gas treatment.
2. Performance Tests shall be conducted using the original iron sponge media and siloxane scrubber media supplied as part of the original contract. Test procedures shall be provided by the Gas Handling and Treatment System vendor and approved by the Owner's Representative. Chemical analysis shall be provided by the Gas Handling and Treatment System vendor.
3. The Owner may independently sample and analyze the gas. If the Owner's sample analysis and the Gas Handling and Treatment System vendors analysis differ, a subsequent sample shall be taken and sent to an independent laboratory for verification. If the subsequent analysis shows that the Gas Handling and Treatment System is meeting the performance specifications of this section than the Owner will pay for the subsequent sampling and gas analysis. If the subsequent analysis shows that Gas Handling and Treatment System fails to meet the performance requirements of this specification, then the Gas Handling and Treatment System vendor shall pay for the subsequent sampling and gas analysis.
4. Failure to meet the performance requirements listed in this Section shall be cause for replacement or repair at the Gas Handling and Treatment System at vendors expense.
5. The Gas Handling and Treatment System vendor may request monthly samples and gas analysis of the digester gas prior to treatment to verify that the digester gas is in compliance with the Design Requirements and Operating Conditions of this Section. All equipment and gas analyses required for the monthly testing shall be paid by the Gas Handling and Treatment System vendor.

C. Service Support

1. The vendor of the Gas Handling and Treatment System shall provide a service proposal for 5 years that supports the system gas quality monitoring and process guarantee. The service proposal shall include gas testing, labor, equipment, disposal, and replacement of the siloxane removal media and hydrogen sulfide scrubber media to allow for consistent operation of the hydrogen sulfide and siloxane removal systems. A monthly report shall be provided by the vendor based on the gas samples collected. The monthly report shall summarize test results and recommend any operation changes. All costs associated with this service proposal shall be included as a bid alternate.

3.3 SYSTEMS STARTUP

A. Field Startup and Training

1. The vendor of the Gas Handling and Treatment System shall provide three days of startup training services for this system. Training shall include how to take gas samples and preparation on chain of custody for sample taking.

END OF SECTION

SECTION 46 73 41
BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Hot water boilers.
   2. Boiler Stack.
   3. Appurtenances.

B. Related Specification Section include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 40 90 00 - Instrumentation for Process Control.
   5. Section 23 05 93 - HVAC Systems: Balancing and Testing.

1.2 QUALITY ASSURANCE

A. Reference standards:
   1. ASME:
      a. Boiler and Pressure Vessel Code (Latest Edition).
      b. Controls and Safety Devices for Automatically Fired Boilers (Latest Edition).
   2. UL.
   3. FM Insurance.
   4. AGA.
   5. NFPA.
   6. IRI.

1.3 SUBMITTALS

A. Shop Drawings and product data:
   1. Submit complete fabrication, assembly, foundation, and installation drawings.
   2. Submit detailed specifications and data describing materials parts, devices, and accessories.
   3. Submit capacities, sizes, manufacturers and model of each device Boiler:
      a. Net boiler output capacity in Btuh.
      b. Total heat transfer surface in square foot.
      c. Water content in pounds.
      d. Auxiliary power requirements in kWh.
      e. Operational efficiency.
      f. Combustion space (furnace volume) in cubic foot.
      g. Combustion air and venting requirements.
      h. Manufacturer's installation instruction.
      i. Layout showing dimensions, elevations, etc.
      j. Control wiring diagrams.
      k. Fuel train layout.

B. Operation and Maintenance Manuals:
   1. See Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.
   2. Equipment shall not be started until a manufacturer Operation and maintenance manual has been submitted and approved.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Package hot water boiler:
      a. Hurst Boiler & Welding Company, Inc.
      b. Burnham.
      c. Or equal.
   2. Burners:
      a. Webster Engineering.
      b. Power Flame.
      c. Or equal.
   3. Stacks:
      a. Van Packer Co.
      b. Schebler.
      c. Selkirk Metalbestos.
   4. Flame arresters:
      a. Varec.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Boiler (BLR-01, BLR-02):
   1. ASME code constructed for 30 psi water working pressure.
   2. Rating (digester-gas)
      a. Input (Max, Min): 2,500,000 Btu/hr, 800,000 Btu/hr.
      b. Output: 2,000,000 Btu/hr (sea level to 7,200 ft) at max input.
      c. Furnace volume: 20 CU FT.
      d. Waterside heating surface: 50 SF.
      e. Fireside heating surface: 5 SQ FT / rated boiler horsepower.
   3. Boiler must be capable of operating on biogas and natural gas.

2.3 MATERIALS

A. Boiler:
   1. Jacket: Min 22 gauge steel.
   2. Tubes: 13 gauge steel.
   3. Tube sheet: 1/2" IN steel.

B. Digester and natural gas trains:
   1. Piping, valves and appurtenances for digester gas: stainless steel.
   2. Digester gas valve(s): Stainless steel.
   3. Orifices, gas control devices and gas safety devices in direct contact with digester gas: Stainless Steel with aluminum trim or other approved materials.

C. Stack:
   1. Inner wall: Min 20 gauge, 316 Stainless Steel.
   2. Outer wall: Min 20 gauge, 304 Stainless Steel.
   3. Joint material: Acid-proof, high temperature adamant cement.
   4. 2 IN insulation material between walls.

2.4 FABRICATION AND MANUFACTURE

A. General.
  1. All welded integral construction.
  2. Factory assembled and wired with burner, accessories, gas trains, control panel on skid type base.
  3. Finishes:
    a. Boiler: Factory applied enamel finish.
    b. Non-painted ferrous metals: See Section 09 91 10.

B. Boilers:
  1. Three pass wetback; fire box design.
  2. Fuel:
    a. Primary: Wet corrosive digester gas at 8 in w.c. at inlet to gas train, 600 Btu/CF HHV.
    b. Secondary: Natural gas at 5 psi inlet pressure.
  3. Insulation: Min 2" mineral wool.
  4. Burner:
    a. UL and FM listed for natural gas.
    b. Type: Forced draft combination digester gas and natural gas.
    c. Electronic ignition.
    d. Dual manifold each with orifices.
    e. Externally mounted natural gas pilot.
      1) Include pilot shutoff cock, pilot regulator, and pilot solenoid valve.
  5. Blower: 0.5 HP.
  6. Factory pre-wired splash control cabinets.
  7. Single point power connection.
  8. Supply voltage: 120 V, 1 phase, 60 Hz.
  9. Electrical MOCP: 25 Amps.
  10. Burner control voltage: 120 V:
  11. Front clean out doors.
  12. Fuel air control:
    a. On-off.
    b. Low fire start.
    c. Proven low fire.
  13. Flame safeguard:
    a. Fireye E100.
    b. Or equal.

C. Accessories:
  1. 30 psi ASME rated relief valve.
  2. Low water cut off and alarm.
  3. Dial type thermometers.
  4. Boiler drain valve.
  5. Adjustable damper section at boiler exhaust with set screws to lock damper in position.
  6. Digester and natural gas trains as shown.
  7. Manually and automatically operated gas selector switches.
  8. Digester gas flame check valves.
  9. Digester gas flame arrester.
  10. Digester gas valves(s) suitable for wet and corrosive digester gas:
    a. Automatic valves:
      1) Motorized type.
      2) Proof of closure switch.
  11. Gas pressure gages:
    a. Digester gas gages to have inconel bourbon tube.
  12. Gas cocks with lubricated plug cocks and operating handles.
  13. Gas piping meeting NFPA recommendations.
  14. Digester gas low pressure check valve.

15. Minimum gas train equipment for each boiler size as recommended by burner manufacturer.

D. Stack:
   1. Double wall stainless steel:
      a. Inner liner minimum 20 gauge 316 stainless steel.
      b. Outer shell minimum 20 gauge 304 stainless steel.
      c. Stacks Incorporated model PS.
   2. Suitable for use on a forced draft boiler with temperature up to 1000 DegF.
   3. Pressure tight fittings and joints.
   4. Flanged connection to boiler breeching.
   5. Cleanout tee, rain cap and barometric damper.
   6. UL listed and manufactured in accordance with NFPA standards.

E. Control panel:
   1. Control Panel shall be located as shown on the Contract Drawings.
   2. Supply all components necessary for stand alone control panel.
      a. Control transformer.
      b. Switches.
      c. Indication lights.
      d. Indicators.
      e. Auxiliary contacts and relays.
      f. Other miscellaneous components required for complete operating system.
      g. Enclosure NEMA 12 type.
   3. Individual lights:
      a. Power on.
      b. Type of fuel being used.
         1) Digester gas.
         2) Natural gas.
      c. Boiler on.
      d. Boiler ready.
      e. Alarms:
         1) Low water cutoff.
         2) Flame failure.
         3) High temperature.
         4) High pressure.
         5) Ventilation alarm.
   4. Provide boiler lockout for combustion air fan failure.
   5. Front panel 480 V disconnect switch:
      a. In off position all internal wiring disconnected from power.
   6. All boiler controls for complete operating system.
   7. All miscellaneous starters required by manufacturer for complete operating system.
   8. Metal barrier to separate instrumentation/control wiring from power cables.
   9. Isolated contacts for remote monitoring.
      a. Boiler on.
      b. Boiler off/ready.
      c. Natural gas being used.
      d. Digester gas being used.
      e. One common alarm for any alarm condition:
         1) Any alarm condition at panel is sealed in until operator presses reset button at control panel.
   10. Local disconnect switch for shutoff of all boiler, controls and accessory power.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 40 05 05.

B. Boiler and burner-Manufacturer's factory trained service representative, to perform the following tasks:
   1. Boil out and wash out of unit.
   2. Setting safety valves.
   3. Adjusting firing equipment:
      a. Adjust for not more than 20 percent excess air, no CO in products of combustion gas firing and maximum No. 2 smoke as measured on Bacharach Scale.
   4. Boiler performance demonstration:
      a. 16 hrs (minimum) over complete operating range using all fuels.

C. Install where indicated on Drawings.

D. Connect digester gas piping to digester gas train.

E. Connect natural gas piping to natural gas train.

F. Install vents which extend to exterior of building on both natural gas and digester gas pressure regulators.

G. Install stacks where indicated on Drawings in accordance with approved shop drawings:
   1. Seal joints and cover with draw bands.
   2. Guy wire to roof structure.
   3. Flash penetrations through roof.

3.2 FIELD QUALITY CONTROL

1. Employ and pay for services of authorized manufacturer's field service representative(s) as described in Section 40 05 05.
2. Training:
   a. One 4 hour training session shall be provided.

END OF SECTION

SECTION 46 73 42

DIGESTER HEATING HEAT EXCHANGER

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Water by sludge spiral heat exchangers for anaerobic digestion.

B. Equipment Numbers:
   1. Heat Exchangers: HX-101, HX-102, HX-103

C. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. Section VIII, Rules for Construction of Pressure Vessels Division 1.
   2. ASTM International (ASTM):
      a. A36, Standard Specification for Carbon Structural Steel.
      b. A48, Standard Specification for Gray Iron Castings.
   3. American Welding Society (AWS).
   4. FM Global (FM).
   5. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   6. Underwriters Laboratories, Inc. (UL).

B. Qualifications:
   1. Employ welding procedures and practices which comply with AWS.

1.3 SYSTEM DESCRIPTION

A. The Contractor shall coordinate the work in this Section with Section 40 90 00.

B. All equipment included in this Section shall be furnished by or through a single manufacturer

1.4 SUBMITTALS

A. Shop Drawings: See Section 01 33 00.

B. Operation and Maintenance Manuals:
   1. See Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.
      c. Equipment shall not be started until a manufacturer Operation and maintenance manual has been submitted and approved.

C. Certification that heat exchanger have been inspected, stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors.

D. Complete fabrication, assembly, and installation drawings.

E. Detailed specifications and data describing materials, parts, devices and accessories.

F. Name of manufacturer.

G. Type and model.

H. Size of inlets and outlets.

I. Net weight of unit.

J. Headloss versus performance curves.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers and models are acceptable:
   1. Alfa Laval.
   2. Approved equal.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Sludge Heat Exchangers HX-101, HX-102, HX-103:
   1. Minimum sludge heating capacity: 2,000,000 Btu/hr.
   2. Minimum heat transfer area: 180 sq ft.
   3. Minimum design pressure: 50 psi.
   4. Digester operating temperature: 95 °F.
   5. Sludge at rated transfer capability:
      a. Flow rate, total: 250 gpm.
      b. Maximum sludge inlet temperature: 95 °F.
      c. Exit temperature: 101 °F.
      d. Maximum friction loss: 5 psi.
   6. Hot water at rated capacity:
      a. Flow rate: 100 gpm.
      b. Maximum water inlet temperature: 155 °F.
      c. Maximum allowable pressure drop through unit: 0.7 psi.

2.3 MATERIALS

A. Sludge Heat Exchangers:
   1. Casing, doors, supports, pipe: ¼ IN minimum thickness steel plate.
   2. Gaskets: 1/8 IN thick, non-asbestos.
   3. Spiral element: Carbon steel, minimum 0.23 IN thickness.

2.4 FABRICATION

A. General:
   1. Especially designed to heat sludge to digester temperatures.
   2. Units shall be shop assembled and pressure tested at 50 psi
   3. Heat exchanger shall be inspected, stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors by an inspector holding a valid National Board Commission.

B. Spiral tube construction, 50 psi design pressure:
   1. No pins or other obstructions to flow in the sludge channel.

C. Hinged door:
   1. To expose channels for cleaning.
   2. Full size of exchanger.
   3. Fastened with hook bolts and clamps:
      a. Minimum ¾ IN diameter bolts.

b. Maximum 6 IN spacing between bolt centers.
c. Through bolt construction not acceptable.

D. Connections:
1. General: 150 psi standard flanges
2. Drains: standard pipe threads.
3. Sizes:
a. Heated sludge outlet: 6 IN.
b. Cold sludge inlet: 6 IN.
c. Hot water inlet: 4 IN.
d. Hot water outlet: 4 IN.
4. Provide ¾ IN drain with valve in water channel.
5. Provide 2 IN back flush connections on the sludge side.

E. Provide with legs suitable for floor mounting.

F. Designed, fabricated, tested, stamped, and certified in compliance with ASME code.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with the manufacturer's recommendations and as shown on Drawings.

B. Exercise care to ensure piping stresses are not transmitted to the heat exchanger and pump connections.

3.2 FIELD QUALITY CONTROL

A. Tests:
1. Pressure test installed system at 30 psi with water for 2 HRS and repair any leakage.

B. Employ and pay for services of authorized manufacturer's field service representative(s) to:
1. Inspect equipment to be installed by these Specifications.
2. Supervise adjustments, perform modifications as necessary.
3. Conduct start-up of equipment and perform operational checks.
4. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.
5. Instruct Owner's personnel for four hours at the jobsite on operation and maintenance of equipment specified herein.

END OF SECTION

SECTION 46 73 43
HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Hydronic specialties.

B. Equipment Numbers:
   1. Automatic Air Vent: ARV-01
   2. Combination strainer and air separator: AEX-01
   3. Self-Contained Three-Way Thermostatic Control Valves: TCV-01, TCV-02, TCV-03, TCV-04, TCV-05
   4. Balancing Valves (Circuit Setters) and Readout Meter
   5. In-Line Centrifugal Circulating Pumps: P-401, P-402, P-403, PBLR-01, PBLR-02, P-204, P-205, P-206
   6. Single-Arch Elastomeric Expansion Joints
   7. Stainless Steel Pump Connectors
   8. Expansion Tank: ET-01
   9. Bypass Feeder (Chemical Addition Pot): CFP-01
   10. Glycol Feed System: GFS-01

C. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 40 05 05 - Equipment: Basic Requirements.
   4. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements
   5. Section 23 05 93 - HVAC Systems: Balancing and Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. American Society of Mechanical Engineers (ASME).
   3. ASTM International (ASTM):
      a. A159, Standard Specification for Automotive Gray Iron Coating.
      b. B36, Standard Specification for Brass Plate, Sheet, Strip and Rolled Bar.
      c. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
      d. B85, Standard Specification for Aluminum-Alloy Die Castings.
      e. B99, Standard Specification for Copper-Silicon Alloy Wire for General Purposes.
      f. B371, Standard Specification for Copper-Zinc-Silicon Alloy Rod.
      g. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
   4. Expansion Joint Manufacturer's Association (EJMA).
   5. National Electrical Manufacturers Association (NEMA).
   6. Society of Automotive Engineers (SAE).

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Section 40 05 05.
   3. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.

b. Manufacturer's installation instructions.
c. Manufacturer's catalog cuts and technical information.
d. Pump curves.
4. Certifications.
5. Test reports.

B. Operation and Maintenance Manuals:
1. See Section 01 33 04 for requirements for:
a. The mechanics and administration of the submittal process.
b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Automatic Air Vents:
a. Val-Matic Valve and Manufacturing Corp., Single Lever Type
b. American Wheatley, Air Release Valve
c. Or equal
2. Combination Strainer and Air Separator:
a. Bell and Gossett
b. American Wheatley, Tangential Design
c. Or equal
3. Self-Contained Three-Way Thermostatic Control Valves:
a. Belimo,AF24-SR US Actuators, Proportional
b. Robertshaw
c. Or equal
4. Electrically-Actuated Three-Way Control Valve
a. Belimo. B3 Series
b. Or equal
5. Balancing Valves and Readout Meters:
a. Bell and Gossett; Circuit Setter Plus calibrated balance valves and differential pressure meter
b. Or equal
6. In-Line Centrifugal Circulating pumps:
a. Bell and Gossett.
b. Aurora
c. Taco
d. Armstrong
e. Or equal
7. Expansion Joints:
a. Red Valve
b. Procor
c. American Wheatley
d. Or equal
8. Stainless Steel Pump Connecters:
a. American Wheatley
b. Or equal
9. Expansion Tank:
a. American Wheatley
b. Wessels.
c. Bell and Gossett
d. Or equal
10. Bypass Feeder (Chemical Addition Pot)

a. Neptune Model DBF-5HP
b. Or equal
11. Glycol Feed System
a. Neptune G-50-1-RC-LP
b. Or equal

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 EQUIPMENT

A. Automatic Air Relief Vents:
1. Type: Single-lever.
2. Material: Cast iron.
3. Vessel design limitations (psig): 150 at 250 deg F
4. Relief tubing: K copper or steel.
5. Size: 1/2-IN.

B. Combination Strainer and Air Separator:
1. ASME code constructed.
2. Type: Tangential flow.
3. Design pressure: 125 psig minimum at 250 deg F
4. Air collector tube.
a. Stainless steel.
b. 63 percent open area design (minimum).
5. NPT vent connection.
6. NPT blowdown connection.
7. Tangential nozzles: Flanged, 4 IN
8. Strainer:
a. Galvanized steel.
b. Free area not less than five (5) times the cross sectional area of the connecting pipe.
c. Removable.
9. GPM and Headloss: 300 gpm at 2-3 feet headloss

C. Self-Contained Three-Way Thermostatic Control Valves
1. Materials:
a. Body: Bronze, cast iron or semisteel.
b. Trim, throttling plug: Bronze or Type 316 SS.
c. Spring, stem assembly and bonnet: Cadmium-plated steel or type 316 SS.
d. Stem head retainer: Brass or steel.
e. Packing: Teflon.
f. Bulb and capillary: Type 304 SS.
2. Modulating for mixing service.
3. Three-way diverting flow pattern
4. Linear flow characteristics
5. 3-IN 125 LB ANSI flanges
6. Valve schedule: TCV-01, 3-IN, CV=100; TCV-02, 3-IN, CV=100; TCV-03, 3-IN, CV=100; TCV-04, 3-IN, CV=100; TCV-05, 3-IN, CV=100

D. Balancing Valves (Circuit Setters) and Readout Meter:
1. Type: Calibrated balance valve.
2. Connections:
a. NPT up to 3 IN DIA.
b. Flanged for 4 IN or larger.
3. Calibrated nameplate.
4. Integral seals.
5. Working pressure: 125 psig at 250 DegF minimum.
6. Readout Meter for Balancing Valves.
a. Type: Portable.

b. Range: 0 to 100 FT of water.
c. Increments: 0.5 FT.
d. Accuracy: +0.5 percent.
e. Accessories:
   1) Carrying case.
   2) 10 FT hoses.
   3) Shut-off and vent valves.
   4) Balance valve calculator.
f. Maximum operating temperature: 250 °F liquids and gases.

E. In-Line Centrifugal Circulating Pumps:
1. Type: Centrifugal, single-stage, in-line suction and discharge.
2. Material:
   a. Volute: Cast iron ASTM A159.
   b. Impeller:
      1) Brass, ASTM B36 or Cast bronze, ASTM B584.
   c. Pump shaft: Alloy steel.
   d. Seal assembly:
      1) Housing: Brass.
      2) Bellows: Buna-N.
      3) Ring: Carbon.
      4) Spring: 304 stainless steel.
      5) Seat: Ceramic.
      6) Seat gasket: Buna-N.
   e. Volute gasket: Cellulose fiber.
   f. Companion flanges:
      1) 1 to 1-1/2 IN: Formed steel.
      2) 2 IN: Cast iron, ASTM A159.
   g. Shaft sleeve: Copper alloy 110 or aluminum bronze, ASTM B584.
   h. Motor:
      1) Meets NEMA requirements.
      2) 480 V, 3 PH, 60 HZ.
   i. Pump Schedule:

Equipment No.	Description / Location	Flow (GPM)	TDH (FT)
P-401	Primary Hot Water Pump No. 1	300	20
P-402	Primary Hot Water Pump No. 2	300	20
P-403	Cogeneration Hot Water Pump	300	40
P-204	Sludge HX-01 Hot Water Pump	200	20
P-205	Sludge HX-02 Hot Water Pump	200	20
P-206	Sludge HX-03 Hot Water Pump	200	20
PBLR-01	Boiler 1 Loop Pump	160	14
PBLR-02	Boiler 2 Loop Pump	160	14

F. Single-Arch Elastomeric Expansion Joints :
1. Hot Water Supply and Return:
   a. Type: Single arch with anchoring to limit expansion and compression.
   b. Materials:
      1) Expansion joint: EPDM.
      2) Retaining Rings: Galvanized steel.
      3) Bolts and nuts: As required for adjoining pipe.
   c. Maximum Temperature: 200 deg F.
   d. Fittings: Flanged.

G. Flexible Connectors:
1. Type: Flexible corrugated single braid hose.
2. Material: Stainless steel.
3. Maximum working pressure: 150 psig.
4. Maximum test pressure: 250 psig.
5. Normal burst pressure: 650 psig minimum.

H. Expansion Tank:
1. ASME code construction and ASME stamped 125 PSI working pressure.
2. Pre-charged steel expansion tank, 12 psig.
3. Replaceable heavy-duty EPDM bladder.
4. Top 1-1/2 IN NPT connection.
5. Air charging valve.
6. Lifting rings.
7. Seismic mounting clips
8. Floor mounting skirt.
9. Size: XT-763-01: 82 GAL. Full Acceptance

I. Bypass Feeder (Chemical Addition Pot)
1. Capacity: 5 gallons
2. Working pressure: 300 psi at 200 deg F
3. Cap: Cast iron with Buna N o-ring and epoxy coating on liquid side
4. Mounting legs
5. ¾-IN NPT connections

J. Glycol Feed System:
1. General: Provide packaged pre-piped, prewired feed system for each system containing glycol to automatically maintain the pressure in the system by adding glycol solution to make up for losses which occur due to leakage.
   a. Tank: 50 gallon polyethylene tank mounted in steel frame.
   b. Pump: Bronze rotary gear pump rated at 3 GPM and 100 psig.
   c. Float Switch: Include low level float switch to shut off pump and indicate alarm.
   d. Control Panel:
      1) Hand-off-auto switch.
      2) Pump "on" indicator light.
      3) "Low" tank level indicator light and dry contacts for remote alarm.
      4) NEMA 4X enclosure.
   e. Suction assembly :
      1) PVC tubing and fittings.
      2) PVC ball valve.
      3) Cast iron wye strainer
   f. Discharge assembly:
      1) Schedule 80 PVC pipe and fittings.
      2) PVC ball valve.
      3) PVC check valve.
      4) Brass relief valve with return to tank.
   g. Manufacturer: Neptune G-50-1-RC-LP.

2.3 FABRICATION

A. Fabricate pumps complete with motor and pump as one (1) unit.

2.4 SOURCE QUALITY CONTROL

A. Pump Impeller Trimming:
1. Trim impellers to a diameter to provide design flow and head with minimum pump power consumption for each pump.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install hydronic specialty items where indicated or required.

B. Install 1-IN high point manual vents at high points in closed water systems and at high point of coil headers.
   1. Install shut-off valve ahead of each vent.
   2. Extend relief tubing from vent to or drain.

C. Install flexible connectors at pump suction and discharge and where indicated.

D. Install pipe guides in accordance with EJMA Standards.
   1. Space at 4 and 14 pipe diameters from expansion joints.
   2. Install at expansion loops as indicated.

3.2 FIELD QUALITY CONTROL

A. See Section 23 05 93.

END OF SECTION

SECTION 46 76 21

BELT FILTER PRESS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. All belt filter presses.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 – Procurement and Contracting Requirements.
   2. Division 01 – General Requirements.
   3. Section 40 05 05 – Equipment: Basic Requirements.
   4. Division 40 – Process Interconnections.
   5. Section 46 33 13 – Polymer Blending Unit.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Bearing Manufacturers Association (ABMA).
   2. ASTM International (ASTM):
      a. A36, Standard Specification for Carbon Structural Steel.
      b. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Society for Protective Coatings/NACE International (SSPC/NACE):
      a. SP 10/NACE No. 2, Near-White Blast Cleaning.

B. Miscellaneous:
   1. Press manufacturer shall have single source responsibility for coordination of all variable speed drive units utilized with press motors.
   2. Belt press manufacturer shall coordinate all components of booster wash water system to assure completely functional wash system is provided to presses.
   3. Coordinate placement of manually operated equipment and appurtenances to locations easily accessible to operator following installation of all systems and equipment included in this Contract.
      a. Manually operated equipment and appurtenances include but are not limited to valves, reservoirs, grease zerks and other lubricating devices, handwheels for wash tube assemblies, and electrical control devices.

C. Coordination:
   1. The belt filter press systems supplier shall be responsible for coordinating the belt filter press equipment with related equipment and suppliers as required for proper operation, including, but not limited to, the following:
      a. Sludge feed pumps and related VFDs.
      b. Chemical feed systems (polymer feed system).
      c. Electrical equipment (includes, but is not limited to, conduit routing, starters, feeder breakers, and cable).
      d. Sludge feed flowmeters.
      e. Instrumentation and controls.
   2. All contacts or signals required for proper interface to external devices and systems shall be provided. Additional software and hardware contacts shall be provided as recommended by the manufacturer for proper operation of the equipment.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Section 40 05 05.
   3. Certification of compatibility of all variable speed drives.
   4. Utility utilization rates and pressures.
   5. Performance criteria statement:
      a. On manufacturer's letterhead.
      b. Signed by officer of the company.
      c. Restate specified operating parameters and equipment ability to meet same.
   6. Technical data defining all components of the hydraulic system.
   7. Certification of bearing life.
   8. Control panel data sheets.
      a. Catalog sheet on all components.
      b. Wiring diagrams.
      c. Short Circuit Current Rating (SCCR) nameplate marking per NFPA 70. Include any required calculations per Section 40 05 05.
   9. Belt fabric specifications including material type, seam closure design and weave.
   10. Certified, delivered cost per pound for polymer(s) to be used in performance test.
   11. Performance test protocol.

B. Samples:
   1. 1 SQFT of belt material.

C. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

1.4 PROJECT CONDITIONS

A. Sludge Characteristics:
   1. Combination of primary sludge (55%) and secondary DAF thickened waste activated sludge (45%) anaerobically digested by volume.
   2. Solids content: 2 – 3%.
   3. Volatile solids: 19,000 milligrams/liter.

1.5 WARRANTY

A. The manufacturer shall warrant against any defects in material or workmanship to comprehensive belt filter press system for a period of two (2) years from the date of substantial completion of the project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Belt filter presses:
      a. See Specification Section 01 61 05.
   2. Hydraulic pump:
      a. Hyvair (Model C-204 or PVC3 Series).
      b. Or engineered approved equal.

2.2 MATERIALS

A. Belt Filter Press (BFP): BFP-03.

1. Machine frame: ASTM A36 steel, hot dipped galvanized STM A123.
2. Rollers:
   a. Drive rollers: ASTM A36 steel with Rilsan nylon, Buna-N or chlorinated rubber coating.
   b. Others:
      1) 304 stainless steel or ASTM A36 steel with thermo plastic nylon, Buna-N, or Teflon coating.
3. Roller shafts:
   a. 1018 carbon steel, 304 stainless steel or forged steel, ASTM 572, Grade 50.
4. Plows and sludge mixing equipment: Hot-dipped galvanized cast iron or stainless steel with high-density polyethylene blade.
5. Gravity grid: High-density polyethylene.
6. Gravity grid frame: 304 stainless steel frame.
7. Scraper blades:
   a. High-density polyethylene or
   b. Laminated fiberglass.
   c. Springs: 304 or 316 stainless steel.
8. Belt filter cloth: Continuous weave monofilament polyester twill.
9. Belt seam closures: Type 316 stainless steel.
10. Spray headers and nozzles: Type 304 stainless steel.
11. Spray headers housing: Type 304 stainless steel and high-density polyethylene.
12. Spray nozzle cleaning brush: Brass or stainless steel.
13. Drainage pans:
    a. 304 stainless steel.
14. Internal piping: Schedule 80 PVC.
15. Miscellaneous hardware and anchor bolts: Type 316 stainless steel.
16. Polymer injection ring:
    a. High-density polyethylene or PVC.
17. Variable orifice mixer:
    a. Cast aluminum or 316 stainless steel.
18. Sludge distribution chute: 304 stainless steel.
19. Sludge discharge chute: 304 stainless steel.
20. Pressurized hydraulic fluid lines: 316 stainless steel tubing. Flexible lines at connections shall be hose material appropriate to the application.
21. Belt spray station enclosure: 316 stainless steel.
22. All other parts in contact with belt:
    a. Stainless steel or nylon-coated or Rubber-coated steel.
23. Control panel:
    a. 304 stainless steel.
24. Grease extension tubing: 304 stainless steel.

2.3 EQUIPMENT

A. Performance and Configuration Requirements for Each Press:
   1. Belt press BFP-03:
      a. Capacity in LB/HR dry weight solids: 1,900.
      b. Hydraulic capacity in gpm: 125.
      c. Dewatered cake solids: 15 percent.
      d. Solids capture rate: 95 percent.
      e. Wash water: 90 gpm at 120 PSI maximum.
      f. Air requirements: 3 scfm at 90 PSI.
      g. Dimensional limitations: 2 meter.
      h. Active polymer dose: 15 – 20 lb/dry ton.
      i. Layout configuration: As shown on Drawings.

2.4 ACCESSORIES

A. See Section 40 05 05.

B. Provide one (1) set of all tools required to change belts and rollers.

C. Controls:
1. General:
    a. Provide NEMA 4X Control Panel.
    b. Panel to include all controls, interlock, relays and contacts required to interface with related panels and MCC's.
        1) Control Panel Components:
            a) Circuit Breakers – See Section 26 28 00.
            b) Motor Starters – See Section 26 24 19.
            c) Control Devices – See Section 26 09 16.
            d) Variable Frequency Drives – See Section 26 29 23.
            e) Programmable Logic Controller
                (1) See Section 40 94 43.
        2) Equipment shall be controlled by a PLC.
        3) The belt filter press supplier will provide and program the PLC for this system. System loop checkout will be a coordinated effort between vendor and Contractor.
        4) Belt Feed Sludge Pump Interface.
            a) The panel PLC shall accept the following DH+ signals:
                (1) Sludge Feed pump RUNNING, each pump.
                (2) Sludge Feed pump FAIL, each pump.
            b) The panel shall provide the following networked signals to the Belt Feed Sludge Pumps' local PLC.
                (1) Sludge pump call to run, each pump.
                (2) Sludge pump speed command, each pump.
            c) The panel shall accept a 4-20 mA signal from sludge feed flow meter to control speed of VFD
        5) Grinder Interface:
            a) The panel shall accept the following signals from the MCC:
                (1) Grinder RUNNING.
                (2) Grinder FAIL.
            b) The panel shall provide the following signals to the MCC:
                (1) Grinder call to run.
        6) Belt Conveyor Interface:
            a) The panel shall accept the following signals from the MCC:
                (1) Belt conveyor RUNNING.
                (2) Belt conveyor FAIL.
            b) The panel shall provide the following signals to the MCC:
                (1) Belt conveyor call to run.
        7) Polymer Blending Unit (PBU) Interface.
            a) The panel shall accept the following signals from the PBU control panel:
                (1) Polymer system running.
                (2) Polymer system fail.
                (3) Polymer pump speed feedback.
            b) The panel shall accept a 4-20 mA signal from PBU flow meter to control speed of VFD
            c) The panel shall provide the following signals to the PBU control panel:
                (1) Start/Stop polymer system.
                (2) Polymer pump speed.
    c. Panel components per Section 40 94 43 and Division 26.
    d. Panel face instruments:
        1) HOA switch and indicating light for each system component except sludge and polymer feed pumps.
        2) START/STOP switch with indicating lights (including FAIL) for sludge and polymer feed pumps.
        3) RUN/OFF lights for all motors.

4) Alarm lights per paragraph C.7.
5) Belt speed indication.

2. Automatic start-up sequence:
   a. Place all individual components in auto mode.
   b. Activate single master switch at each press to initiate automatic sequence.
   c. Start belt drives and hydraulic (or pneumatic) system.
   d. After field adjustable time interval, open associated belt spray valve and start associated spray water booster pump.
   e. Manually start sludge feed pumps
3. Automatic shutdown sequence:
   a. Activate single master switch at each press to initiate automatic sequence.
   b. Stop sludge and polymer feed pump.
   c. After adjustable timed cycle to wash belts:
      1) Stop associated spray water booster pump.
      2) Close spray water valve.
   d. Shut down belt drives and hydraulic or pneumatic system.
4. Interlock controls such that automatic shutdown of belt press for any reason shuts down belt press feed pumps and polymer feed pumps.
5. Provide manual override controls for manual operation of belt press equipment.
6. Special functions:
   a. Emergency shut-off system:
      1) Pull cable system ringing press which will stop all equipment associated with the belt press.
      2) All components stainless steel.
   b. Gravity section sensors:
      1) High liquid level before sludge overflows side bars.
      2) Loss of cake.
   c. Belt speed indication.
7. Shutdown alarms:
   a. Belt alignment failure.
   b. Tensioning systems failure.
   c. Hydraulic or pneumatic system low pressure.
   d. Spray water system low pressure.
   e. Broken belt.
   f. Emergency stop.
   g. High liquid level in gravity drainage zone.
   h. Loss of cake.
8. Provide NEMA 4X stainless steel terminal strip enclosure mounted on the belt press and all press mounted devices wired to this enclosure.

2.5 FABRICATION

A. General:
   1. Fabricate continuous belt filters having gravity, wedge and pressure zones.

B. Frame:
   1. Welded and/or bolted structural shapes.
   2. Maximum deflection of frame member at belt tension of 40 LB/linear inch: 0.025 IN.
   3. Construct to allow removal of any roller without removal of other rollers or disassembly of frame.
   4. Maximum stress at any point at belt tension of 40 LB/linear inch: 25 PCT of member's yield strength.
   5. Provide appropriate lifting lugs to permit ready removal of pieces with overhead monorail for maintenance or access.
   6. Chamfer all fixed edges along belt operating surfaces.
   7. Minimum cross-section moment of inertia: 32.1 IN(4).
   8. Finishes:

a. Frame shall be abrasive blast steel per SSPC SP 10/NACE No. 2 or
b. Pickled per SSPC SP 8.
c. 4 to 7 mils hot-dipped galvanizing or
d. Hot-dip galvanize with surface density of 2.0 OZ zinc per square foot followed by one (1) coat of polyamide primer and two (2) coats of polyamide paint, ASTM A123

C. Rollers:
1. Provide minimum of one (1) perforated drum immediately following gravity dewatering zone.
    a. Perforations 1 1-/4 IN DIA minimum.
2. Utilize minimum of seven (7) drum rollers of perforated or solid design in shear-pressure zone.
3. Assure belts in contact with roller for minimum of 180 DEG average of all of the pressure rollers.
4. Maximum deflection at belt loading/tension of 50 LB/linear inch: 0.05 IN.
5. Apply minimum 1/4IN thick coating to drive rollers and 25 MIL coating on all others.
6. Coat all rollers to point of insertion into pillow block.
    a. Assure coating does not extend into bearing flat seal.

D. Roller Bearings:
1. Externally mounted, split case, self-aligning ball or roller type.
2. Locate in cap-sealed, splash proof pillow block housings.
3. Minimum ABMA L-10 life: 300,000 HRS at maximum belt speed.
4. Include grease seals and zerks extended to face of frame.
5. Fabricate to assure all bearings greaseable while press is running.
6. Bearing housing shall be cast iron with two mounting bolts and four cap bolts.

E. Roller Shafts:
1. Safety factor for bending stress on shaft: 4.0.

F. Polymer Injection Mix Equipment:
1. Variable orifice mixer:
    a. One (1) unit per belt press.
2. Injection rings:
    a. Number and size: 4 rings at 6 inches.
    b. Solid PVC block fabricated to same ID and OD of pipe flange.
    c. Split polymer flow into four (4) feed points around periphery of pipe.

G. Sludge Inlet Box:
1. Design to distribute sludge evenly over entire working width of belt ahead of gravity drainage section.
2. Provide skirt around perimeter to prevent leakage or splashing.

H. Gravity Dewatering Section:
1. Horizontal gravity belt system:
    a. Belt supported by grid assembly or free-turning rolls across entire width.
    b. Contain sludge on belt with flexible seals.
    c. Sludge plows:
        1) Provide plows or similar devices to promote dewatering and to distribute sludge across belt.
        2) Minimum of five (5) rows.
        3) Stagger positions of plows between adjacent rows.
        4) Minimum of seven (7) plows per row.
        5) Provide lifting handles or similar mechanism on each row to permit lifting of plows with means to lock in retracted position.
    d. Minimum effective area: 65 SF. Manufacturer shall determine square footage.
    e. Horizontal section configuration only, inclined section not acceptable.

I. Wedge Zone:

1. Provide gradually increased application of pressure to sludge through wedge-shaped section.
2. Wipers to remove water from both sides of belt.
3. Minimum effective area: 35 SF. Manufacturer shall determine square footage.
4. Adjustable while press is operating.

J. Pressure Zone:
1. Provide increased compression of cake by passing over rolls to alternate pressure from one side to the other.
2. Minimum effective area: 120 SF. Manufacturer shall determine square footage.

K. Belt Alignment System:
1. Provide continuous tracking and correction of belt alignment.
2. Hydraulic or pneumatic align belt devices.
3. System to provide smooth and slow adjustments without sharp or sudden movement.
4. Provide backup limit switches to stop drives and sound alarm upon detecting belt overtravel.
5. Anchor hydraulic or pneumatic piping rigidly and securely to frame.
6. System allowing tracking rollers to oscillate from full deflection one direction to full deflection in the opposite direction are not acceptable.

L. Belt Tensioning:
1. Hydraulic or pneumatic tensioning system to maintain dewatering pressure.
2. Manually adjustable tension set point.
3. Individual control station for each tension control point located by each press control panel.
    a. Provide pressure gage to read out in PSI and to indicate normal operating limits.
4. Assure parallel movement of tensioning rollers.
5. Furnish one (1) tensioning roller system for each belt.
6. System to accommodate at least 2.5 PCT increase in belt length.
7. Furnish sensing devices to stop press in case of tensioning system failure.
8. If pneumatic tensioning system is selected, Manufacturer shall provide required air compressor units equipped with air compressor, air tank, motors, motor starters, controllers, air piping from air compressor to the belt press and pressure gauges to ensure fully operational system. Location of air compressors to be field located in the Sludge Dewatering Building.

M. Belt Press Drive:
1. Adjustable speed gear motor rigidly attached to frame.
2. Variable frequency drive per Section 26 29 23.
3. Size: 3 HP.
4. Operating range: 3 to 15 FT per minute.
5. TEFC chemical duty enclosure.
6. See Section 40 05 05.

N. Belt Washing Systems:
1. Provide washing stations for upper and lower belts.
2. Enclosure boxes:
    a. 14 GA.
    b. Completely enclose spray system.
    c. Replaceable seals at belt entrance and exit.
    d. Provide continuous hinged door to allow access to spray system.
    e. Latch to hold access door closed.
3. High-pressure spray header with flat spray nozzles.
4. Include handwheel-operated brush, operable from center platform, to permit nozzle cleaning without disassembly or interrupting operation.
5. Provide in-line strainer ahead of inlet to nozzles.
6. Solenoid or motor operated valves:
    a. Provide at inlet to each spray header.
    b. Enclosure: Rated for area classification.
    c. 115 V/1 PH/60 HZ power.

O. Drainage System:
   1. Provide drainage pans for gravity and pressure dewatering zones.
   2. Mount drain system securely to frame in such a way as to prevent vibration noise and allow cleaning.
   3. Provide sampling points for each stream.
   4. Drainage pans 1/4 IN thick (FRP) or 14 GA (stainless steel).

P. Belts:
   1. Width: 2.0 meters minimum.
   2. Seams:
      a. Strength equal to or greater than belt.
      b. Readily repairable and replaceable.
      c. Closures to not interfere with scraper blades or other equipment.
      d. Provide protective flap for seam.
   3. Manufacturer to determine type and mesh size.
   4. Belt replaceable without requiring removal of machine components or changes in tension adjustments.
   5. Tensile strength at least five times normal maximum dynamic belt tension.
   6. Minimum guaranteed operating life: 3,000 HRS.

Q. Scraper Blades:
   1. Furnish to separate cake from top and bottom belts across entire width.
   2. Mount on spring-loaded counter-weighted assembly.
   3. Blades factory tensioned and field replaceable.
   4. Provide means to retract and lock blades in single motion.

R. Hydraulic Power Pack (For Hydraulically Powered Systems):
   1. Complete system including pumps, motors, valves, controls, tubing, system enclosure and appurtenances.
   2. Pressure rating: 1,000 PSI.
   3. Furnish one per belt press.
   4. Self-contained unit.
   5. Accessories:
      a. Oil filter.
      b. Pressure gage.
      c. Temperature gage.
      d. Level gage.
      e. Filler strainer breather cap.
      f. Reservoir: 1 GAL minimum.
   6. Hydraulic pump:
      a. Motor:
         1) 1.0 HP minimum.
         2) Chemical duty; TEFC.
         3) Mount on heavy-duty pump motor mounting plate.
   7. Provide rubber pads between both pump and motor mounting.
   8. Incorporate necessary time delays to assure power pack is at operating pressure before starting of belt press motor.

S. Air Supply:
   1. Furnish 1 IN HPA line from air compressor supplied by belt press manufacturer to belt press.
   2. Provide pressure gage on each line.
   3. Provide intake filter-regulator on each line.
   4. Supply conditions:
      a. To be determined by belt press manufacturer.

T. Press Connections:
   1. Sludge: 6 IN ANSI 125 LB flanged.

2. Polymer: 1 IN NPT.
3. Belt spray: 1.5 IN NPT.
4. Hydraulics/pneumatics: 3/8 IN.

2.6 WASHWATER BOOSTER PUMP:

A. Single stage, centrifugal, close coupled, vertical in-line pumping unit

B. Coordinate booster pump with belt filter press.

C. Belt filter press shall include pump electrical motor, controls (including starter), and all other appurtenances required for proper operation

D. One spare mechanical seal for each pumping unit.

E. Pump Unit
   1. Design to provide sufficient flow at the required head to meet each belt filter press's wash water requirement.
   2. Pump performance stable and free of cavitation and noise throughout the specified operating head range at design suction pressure.
   3. Design performance based on a wearing ring diametrical clearance of not less than 0.012 inches, or 1 mil per of wearing ring diameter, whichever is greater.
   4. Materials:
      a. Casing: Cast iron, ASTM 48
      b. Casing Wearing Rings: Cast iron, ASTM48, or bronze ASTM B62
      c. Impeller: Bronze, ASTM B62
      d. Shaft: Carbon Steel.
      e. Shaft Sleeve: Bronze ASTM B144 Alloy 937, or AISI Type 416 stainless steel
      f. Stuffing Box Hardware: Corrosion-resistant metal
      g. Mechanical Seal: Durametallic "Type RO", Chesterton "Style 830", or John Crane "Type 21"
      h. Base: Cast iron or fabricated steel.
   5. Casing shall permit the removal of the rotating element without disconnecting the piping.
   6. Registered fit between casing parts shall maintain alignment.
   7. Nozzle will have ANSI/ASME Class 150 flange diameter and drilling.
   8. Pipe tapped opening shall be provided for draining and venting casing.
   9. Impeller enclosed type, one piece casting completely machined on all exterior surfaces, and dynamically balanced. Keyed to the shaft and positively held in the center of the discharge volute.
   10. Pump shaft completely machined and large enough to hold shaft deflection as the seal to less than 0.002 inch at all operating heads.
   11. Shaft sleeve to extend from impeller through each stuffing box. Sleeves shall be positively locked against rotation and axial movement and shall be sealed to prevent leakage between the shaft and the sleeve. Runout not to exceed 0.002 inch after assembly.
   12. Wear rings shall be provided in the casing. Design clearances not to be less than 1 mil per inch of ring diameter. The casing ring shall be positively locked against rotation.
   13. Each stuffing box shall contain a mechanical seal as specified in the materials list.
   14. Provide lifting eyebolt or lug, plugged gauge cock connections at the suction and discharge flange, and tapped and plugged openings for casing and bearing housing vents and drains.
   15. All rotating parts shall be accurately machined and balanced. Excessive vibration shall be sufficient cause for rejection of the equipment. In any case, the vibration displacement (peak to peak) as measured at any point on the machine shall not exceed 2.0 mils.
   16. Spray Water Pump Motor:
      a. Total enclosed fan cooled, induction type
      b. 460 volt, 60 Hz, 3 phase.
      c. Grease or oil lubricated.
      d. Bearing life – AFBMA minimum L_{10} life rating of 40,000 hours
      e. Vertical solid shaft.
      f. Corrosion resistant

17. Spray Water Pump Motor Controls:
    a. All controls required for operation of the spray water pump, including motor starter, shall be provided in the Belt filter press control panel.

2.7 POLYMER BLENDING UNIT

A. Belt filter press manufacturer shall supply polymer blending unit. See Specification 46 33 13.

2.8 MAINTENANCE MATERIALS

A. Furnish Owner the following extra materials:
   1. One (1) complete set of filter belts.
   2. Two (2) sets of doctor blades.
   3. Two (2) valves (solenoid or motor operated) for each size used on press.
   4. Two (2) sets of each type of bearing and housing.
   5. Two (2) steering sensors used for belt alignment.
   6. One (1) repair kit for each size hydraulic or pneumatic cylinder or diaphragm.
   7. Two (2) hydraulic or pneumatic belt tensioning and steering valves.
   8. Spare drive belt of each type used.
   9. One (1) set of spray header housing seals to replace one complete belt press housing seal.
   10. Two (2) sets of replaceable seals, gaskets, and wearing parts for drive.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 40 05 05.

B. Mount control panels at locations shown on Drawings.

C. Securely fasten all pneumatic/hydraulic control tubing to press frame or other structural members.

D. Controls for hydraulic system located on press shall be accessible from operating platform of press.

E. Install injection rings upstream of in-line static mixers or spool pieces in sludge feed lines as located on Drawings.

F. Install static mixer downstream of polymer injection ring.
   1. Belt press supplier to recommend location of mixing device, selecting from given points as shown on Drawings.

G. Mount emergency stop cable system around periphery of press, away from moving parts.
   1. Assure cable is easily reachable from all platforms adjacent to press.

H. Drainage System Piping:
   1. Interconnect, allowing space for sampling.
   2. Interconnect drains for belt wash sprays.
   3. Terminate all drain lines within 6 IN of floor drain vertically and horizontally.
   4. Provide connections for flushing water with easy access.

I. Use maximum 1 FT of hydraulic hose to make connection from equipment to stainless steel tubing.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of equipment manufacturer's field service representative(s) to:
   1. Inspect equipment covered by this Specification Section.
   2. Supervise adjustments and installation checks.
   3. Conduct start-up of equipment and perform operational checks.
   4. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.

5. Instruct Owner's personnel for 24 HRS at jobsite on operation and maintenance.

B. Performance Test:
1. Test performed by representative of manufacturer in presence of Engineer and/or Owner.
2. Run test over continuous 6 HR period.
3. Results from test will be used to verify compliance with requirements in PART 2 of this Specification Section.
4. Samples taken one (1) per HR (six (6) total).
5. Tests conducted:
   a. Feed percent solids (total residue).
   b. Feed flow rate.
   c. Suspended solids of beltwash and filtrate (combined sample).
   d. Polymer feed rate.
   e. Polymer concentration.
   f. Wash water consumption.
   g. Dewatered sludge solids (total residue).
6. Test will be run at press capacity listed under Article 2.2.

C. Referee Test:
1. In the event that performance requirements are not met, belt press supplier may request referee test to verify that requirements are achievable.
2. Request must be made within 10 days after completion of performance test.
3. Test to be arranged and paid for by Owner.
4. Owner may choose any portable machine meeting basic design requirements of this Specification Section.
5. Test to be performed according to procedure outlined for performance test.
6. Results will be used to establish new performance requirements, to be no more stringent that those specified herein.
7. If results of referee test meet or exceed listed performance requirements, belt press supplier will reimburse Owner for all costs associated with running referee test.

D. See Section 01 75 00.

END OF SECTION