JORDAN VALLEY WATER CONSERVANCY DISTRICT

JORDAN VALLEY WATER CONSERVANCY DISTRICT
WEST JORDAN, UTAH

JORDAN VALLEY WATER TREATMENT PLANT FILTER AND CHEMICAL UPGRADES

CLIENT PROJECT NO. 202001

CONTRACT/TECHNICAL SPECIFICATIONS

100% SUBMITTAL

VOLUME 3 OF 6

DIVISIONS 10 - 16 *(16050 to 16235)*

FEBRUARY 2025

carollo®

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JORDAN VALLEY WATER CONSERVANCY DISTRICT

JORDAN VALLEY WATER TREATMENT PLANT FILTER AND CHEMICAL UPGRADES

SEALS PAGE

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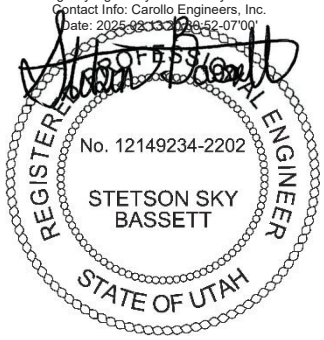

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Section 06611

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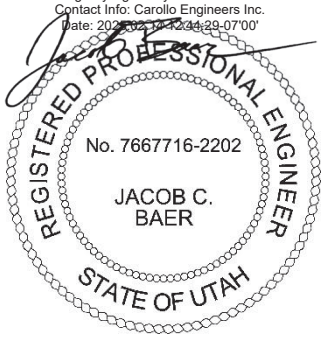

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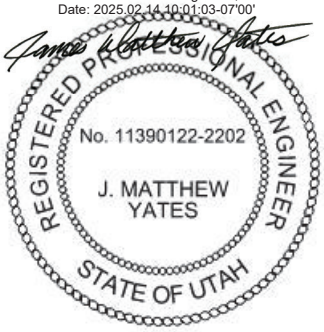

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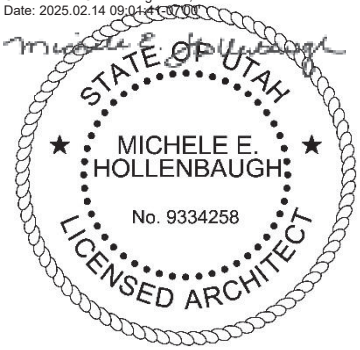

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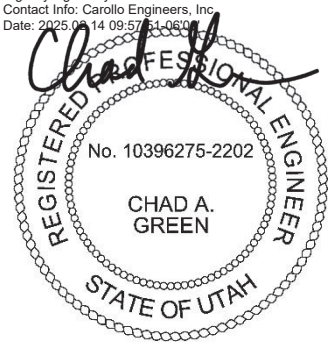

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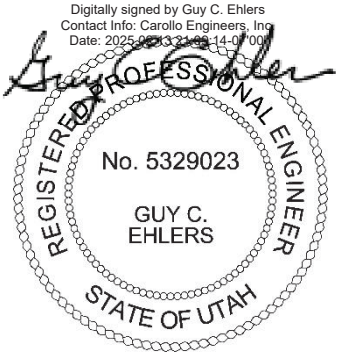

Divisions 16, 17
Section 13447

JORDAN VALLEY WATER CONSERVANCY DISTRICT

JORDAN VALLEY WATER TREATMENT PLANT FILTER AND CHEMICAL UPGRADES

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APPENDICES

SECTION 10400

SIGNAGE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic and metal signs for building and site use.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.

B. Occupational Safety and Health Administration (OSHA).

1.03 SUBMITTALS

A. Product data.

B. Shop drawings: Include lists of sign types, sizes, text, and colors; mounting details; locations; and cast metal plaque rubbings and templates.

C. Samples: Include actual materials.

D. Manufacturer's installation instructions.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed products for minimum 5 years with satisfactory performance record of minimum 5 years.

B. Installer qualifications: Manufacturer approved installer of products similar to specified products on minimum 10 projects of similar scope as Project with satisfactory performance record.

C. Regulatory requirements: Provide signage in accordance with Americans with Disabilities Act as published in the Federal Register, Volume 56, No. 144, Friday, July 26, 1991.

PART 2 PRODUCTS

2.01 PLASTIC SIGNAGE SYSTEM

A. Manufacturers:
   1. One of the following or equal:
      a. Best Manufacturing Sign Systems, System 900013.

b. Andco Industries Corp., equivalent product.
c. Vomar Products, Inc., equivalent product.

B. Attachment:
1. Vinyl tape, self-adhering.

C. Lettering:
1. Helvetica medium, 3/4 inches high.

D. Material for interior use:
1. Plastic 1/8-inch thick raised letters.

E. Material for exterior use:
1. Fiberglass 1/4-inch thick with high gloss finish, raised letters, blasted from single piece of fiberglass for integral letter and background.
2. No adhesive as mechanical fastening of letters shall be allowed.

F. Colors:
1. As selected by Engineer from manufacturer's standard colors.

G. See Attachment A - Plastic Signage System Schedule for specific sign size, location, text, pictogram, and quantity.

2.02 METAL SAFETY SIGNS

A. Manufacturer: Meeting OSHA Requirements; 40-mil thick aluminum with baked enamel finish. One of the following or equal:
1. Seton Name Plate Co., Special Wording.
2. Emedco.

B. Danger sign colors:
1. Background: White.
2. Heading: White lettering on red oval with white border in black rectangular panel.
3. Message: Black lettering on white.
4. Size: As scheduled.

C. Caution sign colors:
1. Background: Yellow.
2. Heading: Yellow lettering on black rectangular panel.
3. Message: Black lettering on yellow.
4. Size: As scheduled.

D. Safety instruction signs:
1. Background: White.
2. Heading: White lettering on green rectangular panel.
3. Message: Black lettering.
4. Size: As scheduled.

E. Warning sign colors:
   1. Background: Orange.
   2. Heading: Black lettering on orange diamond in black rectangular panel.
   3. Message: Flack lettering on orange.
   4. Size: As scheduled.

F. Notice information signs:
   1. Background: White.
   2. Heading: White lettering on blue rectangular panel.
   3. Message: Black lettering.
   4. Size: As scheduled.

G. Fasteners: Round head stainless steel bolts or screws.

H. See Attachment B - Metal Safety Sign Schedule for specific sign size, location, text, and quantity.

2.03 EXTERIOR INFORMATION SIGNS

A. Able to withstand 100 miles per hour wind load without damage:
   1. Manufacturers: One of the following or equal:
      a. Best Manufacturing Sign Systems; equivalent product.
      b. Andco Industries Corp., equivalent product.
      c. Vomar Products, Inc., equivalent product.

B. Sign panel: Nominal 3 inches thick, consisting of 1/8-inch thick fiberglass material with integral returns fully encapsulating wood and foam core, 1/8-inch radius edges and corners, size as indicated on the Drawings.

C. Text: Helvetica medium, size and wording as indicated on the Drawings.

D. Posts: Nominal 3 inch square extruded aluminum sections with aluminum fillers at top and bottom, mounting hardware, and aluminum baseplates drilled for anchor bolts.

E. Fasteners: Manufacturer's standard, suitable for application.

F. Colors: As selected from manufacturer's standard colors.

2.04 CAST METAL PLAQUE

A. Manufacturers: One of the following or equal:
   1. Andco Industries Corp.
   2. Southwell Co.
   3. ARK-RAMOS Inc.

B. Material: Cast bronze.

C. Size: Approximately 28 by 34 inches by minimum 3/16 inches thick; lettering, center panel, and trim raised 1/8 inch.

D. Lettering: Text as indicated on the Drawings. Verify before fabrication.

E. Finishes:
   1. Lettering, center panel, and trim: Fine satin.
   2. Background: Finely pebbled, oxidized to dull black color.

F. Mounting: Concealed with fasteners.

2.05 HAZARD MATERIAL SIGNALS

A. Manufacturer: One of the following or equal:
   1. Seton Name Plate Co.
   2. Emedco.

B. Hazard material signals: In accordance with NFPA 704; vinyl panels, letters, and symbols with pressure sensitive adhesive, sizes as required for viewing distances, letters and symbols in accordance with Attachment C - Hazard Material Signals.

2.06 CAST ALUMINUM LETTERS

A. Manufacturers:
   1. One of the following or equal:
      a. Metal Arts.
      b. Southwell Co.
      c. OMC Industries.

B. Material:
   1. Cast aluminum.

C. Text size and font:
   1. As indicated on the Drawings.

D. Finish:
   1. Black duranodic coating.

E. Mounting:
   1. Projected jamb nut mounting, concealed.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect adjacent surfaces which may be damaged by installation of signs.

B. Prepare substrates in accordance with sign manufacturer's instructions.

C. Remove scale, dirt, grease, and other contaminates from substrates.

3.02 INSTALLATION

A. Install signs in accordance with sign manufacturer's instructions.

B. Fasten signs securely in level, plumb, and true to plane positions.

C. Install signs where indicated on the Drawings or as indicated in the following Attachments.

END OF SECTION

ATTACHMENT A - PLASTIC SIGNAGE SYSTEM SCHEDULE

PLASTIC SIGNAGE SYSTEM SCHEDULE

A. Room Numbers:
   1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: As selected by the Engineer.
   5. Text: Room number as indicated on the Drawings.

B. Room Names:
   1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
   2. Height: 60 inches above floor to center or sign.
   3. Size: 6 inches square.
   4. Colors: As selected by Engineer.
   5. Text: Sign per door describing room function as indicated on the Drawings.

C. Stair Doors:
   1. Location: On wall outside room adjacent to latch side of doors or when not enough space on latch side, on nearest adjacent wall.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: As selected by Engineer.
   5. Pictogram: Means of egress indication.

D. Stair Landings:
   1. Location: At each floor landing in stairwells.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: As selected by Engineer.
   5. Text: Stair number, access or no access to roof to suit application, and floor level, as follows:

E. Fire Extinguishers:
   1. Location: Adjacent to fire extinguishers.
   2. Height: 60 inches above floor to center of sign.
   3. Size: 6 inches square.
   4. Colors: White letters on OSHA Red background.
   5. Text: FIRE EXTINGUISHER.

F. Nonpotable Water:
   1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: CAUTION
   5. Text: IMPURE WATER
DO NOT DRINK

G. Hazardous Materials Abatement:
   1. Location: At three locations as designated by Engineer.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 10 inches high.
   4. Heading: None
   5. Text: Lead and Asbestos have been mitigated in this area to meet OSHA requirements.
      Refer to JVWCD Project No. 4289 and the 2025 Hazardous Materials Report
   6. Graphic: Provide a graphic of the area where lead and asbestos were tested and/or mitigated. Coordinate graphic style and content with Engineer. This includes:
      a. Filter Area.
      b. PEA Area.
      c. PEC Area .

ATTACHMENT B - METAL SAFETY SIGN SCHEDULE

METAL SAFETY SIGN SCHEDULE

A. CHLORINATION AND SULFONATION EQUIPMENT:
   1. Location: Adjacent to exterior doors and gate of Chlorination-Dechlorination building.
   2. Height: 5 feet above finish floor.
   3. Size: 14 inches wide by 10 inches high.
   4. Heading: CAUTION
   5. Wording: CHLORINATION AND SULFONATION EQUIPMENT
      DANGEROUS GAS

B. CHLORINE OR SULFUR DIOXIDE GAS:
   1. Location: Outside of Chlorination-Dechlorination-Dechlorination Building next to air packs.
   2. Height: 5 feet above finish floor.
   3. Size: 20 inches wide by 14 inches high.
   4. Heading: CAUTION
   5. Wording: IN CASE OF EXPOSURE
      TO CHLORINE OR SULFUR DIOXIDE GAS
      OBTAIN BREATHING EQUIPMENT
      REMOVE VICTIM TO SAFE PLACE
      SEND FOR AMBULANCE

C. EMERGENCY EXIT:
   1. Location: Exterior side of Chlorination-Dechlorination Building doors.
   2. Height: 5 feet above finish floor.
   3. Size: 20 inches wide by 14 inches high
   4. Heading: DANGER
   5. Wording: BEFORE ENTERING
      TURN ON EXTERIOR VENTILATION
      AND LIGHT SWITCHES

      ALLOW BUILDING TO VENTILATE
      WAIT 5 MINUTES
      BEFORE ENTERING

      TWO PEOPLE MUST BE PRESENT
      WEAR SELF-CONTAINED AIR SYSTEM
      WHEN CHANGING OR MOVING CHLORINE CYLINDERS

D. NONPOTABLE WATER:
   1. Location: At impure water and nonpotable water hose valves in accordance with Typical Detail M276.
   2. Height: In accordance with Typical Detail.
   3. Size: 10 inches wide by 7 inches high.
   4. Heading: DANGER
   5. Wording: DO NOT DRINK THIS WATER

E. CHLORINE CONTAINMENT STRUCTURE:
   1. Location: On wall adjacent to latch side of doors within tow container storage rooms.
   2. Height: 5 feet above finish floor.
   3. Size: 10 inches by 14 inches.
   4. Heading: CAUTION
   5. Wording: CHLORINE CONTAINMENT STRUCTURE
      DO NOT PROP DOOR OPEN

F. CHLORINE GAS STORAGE:
   1. Location: On each exterior wall of Chlorine Storage Building.
   2. Height: 5 feet above finish floor.
   3. Size: 10 inches by 14 inches
   4. Heading DANGER
   5. Wording: TOXIC GAS

G. CHLORINE SCRUBBER EMERGENCY START BUTTON:
   1. Location: On wall adjacent to start button.
   2. Height: 5 feet above finish floor.
   3. Size: 10 inches by 14 inches.
   4. Heading: CAUTION
   5. Wording: CHLORINE SCRUBBER
      EMERGENCY START BUTTON

H. CHLORINE SCRUBBER REACTION TANK:
   1. Location: On chlorine scrubber reaction tanks.
   2. Height: 5 feet above finish floor.
   3. Size: 10 inches by 14 inches.
   4. Heading: CAUTION
   5. Wording: 25 PERCENT SODIUM HYDROXIDE
      DILUTE WITH SOFT WATER ONLY

I. SODIUM HYDROXIDE WARNING:
   1. Location: On chlorine scrubber reaction tank and on exterior wall of containment areas, sodium hydroxide storage tanks.
   2. Height: 5 feet above finish floor.
   3. Size: 10 inches by 14 inches.
   4. Heading: DANGER
   5. Wording: SODIUM HYDROXIDE
      CAUSES SEVERE BURNS

J. CHLORINE SCRUBBER STOP BUTTON:
   1. Location: On exterior wall of containment area, adjacent to stop button.
   2. Height: 5 feet above finish floor.
   3. Size: 10 inches by 14 inches.
   4. Heading: CAUTION
   5. Wording: CHLORINE SCRUBBER
      STOP BUTTON

K. REMOTELY CONTROLLED AUTOMATIC EQUIPMENT:

1. Location: On front and back of equipment that starts automatically by remote control.
2. Height: As directed by Engineer.
3. Size: 10 inches by 14 inches.
4. Heading: DANGER
5. Wording: THIS EQUIPMENT STARTS AUTOMATICALLY
   BY REMOTE CONTROL

L. HIGH VOLTAGE WARNING:
1. Location: On front and back of equipment, adjacent to doors to rooms containing devices, and devices that operate at 600 volts or greater.
2. Height: 5 feet above finish floor.
3. Size: 10 inches by 14 inches.
4. Heading: DANGER
5. Wording: HIGH VOLTAGE
   KEEP OUT

M. NO SMOKING INFORMATIONAL SIGNS:
1. Location: On exterior face of wall, adjacent to each entry point (exterior door) to all buildings.
2. Height: 60 inches above floor to center of sign. Where metal safety signs are also located adjacent to entry points, place no smoking signs below these signs.
3. Size: 6 inches square.
4. Heading: None.
5. Wording: None.
6. Pictogram: International “No Smoking” symbol.

N. NO SMOKING WITHIN 25 FEET OF BUILDING ENTRY:
1. Location: As indicated on the Drawings.
2. Height: Pole mounted with top of sign at 5 feet above grade.
3. Size: 14 inches wide by 10 inches high.
4. Heading: NOTICE
5. Wording: NO SMOKING WITHIN 25 FEET OF BUILDING.
6. Pictogram: International “No Smoking” symbol.

O. ACCESSIBLE PARKING SIGN (POST MOUNTED AND REFLECTORIZED):
1. Location: Centered on the parking space reserved for persons with disabilities in accordance with UBC 1129B5.
2. Height: 60 inches from the bottom of sign to parking space finished grade, in accordance with UBC 1129B5.
3. Size: Not smaller than 70 square inches.
4. Wording: As required to suit local regulations.
5. Pictogram: Symbol of accessibility in white on dark blue.

ATTACHMENT C - HAZARD MATERIAL SIGNALS

HAZARD MATERIAL SIGNALS

A. HAZARD SIGNAL FOR SODIUM HYDROXIDE (CAUSTIC SODA) 50 PERCENT:
   1. Location: At entrances to locations where stored and on storage tanks.
   2. Height: As directed by Engineer.
   3. View Distance: Up to 11 feet 0 inches.
   4. Health: 3
   5. Flammability: 0
   6. Reactivity: 0
   7. Special: COR

B. HAZARD SIGNAL FOR CHLORINE GAS:
   1. Location: At entrances to locations where stored and on storage tanks.
   2. Height: As directed by Engineer.
   3. View Distance: Up to 11 feet 0 inches.
   4. Health: 4
   5. Flammability: 0
   6. Reactivity: 0
   7. Special: OX

SECTION 10401

SAFETY EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Safety equipment.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME).

B. National Fire Protection Association.

C. National Institute for Occupational Safety and Health (NIOSH):
   1. Schedule 13F - Self-Contained Breathing Apparatus (SCBA).

D. Occupational Safety and Health Administration (OSHA).

E. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Shop drawings.

B. Product data:
   1. Submit manufacturer's product literature information for products specified.
   2. Manufacturer's installation instructions.

C. Samples.

D. Operation and maintenance data.

E. Operating and maintenance information for safety detectors and breathing apparatus: 6 complete sets.

F. Warranty.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Show evidence that the firm has been engaged in producing such materials and products for at least 5 years and that the product submitted has a satisfactory performance record of at least 5 years.

B. Installer qualifications: Installer shall have 3 years' experience in installing these materials for similar projects and shall be approved by the manufacturer prior to bidding of the project.

C. Regulatory requirements: As applicable, equipment of this Section shall comply with requirements of public agencies of the state where the project is located, including OSHAULNFPAASMEU.S. Coast Guard.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver to the job site in manufacturer's original containers.

B. Delivery: After wet operations in building are completed.

C. Storage and protection: Store materials in original, unopened containers in compliance with manufacturer's printed instructions.

D. Keep materials dry until ready for use.

E. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.

F. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS

2.01 FIRE BLANKET KIT

A. Manufacturers: One of the following or equal:
   1. VWR Scientific, No. 56611-202.
   2. Fire Safety Source, M2FBCBR.

B. Features/characteristics:
   1. Blanket: Roller-type, fireproofed, nominal 62 by 84 inches.
   2. Case: Wall mounted, metal or ABS, if, no latch.

2.02 FIRST AID KIT

A. Manufacturers: One of the following or equal:
   1. VWR Scientific, 56613-216.
   2. Fire Safety Source, 223UFAO.

B. Features/characteristics:
   1. Prefinished, wall-mounted metal cabinet.
   2. Standard medical supplies capable of serving up to 25 people.
   3. Meets OSHA requirements.

2.03 EMERGENCY REPAIR KITS

A. Chlorine Institute Emergency Kit B.

B. Features/characteristics:
   1. Repair kit for 1-ton containers.
   2. Instructions.

3. Metal footlocker container.

2.04 SAFETY ROPE

A. Manufacturers: One of the following or equal:
   1. Mine Safety Appliances Co.
   2. California Safety.

B. Characteristics:
   1. Diameter: 9/16-inch.
   2. Length: 50 feet.
   3. Accessories: Snap hook on one end.

2.05 LIFE PRESERVER

A. Characteristics:
   1. Doughnut-shaped.
   2. Diameter: 30 inches.
   3. U.S. Coast Guard approved.

B. Accessories:
   1. Mounting brackets.
   2. U.S. Coast Guard approved poly-Dacron rope:
      a. Length: 90 feet.

2.06 SELF-CONTAINED BREATHING APPARATUS

A. General: Approved by NIOSH Schedule 13F.

B. Manufacturers: One of the following or equal:
   1. Mine Safety Appliances Co., Model Air Hawk II.
   2. Scott Health and Safety, Airpak 50I SCBA.

C. Quantity of Complete Self-Contained Breathing Apparatus: 2.

D. Air cylinders:
   1. Number per breathing apparatus: 2.
   2. Capacity: Suitable for 30 minute air supply each.
   3. Pressure: 2,200 pounds per square inch gauge.
   4. Type: Composite.
   5. Connections: Air-pressure gauge and 1-way nonslip cylinder valve handle.

E. Case:
   1. Type:
      a. Weatherproof.
      b. Weather-resistant not acceptable.
   2. Mounting: Exterior wall.
   3. Finish: Safety Green paint finish.

F. Harness: Nylon with shoulder pads, back plate, and stainless steel cylinder clamp.

G. Hose leading to demand regulator, attached to cylinder valve: Neoprene-covered, high-pressure.

H. Demand regulator: 2-stage, with radial dial air pressure gauge and cross-thread proof, quick connect coupling, main line valve and emergency bypass valve.

I. Breathing tube material: Natural rubber.

J. Facepieces:
   1. Manufacturers: One of the following or equal:
      a. Mine Safety Appliance Co., Advantage 4000.
      b. Scott Health and Safety, AV 3000.
   2. Masks: With positive pressure to face mask feature.
   3. Material: Natural rubber.
   4. Lenses:
      a. 1-piece, panoramic safety resin lens.
   5. Facepiece harness: With roller-type, quick-release buckles, and 5 or 6 straps.
   6. Accessories:
      a. Free-flowing exhalation valve.
      b. Speaking diaphragm.

K. Exposed metal finishes: Corrosion-resistant.

L. Safety precautions sign: Manufacturer's standard.

2.07 DEMAND WORK MASK APPARATUS

A. General: Approved by and NIOSH Schedule 13F.

B. Manufacturers: One of the following or equal:
   1. Mine Safety Appliances Co., PremAire Cadet Escape.
   2. Scott Health and Safety, SKA PAK Plus.

C. Quantity of Complete Self-Contained Breathing Apparatus: 2.

D. Air cylinders:
   1. Number per breathing apparatus: 2.
   2. Capacity: 300 cubic feet.
   3. Pressure: 2,400 pounds per square inch gauge.
   4. Connections: Air-pressure gauge and 1-way nonslip cylinder valve handle.

E. Cases:
   1. Type:
      a. Weatherproof.
      b. Weather-resistant not acceptable.
   2. Mounting: Exterior wall.
   3. Finish: Safety Green paint finish.

F. Harness: Nylon.

G. Air supply: 5-minute air cylinder with valve along with demand work mask, complete with clearview facepiece and speaking diaphragm, demand regulator and harness.

H. Pressure reducer: With gauges for attachment to large cylinder with 4 man capacity per unit.

I. Connecting hoses: Four 25-foot long with quick disconnect couplings.

J. Demand regulator: 2-stage, with radial dial air pressure gauge and cross-thread-proof, stainless steel snap-tite quick connect coupling.

K. Breathing tube material: Natural Rubber.

L. Facepiece:
   1. Masks: With positive pressure to face mask feature.
      a. Material: Natural Rubber:
   2. Lenses:
      a. 1-piece, panoramic safety resin lens.
   3. Facepiece harness: With roller-type, quick-release buckles, and 5 or 6 straps.
   4. Accessories:
      a. Free-flowing exhalation valve.
      b. Speaking diaphragm.

2.08 CHEMICAL HANDLING SAFETY EQUIPMENT

A. Personal Protective Equipment (PPE) Stock:
   1. Chemical exposure: 35 percent hydrogen peroxide.
   2. Gloves:
      a. Manufacturer: The following or equal:
         1) Showa.
      b. Material: Neoprene over natural rubber and cotton flock lined.
      c. Length: 12 inches.
      d. Size and quantity:
         1) Small: 2 pairs.
         2) Medium: 2 pairs.
         3) Large: 2 pairs.
         4) Extra large: 2 pairs.
   3. Chemical protective suit:
      a. Manufacturer: The following or equal:
         1) Kleenguard.
      b. Material: 1.5 mil polyethylene-coated fabric.
      c. Size and quantity:
         1) Small: 2 suits.
         2) Medium: 2 suits.
         3) Large: 2 suits.
         4) Extra large: 2 suits.
   4. Chemical goggles:
      a. Manufacturer: The following or equal:
         1) Honeywell, UVEX.
      b. Soft elastomer seal and nose bridge.
      c. Clear, anti-fog lens.

d. Wrap around design for gap-free fit.
e. Custom fit neoprene headband.
f. Size and quantity:
1) Adult: 2 pairs.

5. Face shield (without hard hat):
a. Manufacturer: The following or equal:
1) Jackson Safety, Model 14955.
b. Nylon single crown with a ratchet adjustment suspension system.
c. Window material: Clear acetate.
d. Quantity: 2 shields.

6. Face shield (with hard hat):
a. Frame:
1) Manufacturer: The following or equal:
a) Jackson Safety, Model 14390C.
2) Attaches to a hard hat.
b. Replacement face shield:
1) Manufacturer: The following or equal:
a) ERB.
2) Material: Polycarbonate.
3) Quantity: 2 shields.

7. Chemical boots (PVC):
a. Manufacturer: The following or equal:
1) Servus Comfort Technology.
b. Material:
1) PVC polyblend injection molded construction.
2) Waterproof.
c. Height: 14 inches.
d. Size and quantity:
1) 10: 2 pairs.
2) 11: 2 pairs.

8. Small spill kit: Hazmat-10-Gallon-Spill Kit:
a. Manufacturer: The following or equal:
1) SpillTech.

B. Personal Protective Equipment (PPE) Storage Cabinets:
1. Manufacturer: The following or equal:
a. Grainger.
2. Pre-assembled.
3. Size: As directed by Owner.
4. Material: Steel.
5. Configuration:
a. Stationary with raised legs, combination shelving/wardrobe.
6. Personal Protective Equipment (PPE) Cabinet Signage:
a. Manufacturer: The following or equal:
1) J.J. Keller & Associates, Inc.
b. Yellow sign with black letters “PPE Supply Station”.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products and fixed equipment in accordance with manufacturers' recommendations.

B. Post safety precautions sign adjacent to breathing apparatus masks.

C. Coordinate delivery and installation of chemical handling safety equipment.

D. Replace any equipment found defective with new.

END OF SECTION

SECTION 10520

FIRE PROTECTION SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fire extinguishers and cabinets.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E814-11a - Standard Test Method for Fire Tests of Penetration Firestop Systems.

B. National Fire Protection Association (NFPA):
   1. 10 - Standard for Portable Fire Extinguishers.

C. Underwriters Laboratories, Inc. (UL):
   1. 711 - Rating and Fire Testing of Fire Extinguishers.

1.03 SUBMITTALS

A. Product data.
   1. Cabinets: Materials description for fire extinguisher cabinets include roughing-in dimensions, details showing mounting methods, relationships to surrounding construction, door hardware cabinet type and materials, trim style and door construction, door style and materials.
   2. Extinguishers: Materials description for fire extinguishers; include ratings and classifications.
   3. Installation instructions for each product specified.

B. Shop drawings:
   1. Small-scale plans showing locations of fire extinguisher cabinets and individual fire extinguishers.
   2. Schedule showing each type of cabinet and extinguisher to ensure proper fit and function.
   3. Indicate installation procedures and accessories required for a complete installation.

C. Samples:

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Minimum 5 years with satisfactory performance record.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following or equal:
   1. Activar Construction Products Group - JL Industries.

2.02 FIRE EXTINGUISHERS

A. Multi-purpose chemical type:
   1. Extinguisher unit containing a fluidized and siliconized mono ammonium phosphate powder; nonconductive and nontoxic.
   2. Construction: Heavy duty steel cylinder with metal valve and siphon tube, o-ring seal, replaceable valve stem seal, visual pressure gage, pull pin and upright squeeze grip.
   3. Finish: Factory powder-coated: Red.
   4. UL Effectiveness Rating in accordance with UL 711: Class A, B, and C fires.
   5. UL Rating in accordance with UL 711: 10A-120BC.
   6. Drawing will use the symbol FE for “Fire Extinguisher.”

B. Regular dry chemical type:
   1. Extinguisher unit containing Halotron™.
   2. Size minimum: 11 pounds.
   3. Construction: Heavy duty steel cylinder with metal valve and siphon tube, o-ring seal, replaceable valve stem seal, visual pressure gage, pull pin, and upright squeeze grip.
   4. Finish: Factory powder-coated; Red.
   5. UL Effectiveness Rating in accordance with UL 711: Class B and C fires.
   6. UL Rating in accordance with UL 711: 2A-10BC.
   7. Drawing will use the symbol EFE for “Electrical Fire Extinguisher.”

2.03 WALL BRACKETS

A. Type: Standard as manufactured by fire extinguisher manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance NFPA 10, Standard for Portable Fire Extinguishers.

3.02 LOCATIONS

A. Install fire extinguisher type, FE and FXE, as indicated on the Drawings.

END OF SECTION

SECTION 11242

LIQUID CHEMICAL DIAPHRAGM-TYPE METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Positive displacement, diaphragm metering pumps; accessories, drives, and control panel requirements for pumping chemical solutions.

B. Tag numbers:
   1. As specified in Pump Schedule.

1.02 REFERENCES

A. Instrumentation Controls Specialty Contractor (ICSC).

B. International Society of Automation (ISA):
   1. ISA5.4 - Instrument Loop Diagrams.

C. National Electrical Code (NEC).

D. National Electrical Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

E. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

F. Underwriters Laboratories, Inc. (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.
   3. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
   4. 1283 - Standard for Electromagnetic Interference Filters.
   5. 1449 - Surge Protective Devices.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
    1. Design data, test reports, certificates, manufacturer's instructions, manufacturer's field reports:
        a. Chemical feed pumps:
            1) Submit calculations for each metering pump showing the suitability of each pump for the suction and discharge conditions of each application point.
                a) Pump manufacturer shall recommend and size an accumulator to be piped to the suction side of each metering pump, when required based on calculations.
            2) Submit calculations recommending dimensions of pulsation dampener indicated on the Drawings.

C. Shop drawings: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
    1. Provide a list of parameters, ratings, or other characteristics where the proposed chemical feed systems deviate from the requirements.
    2. Dimensions, including anchor bolt layout, materials of construction, size, weight, and performance data.
    3. Drawings: Provide electrical and instrumentation drawings showing coordination with electrical control devices operating in conjunction with the associated feed system.
    4. Dimensioned inlet and outlet connections.
    5. Current NSF 61 Certification for components to be in contact with associated chemical or potable water.
    6. Provide data showing chemical compatibility and history of service with the associated chemical for materials in the system.
    7. Manufacturer's certificate stating that the materials of construction are compatible with the pumped fluid.
    8. Calibration curves for each pump relating stroke length to flow rate shall be supplied.
    9. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.

D. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
    1. For each pump type, submit calibration charts and tables relating flow rate to speed.
    2. Submit calculations for each metering pump showing the suitability of each pump for the suction and discharge conditions of each application point. Pump manufacturer shall recommend and size an accumulator to be piped to the suction side of each metering pump, when required based on calculations.
    3. Calibration curves for each pump relating speed to flow rate shall be supplied.
        a. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.

E. Vendor operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete pump and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.
   4. Provide information on each piece of equipment, including instrumentation.
   5. Provide all safety considerations relating to operations and handling of the associated chemical.
   6. Maintenance data shall include all information and instructions required by plant personnel to keep equipment properly cleaned, lubricated, and adjusted so that it functions economically throughout its full design life.
   7. Lubrication charts and tables of alternate lubricants.
   8. Name, address, and phone number of manufacturer and manufacturer's local service representative.

F. Commissioning submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer's representative qualifications.
      b. Certificates.
         1) Requirements as specified in this Section.
      c. Test Plans.
         1) Test requirements as specified in this Section.
      d. Test Reports.
      e. Manufacturer's representatives field notes and data.
      f. Owner training.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

B. Special warranty:
   1. Provide an additional 1-year manufacturer's warranty, issued in the name of the Owner, for all equipment provided under this Section.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packing, shipping, handling and unloading:
   1. Pack for shipping and outdoor storage at the project site for up to 6 months.
      a. Apply temporary corrosion protective coatings to unpainted components and pack components to protect from the elements.
   2. Ship pump and drive completely assembled.

PART 2 PRODUCTS

2.01 GENERAL

A. A single pump manufacturer shall furnish and coordinate all pump components specified in this Section.

B. The manufacturer of the pumps shall have sole-source responsibility for furnishing the complete assemblies and meeting the specified performance requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General: Provide mechanically actuated, positive displacement, diaphragm type chemical metering pumps, accessories, and other items required for a complete and operational system. Each chemical metering pump system shall include, but not be limited to, the following items, which shall be supplied by the chemical metering pump manufacturer.
   1. Pumps.
   2. Motors.
   3. Variable speed drive (VSD).
   4. Calibration columns.
   5. External pressure relief valves.
   6. Diaphragm back pressure valves.

B. Fluid characteristics:
   1. Aluminum Chlorohydrate (solution):
      a. Dry chemical formula: $Al_2(OH)_5Cl$.
      b. Solution concentration: 100 percent by weight.
      c. Solution pH: 7 to 8.
      d. Solution specific gravity: 1.3 to 1.35.
   2. Sodium hydroxide (Caustic Soda):
      a. Dry chemical formula: NaOH.
      b. Solution concentration: 25 or 50 percent by weight.
      c. Solution pH: 14.
      d. Solution specific gravity: 1.28 or 1.53.
   3. An/Nonionic polymer (PEA):
      a. Solution concentration: 0.2 percent by weight (batched).
      b. Solution pH: 8.
      c. Solution specific gravity: 1.05.

C. Design requirements:
   1. Pump:
      a. Dry self-priming, capable of being run dry without damaging effects to pump.
   2. Motor characteristics:
      a. As specified in this Section and in Section 16222 - Low Voltage Motors up to 500 Horsepower.
   3. VSD characteristics: As specified in this Section.

D. Performance requirements:
   1. Systems shall deliver the pressures and volumes listed for their respective services in the Pump Schedule.

E. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 PUMPS

A. Existing products:
   1. Existing facility has Grundfos DDA 200 brand pumps.
   2. New pumps must match style, material, finish, operation, and dimensions.

B. Equipment:
   1. Pump:
      a. Manufacturers: One of the following, no equal:
         1) Grundfos, DDA 200-4 AR-PVC/V/C-F-31A7A7BG.
   2. Type: mechanically actuated diaphragm, positive displacement, motor driven, metering pump.
   3. Materials:
      a. The metering pumps and their components and accessories shall be suitable for the following chemical concentrations, as scheduled in this Section:
         1) Aluminum chlorohydrate (ACH):
            a) Wetted parts shall be suitable for use with 100 percent aluminum chlorohydrate solution.
            b) Other non-specified materials are to be manufacturer's standard for continuous service with 100 percent aluminum chlorohydrate solution.
         2) Sodium hydroxide (Caustic Soda):
            a) Wetted parts shall be suitable for use with 25 to 50 percent sodium hydroxide solution.
            b) Other non-specified materials are to be manufacturer's standard for continuous service with 25 to 50 percent sodium hydroxide solution.
         3) An/Nonionic polymer (PEA):
            a) Wetted parts shall be suitable for use with up to 0.4 percent by weight (batched) solution.
            b) Other non-specified materials are to be manufacturer's standard for continuous service with PEA solution.
   4. Description:
      a. Chemical metering pump shall be driven by a microprocessor controlled PMSM (Permanent Magnet Synchronous Motor) providing a minimum of 800:1 turndown ratio. The PMSM is to be coupled to a flat, PTFE diaphragm via a gear assembly. The drive assembly shall be a maintenance free design.
      b. The pump shall operate at 100% stroke length throughout the pumps entire capacity range.
      c. Repeatable metering accuracy shall be ±1.5% of set point plus 0.1% full scale at constant hydraulic conditions throughout the entire output range.

d. Solenoid-driven pumps, hydraulically actuated diaphragm pumps and those with a lost motion spring return will not be accepted

5. Accessories: As indicated on the Drawings, pumps shall be equipped with:
   a. Calibration column in suction piping.
   b. Diaphragm backpressure, and pressure relief valve in discharge piping.
6. Tests and inspections:
   a. As scheduled in this Section.
7. Verification of performance.

2.04 COMPONENTS

A. Enclosure:
1. Drive mechanism and microprocessor shall be housed in a corrosion resistant, plastic UV stabilized enclosure.
2. The pump design shall include provisions for optional positioning of the control interface/display, for right/left side and front mounting.
3. Pump enclosure rating shall be to IP65 and NEMA 4X standards.
4. The pump design shall include an integral removable click stop mounting plate, to allow for flat base mounting.

B. Liquid End:
1. The process diaphragm shall be PTFE. PTFE coated diaphragms are not
2. acceptable.
3. Head and valves body material shall be PVC plastic with Ceramic ball material.
4. Wetted gasket material shall be FKM.
5. Suction and discharge valve design shall incorporate single ball arrangement. Direction of flow shall be clearly marked on each check valve to ensure correct installation.
6. Head design shall incorporate integral priming valve.
7. A back-plate with separation chamber shall have a safety diaphragm and drain hole

2.05 DRIVE

A. Type:
1. An integral variable speed PMSM shall be used to ensure the pump discharge phase extends throughout the full period between suction intervals.
2. External variable frequency drives shall not be accepted.
3. The drive shall have 800:1 constant torque speed range.
4. The drive shall respond automatically to a remote setpoint speed signal (4-20 mA). The drive shall provide a 4-20 mA speed signal output proportional to pump output for remote indication. The speed signal output shall be measured independently of the remote setpoint speed signal. The drive shall also receive a remote start/stop signal and provide discrete signals for pump, failure alarm, diaphragm leak alarm, speed indication, and run indication. The manufacturer shall furnish required additional components for the drive to function as described herein and shown on the Drawings.
5. The motor shall have TEFC enclosure with horsepower of not less than the minimum specified rating.

B. Pumps must meet the following minimum requirements for operator interface functionality:
   1. User interface/display shall be backlit LCD with selectable on-site positioning for either side or front mounting.
   2. Keypad for start, stop, speed increment, speed decrement, forward/reverse direction, rapid prime, and programming.
   3. Menu driven on screen programming of manual or auto control, flow and remote signal calibration, and general programming.
   4. Programmable “Auto Restart” feature to resume pump status in the event of power outage interruption.
   5. Programmable “Keypad Lock” to allow operator lockout of all keys except emergency start/stop.
   6. Programmable “Maximum Speed” to allow operator to set the maximum speed of the pump within the revolutions per minute (rpm) as scheduled.

C. Characteristics:
   1. Provide motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower and the Pump Schedule.
   2. Supply: Supply mains power cord at least 5 feet in length with standard 115 volt 3-prong plug.
   3. Max drive power consumption: 135 VA.

D. Monitoring and control:
   1. Provide the following connections to the plant control system for each pump:
      a. Speed setpoint: 4-20 mA.
      b. Speed feedback: 4-20 mA.
      c. Stroke position 4-20 mA.
      d. REMOTE status dry contact.
      e. RUN status dry contact.
      f. LEAK alarm dry contact.
      g. FAILURE alarm dry contact.
      h. Pump Run Command.

2.06 ACCESSORIES

A. Calibration columns:
   1. Materials:
      a. Materials shall be compatible with the pumped liquid and concentration specified in this Section, and suitable for outdoor use and exposure.
   2. Characteristics:
      a. Furnish and install calibration columns, 1 for each chemical metering pump, on each chemical pump’s inlet line as indicated on the Drawings and specified in this Section.
         1) Columns shall be translucent.
      b. Provide top cap threaded connection with vent piped to floor to prevent entry of foreign materials and to direct spillage or overflow.
      c. End connections shall be threaded.
      d. Capacities and graduations shall be as indicated in the schedule in this Section.

B. Diaphragm backpressure and pressure relief valves:
   1. As specified in Section 15118 - Pressure Reducing and Pressure Relief Valves.
   2. Manufacturers: One of the following or equal:
      a. Wallace and Tiernan.
      b. Pulsafeeder.
      c. Griffco.
      d. Milton Roy Co.
   3. Materials:
      a. Valves shall be of suitable materials for the pumped liquid.
   4. Characteristics:
      a. Ported to serve as either a backpressure valve or a pressure relief valve.
      b. Relief valve shall be plumbed to the nearest chemical drain, or back to the pump suction on the non-pump side of the pump suction isolation valve, to avoid spillage, as indicated on the Drawings.
      c. Valves shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings and scheduled in this Section.
      d. Valves shall have an adjustable spring range of 15-50 pounds per square inch. Valves shall be factory adjusted for the backpressure recommended by the pump manufacturer.
      e. Valves shall produce a back pressure no greater than 10 pounds per square inch above valve set pressure when metering pumps are operating at full capacity, pulsating flow.

C. Pressure relief valves:
   1. Furnish and install pressure relief valves on each chemical metering pump's discharge line as indicated on the Drawings.
   2. Materials:
      a. Wetted materials shall be compatible with the pumped liquid.
   3. Characteristics:
      a. Valves shall have an adjustable spring range of 15-50 pounds per square inch. Valves shall be factory adjusted for the relief pressure recommended by the pump manufacturer.

D. Additional accessories:
   1. Additional accessories required for the system but not required to be supplied by the pump manufacturer include:
      a. Diaphragm seals as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals, except as modified in this Section:
         1) Materials shall be compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.
      b. Pressure switches as specified in Section 17403 - Pressure/Vacuum Measurement: Switches.
      c. Pressure gauges as specified in Section 17404 - Pressure/Vacuum Measurement: Gauges.
      d. Isolation valves as specified in Section 15111 - Ball Valves for suction and discharge piping as indicated on the Drawings.

2.07 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts: Furnish the following spare parts packed and labeled for warehouse storage:
   1. One complete spare parts kit for each pump provided.
   2. One spare parts kit for each size and type of backpressure and pressure relief valve.

B. Vendor to provide spare parts that are required to provide uninterrupted operation for a minimum of 2 years.

C. Additional spare part requirements as specified in the Contract Documents.

D. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

PART 3 EXECUTION

3.01 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.

C. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. As scheduled.
   2. System testing:
      a. As specified in Section 01756 - Commissioning
   3. Furnish Manufacturer's Certificate of Functional Compliance.

E. Owner Training:
   1. Not required.

3.02 SCHEDULES

A. Pumps:

Tag Number	**PMP-6211** **PMP-6221**	**PMP-6541** **PMP-6562**	**PMP-6911** **PMP-6916** **PMP-6956**
Feed Point	Rapid Mix	Clearwell	North Filter Influent Channel South Filter Influent Channel Individual Filter
Service	Aluminum Chlorohydrate (ACH)	Sodium Hydroxide (Caustic Soda)	Anionic Polymer – Filter Aid
Pump Type	Digital Diaphragm	Digital Diaphragm	Digital Diaphragm
Number of Pumps	2	2	3
Named Manufacturer	Grundfos	Grundfos	Grundfos
Rotodynamic Analysis	Not Required	Not Required	Not Required
Pump Characteristics			
Design Conditions:			
Maximum Flow, (gallons per hour)	52	52	52
Minimum Flow, (gallons per hour)	0.7	0.7	0.7
Normal Flow, (gallons per hour)	23	30	24
Maximum Discharge Pressure (psig)	60	60	60
Minimum Suction Lift (feet)	10	10	10
Relief Valve Setting (psig)	30	30	25
Pump Materials			
Pump Housing/Enclosure	See 2.04	See 2.04	See 2.04
Diaphragm	See 2.04	See 2.04	See 2.04
Pump Housing Support	See 2.04	See 2.04	See 2.04
Pump Connections	See 2.04	See 2.04	See 2.04
Driver Characteristics			
Driver Type	Motor with VSD	Motor with VSD	Motor with VSD

Tag Number	PMP-6211 PMP-6221	PMP-6541 PMP-6562	PMP-6911 PMP-6916 PMP-6956
Source Testing			
Performance Test Level	1	1	1
Vibration Test Level	None	None	None
Noise Test Level	None	None	None
Functional Testing			
Performance Test Level	1	1	1
Vibration Test Level	None	None	None
Noise Test Level	None	None	None

1. Provide pumps that deliver the maximum capacity, listed in the above table, when at full speed and maximum stroke length.

B. Calibration columns:

Tag Number	Service	Graduation Volume (ml)	Graduation Scale (ml)
	ACH	3,000	100
	Caustic Soda	3,000	100
	PEA – Filter Aid	2,000	10

C. Backpressure valves:

Tag Number	Service	Spring Range	Minimum Backpressure
	ACH	0 - 50 psi	20 psi
	Caustic Soda	0 - 50 psi	20 psi
	PEA – Filter Aid	0 - 50 psi	20 psi

D. Pressure relief valves:

Tag Number	Service	Spring Range	Relief Pressure (factory setting)
	ACH	0 - 50 psi	30 psi
	Caustic Soda	0 - 50 psi	30 psi
	PEA – Filter Aid	0 – 50 psi	30 psi

END OF SECTION

SECTION 11244

LIQUID CHEMICAL PERISTALTIC HOSE METERING PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Positive displacement peristaltic hose pumps complete with drives, controls, and features specified and scheduled in this Section.
   2. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

A. National Electrical Manufacturer's Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

B. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01600 - Product Requirements.

B. Product data:
   1. Provide a list of parameters, ratings, or other characteristics where the proposed chemical feed systems deviate from the requirements.
   2. Current NSF 61 Certification for components to be in contact with associated chemical or potable water.
   3. Provide data showing chemical compatibility and history of service with the associated chemical for materials in the system.
   4. Vendor control panel components.

C. Shop Drawings:
   1. Dimensions, including anchoring layout, materials of construction, size, weight, and performance data.
   2. Drawings: Provide electrical and instrumentation drawings showing coordination with electrical control devices operating in conjunction with the associated feed system.
   3. Dimensioned inlet and outlet connections.

4. Motor and VFD supplier shall carefully review the intended application of the VFD and certify in writing that sizes provided are adequate for continuous or intermittent operations (whichever is the most severe operating condition).
5. Control panel:
    a. Wiring schematics and control panel layouts:
        1) Scaled exterior front and side elevations with dimensional information.
        2) Scaled interior panel layout showing all components coordinated with the bill of materials.
        3) Bill of materials with detailed description of components.
        4) Wiring schematics including wire numbers and terminal numbers.
        5) Single-line diagram of power distribution.
        6) Control wiring, control logic, and instrumentation.

D. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
    a. To structures for control panels installed in structures designated as seismic design category C, D, E, or F.

E. Calculations:
1. For each pump type, submit calibration charts and tables relating flow rate to speed.
2. Submit calculations for each metering pump showing the suitability of each pump for the suction and discharge conditions of each application point.
    a. Pump manufacturer shall recommend and size an accumulator to be piped to the suction side of each metering pump, when required based on calculations.
3. Submit calculations recommending dimensions of pulsation dampener indicated on the Drawings.
4. Calibration curves for each pump relating speed to flow rate shall be supplied.
    a. Capacity control shall be 0 to 100 percent with delivery repeatable within plus or minus 1 percent accuracy over at least a 10 to 1 range.

F. Vendor operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.
2. Include a list of configurable parameters and the final values for each.
3. Include a troubleshooting chart covering the complete pump and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

G. Commissioning Submittals:
1. As specified in Section 01756 - Commissioning, including the following:
    a. Manufacturer’s representative qualifications.
    b. Certificates.
        1) Requirements as specified in this Section.
    c. Test Plans.
        1) Test requirements as specified in this Section.
    d. Test Reports.
    e. Manufacturer’s representatives field notes and data.

f. Owner training.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing, shipping, handling and unloading:
   1. Pack for shipping and outdoor storage at the project site for up to 6 months.
   2. Apply temporary corrosion protective coatings to unpainted components and pack components to protect from the elements.
   3. Ship pump and drive completely assembled.
   4. Ship hose element separately for field installation and process line connection by Contractor.

1.06 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

B. Manufacturers Special Warranty:
   1. Provide an additional 1-year manufacturer's warranty, issued in the name of the Owner, for all equipment provided under this Section.

PART 2 PRODUCTS

2.01 GENERAL

A. A single pump manufacturer shall furnish and coordinate all drives and pump components specified in this Section, including motors, gears, couplings, supports, and other specified accessories and appurtenances to ensure compatibility and integrity of the individual components.

B. The manufacturer of the pumps shall have sole-source responsibility for furnishing the complete assemblies and meeting the specified performance requirements.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General:
   1. Provide positive displacement, peristaltic hose type chemical metering pumps; accessories, and other items required for a complete and operational system.
   2. Each chemical metering pump system shall include, but not be limited to, the following items, which shall be supplied by the chemical metering pump manufacturer:
      a. Pumps.
      b. Motors.
      c. Variable speed drives.
      d. Calibration columns.
      e. External pressure relief valves.

B. Fluid characteristics:
   1. An/nonionic polymer (PEA):
      a. Solution concentration: 0.2 percent by weight (batched).
      b. Solution pH: 8.

c. Solution specific gravity: 1.05.

2. Sodium Hydroxide (Caustic Soda):
   a. Dry chemical formula: NaOH.
   b. Solution concentration: 25 to 50 percent by weight.
   c. Solution pH: 14.
   d. Solution specific gravity: 1.28 to 1.53.

C. Design requirements:
1. Check valves and seals:
   a. Check valves and diaphragms are not permitted.
   b. Dynamic seals in contact with the pumped liquid are not permitted.
   c. Pumped liquid shall be contained within pump hose or tubing and shall not directly contact any rotary or metallic components.
2. Pumps:
   a. Dry self-priming, capable of being run dry without damaging effects to pump or tube.
   b. Maximum suction lift capability of up to 30 feet vertical water column.
   c. Maximum pressure rating of 100 pounds per square inch.
   d. Flow shall be proportional to rotor speed and reversible in direction.
   e. Shafting and couplings: Design shafting and couplings to withstand a minimum of 1.5 times the maximum operating torque or other imposed loads.
   f. Supports:
      1) Provide pump and driver factory-mounted on a common base.
      2) Design anchor bolts to withstand a minimum of 1.5 times the maximum imposed operating loads or 1.0 times the imposed seismic loads, whichever is greater.
3. Pump performance characteristics: As specified in Pump Schedule in this Section.
4. Motor characteristics: As specified in this Section and in Section 16222 - Low Voltage Motors up to 500 Horsepower.

D. Performance requirements:
1. Systems shall deliver the pressures and volumes listed for their respective services in the Pump Schedule.

E. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 PUMPS

A. Pump manufacturers: One of the following or equal:
1. Watson-Marlow Bredel Pumps, model series as scheduled.
2. Verderflex, model series as scheduled.

B. Type: Simplex chemical proportioning pumps of the peristaltic hose type.

C. Features:
1. Fixed track providing 180 degrees of contact with hose.

2. Guard door of a removable or hinged, breakaway design that provides a clear window for viewing rotor rotation.
    a. Guard door shall be tool-unlockable, and seal against the track or housing to contain leakage from hose failure for direction to a waste port.
3. Rotor assembly having a minimum of 2 equally spaced, spring-loaded roller/shoe arms that provide complete occlusion through a swept track angle of 180 degrees.
    a. Compression rollers/shoes shall provide gradual occlusion of the hose and compensate for hose dimensional tolerance.
    b. Hose shall be fully compressed at all times by a minimum of 1 roller/shoe to prevent backflow.
    c. Spring tension shall be factory set for specified fluid and Manufacturer's recommended hose.
    d. Rotor shall include non-compressing guide rollers/shoes.
4. Manually-activated clutch and central handgrip hub to disengage drive when replacing hose.
    a. Clutch shall automatically reengage rotor to drive upon 1 complete revolution.
5. Other required features are a waste port for leak control, and a system to detect hose failure. Upon actuation, the leak detector shall stop the pump, light a locally visible LED and sound a remote alarm. Leak detection outside of the pump housing is not acceptable.
6. Hose:
    a. Molded fittings, be self-locating when fitted into the pumphead, and be held in place on the suction and discharge by the element fittings.
    b. Replaceable without the use of tools and without disassembly of the pumphead.
7. Gearbox shall be of the in-line helical design, powder epoxy coated cast aluminum or cast aluminum alloy, rated for continuous duty with a service factor of 1.4 based on the motor nameplate rating.
8. Pump, gearbox and motor shall be direct-coupled and self-aligning.

D. Materials:
1. Housing: Fluoropolymer powder coated cast aluminum or cast aluminum alloy.
2. Track: Polyphenylene sulfide (PPS).
3. Guard door: Impact-resistant polycarbonate.
4. Rotor: Polyphenylene sulfide or Fluoropolymer powder coated carbon steel.
5. Springs: Helical, stainless steel.
6. Compression rollers/shoes: Type 316 stainless steel or Reinforced Delrin®.
7. Bearings: Stainless steel.
8. Shafts: Type 316 stainless steel.
9. Seals: PTFE.
10. Guide rollers/shoes: Nylatron.
11. Hose: Shall have a wetted layer of natural rubber, Buna-N, EPDM or Hypalon as required for the scheduled service, with male PVDF quick-release connectors.

E. Accessories: As indicated on the Drawings, pumps shall be equipped with:
1. Calibration column in suction piping.
2. Pressure relief valve in discharge piping.

F. Source quality control:
    1. Tests and inspections:
        a. As specified in Section 01756 - Commissioning and Section 15050 - Common Work Results for Mechanical Equipment.
        b. As scheduled in this Section.
    2. Verification of performance.

2.04 MOTOR

A. Characteristics:
    1. Provide motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower and the Pump Schedule.

B. Horsepower:
    1. As scheduled.
    2. Listed driver horsepower is the minimum to be supplied.
        a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
        b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
        c. Make all structural, mechanical, and electrical changes required to accommodate increased horsepower.

2.05 ACCESSORIES

A. Flexible piping:
    1. Supply two 1 meter lengths of reinforced transparent PVC flexible hose for connection of pump to suction and discharge process lines.
        a. Each flexible hose shall have a PVDF female Quick Release fitting for connection to the tubing element and male Quick Release fitting for connection to barbed adaptor with built in shut off valve for ease of maintenance and connection to process lines.

B. Calibration columns:
    1. Furnish and install calibration columns, 1 for each pump, on the inlet line as indicated on the Drawings and specified in this Section.
        a. The column shall be translucent and graduated for chemical pump calibration operations.
        b. Provide a top cap threaded connection with vent to prevent entry of foreign materials and to direct spillage or overflow.
    2. Materials shall be compatible with the associated chemical and concentration and suitable for outdoor use and exposure.
    3. End connection: Threaded.
    4. Capacity as scheduled in this Section and as indicated on the Drawings.

C. Backpressure and pressure relief valves:
    1. As specified in Section 15118 - Pressure Reducing and Pressure Relief Valves.
    2. Manufacturers: One of the following or equal:
        a. Wallace and Tiernan.

b. Pulsafeeder.
c. Griffco.
d. Milton Roy Co.

3. Materials:
   a. Valves shall be of suitable materials for the pumped liquid.
4. Characteristics:
   a. Ported to serve as either a backpressure valve or a pressure relief valve.
   b. Relief valve shall be plumbed to the nearest chemical drain, or back to the pump suction on the non-pump side of the pump suction isolation valve, to avoid spillage, as indicated on the Drawings.
   c. Valves shall be furnished and installed on each chemical metering pump's discharge lines as indicated on the Drawings and scheduled in this Section.
   d. Valves shall have an adjustable spring range of 15-50 pounds per square inch. Valves shall be factory-adjusted for the backpressure recommended by the pump manufacturer.
5. Valves shall produce a back pressure no greater than 10 pounds per square inch above valve set pressure when metering pumps are operating at full capacity, pulsating flow.

D. Additional accessories:
   1. Additional accessories required for the system but not required to be supplied by the pump manufacturer include:
      a. Diaphragm seals as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals, except as modified in this Section:
         1) Materials shall be compatible with the pumped liquid at the specified concentration and suitable for outdoor use and exposure.
         2) Shutoff valve shall be provided.
      b. Pressure switches as specified in Section 17403 - Pressure/Vacuum Measurement: Switches.
      c. Pressure gauges as specified in Section 17404 - Pressure/Vacuum Measurement: Gauges.
      d. Isolation valves as specified in Section 15111 - Ball Valves for calibration column and suction and discharge piping as indicated on the Drawings.

2.06 SPARE PARTS AND SPECIAL TOOLS

A. Spare Parts:
   1. Four hose elements for each pump type.
   2. One complete spare parts kit for each pump type provided.
   3. One spare parts kit for each size and type of pressure relief valve.
   4. An initial supply of all oils, greases, and lubricants required to start operations.
      a. Supply an amount of these materials equivalent to 1 year of continuous operation for each system.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the control panel in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Source Testing (Factory Acceptance Tests):
   1. As specified in Pump Schedule.
   2. Furnish test reports and Manufacturer's Certificate of Source Testing.

C. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. As scheduled.
   2. System Testing:
      a. As specified in Section 01756 - Commissioning
   3. Furnish Manufacturer's Certificate of Functional Compliance.

E. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
      a. Training topics should focus on maintenance
   2. Number of sessions:
      a. Operations and Maintenance 1.

3.04 SCHEDULES

A. Pumps:

Tag Number	PMP-6931 PMP-6936 PMP-6941 PMP-6946 PMP-6951	PMP-6921 PMP-6926	PMP-6572 PMP-6582
Feed Point	Floc Basin 1 Floc Basin 2 Floc Basin 3/4 Floc Basin 5/6 Standby	North Filter Influent Channel South Filter Influent Channel	Clearwell Outlet Structure
Service	Anionic Polymer - Floc Aid	Anionic Polymer - Filter Aid	Sodium Hydroxide (Caustic Soda)
Pump Type	Peristaltic Hose	Peristaltic Hose	Peristaltic Hose
Number of Pumps	5	2	2
1st Named Manufacturer's Model	Watson-Marlow Bredel	Watson-Marlow Bredel	Watson-Marlow Bredel
	Apex28	Apex28	Apex28
Torsional Analysis	Not Required	Not Required	Not Required
Pump Characteristics			
Design Conditions			
Maximum Flow, (gallons per minute)	7.0	2.3	6.9
Minimum Flow, (gallons per minute)	0.2	0.2	0.2
Normal Flow, (gallons per minute)	3.0	0.8	1.0
Pump rpm	140	140	140
Maximum Discharge Pressure (psi)	60	60	60
Minimum Required Suction Lift (feet)	10	10	10
Relief Valve Setting (psig)	25	25	25

Tag Number	PMP-6931 PMP-6936 PMP-6941 PMP-6946 PMP-6951	PMP-6921 PMP-6926	PMP-6572 PMP-6582
Pump Materials			
Pump Housing/Enclosure	See 2.03 D	See 2.03 D	See 2.03 D
Hose/Tubing	See 2.03 D	See 2.03 D	See 2.03 D
Rotor	See 2.03 D	See 2.03 D	See 2.03 D
Pump Shaft	See 2.03 D	See 2.03 D	See 2.03 D
Pump Housing Support	See 2.03 D	See 2.03 D	See 2.03 D
Pump Connections	See 2.03 D	See 2.03 D	See 2.03 D
Motor Characteristics			
Minimum Motor Size (hp)	1.0	1.0	1.0
Motor Service Factor	1	1	1
Voltage/Phase/Frequency	480/3/60	480/3/60	480/3/60
Maximum Motor Speed (rpm)	1,800	1,800	1,800
Source Testing			
Test Witnessing	Not Witnessed	Not Witnessed	Not Witnessed
Performance Test Level	1	1	1
Vibration Test Level	None	None	None
Noise Test Level	None	None	None
Functional Testing			
Performance Test Level	1	1	1
Vibration Test Level	None	None	None
Noise Test Level	None	None	None

B. Calibration columns:

Tag Number	Service	Graduation Volume (ml)[1]	Graduation Scale (ml)
	PEA - Floc Aid	20,000	100
	PEA - Filter Aid	7,000	10
	Caustic Soda	20,000	100

Notes:

(1) The volume of the calibration column should equal 100 percent of the volume delivered by the pump at maximum capacity for a period of 30 to 60 seconds.

C. Pressure relief valves:

Tag Number	Service	Spring Range	Relief Pressure (factory setting)
	PEA - Floc Aid	0 - 50 psi	30 psi
	PEA - Filter Aid	0 - 50 psi	30 psi
	Caustic Soda	0 - 50 psi	30 psi

END OF SECTION

SECTION 11256

POLYMER BLENDING AND FEED EQUIPMENT: DRY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Automatic polymer blending and feed systems to handle dry polymer and delivery of activated polymer.

B. Equipment tag numbers:
   1. VCP-6901 PEA Feed System.

C. All polymer system equipment shall be supplied by the same Polymer System Manufacturer.

D. Scope of Polymer System Manufacturer's supply shall be as follows (to be installed by the contractor):
   1. Two bulk bag unloaders with hoist and trolley.
   2. Two skid-mounted dry polymer feed system with tank mounted dilution wetting heads.
   3. Two 2-way motorized diverter valve - switchover assemblies for pneumatic conveyance system.
   4. Two 2,000 gallon fiberglass polymer aging tanks with mixers and level-indicating pressure transducers and load cells.
      a. As specified in Section 13206A - Fiberglass Reinforced Plastic Aboveground Storage Tanks, Section 17404 - Pressure/Vacuum Transmitter, and Section 17622 - Weight Measurement: Platform Scale and Load Cells.
   5. All necessary controls for a complete and operational automated polymer system.
   6. Wetting head and dilution water accessories and appurtenances for both systems.

1.02 REFERENCES

A. American Welding Society (AWS):
   1. D1.1 - Structural Welding.

B. National Electrical Manufacturers Association (NEMA).

C. Underwriters Laboratories, Inc. (UL):
   1. 508 - Standard for Industrial Control Equipment.
   2. 508A - Standard for Industrial Control Panels.
   3. 698A - Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations.
   4. 1449 - Surge Protective Devices.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product Submittals:
   1. As specified in Section 01600 - Product Requirements.
   2. Product data:
      a. Vendor control panel (VCP) components.
   3. Shop Drawings:
      a. Showing both isometric and orthogonal views of the proposed installation, including dimensions, weights, and complete parts list.
      b. VCP:
         1) Wiring schematics and control panel layouts:
            a) Scaled interior and exterior front and side elevations with dimensions and bill of materials.
            b) Wiring schematics including wire numbers and terminal numbers.
            c) Single-line diagram of power distribution.
   4. Hydraulic characteristics of the mixer.
   5. Motor data as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

C. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.

D. Calculations:
   1. Thermal management calculations for each control panel containing a PLC.

E. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. Provide manufacturer’s installation instructions.

F. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer’s representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.
      c. Test Plans:
         1) Test requirements as specified in this Section.
      d. Test Reports.

e. Manufacturer's representatives field notes and data.
f. Owner Training.

G. Operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.
2. Include a list of configurable parameters and the final values for each.
3. Include a troubleshooting chart covering the complete system and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.05 ADMINSTRATIVE REQUIREMENTS

A. Programming coordination:
1. Coordinate requirements for data transfer with plant control system, PCS:
a. Include all data registers, data types, and engineering units, etc.
2. Coordinate with the instrumentation and controls subcontractor, ICSC and programmer for factory testing.
a. Vendor shall supply PLC and LOI programming file prior to the testing.
3. Coordinate data transfer to and from PCS with ICSC and programmer at programming meetings as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Equipment included with the polymer system includes:
1. Polymer storage hopper:
a. Volumetric feeder.
b. Heated feed funnel.
c. Pneumatic polymer conveyance system.
d. Shower-type dry polymer wetting head.
e. Integral dilution water system.
f. FRP Mix/age tank system with level controls.
g. Scale package for mix/age tanks

h. Tank mixer(s).
i. VCP.
j. Bulk-bag frame system with hoist and trolley.

2.02 MANUFACTURERS

A. The following or equal:
1. Velocity Dynamics, Inc., HydraMax, Model D3000S.
2. UGSI Chemical Feed, Inc. Dynajet Model DJM-8-3000-F-D.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
1. Designed to prepare up to 35 pounds per hour of dry polymer at a 0.20 percent solution concentration with an aging time of not less than 60 minutes.
a. Aging time shall be calculated after all the polymer has been delivered to the mix/age tank.
b. Total cycle time shall not exceed 100 minutes.
c. System shall be a modular design.
2. Dry feed system shall operate in a duty/standby configuration.

B. Pre-assemble and shop-test system to ensure compliance with pressure and operational requirements.

C. Design criteria:
1. Polymer type: Dry.
2. Final percent solution desired: 0.20.
3. Design capacity: 35 pounds per hour.
4. Maximum solution available: 35 gpm.
5. Minimum Mix/Age Time: 60 minutes.

D. Utility Services Available:
1. Power:
a. Voltage: 480V/3PH/ 60HZ.
2. Water Supplied.
3. Polymer Hydration Device Rate: 90 gpm:
a. Pressure: 50 psi.
4. Direct Fill - Rapid Fill Rate: 150 gpm:
a. Pressure: 50 psi.

E. Maximum water pressure available for dilution water is 50 to 105 pounds per square inch.
1. For polymer feed systems requiring higher working differential pressures for dilution water, the manufacturer must provide booster pumps and appurtenances as a part of a fully operational, pre-packaged system.
2. Booster pump to be controlled by polymer blending unit and must be able to fit in area indicated on the Drawings without any interferences or changes to the specified system.

2.04 MATERIALS

A. General:
   1. System shall be constructed with a Type 304 stainless steel chassis.
   2. Hardware shall be Type 304 stainless steel.
   3. Any components in contact with polymer or water shall be constructed of electrolysis nickel plated brass, brass, stainless steel, or an inert plastic.

2.05 EQUIPMENT

A. Polymer storage and metering skid:
   1. Provide Type 304 stainless steel skid incorporating the dry polymer storage hopper system, volumetric feeder and dry polymer pneumatic conveyance system.

2.06 COMPONENTS

A. Dry material storage.

B. A polymer storage hopper shall be provided having a minimum capacity of 4 cubic feet.

C. Storage hopper shall be the manual fill type, 50# bag unloading type with dust collector, designed for receiving polymer from 2000# bulk-bags, designed for bulk deliveries.

D. Hopper shall be fabricated of not less than 12-gauge Type 304 stainless steel with the lower portion of the hopper tapering to facilitate flow of the dry product to the ensuing screw feeder.

E. Storage hopper shall include a capacitance type low-level sensor positioned at roughly 1 cubic feet of remaining polymer storage.

F. Provide a stainless steel screen in the hopper to prevent foreign material from entering auger.
   1. Screen shall have 1/4-inch square area openings and constructed 12-gauge wire.
   2. Screen shall not be the woven type capable of coming apart and fouling the feed auger.

2.07 VOLUMETRIC SCREW FEEDER

A. Provide a volumetric screw feeder to accurately meter dry product from the storage hopper to the pneumatic transfer line through the feed funnel described below.

B. Screw auger shall be direct driven by a motor and a heavy-duty right angle gear reducer.
   1. Chain drives shall not be used.

C. Sized to supply dry polymer at a feed rate output of up to 10 pounds per minute based on 40 #/CF.

D. Auger shall be solid shaft, 1-piece design, machined from Type 304 stainless steel bar stock.
   1. Augers with any welded components or open flight augers are not acceptable.

E. Design shall allow the motor, gear reducer and auger to be removed as a single unit.
   1. Accessing the hopper interior shall not be required.

F. Housing material: Type 304 stainless steel construction.

G. Motor:
   1. As specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
   2. Horsepower: Not less than 1/2 hp.
   3. Enclosure: TENV or TEFC.
   4. Voltage: 460 VAC, 3-phase, 60 Hz or 90 VDC.

2.08 DRY POLYMER FEED FUNNEL

A. Receives the metered product from the screw feeder and allows for smooth transition of the product into the pneumatic conveying line.

B. Equipped with a forced heated air system designed to prevent condensation.
   1. Heat rope or heating pads shall not be acceptable.

C. Fabricated of Type 304 stainless steel.

D. Provide an airflow sensor to verify and monitor the conveyance airflow and velocity.
   1. Airflow monitor shall indicate an alarm condition when insufficient airflow exists.

2.09 PNEUMATIC CONVEYANCE SYSTEM

A. Provide a regenerative blower to pneumatically convey the dry polymer from the feed funnel via the air eductor up to the wetting head.
   1. Designed to meet the process requirements specified.
   2. Designed for continuous operation.

B. Motor:
   1. As specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
   2. Horsepower: minimum 5.5 hp.
   3. Enclosure: TEFC.
   4. Voltage: 460 VAC, 3-phase, 60 Hz.
   5. Service factor: 1.15.

C. Provide an eductor designed to pneumatically convey up to 10 pounds per minute of dry polymer.
   1. Fabricated of Type 304 stainless steel and include cast aluminum or stainless steel cam-lock quick disconnect fittings on the inlet and outlet.

D. Type 304 stainless steel pneumatic conveyance tubing, wide radius elbows, and compression type tube clamps with neoprene seals for each dry feeder to be supplied, assembled, and installed by the Contractor.

E. Provide diverter valve to allow for duty/standby operations of dry feed system:
   1. Type: Sliding tube.
   2. Size: 3 inch.
   3. Actuation: Electric.

2.10 BULK BAG HANDLING SYSTEM

A. Provide a 2-ton hoist assembly to lift 2000# bulk-bags:
   1. Motorized hoist, motorized trolley, operator handheld controller with extended pendant cord.

B. Bulk bag lifting and support frame assembly:
   1. Provide a big-bag frame system designed to lift, position and support a big-bag weighing up to 2,000 pounds over the dry polymer hopper inlet.
   2. The frame system shall be constructed of 4-inch structural steel tubing with a minimum of 1/4 inch wall thickness. Each corner shall have gusset reinforced construction, with the exception of the travel zone of the big-bag.
   3. The entire bag support system shall be finished with a baked powder coating.
   4. Provide a bag hanging spreader adapter. The crossbar shall be constructed with bag loop positioning tabs to position the bag loops at the end of each bar arm.
   5. Provide a motorized electric hoist and trolley, 2,000 pound nominal capacity to lift and position bulk bags.

C. Motor:
   1. As specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
   2. Enclosure: TENV or TEFC.
   3. Voltage: 460 VAC, 3-phase, 60 Hz.

2.11 DILUTION WATER ASSEMBLY

A. Dilution water valves and instruments shall be mounted on a bracket mounted on the side of the tank or in a position for easy access.

B. Provide an electric, slow-closing, 3-inch motor operated ball valve for on/off control of make-down water flow to the polymer wetting head.

C. Provide an electric, slow-closing, 3-inch motor operated ball valve for on/off control of make-down water flow for rapid fill.

D. Provide a 2-1/2-inch stainless steel liquid filled pressure gauge.

E. Provide a pressure transmitter to monitor low water pressure. Pressure transmitter shall be rated NEMA 4X.

F. Pressure regulating valve, 3-inch carbon steel

2.12 MIX/AGE TANK SYSTEM

A. Tank system shall be the side-by-side, sequential batch design.

B. Design tank(s) and anchoring to withstand the following loads:
   1. Tank self-weight (dead load).
   2. Roof live loads.
   3. Weight of tank contents.
   4. Loads specified in Section 01850 - Design Criteria:
      a. Seismic load.

2.13 MIX/AGE TANK

A. One 2,000 gallon usable capacity mix/age tank shall be provided to mix and age dry polymer solution. Tanks shall be vertically oriented with a diameter of 8’ and a sidewall height of 6 feet.
   1. Polymer shall be fully wetted prior to entering the mix tank.
   2. Mix tank shall provide a minimum of 60 minutes of aging, after all of the polymer has been delivered to the mix/age tank and shall effectively and thoroughly mix the polymer solution without damaging its molecular structure prior to transfer to the feed tank.

B. Tank Scale As specified in Section 17622 - Weight Measurement: Platform Scale and Load Cells.

C. Mix tank shall be constructed of fiberglass and shall be cylindrical, sloped flat, open top with 4 mixing baffles. Mix tank shall have blade gusseted flanged NPT connections as follows:
   1. One 4-inch outlet.
   2. One 4-inch overflow.
   3. One 2-inch drain.

2.14 POLYMER WETTING DEVICE

A. Dry product shall be pneumatically conveyed to a tank top mounted, non-mechanical dry polymer disperser and wetting device.

B. Materials:
   1. Polymer inlet connection and chamber flange material: Type 304 stainless steel.
   2. Water manifold material: PVC.
   3. Water spray nozzle material: Brass.

C. Wetting containment cylinder:
   1. Material: Clear PVC with Viton™ seals.
   2. Designed:
      a. Minimum 6-inch wetting chamber.
      b. Rated for up to 90 gpm.
      c. Provide a means for accessing the wetting containment chamber and internal area of the water manifold without the need for tools.
      d. Lanyards shall be provided on each component to allow access to wetting containment chamber and to prevent the part from being dropped into the mix tank during service.
   3. Disperser shall have a proven track record and shall be specifically designed for dry product wetting.

4. Devices that do not completely disperse polymer prior to contact with water, or which utilize eductors or “wetting bowls” prone to ineffective polymer-particle wetting and or plugging shall not be considered.

2.15 TANK MIXER

A. Provide a tank mixer to ensure adequate agitation of the polymer solution before transfer to the polymer age/feed tank. Mixer drive shall be capable of handling solution viscosity up to 3,300 CPS.

B. Provide Type 316 stainless steel mixing impellers and Type 316 stainless steel shaft. Impeller(s) shall be affixed to the shaft in location(s) to provide for optimum mixing of the polymer solution.
   1. Top Entry Mixer: supported by mixer support bridge

C. Motor:
   1. As specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
   2. Horsepower: 1 hp minimum.
   3. Enclosure: TEFC.
   4. Voltage: 460 VAC, 3-phase, 60 Hz.
   5. Service factor: 1.0.
   6. Inverter duty rated.
   7. Integral gear reducer shall reduce the shaft speed to not more than 350 rpm.

D. Manufacturer:
   1. Chemineer or approved equal

2.16 LEVEL SENSOR

A. Top or side mounted pressure transducer type level sensor in the mix/age tank.
   1. Output: 4 to 20 mA signal proportional to level for system batch cycle control.
   2. Installed in a stilling well or bottom side mounted.

B. Provide a Type 304 stainless steel mix tank bridge to support the mixer, wetting device.

C. Ball Float - High-High Overflow Sensor

2.17 VENDOR CONTROL PANEL

A. General:
   1. VCP components and construction shall be as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
   2. Provide components and equipment with UL 508 listing.
   3. Provide control panels with a UL 508A label.
   4. Provide intrinsically safe circuits and equipment in accordance with UL 698A.
   5. VCP shall be fully functional, wired, and factory tested prior to shipment.
      a. Provide field wiring terminal strips for external connections.
      b. Additional testing requirements as specified in Section 17950 - Commissioning for Instrumentation and Controls.

6. Provide surge protection on the incoming power feed.
    a. Provide UL 1449 rated SPD.
7. Provide necessary control hardware, software, and components as required for a fully functional and operational installation.
8. Provide heating, cooling, and dehumidifying devices to maintain devices within their rated temperature range.
9. Provide GFCI duplex 120 VAC convenience receptacle.
10. Provide internal cabinet LED light for every 36 inches of enclosure width.
11. Power supply:
    a. 480 VAC, 3-phase 60 Hz.

B. Enclosures and panel components:
1. Enclosure:
    a. Manufacturers: One of the following, or equal:
        1) nVent/Hoffman.
        2) Saginaw Control & Engineering.
    b. Rating: NEMA Type 4X stainless steel.
2. Main circuit breaker:
    a. As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
    b. Rated for 65 kAIC fault current.
    c. Operator:
        1) Flange-mounted.
        2) Pad-lockable in the off position.
        3) Interlocked with the door with a defeat mechanism.
3. Motor starter:
    a. As specified in Section 16422 - Motor Starters.
    b. Motor circuit protector circuit breaker.
    c. Thermal or electronic overloads.
4. Variable frequency drive:
    a. As specified in Section 16262 - Variable Frequency Drives 0.50 to 50 Horsepower.
    b. Thermal magnetic circuit breaker.
5. Control power transformer:
    a. VCP will be powered by a single power source. Provide a control power transformer as required.
    b. Primary voltage: 460 VAC, 3-phase, 60 Hz.
    c. Secondary voltages:
        1) 24vdc for controls.
        2) Derive additional voltages as required by the application.
        3) Sized for all panel components plus 10 percent spare capacity.
        4) Primary and secondary fuses.
6. Programmable logic controller (PLC):
    a. Manufacturers:
        1) Modicon:
            a) M340.
    b. Provide individual isolation for I/O modules.
7. Local operator interface (LOI):
    a. Manufacturers: The following, no equal:
        1) Schneider Electric:
            a) Harmony GTU.

b. General:
    1) Provide the LOI graphic software if different than the PLC programming software.
    2) NEMA rating shall match enclosure rating.
c. Widescreen format screen size:
    1) 10-inch.
d. Easy viewing in outdoor light conditions.

8. Pilot devices:
    a. Emergency stop pushbutton.
9. Provide the following IO communications to the owner's control system using 24VDC signals.
    a. P-6906 PRESSURE ANALOG INPUT.
    b. PD-6905 DIFF PRESS ANALOG INPUT.
    c. AUTO-6902 AUTO DIGITAL INPUT.
    d. AUTO-6903 AUTO DIGITAL INPUT.
    e. AUTO-6904 AUTO DIGITAL INPUT.
    f. AUTO-6905 AUTO DIGITAL INPUT.
    g. LAH-6901 HIGH-LEVEL DIGITAL INPUT.
    h. LAHH-6905 HIGH-HIGH LEVEL DIGITAL INPUT.
    i. LAL-6901 LOW-LEVEL DIGITAL INPUT.
    j. RNG-6905 RUNNING DIGITAL INPUT.
    k. ZSC-6902 CLOSED DIGITAL INPUT.
    l. ZSC-6903 CLOSED DIGITAL INPUT.
    m. ZSC-6904 CLOSED DIGITAL INPUT.
    n. ZSO-6902 OPENED DIGITAL INPUT.
    o. ZSO-6903 OPENED DIGITAL INPUT.
    p. ZSO-6904 OPENED DIGITAL INPUT.
    q. XC-6901 ENABLE DIGITAL OUTPUT.
    r. ZCC-6902 CLOSE DIGITAL OUTPUT.
    s. ZCC-6903 CLOSE DIGITAL OUTPUT.
    t. ZCC-6904 CLOSE DIGITAL OUTPUT.
    u. ZCO-6902 OPEN DIGITAL OUTPUT.
    v. ZCO-6903 OPEN DIGITAL OUTPUT.
    w. ZCO-6904 OPEN DIGITAL OUTPUT.
    x. P-6916 PRESSURE ANALOG INPUT.
    y. PD-6915 DIFF PRESS ANALOG INPUT.
    z. AUTO-6912 AUTO DIGITAL INPUT.
    aa. AUTO-6913 AUTO DIGITAL INPUT.
    bb. AUTO-6914 AUTO DIGITAL INPUT.
    cc. AUTO-6915 AUTO DIGITAL INPUT.
    dd. LAH-6911 HIGH-LEVEL DIGITAL INPUT.
    ee. LAHH-6915 HIGH-HIGH LEVEL DIGITAL INPUT.
    ff. LAL-6911 LOW-LEVEL DIGITAL INPUT.
    gg. RNG-6915 RUNNING DIGITAL INPUT.
    hh. ZSC-6912 CLOSED DIGITAL INPUT.
    ii. ZSC-6913 CLOSED DIGITAL INPUT.
    jj. ZSC-6914 CLOSED DIGITAL INPUT.
    kk. ZSO-6912 OPENED DIGITAL INPUT.
    ll. ZSO-6913 OPENED DIGITAL INPUT.
    mm. ZSO-6914 OPENED DIGITAL INPUT.
    nn. XC-6911 ENABLE DIGITAL OUTPUT.

oo. ZCC-6912 CLOSE DIGITAL OUTPUT.
pp. ZCC-6913 CLOSE DIGITAL OUTPUT.
qq. ZCC-6914 CLOSE DIGITAL OUTPUT.
rr. ZCO-6912 OPEN DIGITAL OUTPUT.
ss. ZCO-6913 OPEN DIGITAL OUTPUT.
tt. ZCO-6914 OPEN DIGITAL OUTPUT.

2.18 CONTROL STRATEGY

A. General:
   1. For systems with a PLC, provide access to control parameters and settings.
   2. Provide security lock out capability for vital settings and functions.
   3. Coordinate the following with the PCS programmer:
      a. Include programming functions for syncing the PLC clock with the plant network time server.
      b. Include a watchdog that allows the PCS to confirm active communications with the VCP.
      c. Include a timer to verify communications with the PCS.
   4. Refer to and coordinate with Section 17101 - Specific Control Strategies and Digital I/O Tables.
   5. Provide a minimum of 1 screen to display communication errors and status within the control system network and generate alarms.
   6. Provide complete program in electronic format, unlocked, via USB drive.

B. Control system requirements as specified in Section 17101 - Specific Control Strategies.

2.19 DRY POLYMER

A. Provide a 30-day supply of dry polymer, delivered as appropriate for the application (supplied by contractor).

B. Manufacturers: One of the following, or equal:
   1. Clarifloc N-3300P

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION (BY CONTRACTOR)

A. Field welding:
   1. Field weld components of the mechanism as required for installation as indicated on the Drawings.

2. Use welding procedures, welders, and welding operators qualified and certified in accordance with AWS D1.1.
3. Shielded arc welding is required for field welding and shall conform to the Shop Drawing requirements.

B. Field finishes:
1. Protect motors.
2. Clean equipment and prepare shop primer.
3. Apply field primer and coating systems in the field as specified in Section 09960 - High-Performance Coatings requirements:
   a. Submerged equipment: High solids epoxy.
   b. Other equipment: Epoxy-polyurethane.

C. Install the equipment in accordance with the accepted installation instructions and anchorage details under the direction of the system supplier.

D. Alignment of piping may vary from that indicated on the Drawings. Upon acceptance by the Engineer, align piping to suit the equipment furnished, without additional cost to the Owner.

E. Flush the potable water line until water discharged from line is clear and free of debris.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning, and this Section.

B. Source Testing:
1. As specified in Section 01756 - Commissioning, and this Section.
2. Test as specified in Section 15958 - Mechanical Equipment Testing.
3. Equipment:
   a. Test witnessing: Witnessed.
   b. Conduct Level 1 General Equipment Performance Test.
   c. Conduct Level 1 Vibration Test.
   d. Conduct Level 1 Noise Test.
4. Furnish test reports and Manufacturer’s Certificate of Source Testing.

C. Installation Verification:
1. As specified in Section 01756 - Commissioning, and this Section.
2. Furnish Manufacturer’s Certificate of Installation Verification.

D. Functional Testing:
1. As specified in Section 01756 - Commissioning, and this Section.
2. Equipment:
   a. Test witnessing: Witnessed.
   b. Conduct Level 2 General Equipment Performance Test.
   c. Conduct Level 2 Vibration Test.
   d. Conduct Level 2 Noise Test.
   e. Verify that connections are watertight.
   f. During testing, make final adjustments necessary to place equipment in satisfactory working order.

g. Test and calibrate controls, switches, automatic valves, and other instrumentation and control equipment associated with the polymer feed system specified in this Section, in accordance with the manufacturer's printed instruction over the full operating range of the equipment.

3. Polymer blending and feed equipment:
   a. Test witnessing: Witnessed.
   b. Conduct Level 2 General Equipment Performance Test.
   c. Conduct Level 2 Vibration Test.
   d. Conduct Level 2 Noise Test.
   e. Process test.
4. Furnish Manufacturer's Certificate of Functional Compliance.

E. Owner Training:
   1. Perform Owner Training as specified in Section 01756 - Commissioning.
   2. Number of sessions:
      a. Operations and Maintenance 1.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's onsite services during the process operational period as required by the Owner or Contractor.

B. A 1-day site visit during the first year of operation coordinated with the Owner.

END OF SECTION

SECTION 11260

GASEOUS CHLORINATION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Complete chlorination system.
   2. As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   3. Tag numbers:
      a. Chlorination system as shown in the Drawings.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. Boiler Pressure Vessel Code (BPVC) Section VIII-Rules for Construction of Pressure Vessels Division 1.

C. American Welding Society (AWS):
   1. D1.1 - Structural Welding.

D. ASTM International (ASTM):
   1. A106 - Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
   2. A181 - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   3. B88 - Standard Specification for Seamless Copper Water Tube.

E. Chlorine Institute.

F. CSA International (CSA).

G. International Fire Code (IFC).

H. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

I. Occupational Safety and Health Administration (OSHA).

J. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product Submittals:
   1. As specified in Section 01600 - Product Requirements.
   2. Product data.
   3. Shop Drawings.
   4. Calculations.

C. Vendor operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete system and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

D. Commissioning Submittals:
   1. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Special warranty:
   1. Duration: Provide 2-year warranty from completion of installation. See Specification 01783 - Warranties and Bonds.
   2. Respond within 48 hours to a written notification of a warranty service problem by the Owner.
      a. Response will consist of an immediate remedy in which the manufacturer will correct the problem, or if the problem cannot be immediately corrected due to insufficient materials, the manufacturer will notify the Owner of the anticipated schedule for equipment repair.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Manufacturers must have at least 10 years of experience in the design, assembly, and integration of chlorine feed equipment, and supply a list of not less than 15 operating installations as evidence of meeting the experience requirement.
   2. Demonstrate to the satisfaction of the Engineer that the quality is equal to the equipment made by the manufacturers named in this Section.

B. Chlorine System Supplier qualifications:
   1. Minimum of 10 years' experience in the supply of similar gaseous chlorine feed systems.

C. Unit responsibility: All of the equipment and appurtenances specified shall be the end product of one Chlorine System Supplier.

D. Coordination:
   1. The manufacturer shall assist in the integration effort and shall provide all information, testing, start-up, documentation, and training services required by the Instrumentation and Control Subcontractor (ICSC) to fully integrate the control systems specified in this Section.

E. All materials and equipment incorporated into the manufacturer's equipment shall be of good quality and new.
   1. If required by Engineer, manufacturer shall furnish satisfactory evidence as to the source, kind and quality of the materials, and equipment incorporated into the work.

F. All field services shall be performed by competent and qualified personnel with at least 5 years of experience in providing field services for similar equipment and providing field services on at least 2 similar installations for manufacturer.
   1. Submit resume of qualified field personnel for Engineer's review and approval.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide equipment of best construction with components designed for long and continuous operation in a corrosive (chlorine) atmosphere.

B. Provide all equipment and components of the chlorine system from a single manufacturer.

C. Entire chlorination system and all associated items shall meet the suggested, recommended, and mandatory requirements of the Chlorine Institute.

D. Miscellaneous accessories not explicitly specified, but necessary for complete installation, shall be provided and shall meet Chlorine Institute requirements.

E. Safety devices:
   1. Completed Work shall include necessary permanent safety devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.

F. Nameplates:
   1. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

G. Wiring and control diagrams:
   1. Provide for equipment, panels, and instrument components.
      a. Submit with Operation and Maintenance Manual, as specified in Section 01782 - Operation and Maintenance Manuals.
   2. Point-to-point wiring and control schematic diagrams shall conform to the format and content requirements contained in the Contract Documents.

H. Lifting lugs:
   1. Provide for equipment components weighing over 100 pounds.

I. Valves:
   1. As specified in Section 15110 - Common Work Results for Valves and Section 15111 - Ball Valves, suitable for intended service, and shall be the same size as adjoining pipe.
   2. Valve ends shall suit adjacent piping.

2.02 MANUFACTURERS

A. One of the following, no equal:
   1. Evoqua/Wallace & Tiernan Co:
      a. Supplier: Waterford Systems

2.03 DESIGN AND PERFORMANCE CRITERIA

A. System description: the Jordan Valley Water Treatment Plant has an existing chlorine gas system that is undersized for future expansion. A new chlorine gas building with all new components will be constructed and the old system will be demolished. Sequence the work per Section 01140 - Work Restrictions, such that continuous disinfection is maintained to meet plant demands.

B. System components:
   1. Chlorine container weight scales.
   2. Chlorine storage.
   3. Emergency shutoff system.
   4. Pressure and Vacuum gauges (Contractor).
   5. Vacuum regulators.
   6. Chlorinators.
   7. Eductors.
   8. Chlorine gas leak detectors (Contractor).
   9. Chlorine piping (Contractor).
   10. Chlorine valves(Contractor).
   11. Passive chlorine gas arrestor.
   12. All other accessories required for a complete and functional chlorination system (Contractor).

C. Chlorine System Supplier:
   1. The gas chemical feed equipment specified herein shall be supplied by a competent chorine system supplier.
      a. The chlorine system supplier shall be regularly engaged in the business of supplying liquid chlorine and chlorine gas chemical feed systems and related appurtenances for water treatment or wastewater treatment plant projects.
      b. The chlorine system supplier shall be responsible for coordinating the equipment, valves, and appurtenances for the system as shown on the Drawings and as specified herein.

D. Contractor is responsible for the following as indicated on the Drawings and as specified herein:
    1. The gas feed system shall be coordinated by a competent chlorine system installer.
        a. The chlorine system installer shall be regularly engaged in the business of designing and assembling liquid chlorine and chlorine gas chemical feed systems for water treatment or wastewater treatment plant projects.
        b. The chlorine system installer shall be responsible for ensuring that a complete functioning system is supplied.
        c. The chlorine system installer shall be responsible for coordinating all equipment piping, valves, and appurtenances for the system as indicated on the Drawings and specified herein.
    2. Provide all piping, valves, valve fittings, gauges, gaskets, bolts, nuts, couplings, supports, and other materials required for the entire installation.
    3. Route the chlorine system piping in such a manner to avoid interference with other piping or equipment.
    4. Verify and adjust the alignment of the piping and the arrangement of the indicated equipment to suit the equipment furnished, with approval by Engineer.
    5. Field verify the location of existing equipment and piping.

E. General:
    1. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in conformity with Drawings, Specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by the Engineer.
    2. Each item shall be furnished and installed complete with all mechanical, electrical, instrumentation and control equipment required for proper operation, all components indicated on the Drawings or specified, and all additional materials or construction required by the design of the system.
    3. Coordination: The chlorine system supplier shall verify that each system component is compatible and consistent with all other components of the system, that pipe materials and sizes are appropriate, and that all devices necessary for a properly functioning system have been provided. Devices and appurtenances necessary for a properly functioning system shall be constructed of materials consistent with the piping materials unless otherwise indicated.

F. Design requirements:
    1. Chlorine ton containers (to be provided by owner):
        a. Tank capacity (each): 1 ton of liquid chlorine at design pressure.
        b. Number: as indicated on the Drawings.

2. Chlorinators:

Chlorinators/Feed Rotameters				
Chlorinator Tag No.	**Use**	**Capacity (lb/d)**	**Rotameter (lb/d)**	**Control (manual/automatic)**
CHL-6331	Finished Water - Clearwell	3,000	3,000	Automatic
CHL-6332	Finished Water - Clearwell	3,000	3,000	Automatic
CHL-6333	Finished Water - Clearwell	3,000	3,000	Automatic
CHL-6334	Raw Water - Rapid Mix	3,000	1,000	Automatic
CHL-6335	Raw Water - North Filter Inlet Channel	3,000	1,000	Automatic
CHL-6336	Raw Water - South Filter Inlet Channel	3,000	1,000	Automatic

3. Eductors:

Eductors						
Injector Tag No.	**Injector Service**	**Design Chlorine Feed Rate min/max (lb/d)**	**Water Flowrate, Minimum (gpm)**	**Minimum Available Injector Water Supply Pressure, (without boosting) (psig)**	**Maximum Back Pressure (psig)**	**Injector Size (in)**
EDU-6341	Finished Water - Clearwell	170 - 3,000	80	80	5	2
EDU-6342	Finished Water - Clearwell	170 - 3,000	80	80	5	2
EDU-6346	Finished Water - Clearwell	170 - 3,000	80	80	5	2
EDU-6343	Raw Water - Rapid Mix	20 - 3,000	80	80	15	2
EDU-6344	Raw Water - North Filter Inlet Channel	20 - 3,000	80	80	15	2
EDU-6345	Raw Water - South Filter Inlet Channel	20 - 3,000	80	80	15	2

2.04 CHLORINE CONTAINER SCALES

A. All chlorine container scales and weight instruments shall be provided by the Chlorine System Supplier as specified in Section 17622 - Weight Measurement: Platform Scale and Load Cells and as indicated on the Drawings.

2.05 CHLORINE STORAGE

A. All chlorine storage components shall be provided by the Chlorine System Supplier.

B. Chlorine ton container trunnions:
   1. Manufacturers: One of the following, no equal:
      a. Force Flow, Type 21L.
   2. Type: 3/4-inch gray cast iron with cadmium plated steel wheels and bronze bushings.
   3. Number and sequencing: 48 pairs (1 pair per chlorine container), spaced as indicated on the Drawings.
   4. Wheel shaft: Hollow slots design for lubrication.
   5. Frame: Having slotted end holes for final adjustment using 1/2-inch anchor bolts.

2.06 EMERGENCY SHUTOFF SYSTEM

A. The Emergency Shutoff System shall be provided by the Chlorine System Supplier and consist of 20 emergency shutoff actuators that mount directly upon the ton container valve and 10 Emergency shutoff control panels.

B. Manufacturers: One of the following, no equal:
   1. Halogen Valve Systems, Eclipse Series with Duplex II Controller.

C. Actuators:
   1. Type: 10 banks of 2 electrically driven actuators (total of 20) that act directly upon emergency shut-off ton container valves via building alarm or emergency close push buttons located as indicated on the Drawings.
   2. Provide each actuator to deliver:
      a. 40 to 50 foot-pounds of closing torque to the valve stem upon receipt of a shutdown signal.
      b. 30 foot-pounds of closing torque to the valve stem for testing.
   3. Actuators shall mount upon the ton container yoke or valve assemblies by means of a clamping mechanism and coupling so as to be removable during cylinder changes.
   4. Enclosure Rating: NEMA 4X.
   5. Actuator shall be powered only in the closing direction with provision for manual override in either the open or the closed direction.

D. Actuator components:
   1. Actuator: Electrically driven, directly mounted on ton container valve or yoke.
   2. Clutch and shaft that allows manual opening and closing of valve.
   3. Valve and stem coupling.
   4. Clamp/Frame.
   5. Sealing devices.

6. Wall bracket for mounting actuator when not connected to a container.
7. Include V-R Extension for direct mount vacuum regulators.

2.07 PRESSURE AND VACUUM GAUGES

A. All components of each Pressure and Vacuum Gauge shall be provided by the Contractor per Section 17404 - Pressure/Vacuum Measurement: Gauges.

B. Provide diaphragm seals as specified in Section 17401 - Pressure/Vacuum Measurement: Diaphragm and Annular Seals:
   1. Diaphragm seal and pressure switch shall be assembled by manufacturer and shipped as an assembly.

2.08 VACUUM REGULATORS

A. All vacuum regulator assemblies shall be provided by the Chlorine System Supplier and shall be from the same manufacturer as the chlorinators.

B. Manufacturers: One of the following, no equal:
   1. Wallace & Tiernan, S10K.

C. Type: Vacuum operated with integral check valve feature and a gas flow direction indicator, able to reduce gas pressure to vacuum.

D. Quantity: 20.

E. Mounting: Directly on ton container isolation valve with a yoke type valve or adapter.

F. Capacity: Minimum 500 pounds per day each, suitable for chlorine gas service.

G. Able to vent gas under excess pressure through pressure relief valve. Route pressure relief exhaust to chlorine gas arrestor indicated on the Drawings.

H. Components:
   1. Vent tubing: Able to vent each regulator independently to scrubber.
   2. Heater: On each regulator.
   3. Heating element: Minimum 25 watt, 120 VAC, 60 hertz.
   4. Heater unit cord length: Minimum 6 foot.

2.09 CHLORINATORS

A. Chlorinators shall be provided by the Chlorine System Supplier.

B. Manufacturers: One of the following, no equal:
   1. Wallace & Tiernan, Series V2000 Wall-Mounted.

C. Type: Vacuum operated with the following features and capabilities:
   1. Wall-mounted panel with gas-control unit and electronic controller.
   2. Direct reading gas flow meter of the variable orifice type with linear scale reading in pounds per day.
   3. A control knob by which the dosage can be manually set by adjusting the chlorine metering orifice or flowrator.

4. V-notch variable orifice or flowrator with electric positioner with a 30 second maximum range response; with an accuracy of plus or minus 4 percent of the actual flow; 20:1 operating range.
    a. Manufacturers: The following or equal:
        1) Wallace & Tiernan, Series SFC.
5. High and low vacuum alarm switches, to activate remote alarm units:
    a. Switches shall be 5 amps, 250 VAC, 60 hertz, wired to coded terminal blocks.
6. Means of pressure and vacuum relief
7. Internal wiring for outgoing and incoming signals shall be wired to coded terminal blocks, as required.
8. Parts and accessories usually furnished with the equipment.

D. Variable area gas flow meters (rotameters):
1. Installed 3,000 pounds per day gas rotameters within the chlorinators.
2. Straight through flow design suited for metering chlorine gas.
3. Full view type with Viton O-ring seals with compression type vertical connections.
4. Able to operate at working vacuums of 24-inch mercury gauge at 100 degrees Fahrenheit.
5. Glass or ceramic float able to operate at maximum flow of gas with minimal pressure loss.
6. Minimum range of 20:1 and minimum accuracy of within 4 percent of maximum flow.
7. Flow scales either direct etched or detachable with meters supplied having the same flow scale design with a direct reading in pounds per day.
8. Scale length of approximately 250 millimeters.
9. Full open viewing required in the front only with the rear of the meter equipped with white colored backing plate.

E. Control for each chlorinator: Automatic feed:
1. Adjustability: Minimum 10:1 automatic.
2. For automatic control, each gas feeder shall be provided with an integral control system consisting of a dedicated gas feed electronic controller and V-notch actuator.
    a. Control signal provided to each actuator shall be a flow proportional 4 to 20 mA signal.
    b. Manufacturers: The following no equal:
        1) Wallace & Tiernan, Series SFC.
3. Provide 3,000 pounds per day gas flow transmitter with a 4-20mA output directly proportional to gas flow.
    a. Manufacturers: The following, no equal:
        1) Wallace & Teirnan, model compatible with V2000 chlorinator

2.10 EDUCTORS

A. Eductor shall be provided by the Chlorine System Supplier.

B. Manufacturers: One of the following, no equal:
1. Wallace & Tiernan.

C. Type:
   1. Remote mounted 2-inch body with manual shutoff.

D. Quantity:
   1. Provide the number, size, and capacity as indicated in the Eductor Schedule in this Section.

E. Provide each 2-inch eductor with a spring diaphragm check valve and a fixed throat or an adjustable throat for fine-tuning to on-site conditions of operating water and backpressure.

2.11 CHLORINE GAS DETECTION (MODULAR - DRY SENSORS)

A. All chlorine gas detection devices shall be provided by the Contractor as specified in Section 17504 - Analyzers: Gas Monitors and as indicated on the Drawings.

2.12 PIPING

A. Piping and appurtenances described in this section shall be provided by the Contractor as specified in Section 15230 - Plastic Piping and Tubing.

B. General:
   1. Provide piping, valve fittings, gaskets, bolts, nuts, couplings, supports, and other materials required for the entire installation.
   2. Provide materials in contact with chlorine suitable for this service.
   3. Install, clean, and test in accordance with Chlorine Institute's recommendations.

C. Chlorine gas vacuum piping and solution piping: Schedule 80 polyvinyl chloride pipe (PVC):
   1. Service conditions: Chlorine solution at pressures of 0 to 150 pounds per square inch gauge and chlorine gas under a vacuum of 0 to 15 inches Hg at ambient temperatures.

D. Joints for plastic pipe: Solvent welded unless otherwise specified.

E. Install hangers and supports and test pipes as specified in Section 15061 - Pipe Supports, Section 15956 - Piping Systems Testing, and as indicated on the Drawings.

F. Pipe connections, except valves and pipe caps:
   1. Welded and be tested for leaks.
   2. Bushings shall not be allowed in the chlorine gas supply systems.

2.13 VALVES

A. Valves for chlorine system shall be provided by the Contractor as specified in Sections 15111 - Ball Valves, 15114 - Check Valves, and 15117 - Specialty Valves.

2.14 PASSIVE CHLORINE GAS ARRESTOR

A. Passive chlorine gas arrestor shall be provided by the Chlorine System Supplier.

B. The minimum number of passive chlorine gas arrestors are indicated on the Drawings. Additional passive chlorine gas arrestors shall be provided as required due to neutralization capacity and/or location.

C. Manufacturers: The following or equal:
   1. PureAir.

D. Features and characteristics:
   1. Meets or exceeds requirements of NFPA 1 UFC.
   2. Passively neutralize chorine gas from chlorine vacuum regulator assemblies and chlorinators with dry media.
   3. Provide a pH strip at the inlet and at the outlet of the arrestor that changes color to indicate the presence of chlorine gas and media exhaustion.

E. Design Criteria
   1. Passive chlorine gas arrestor shall be designed and conform to the following design criteria:
      a. Chlorine Vent Rate 0.12 pounds per hour
      b. Vaporization Rate 0.65 scfh
      c. Vent Capacity 3 pounds
      d. Chlorine Exhaust Concentration < 100 ppbv

2.15 VENTS

A. Must comply with the IFC and follow manufacturer's instructions.

B. Valves releasing chlorine cannot discharge directly to outside air; must be piped to scrubber or passive chlorine gas arrestor, and in such a way not to allow moisture or the invasion of insects to accumulate.

2.16 MISCELLANEOUS EQUIPMENT

A. Provide the following miscellaneous equipment:
   1. Ammonia bottles: 12 narrow mouth plastic wash bottles, 125 milliliter Cole-Parmer Item EW-06052-20 or equal, filled halfway with 26 degree Baumé aqua ammonia for chlorine leak testing.
   2. Two new Chlorine Institute Emergency Kits "B" for ton chlorine containers.
   3. Two NIOSHA-certified self-contained breathing apparatuses (SCBAs)
   4. Magnetic container signs: Furnish 6-inch high by 8-inch wide magnetic container status labels with minimum 1.5-inch lettering:
      a. Manufacturers: The following or equal:
         1) Lab Safety Supply Item No. 26471.
   5. Provide the following quantities and spares for each type of sign:

Sign Type	Quantity
Pressure Tested - Ready for Use	48
Empty Container - Do Not Use	24
Online - Container in Use	24
Danger - Defective Container	3

2.17 SPARE PARTS

A. Furnish, package and label the following spare equipment:
   1. One complete set of special wrenches needed for ton container valves.
   2. One spare 3/4-inch auxiliary ton container valve.
   3. Eight 1-inch chlorine liquid/gas shut-off line ball valves.
   4. One emergency shutoff actuator.
   5. One spare vacuum regulator valve with hydromotor electric actuator.
   6. Four preventive maintenance kits for vacuum regulating check valves.
   7. Eight spare chlorine gas rotameters for chlorinators, 2 sized for 3,000, 2 sized for 2,000 pounds per day, 2 sized for 1,000 pounds per day, and 2 sized for 500 pounds per day. To include all the parts necessary to modify the chlorinator to the appropriate output (throat, v-notch orifice, float, glass).
   8. One box of spare light bulbs for each light on front face of each local control panel.
   9. Wrenches for working on chlorinators, extra gaskets, and such spare parts as are customarily furnished by the manufacturer or specified for one and two year preventative maintenance.
   10. 500 chlorine gaskets for chlorine yokes.
   11. Two spare heaters with heating elements.

PART 3 EXECUTION

3.01 INSTALLATION

A. Chlorine feed system shall be installed under the direction of the Chlorine System Supplier in strict conformance with the manufacturer's installation instructions and with favorable review of shop drawings.
   1. Final installation, inspection, start-up, calibration, and instruction of operating personnel shall be performed by an authorized representative of the manufacturer.

B. The Supplier/Manufacturer shall inspect the installation of all equipment in this Section before start-up in order to verify that the equipment has been properly installed and operates properly as a system and individually.
   1. The Contractor shall coordinate with the Chlorine System Supplier for the scheduling of this activity.

C. Upon acceptance by the Engineer, alignment of equipment, piping, and accessories may vary from that indicated on the Drawings to suit the equipment furnished, without additional cost to the Owner.

D. Field finishes:
   1. Protect motors.
   2. Clean equipment and prepare shop primer.
   3. Apply field primer and coating systems in the field as specified in Section 09960 - High-Performance Coatings requirements.

E. Preparation:
   1. Remove oil and grease from chlorine piping system.

2. Do not use pipe dope that contains oil or grease.
3. Blow dirt and debris out of the chlorine lines.
4. Do not put water into chlorine pipe.
5. Seal pipe after each day's work to prevent accumulation of dirt and debris.
6. Before introducing chlorine gas, desiccate the lines with nitrogen gas or perform a vacuum test.
7. Refer to and follow guidelines for the preparation for use of chlorine pipelines by the Chlorine Institute.

F. Identification of the health, flammability, and reactivity of hazardous materials shall be affixed as specified in Section 10400 - Signage.

3.02 CLEANING

A. General:
   1. Clean all chlorine system components in accordance with Chlorine Institute's recommendations.
   2. All portions of the system shall be cleaned free of oil and grease.

B. PVC pipe:
   1. Chlorine gas vacuum piping:
      a. Do not flush chlorine gas vacuum piping with water.
      b. Blow pipe clean of loose debris with instrument-grade clean and dry compressed air.
      c. Pipe shall be open and not valved off at the end of the section to be cleaned so that pipe does not become pressurized. Do not pressurize PVC with compressed air.
   2. Chlorine solution piping:
      a. Flush with potable water to clear loose debris.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning, and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Source Testing.
      b. Manufacturer's Certificate of Installation and Functionality Compliance.
   2. Manufacturer's Representative onsite requirements:
      a. Installation: 2 trips, 3-day minimum each.
      b. Functional Testing: 1 trip, 3-day minimum each.
   3. Training:
      a. Perform Owner training as specified in Section 01756 - Commissioning.
      b. Training topics should focus on maintenance
      c. Number of sessions:
         1) Operations and Maintenance: 1.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Source Testing:
   1. Test as specified in Section 15958 - Mechanical Equipment Testing.
   2. Chlorine container weight scales:
      a. Test witnessing: Not witnessed.
      b. Conduct Level 1 General Equipment Performance Test.
   3. Electrical Instrumentation and Controls:
      a. Test witnessing: Not witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

D. Functional Testing:
   1. Chlorination system:
      a. Test witnessing: Witnessed.
   2. Electrical Instrumentation and Controls:
      a. Test witnessing: Witnessed.
      b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.04 ADDITIONAL SERVICES

A. Manufacturer services include two 2-day site visits during the first year as coordinated with the Owner.

END OF SECTION

SECTION 11263

ON-SITE CHLORINE DIOXIDE GENERATION SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. On-Site Chlorine Dioxide Generation System Modifications.

B. Tag numbers:
   1. Chlorine Dioxide Generation System Unit No. 1: CDX-7711, Unit No. 2: CDX-7721.

1.02 ADMINISTRATIVE REQUIREMENTS

A. Costs for Chlorine Dioxide Generator Modifications shall be as submitted at bid time. Contractor shall coordinate with supplier to update attached proposal pricing for work to occur according to Contractor's schedule and within the restrictions indicated in Section 01140.

B. Supplier costs, for generator system modification shall include Technical Service Survey Visit and upgrades to both generators, described in the attached proposal.

C. Supplier costs for optional equipment shall be submitted in the Chlorine Dioxide Generator Optional Equipment Allowance Schedule. See Bidding Documents, section C.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Updated operation and maintenance manuals:
   1. Meeting requirements of Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following, per the attached proposal:
   1. International Dioxcide, Inc.

2.02 SYSTEM DESCRIPTION

A. General
   1. Existing chlorine dioxide generators to be modified per the attached proposal. All other equipment in the chlorine dioxide building is to remain operational, unless indicated on the Drawings.
   2. Contractor to make modifications within the Chlorine Dioxide Building as indicated on the Drawings.
   3. The Owner selected Programmer shall provide any programming for ancillary equipment on the existing PLC. The Programmer shall be contracted to the Contractor.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Supplier of the generation system shall furnish and install components on the skid-mounted package system as indicated in the attached proposal.

B. Contractor shall be responsible for supplying and connecting all conduit, wire, pipe, etc. for the system supplied equipment, as indicated on the Drawings and in the proposal.

C. Performance:
   1. Chlorine dioxide feed equipment shall be comprised of a process for chlorine dioxide generation utilizing sodium chlorite solution and chlorine gas. The sodium chlorite solution shall be 25-31 percent solution (by weight).
   2. The system efficiency shall be 95 percent or greater as defined in AWWA Standard Method 4500 ClO_2 E:
      a. Chlorine dioxide/(Chlorine dioxide plus Chlorite plus Chlorate).
      b. Excess chlorine shall not exceed 5 percent when tested in accordance with AWWA Standard Method 4500 ClO_2 E.
   3. Chlorine dioxide concentrations must not exceed 3,000 milligrams per liter at any time to maximize the safety of the process.
   4. The system shall be designed to meet these specifications using any sodium chlorite that meets the ANSI/AWWA B303-18, AWWA Standard for Sodium Chlorite. Use of a sodium chlorite from a supplier not affiliated with the sodium chlorite generator manufacturer, provided that the sodium chlorite meets ANSI/AWWA B303-10, shall not violate or compromise the sodium chlorite generator warranty in any way.

2.04 MATERIALS

A. The materials of construction for the chlorine dioxide generator feed system shall be compatible with chlorine dioxide and its chemical precursors.

B. Chlorine dioxide equipment shall be of substantial construction with all parts designed for long life under working conditions, including chemical contact, corrosive atmospheres, and intermittent or continuous operation.
   1. All wearing parts and items requiring adjustment shall be readily accessible.
   2. All parts exposed to corrosive conditions shall be made from corrosion-resistant materials or covered with suitable protective coatings as specified in Section 09960 - High-Performance Coatings.

2.05 ON-SITE CHLORINE DIOXIDE GENERATOR

A. The chlorine dioxide generation unit shall be capable of automatically feeding the required amount of chemical to a batch tank system over the full required range without the need for removing any items and replacing them with components or items of another operational capacity. The capacity of each system after modifications shall be as follows:

Parameter	Values
Number of Generators, total	2
Generator Capacity, each (lb/day)	2,500
Operating Concentration (mg/L ClO_2 solution)	300 - 3,000
Utility Water Flow (gpm)	70-100

PART 3 EXECUTION

3.01 INSTALLATION

A. Contractor to coordinate for Technical Service Survey Visit, which must occur prior to modifications. See Section 01140 - Work Restrictions for timing requirements.

B. Contractor shall pull additional wire as needed back to control box to allow for relocation of electrical instruments as indicated in proposal.

C. Modifications of the generator appurtenances shall be done on-site by the Supplier. Contractor to coordinate with the Supplier to give them access to the site and coordinate needs.

D. Field finishes:
   1. Protect motors.
   2. Clean equipment and prepare shop primer.
   3. Apply field primer and coating systems in the field as specified in Section 09960 - High-Performance Coatings requirements.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Training:
      a. Maintenance and Operations: 1 session.

END OF SECTION

International Dioxcide Inc. Equipment Proposal

24 Jan 2025

Carollo for Jordan Valley WTP
Attn: Stetson Bassett, Ali Leeds

RE: Chlorine Dioxide System

Dear Stetson & Ali,

International Dioxcide, Inc., a wholly owned subsidiary of ERCO Worldwide, is pleased to submit a chlorine dioxide generator upgrade proposal for your consideration. This project will cover the on-site upgrade of two 2" MG2 generators. A detailed scope of work has been provided separately.

The major goals of the upgrade include a capacity increase to 2500 PPD, mitigating operator issues, and replacing worn or outdated parts. An additional component of the project will include a maintenance and training program designed to provide tools for operators to keep the systems operating well. International Dioxcide, Inc. would be happy to discuss the engineering aspects of this technology at your earliest convenience.

General Project Milestones:

Schedule a 2-day visit by technical service staff to cover the following:

- Survey the systems and perform high-capacity testing to determine what other steps are required to meet the 2500 ppd goal.
- Ascertain the status of all components on each skid to determine what replacements are needed, including whether 2" or 3" components are required.
- Verify the eductor salting issue and verify the purge cycle timing.
- Verify the chlorine gas flow required to meet 2500 ppd capacity.
- Assess what PLC program changes might be required.

Based on the results of the technical service visit, schedule the first upgrade session where some combination of the following will occur on the first generator:

- Eductor replacement
- Piping changes (2" or 3")
- Component upgrades and relocation (flow meters, valves, flow controls, actuators Optek, pH probe, etc.)
- Chlorine gas component upgrades (if needed)
- Leak testing
- Water testing
- Chemical testing
- Maintenance & Training program, first class

International Dioxcide
AN ERCO WORLDWIDE COMPANY

Upgrade Quote:

Cost for the Technical Service Survey Visit		**US$**	**4,000**
Parts and Labor Breakdown for Each Generator Upgrade			
Cost of the 2" Generator Upgrade Parts for per Generator	US$	6,222	
Cost of the New Optek for One Generator	US$	12,508	
Cost of Misc Parts for One Generator (Flow Meters, Actuators, Eductor, Etc.)	US$	11,465	
Service Visit to Upgrade One Generator and Training	US$	10,000	
Crating and Shipping Estimate per Generator	US$	704	
Total Cost for Upgrade of One Generator		**US$**	**40,897**
Total Cost for Upgrade of Second Generator		**US$**	**40,897**
IDI Engineering, Factory assembly, Programming and Testing		**US$**	**5,927**
Total Cost for Upgrade to Two Generators, Parts, Labor, Training		**US$**	**91,721**

Quantity	**Optional Equipment Description**			
One Lot (1)	IDI recommended spare parts	US$	5,672	
Two Lots (2)	Gen 3" parts if required for flow (net, minus 2" parts)	US$	8,012	
One Lot (1)	3000 PPD Chlorine Rotameter and Installation	US$	2,923	
One Lot (1)	3000 PPD Chlorine Flow Control Valve and Installation	US$	6,462	
Total Cost of the ClO_2 Optional Equipment			**US$**	**23,069**

An upgraded set of documents is included with the service.

The spare part list may be altered based on Maintenance and Training program.

These are budgetary numbers. Actual costs could vary based on actual conditions at the time of service.

Costs of upgrading and testing the PLC code are NOT included in this proposal. They would be extra if required.

No video training is included. If a videographer is desired, that cost is outside this proposal.

The Equipment will be provided Ex Works (Incoterms 2020) at IDI's Facility located in North Kingstown, RI or other location specified by IDI in writing.

Execution

IDI will be able to ship the equipment 4-5 weeks from receipt of order depending on any log lead items. Incomplete design data may delay shipping.

IDI/ERCO Terms and Conditions will apply. See complete T&C included in Appendix A.

The proposal is valid for 60 days.

Payment Terms - Net 30 days upon receipt of invoice (subject for review or approval).

Notes:

- Eductor nozzle increase from 0.500 to 0.625 will raise the motive water flow from ~60 gpm to ~100 gpm.

Assumptions:

- Customer will increase the inlet and outlet piping size as needed.
- Customer will verify that water source can maintain 90 psi with the increased 100 gpm flow.
- Any additional parts deemed unsafe, obsolete, or otherwise requiring replacement during installation will require a scope update and increase the cost of the project.
- No PLC programming changes are anticipated with this upgrade project, but if required, this is out of our scope.
- Any voids in the existing polyboard due to plumbing or instrument changes will be left as is.
- The revising of the 2" pipe to 3" pipe will require the relocation of electrical instruments. Additional wire lengths may be needed to accomplish this. We can provide junction boxes to meet this need, or we can run new wire back to the control box.
- Any seismic updates for the upgrade are out of scope.

Sodium Chlorite Supply:

ERCOPure™ sodium chlorite is available from International Dioxcide, Inc. ERCO is the largest producer of EPA registered sodium chlorite in North America with two independent plants and five terminals geographically located across the country.

Precursor Chemicals & Reaction:

The ADOX™ 2" MG2 utilizes the following precursor chemicals to generate chlorine dioxide:

- Sodium Chlorite Solution, 25%
- Chlorine Gas

This two chemical chlorine dioxide generator theoretically forms 100% efficient chlorine dioxide by the following reaction:

$$2NaClO_2 + Cl_2 \rightarrow 2ClO_2 + 2NaCl$$

The ADOX™ 2" MG2 generator has the capability of operating at greater than 95% conversion efficiency of the sodium chlorite precursor.

Commissioning & Start-Up:

Installation Requirements (Customer):

- Customer responsible for transporting IDI equipment from receiving to the installation location and affixing it to the floor as required by the site.
- Government and local building codes must be observed for equipment placing.
- Refer to NFPA 70 Table 110.26 for minimum clear distances required in front of equipment to define working space.
- Government approval for equipment is the customer's responsibility.
- Vacuum Regulator available for our generator chlorine gas hookup. It must be capable of supplying the required PPD of gas to run each generator.

Installation Responsibilities (Supplier):

- Hook up and commissioning of equipment by IDI Rep is in the pricing of generator.
- Startup and training to be provided, as noted above

Site Preparation & Installation:

Safety

A safety shower and eye wash station should be visible and in close proximity to the chlorine dioxide generator.

Water Utility

A clean water source is preferred, minimum 120 US GPM. Please confirm your water specifications with the design engineers.

Application Points

Feed Distribution to injection points, customer will supply and install feed piping to each injection point. Existing chlorination lines can be used if sized appropriately.

APPENDIX A

IDI-STANDARD TERMS AND CONDITIONS

STANDARD CONDITIONS OF SALE

1. Seller warrants only that (a) any products or services provided hereunder meet Seller's standard specifications for the same or such other specifications as may have been expressly agreed to herein; (b) the sale of any products or services provided hereunder will not infringe the claims of any validly issued United States patent covering such product or service itself, but does not warrant against infringement by reason of (i) the use of any information provided, (ii) the use of any product or service in combination with other products, services, or information or in the operation of any process, or (iii) the compliance by Seller with any specifications provided to Seller by Buyer; and (c) all products provided hereunder were produced` in compliance with the requirements of the Fair Labor standards Act of 1938, as amended.

EXCEPT FOR THE FOREGOING, WITH RESPECT TO ANY PRODUCTS, SERVICES, OR INFORMATION PROVIDED TO BUYER, SELLER MAKES NO WARRANTIES OF MERCHANTABILITY, NON-INFRINGEMENT, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY OTHER EXPRESS OR IMPLIED WARRANTY. Buyer assumes all risk and liability resulting from use of the products, services, or information delivered hereunder, whether used singly or in combination with other products, services, or information.

2. IN NO EVENT WILL SELLER'S AGGREGATE LIABILITY TO BUYER FOR ALL DAMAGES ARISING IN CONNECTION WITH THIS AGREEMENT, REGARDLESS OF WHETHER THE FORM OF ACTION IS BASED ON CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY, STATUTE, OR OTHERWISE, EXCEED THE TOTAL PRICE PAID BY BUYER TO SELLER FOR THE PRODUCTS, SERVICES, OR INFORMATION IN RESPECT OF WHICH DAMAGES ARE CLAIMED. NO CLAIM SHALL BE ALLOWED FOR PRODUCT THAT HAS BEEN PROCESSED IN ANY MANNER. FAILURE TO GIVE NOTICE OF A CLAIM WITHIN NINETY (90) DAYS FROM DATE OF DELIVERY, OR THE DATE FIXED FOR DELIVERY (IN CASE OF NONDELIVERY) SHALL CONSTITUTE A WAIVER BY BUYER OF ALL CLAIMS IN RESPECT OF SUCH PRODUCTS, SERVICES, OR INFORMATION. PRODUCTS SHALL NOT BE RETURNED TO SELLER WITHOUT SELLER'S PRIOR WRITTEN PERMISSION. NO CHARGE OR EXPENSE INCIDENT TO ANY CLAIMS WILL BE ALLOWED UNLESS APPROVED BY AN AUTHORIZED REPRESENTATIVE OF SELLER. IN ADDITION, AND TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, EACH PARTY HERETO WAIVES ANY CLAIM TO INDIRECT, CONSEQUENTIAL, PUNITIVE, EXEMPLARY OR MULTIPLIED DAMAGES ARISING OUT OF OR RELATING TO THIS AGREEMENT OR THE PROVISION OF ANY PRODUCT, SERVICE, OR INFORMATION. TO THE EXTENT PERMITTED BY APPLICABLE LAW, THE PARTIES WAIVE AND AGREE NOT TO ASSERT NON-CONTRACTUAL CLAIMS ARISING UNDER STATE LAW RELATING TO THIS AGREEMENT OR THE PROVISION OF ANY PRODUCT, SERVICE, OR INFORMATION COVERED BY THIS AGREEMENT, AND THIS AGREEMENT SHALL BE DEEMED TO INCLUDE SUCH LANGUAGE AS MAY BE REQUIRED TO EFFECT SUCH WAIVER. WAIVER BY EITHER PARTY OF ANY DEFAULT BY THE OTHER HEREUNDER SHALL NOT BE DEEMED A WAIVER BY SUCH PARTY OF ANY DEFAULT BY THE OTHER WHICH MAY THEREAFTER OCCUR.

3. Seller shall not be liable for delay in performance or for nonperformance, directly or indirectly caused by circumstances beyond the control of Seller, including, but not limited to, act of God, fire, explosion, flood, war, terrorism, act of or authorized by any Government, accident, labor trouble or shortage, pandemic, inability to obtain material, equipment or transportation, failure to obtain or hardship in obtaining reasonably priced supplies of materials, or failure of usual transportation mode (collectively, "Force Majeure").. Quantities so affected may be eliminated from the Agreement without liability, but the Agreement shall remain otherwise unaffected. Seller shall have no obligation to purchase supplies of the product specified herein to enable it to perform this Agreement.

4. If for any reason, including but not limited to Force Majeure, Seller is unable to supply the total demand for products specified herein, Seller may distribute its available supply among any or all purchasers, as well as departments and divisions of Seller, on such basis as it may deem fair and practical, without liability for any failure of performance which may result therefrom.

5. Seller may furnish such technical assistance and information as it has available with respect to the use of the products or services covered by this Agreement. Unless otherwise agreed in writing, all such information will be provided gratis. Buyer agrees to evaluate such information, to make an independent decision regarding the suitability of such information, products and services for Buyer's application, and only use such products, services and information pursuant to then current good product stewardship principles and all regulatory requirements applicable to Buyer's business.

6. Buyer acknowledges that it has received and is familiar with Seller's labeling and literature concerning the products and its properties. Buyer will forward such information to its employees, contractors and customers who may distribute, handle, process, sell or use such products, and advise such parties to familiarize themselves with such information. Buyer agrees that products sold hereunder will not knowingly be resold or given in sample form to persons using or proposing to use the products for purposes contrary to recommendations given by Seller or prohibited by law, but will be sold or given as samples only to persons who can handle, use and dispose of the products safely. Buyer agrees that export of any product, service or information provided hereunder shall be in accordance with applicable Export Administration Regulations.

7. Except as may be contained in a separate trademark license, the sale of product (even if accompanied by documents using a trademark or trade name of Seller) does not convey a license, express or implied, to use any trademark or trade name of Seller, and Buyer shall not use any trademark or trade name of Seller in the conduct of its business without Seller's prior written consent.

8. The Buyer shall reimburse the Seller for all taxes, (excluding income taxes) excises or other charges which the Seller may be required to pay to any Government (National, State or Local) upon the sale, production or transportation of the products, services, or information sold hereunder.

9. Unless otherwise agreed by the Seller and the Buyer, payment terms are net 30 Seller's invoice. If at any time Buyer's financial condition appears unsatisfactory to Seller and Buyer fails to provide, at Seller's request, (i) satisfactory security in advance of any shipment, (ii) Buyer's financial statements for the purpose of examining Buyer's financial condition, or if Buyer fails to comply with the terms of payment or other terms of this Agreement, then Seller shall be entitled, without prejudice to any of its other rights, to: (a) defer shipment hereunder until Buyer fulfils these obligations, (b) amend the payment terms of this Agreement, and (c) terminate this Agreement upon written notice to the Buyer. Seller agrees that Buyer's financial statements shall be considered confidential information and Buyer shall not use the confidential information for any other purpose other as than provided for in this paragraph. Nothing herein shall limit the remedies of Seller in the event of Buyer's breach.

10. This Agreement is not assignable or transferable by Buyer, in whole or in part, except with the prior written consent of Seller. Seller reserves the right to sell, assign, or otherwise transfer its rights and obligations under this Agreement.

11. Dispute Resolution and Arbitration - Buyer and Seller agree to arbitrate all disputes, claims or controversies arising out of or relating to (a) this Agreement or the relationship which results from this Agreement, (b) the breach, termination or validity of this Agreement, (c) the purchase or supply of any product, service, or information provided by Seller, (d) events leading up to the formation of Buyer's and Seller's relationship, and (e) any issue related to the creation of this Agreement or its scope, including the scope and validity of this paragraph. The parties shall before and as a condition to proceeding to arbitration attempt in good faith to resolve any such claim or controversy by mediation under the International Institute for Conflict Prevention & Resolution ("CPR") Mediation Procedure then currently in effect. Unless the parties agree otherwise, the mediator will be selected from the CPR Panels of Distinguished Neutrals. Any such claim or controversy which remains unresolved 60 days after the appointment of a mediator or 60 days after good faith efforts by either party to proceed to mediation shall be finally resolved by binding arbitration in accordance with the CPR Rules for Non-Administered Arbitration then currently in effect by three independent and impartial arbitrators, none of whom shall be appointed by either party. Any arbitration shall be governed by the Federal Arbitration Act, 9 U.S.C. §§ 1-16, to the exclusion of any state laws inconsistent therewith. Such arbitration shall be conducted in Boston, Massachusetts, and the arbitrators and the parties shall conduct such arbitration in accordance with such procedures as may be necessary to permit use of the then current

CPR Arbitration Appeal Procedure. Any judgment upon the award rendered by the arbitrator(s) may be entered by any court having jurisdiction thereof. In the event that either party wishes to appeal an award, the parties shall follow the then current CPR Arbitration Appeal Procedure. Buyer and Seller agree not to file or join any class action or class arbitration, seek or consent to class relief, or seek or consent to the consolidation or joinder of its claims with those of any third party. If any clause within this Arbitration Provision (other than the agreement regarding the conduct of the arbitration) is found to be illegal or unenforceable, that clause will be severed from this Arbitration Provision, and the remainder of the Arbitration Provision will be given full force and effect. If such agreement regarding the conduct of the arbitration is found to be illegal or unenforceable and if the arbitrators permit a class arbitration or consolidated or joined matter to proceed, this entire Arbitration Provision will be unenforceable, and the dispute may be decided by a court. The obligations set forth in this paragraph shall survive the termination or expiration of this Agreement.

12. Except as otherwise provided in the preceding paragraph, this Agreement shall be construed and governed by Delaware law, without regard to any applicable conflicts of law provisions, and the terms of the UCC, rather than the United Nations Convention on Contracts for the International Sale of Goods, shall apply.

13. Except as otherwise expressly provided in any other term or condition of this Agreement, title, liability for and risk of loss to Product sold hereunder passes to Buyer upon loading for shipment at Seller's producing location.

14. Except as expressly provided in any other term or condition of this Agreement, any provision hereof which is prohibited or unenforceable in any jurisdiction shall, as to such jurisdiction, be ineffective only to the extent of such prohibition or unenforceability without invalidating the remaining provisions hereof or affecting the validity or enforceability of such provision in any other jurisdiction.

15. This Agreement supersedes all prior agreements, representations and understandings between the parties (whether written or oral) with respect to its subject matter and constitutes (along with the exhibits and schedules attached hereto) a complete and exclusive statement of the terms of the agreement between the parties with respect to the provision of products or services hereunder. Not by way of limitation of the unqualified nature of the foregoing, Buyer acknowledges, agrees and represents that it is not relying upon, and it has not been induced by, any representation, warranty, statement made by, or other information provided by Seller in connection with its decision to purchase or use any product, service, information or technology, except as and only to the extent expressly provided in this Agreement. No modification of this Agreement shall be binding upon Seller unless separately contracted in writing and executed by a duly authorized representative of Seller. No modification shall be effected by the acknowledgment or acceptance of purchase order forms stipulating different conditions.

Ver. 01/02/2018

Customer:

Carollo for Jordan Valley WTP

Design Lead:

Mike Morris

Sales Lead:

Matt Hinds

Scope:

This scope covers the upgrade of two 2" MG2 generators with the main goal of raising the maximum capacity to **2500 PPD**. The following changes will be proposed to meet this goal:

- Larger eductor: Change the nozzle & throat from 0.500/0.750 to 0.625/0.937.
- Larger piping: Optionally change most of the 2" PVC to 3" PVC if significant flow restrictions are encountered with the 2" pipe at the higher motive flow with the new, larger eductor.
- Chlorine flow: It was reported that the chlorine flow required to maintain the optimal pH is significantly higher than stoichiometry would expect. If this is verified, we would propose a larger chlorine gas rotameter and Hydro flow control valve. Both would raise Cl_2 gas flow max capacity from 2000 ppd to 3000 ppd.

Additional changes will be proposed to address the ongoing **Operator Issues**:

- Hydro flow control valve replacement **
- Plastomatic actuated valve replacement (motive water and chlorine, valve and actuator)
- Replace the ball check valve at generator exit **
- Replace chlorine gas check valve on eductor and verify the generator water purge time **
- Verify the low alarm limits on the chlorine dioxide concentration and change them if possible *
- Replace Optek Analyzers and Optek ClO_2 Detectors **
- Replace all piping which carries chlorine dioxide

  * If the alarm limits are in the PLC code, this may require PLC code changes which are out of scope. If the alarms are Optek generated, we can adjust those when programming the Optek controller.

  ** These items will also be addressed as part of the maintenance and training program.

Aging equipment upgrades:

- Chlorite flow meter – replace with a Keyence ultrasonic meter
- Motive water solenoid – replace with an actuated ball valve or larger solenoid
- Motive water flow meter – Replace with a Keyence ultrasonic meter
- pH probe and preamp - Replace and move downstream for longer mixing time **

As noted in the "Operator Issues" section, a **Maintenance and Training** program will have a meaningful impact on some of the issues noted with ** above.

- Hydro flow control valve rebuild kit usage
- pH probe testing and calibration
- Eductor chlorine check valve, spring, and diaphragm maintenance and replacement
- Optek detector cleaning and re-zero
- Chlorine dioxide valves, check valves, unions, etc. o-ring maintenance

Notes:

- Eductor nozzle increase from 0.500 to 0.625 will raise the motive water flow from ~60 gpm to ~100 gpm.

Assumptions:

- Customer will increase the inlet and outlet piping size as needed.
- Customer will verify that water source can maintain 90 psi with the increased 100 gpm flow.
- Any additional parts deemed unsafe, obsolete, or otherwise requiring replacement during installation will require a scope update and increase the cost of the project.
- No PLC programming changes are anticipated with this upgrade project, but if required, this is out of our scope.
- Any voids in the existing polyboard due to plumbing or instrument changes will be left as is.
- The revising of the 2" pipe to 3" pipe will require the relocation of electrical instruments. Additional wire lengths may be needed to accomplish this. We can provide junction boxes to meet this need, or we can run new wire back to the control box.
- Any seismic updates for the upgrade are out of scope.

Design Overview:

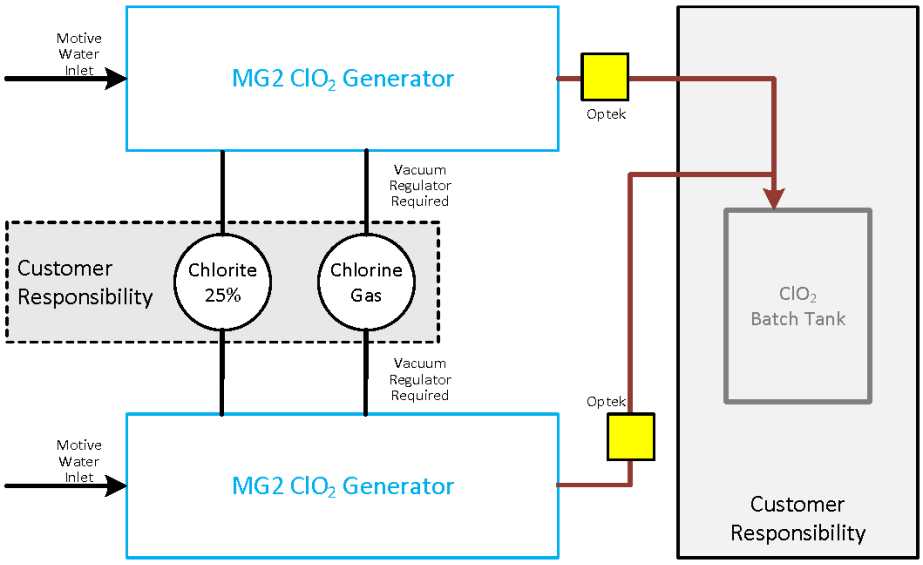


Figure 1 - Dual 3" MG2 2500 PPD Chlorine Dioxide Generators

Water and ClO_2 Path Potential Upgrade

Only the water path from inlet to eductor and from eductor to outlet will change from 2” components to 3” components if needed. The pH probe and sight glass move to the isolation loop with the Optek detector.

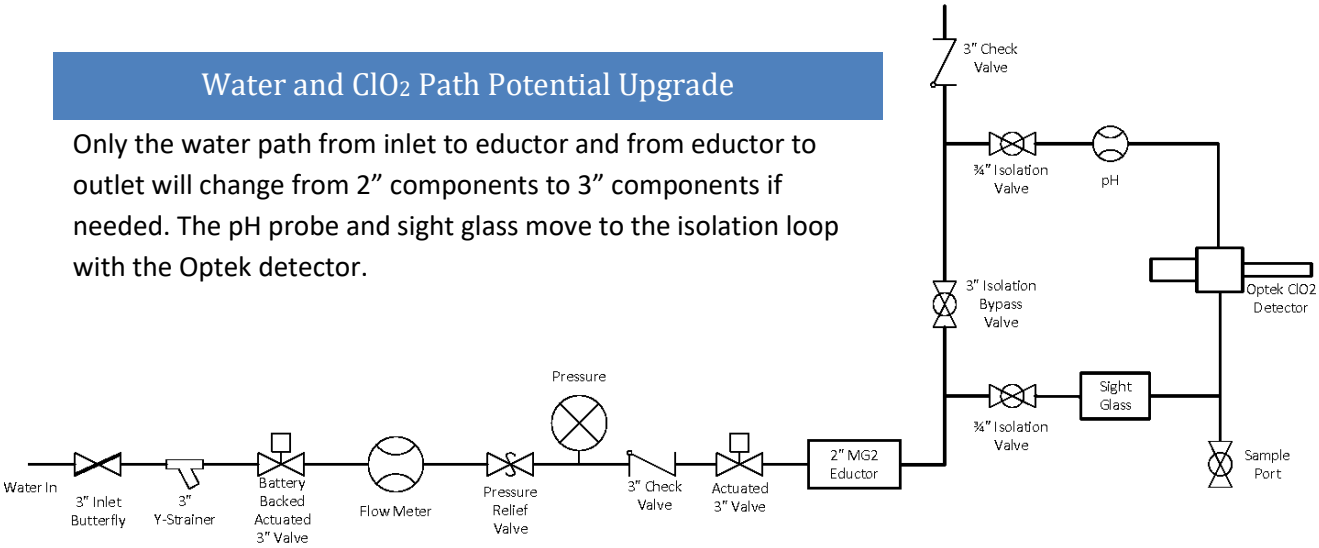


Figure 2 - Upgrade Path from Water Inlet to Chlorine Dioxide Outlet

General System Design/Equipment:

MG2 System

• ClO_2 Production	2500 PPD
• Booster Pump	None required
• Power at System Drop	120vac and 208vac, single phase, Unchanged
• Eductor Size	2" Body / 0.625 Nozzle / 0.937 Throat
• Chlorite Flow Meter	Keyence FD-H20 for ¾" service
• Chlorite FCV	Hydro 4gpm, 02-CV230LQ16DC & 07-HYDROSTM7
• Chlorine FCV 2000 PPD	Hydro 2000ppd, 02-CV230GAS16DC & 07-HYDROSTM8
• Chlorine FCV 3000 PPD	Hydro 3000ppd OV-1000
• Rotameter Chlorite	Brooks (Obsolete), Changed to Krohne 2.3 gpm
• Rotameter Chlorine	Hydro 2000 ppd with possible upgrade for 3000 ppd
• Batch Tank	Customer Supplied and maintained
• Flow meter for motive water 2"	Keyence FD-R50
• Flow meter for motive water 3"	Keyence FD-R80
• pH probe	Replace with GF-3-2724 in ¾" tee, move to Optek loop
• Sight Glass	Replace with ¾" model, 03-SGT1200, move to Optek loop

Application:

- Municipal Water Treatment

Process Factors (Assumptions):

- Chlorite: 25% by weight
- Chlorite Storage: Tank
- Chlorite Usage: 1340 gpd (0.9 gpm) @ 2500 PPD Capacity
- Chlorine Gas Storage Cylinder Type
- Chlorine Gas Usage: 1326 ppd @ 2500 PPD Capacity, Estimated
- Reaction Nominal Yield: >95%
- Control Type: Flow Pace
- pH Range: 2.5 – 4.5, set for maximum efficiency
- ClO_2 Concentration: ~2100 ppm @ 2500 PPD Capacity and 100 gpm flow
- Generation Controlled By: Tank Concentration Setpoint, Dose permissive (Tank Fill)
- Eductor Flow Rate: ~100 gpm @ 90 psi eductor inlet pressure
- ClO_2 Generation: 500 to 2500 ppd
- Water Flow to be Treated: 120 to 275 MGD
- Dosage for Treated Water: 0.5 to 1.1 ppm
- Inlet Water Pressure: 85 to 95 psi
- Back Pressure: Nominal tank head pressure, <20 psi
- Min/Max Water Temp: 40° F Min / 70° F Max

Keynote / Long Lead Items:

- No long lead parts anticipated
- 8 Hour minimum testing

Certifications Associated with the Project:

- UL508A Certified (US)
- CSA/NSF61

Programming Notes:

- **SCADA Programming is the customer's responsibility.**
- **PLC Programming changes are the customer's responsibility.**

Shipping:

- Costs for shipping systems is a contract item. Contact sales with questions.

Installation Requirements (Customer):

- Vacuum Regulator available for our generator chlorine gas hookup

Installation Responsibilities (Supplier):

- Hook up and commissioning of equipment by IDI Rep is in the pricing of generator.
- Startup and training to be provided, minimum 4 days

Support Contact: 800-477-6071 option 4

Spares:

The spare parts list will be finalized when the maintenance & training program is designed. It will likely include:

- O-Ring set, 2x
- Valves
- Eductor nozzle, 14-QB62500
- Eductor chlorine check valve assembly, 14-QF00013
- Hydro PM Kits
- Café Actuator BBU, 02-EP00UAVBBUG
- Check valves
- pH probe, 12-PHG0015

Preliminary Upgrade Parts List, One Set for Each Generator:

Pink rows are for 2”, violet rows are for 3”. This does not include elbows, tees, etc.

QTY	Item Code	Description	
5	02-BP32U00	Valve MBV 2" 2-Way PVC SOC POM	2”
2	02-KC32U00	Valve Chk 2" Chemtrol	
12	03-UNS3200	Union SKT 2" Nibco	
1	03-YSS3200C	Y-Stainer 2" CPVC	
1	07-KYFDR50	Meter Flow 150 GPM 1 1/2 & 2"	
10	15-PBR0000	2" PVC Pipe Bracket	
5	02-BP48U00	Valve MBV 3" SKT PVC POM	3”
2	02-KC48U00	Valve Chk 3" Chemtrol	
12	03-UNS4800	Union SKT 3" Nibco	
1	03-YSS4800C	Y-Stainer 3" CPVC	
1	07-KYFDR80	Meter Flow 390 GPM 2 1/2 & 3"	
10	15-PBS0048	3" PVC Pipe Bracket	
3	02-EP00UAVBBUG	Valve Act CAFE BBU Auto Voltage	Not size dependent.
2	02-BP12U00	Valve MBV 3/4" PVC SOC POM	
1	03-SGT1200	Sight Glass THD 3/4" PVC POM	
1	07-KYFDH20US	Keyence FD-H 0.5 to 0.75	
1	12-PHG0015	Probe pH Flat Surface GF	
1	12-CLO000J	Wall Mount Housing B19-42 for	
1	12-CLO010024	Converter Model C4201-24V	
1	12-CLO0300	Sensor Assy (CL02 Use) AF26-VB	
1	12-CLO0416	1" NPT Sensor Body	
1	14-QB62500	Eductor Noz 0.625" 2" CISI	
1	14-QC93700	Eductor Throat 0.937" 2" CISI	
1	14-Q000003	Educt Body 2" 1x 1" NPT & 3x 1/2" NPT	
1	14-QF00013	Eductor 2" Check Valve Comp As	
1	16-ASH0160	Gauge 0-160PSI SS Ashcroft	
Optional Parts for Higher Chlorine Flow			
1	07-RCH3000	Meter 3000PPD Cl2 12" Cone Float	
1	TBD	Hydro, Gas, OV-1000, 3000PPD	

Revision History:

Rev: 0.1 Date: 05 Jun 2023 **Reason:** Initial Creation

Rev: 0.2 Date: 12 Jun 2023 **Reason:** Minor upgrades to update assumptions

Rev: 0.3 Date: 08 May 2024 **Reason:** Work in Progress

Rev: 0.4 Date: 22 Jan 2025 **Reason:** Upgrade options reviewed

Rev: 0.5 Date: _____ **Reason:** _____

Rev: 0.6 Date: _____ **Reason:** _____

Rev: 0.7 Date: _____ **Reason:** _____

Rev: 0.8 Date: _____ **Reason:** _____

Rev: 0.9 Date: _____ **Reason:** _____

Rev: 1.0 Date: _____ **Reason:** _____

Rev: 1.1 Date: _____ **Reason:** _____

Rev: 1.2 Date: _____ **Reason:** _____

Rev: 1.3 Date: _____ **Reason:** _____

Rev: 1.4 Date: _____ **Reason:** _____

Rev: 1.5 Date: _____ **Reason:** _____

Rev: 1.6 Date: _____ **Reason:** _____

Rev: 1.7 Date: _____ **Reason:** _____

Rev: 1.8 Date: _____ **Reason:** _____

Rev: 1.9 Date: _____ **Reason:** _____

Signature Page:

Name: _____ **Date:** _____

Signature: _____ **Representing:** _____

Name: _____ **Date:** _____

Signature: _____ **Representing:** _____

Name: _____ **Date:** _____

Signature: _____ **Representing:** _____

Name: _____ **Date:** _____

Signature: _____ **Representing:** _____

The signatures above represent acceptance of the design parameters in this scope of work. Changes should be initialed on the pages where the changes are noted and indicate acceptance of those changes. The system will be built as described in this document which supersedes all previous versions and survey data. Please be certain the data is correct.

SECTION 11265

CHLORINE SCRUBBER SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Chlorine Emergency Gas Scrubber (EGS) system.
   1. Dry pack chemical media.
   2. FRP vessel.
   3. Belt driven radial blower fan.
   4. Vertical discharge with chlorine gas analyzer and rain cover.
   5. Magnehelic media bed differential pressure transmitter.
   6. Inlet flow sensor.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 7 - Minimum Design Loads and Associated Criteria for Building and Other Structures.

B. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings.
   2. B73.1 - Specifications for Horizontal End Suction Centrifugal Pumps for Chemical Process.

C. American Water Works Association (AWWA):
   1. D 120 - Thermo Setting Fiberglass - Reinforced Plastic Tank.

D. ASTM International (ASTM):
   1. C582 - Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
   2. D3299 - Filament-Wound Glass Fiber Reinforced thermoset Resin Chemical-Resistant Tanks.
   3. D4097 - Specification for Contact Molded Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks.

E. International Fire Code (IFC):
   1. Chapter 50 - Hazardous Materials - General Provisions.

F. National Bureau of Standards (NBS):
   1. PS15-69 - Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.

G. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

H. Occupational Safety and Health Administration (OSHA).

I. Steel Metal and Air Conditioning Contractors Association (SMACMA):
   1. HVAC Air Duct Leakage Test Manual Contractors National.

J. Uniform Building Code (UBC):
   1. UBC-Section 1630 - Lateral Force on Elements of Structures and Nonstructural Components Supported by Structures.

1.03 DELEGATED DESIGN SUBMITTALS

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SYSTEM DESCRIPTION

A. Chlorine scrubber system:
   1. Deep bed, dry chemical vessel, blower fan, instrumentation and controls, power distribution equipment, valves, appurtenances, ductwork, and supports necessary to provide a chlorine neutralization system that initiates operation upon detection of chlorine greater than 3.0 parts per million and successfully reduces the concentration of chlorine within the Chlorine Storage and Chlorinator Room to 0.5 parts per million without exceeding discharges to atmosphere of greater than 25 parts per billion as measured at the point of discharge.
   2. The scrubber shall operate to remove 99.5 percent of the contaminant until the media is depleted.
   3. The scrubber shall consist of a minimum 18,000 pounds of dry chemical media contained in a FRP vessel. The EGS shall be capable of removing the entire contents of a 1-ton cylinder containing 2,350 pounds of chlorine.
   4. Blower shall be ducted to the FRP vessel and sized to draw a minimum 3,600 cubic feet per minute initial airflow through the scrubber under ambient conditions. When calculating the total system loss the supplier shall use 1.2 inches wc loss (ESP) external static pressure at 5,000 cfm. A maximum blower horsepower of 40 has been provided in the electrical design.
   5. Major components of the EGS shall include:
      a. FRP vessel with two 30-inch manways, inlet and discharge nozzles.
      b. Aluminum grating platform with railings and ladder.
      c. Media sample ports: ball valve type, on the side and top of the vessel.
      d. 18,000 pounds dry chemical media.
      e. Blower and motor assembly.
      f. Inlet flow sensor and discharge chlorine gas analyzer
      g. Magnehelic media bed differential pressure transmitter.

B. Chlorine containment building: Enclosure for storage of chlorine ton containers.

C. Operating conditions: Conditions under which chlorine scrubber system shall be designed to operate:
   1. Maximum air temperature: 110 degrees Fahrenheit.
   2. Atmospheric pressure: 11.8 pounds per square inch absolute 5,800 feet above mean sea level).

D. Design leak event: Scrubber operation to treat 117 pounds/minute of chlorine gas products.

1.05 DESIGN REQUIREMENTS

A. Chlorine scrubber system type: Single pass system shall be capable of neutralizing the entire contents of a 1-ton (2,350 pounds) chlorine container of liquefied chlorine gas at the operating conditions.

B. Combined air and chlorine gas flow rate through chlorine scrubber system: Minimum 3,600 actual cubic feet per minute.

C. Size: Able to fit within area indicated on the Drawings.

D. Access to maintenance points: Provide permanent ladders, cages, handrails, platforms, stairs, and other apparatus and accessories, as defined by OSHA for workers to perform maintenance or adjustments to system components. All apparatus and accessories.

1.06 PERFORMANCE REQUIREMENTS:

A. Chlorine scrubber system shall be capable of withdrawing chlorine and air gas mixture from the Chlorine Storage Room to scrubber system, neutralizing chlorine gas at 117 pounds chlorine per minute, and discharging a maximum of 25 parts per billion chlorine at point of discharge to the atmosphere while maintaining at least 0.125 inches of water column negative pressure in the Chlorine Storage Room.

B. Scrubber shall be controlled from Owner’s motor controls and PLC system. No local control panel (LCP) shall be allowed for the scrubber. See drawings for equipment control and wiring details.

C. System modifications: The cost of any changes and modifications to mechanical, structural, electrical, instrumentation, and emergency electrical facilities necessary to adapt alternate equipment to the layout and design shown shall be borne by the Contractor. Any such proposed changes or modifications are subject to review and acceptance of the Engineer before beginning construction of the same. The Contractor is responsible for Engineer review costs.

1.07 SUBMITTALS

A. Product data: Include operating literature, specifications, performance data and calibration curves for fan, packing, and auxiliary components.

B. Shop drawings: include the following:
   1. Drawings showing mounting details, equipment dimensions, fitting sizes and location, operating weights, materials of construction, and sufficient information to allow the Engineer to check clearance, tie-ins and general conformance with this specification. In addition, the entire system shall be designed for the seismic and wind criteria as specified in Section 01850 - Design Criteria.

2. Interface data: Include drawings showing mounting details, equipment dimensions, fitting sizes and locations, clearances, tie-ins, points of interface between the chlorine scrubber and other facilities, and other information the Engineer may request. Include the following:
    a. Mechanical equipment layout and mounting details.
    b. Size and location of anchor bolts.
    c. Dimensions and tie down and support requirements.
    d. Location of motor control center.
    e. Location of local control panel.
    f. Connection of chlorine scrubber system ductwork to ductwork from chlorine containment building.
    g. Duct supports and mounting details.
3. Tank drawings and data: Fabrication, assembly, and installation drawings, schematics, and wiring diagrams.

C. Calculations: Show documentation in the form of calculations, graphs, or experimental results sealed by a professional engineer regarding the following mass transfer equipment if applicable. Proprietary information will be held in strict confidence at the request of the manufacturer.
1. Packing:
    a. Air and chlorine inlet and exit mass flow rates and chlorine transfer and neutralization efficiency for the flow rate, packing, and reactor dimensions selected.
2. Inlet chlorine gas concentration: Maximum that the system can reduce to 25 parts per billion.

D. Samples: Colors available for fiberglass reinforced plastic.

E. Certificates: Upon completion of installation, provide a certificate sealed by a professional engineer employed by scrubber manufacturer that confirms components of the chlorine scrubber system have been coordinated for physical connection, operation, size and performance and that components have been installed in accordance with the manufacturer's recommendations.

F. Certificates of compliance: Furnish affidavit from the system supplier stating that the system has been properly installed and tested and is ready for full-time operation.

G. Manufacturer's installation instructions: 2 copies of the manufacturer's installation instructions shall be provided.

H. Operation and maintenance manuals:

I. Delegated Design submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
    a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
    b. For equipment installed outdoors.

1.08 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer shall have a quality Management System compliant with ISO 9001:2015 standards.

B. Single source responsibility: Equipment shall be supplied by a single supplier regularly engaged in assembling chlorine absorption systems and representing the manufacturer for a substantial number of the major pieces of equipment, with responsibility for design, coordination, and function of the assembly and capable of verifying that each component is compatible with other components of the assembly; that pipe sizes and materials are appropriate; and that devices necessary for a properly functioning assembly have been provided.

C. Equipment supplied shall meet all local, state and federal regulations having jurisdiction over the equipment and final use, including but not limited to requirements of the IFC Chapter 50, ASCE 7 and OSHA. In addition, the equipment shall meet all current requirements, recommendations, and suggestions published by the Chlorine Institute.
   1. Equipment shall be factory engineered to withstand the specified seismic loads.
      a. Minimum design loads shall be calculated to comply with ASCE 7, or local requirements of Authority Having Jurisdiction (AHJ).

1.09 DELIVERY, STORAGE, AND HANDLING

A. Storage and protection: Store and protect in accordance with manufacturer's recommendations.

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Warranty to correct defects in scrubber system both in material and workmanship for 18 months from ship date or 12 months from start-up date.

1.11 PROJECT CONDITIONS

A. Environmental requirements as specified in Section 01850 - Design Criteria.
   1. Equipment is to be installed in an area exposed to sunlight approximately 365 days per year at the Jordan Valley Water Treatment Plant near Salt Lake City, Utah.
   2. Components shall be of suitable materials and construction so as to perform to specifications and maintain their integrity in the climate found in this area.

1.12 SEQUENCING AND SCHEDULING

A. Coordinate interruptions to chlorination, supporting utility services, ventilation systems, and leak detection and alarm monitoring functions in advance with the Owner.

1.13 MAINTENANCE

A. Spare parts: Emergency Gas Scrubber: Deliver the following to Owner:
   1. One set of exhaust fan gasket.
   2. One set of exhaust fan bearings.
   3. One set (3 belts) exhaust fan V-belts.
   4. One set of special tools required for maintenance of equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Emergency Gas Scrubber system: One of the following or equal:
   1. Purafil, Doraville, Georgia; Model FOC1
   2. PureAir Filtration, Norcross, Georgia: Model EGS-8.

2.02 SCRUBBER INLET AND DUCTWORK

A. Scrubber inlet and outlet ductwork:
   1. As specified in Section 06608 - Fiberglas Reinforced Plastic.
   2. As specified in Section 15814 - Fiberglas Reinforced Plastic Ducts.

B. Special ductwork section: Provided with minimum of six 1/2 inch diameter ports, 2 ports in vertical plane and 3 ports in horizontal plane, for insertion of removable pitot tube for conducting velocity traverse of duct; duct sloped towards chlorine scrubber.

C. Pitot tube ports cover plate and gasket: Removable, constructed out of materials resistant to chlorine.

2.03 MEDIA

A. Non-Toxic, Dry media.
   1. Volume: 400 cubic feet.
   2. Density: 45 lbs/cubic foot (+/- 5 percent).
   3. Minimum Chlorine Gas Removal Capacity: 0.1080 g/cc.
   4. Removal efficiency: 99.5 percent minimum.

2.04 ACCESSORIES

A. Inlet flow sensor/transmitter equal to FCI Model FS2000.

B. Chlorine gas sensor and transmitter in the discharge duct:
   1. Manufacturers: The following or equal:
      a. ATI B14 /B12.

2.05 FABRICATION

A. Custom contact mold fiberglass reinforced plastic equipment in accordance with ASTM D3299, D4097, D2563 D2583, D2584, C582 and ASI B16.5 and NBS PS 15-69.

B. Inter veil: Double layer of Nexus veil, 10 mils thick each ply.

C. Connections: Flanged.

D. Gas connections: Conform to Table 2 of NBS PS15-69.

E. Piping connections: Flat-faced flanges with ASME B 16.5 drilling and thickness per Table 5 of NBS PS 15-69, 25 pounds per square inch rated.

F. Exterior surfaces: Apply pigmented resin with ultraviolet light inhibitor in accordance with manufacturers instructions.

2.06 INSTRUMENTATION AND CONTROLS

A. Monitoring and controls:
   1. As specified in Section 15936 - Instrumentation and Control Devices for HVAC.
   2. As specified in Section 17101 - Specific Control Strategies.
   3. As indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturers instructions.

B. Adequately protect tank and components during transportation, in storage at the site, and during subsequent installation and construction activities. Reject damaged units and replace with undamaged units.

C. Construct concrete supports with level and smooth surfaces to tolerances permitted by tank manufacturer.

D. Make the tank ready for installation of duct and other appurtenances.

E. After installation and connections made, thoroughly clean tank surfaces, interior and exterior, in accordance manufacturer's instructions. Do not use abrasive cleaning agents.

3.02 FIELD QUALITY CONTROL

A. Notify Owner at least 1 week before anticipated tests date.

B. Start test when the Owner and local fire department are present to witness test.

C. Test scrubber system to verify satisfactory operation of the system and design performance Requirements. Include the following:
   1. Simulate the whole system performance for a minimum of 2 hours.
   2. Measure and record air flow and pressure.

3. Test duct for leaks in accordance with SMACNA, "HVAC Air Duct Leakage Test Manual," for 20 inches of water column static pressure construction class, except without leakage.
4. Submit written test results.
5. Certify that the system has met or exceeded the performance requirement.

3.03 MANUFACTURER'S FIELD SERVICE

A. Require the services of a factory representative to ensure proper installation, start-up of scrubber system, and instruction of Owner in proper operation and maintenance of the system.
   1. Perform Owner training as specified in Section 01756 - Commissioning.
      a. Training topics should focus on maintenance
   2. Number of sessions:
      a. Operations and Maintenance: 1.
   3. Allow at least 16 hours, exclusive of travel time, for instruction.

END OF SECTION

SECTION 11312J

SUBMERSIBLE SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for submersible sump pump systems, including pumps, control panels, and level controls.

B. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   3. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

B. Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 11.6 - Rotodynamic Submersible Pump Tests.
   3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   4. 14.3 - Rotodynamic Pumps for Design and Application.

C. National Electrical Manufacturers Association (NEMA).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
   1. Allowable operating region (AOR): Region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   2. Preferred operating region (POR): Region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   3. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 11.6, 14.1-14.2, 14.3, and as modified in this Section.
   4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

C. Rotordynamic analysis.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Delegated Design:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

C. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer's representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.
      c. Test Plans:
         1) Test requirements as specified in this Section.
      d. Test Reports.
      e. Manufacturer's representatives field notes and data.
      f. Owner Training: Perform Owner training as specified in Section 01756 - Commissioning.
         1) Training topics should focus on maintenance
         2) Number of sessions:
            a) Operations and Maintenance 1.

D. Product Submittals:
   1. As specified in Section 01600 - Product Requirements.
   2. Product data.
      a. Include pump curves.
   3. Shop Drawings.
   4. Manufacturer's instructions.
   5. Calculations.
   6. Schedules.

E. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Factory finish:
   1. Exterior cast iron parts:
      a. Water-thinned industrial enamel.
      b. 3 to 4 mils.
   2. Manufacturer to supply touch-up paint for field use.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified Section 01850 - Design Criteria and in the Pump Schedule.

B. Design working pressure: Minimum 1.5 times shut off pressure.

2.03 TYPE 1: SUMP PUMP, GENERAL SERVICE

A. Suitable for continuous operation:
   1. With pump unit dry or unsubmerged at ambient temperature rating.
   2. When immersed in water up to 104 degrees Fahrenheit.

B. Manufacturers: One of the following or equal:
   1. Barnes, SE series.
   2. ITT Goulds, WS series.
   3. Pentair Hydromatic, SKHS series.

C. Housing:
   1. Cast iron: In accordance with ASTM A48, Class 30.
   2. Inlet: Open and clear, without screening, capable of passing 2-inch spheres.
   3. 3-inch NPT vertical discharge connection.
   4. External mating parts shall be machined and Buna-N, O-ring sealed.
   5. Fasteners exposed to the pumped liquid: Type 316 stainless steel.

D. Impeller:
   1. Cast iron: In accordance with ASTM A48, Class 30.
   2. 2-vane, semi-open.
   3. Pump-out vanes on backside.
   4. Mechanically locked to shaft.

E. Bearings:
   1. Upper radial and lower thrust bearings required.
   2. Single row, oil lubricated.
   3. Permanently sealed.
   4. Shaft seal:
      a. Type 21 mechanical seal.
         1) Carbon versus ceramic faces.
         2) Elastomer:
            a) Buna-N in accordance with ASTM D2000.
         3) Hardware:
            a) Type 316 stainless steel in accordance with ASTM A276.

F. Motor:
   1. Oil-filled, NEMA B with horsepower as scheduled.
      a. 3-phase, 480 volts.
      b. 1.15 service factor.
      c. 3,450 revolutions per minute.
   2. Shaft: Type 416 stainless steel in accordance with ASTM A276.
   3. Insulation:
      a. 1.5 horsepower and above: Class B.
      b. Under 1.5 horsepower: Class F.

G. Power cable:
   1. STW sized for motor and length requirements, 16 gauge minimum.
   2. Length to reach connection (control panel or junction box) indicated on the Drawings plus 10 feet.
      a. 20 feet minimum.

H. Factory inspection and test each pump:
   1. Visual inspect for imperfections.
   2. Check ground continuity.
   3. High potential test (Hipot).
   4. Air pressure test of housings for motor and volute.
   5. Test run to:
      a. Monitor voltage and current.
      b. Detect excessive noise.

2.04 TYPE 2: SUMP PUMP, EXPLOSION PROOF

A. Suitable for operation in hazardous locations:
   1. Class 1, Division 1, Group D.

B. Manufacturers: One of the following or equal:
   1. Barnes.
   2. Pentair Hydromatic, SPX series.

C. Housing:
   1. Cast iron: In accordance with ASTM A48, Class 30.
   2. Inlet: Open and clear, without screening, capable of passing 2-inch spheres.
   3. 2-inch NPT vertical discharge connection.
   4. External mating parts shall be machined and Buna-N, O-ring sealed.

5. Fasteners exposed to the pumped liquid: Type 316 stainless steel.

D. Impeller:
   1. Cast iron: In accordance with ASTM A48, Class 20.
   2. Recessed.
   3. Pump-out vanes on backside.
   4. Mechanically locked to shaft.

E. Bearings:
   1. Upper radial and lower thrust bearings required.
   2. Single row, oil lubricated.
   3. Permanently sealed.

F. Shaft seal:
   1. Type 21 mechanical seal:
      a. Carbon versus ceramic faces.
      b. Elastomer:
         1) Buna-N in accordance with ASTM D2000.
      c. Hardware:
         1) Type 316 stainless steel in accordance with ASTM A276.

G. Motor:
   1. Oil-filled, NEMA B with characteristics as scheduled.
      a. 3-phase, 480 volts.
      b. 1.15 service factor.
      c. Seal leak probes.
   2. Shaft: Type 416 stainless steel in accordance with ASTM A276.
   3. Class B insulation.

H. Cables:
   1. Power:
      a. SOOW sized for amp requirements, 16 gauge minimum.
      b. Length to reach connection point (control panel or junction box) indicated on the Drawings plus 5 feet.
   2. Control:
      a. SOW.
      b. Length same as power cable.
   3. Sealed by compression grommet and epoxy potting for wires.

I. Source Quality Control (Factory Acceptance Tests):
   1. Visual inspect for imperfections.
   2. Check ground continuity.
   3. High potential test (Hipot).
   4. Air pressure test of housings for motor and volute.
   5. Test run to:
      a. Monitor voltage and current.
      b. Detect excessive noise.
   6. Furnish test reports and the Manufacturer's Certificate of Source Testing.

2.05 VENDOR CONTROL PANEL

A. As specified in the Pump Schedule or indicated on the Drawings.

B. Construction and components as specified in Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.

C. Electrical components:
   1. Main circuit breaker:
      a. As specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.
      b. Flange-mounted operator:
         1) Pad-lockable in the off position.
         2) Disconnects all power to the panel.
         3) Interlock with the panel door.
         4) Defeat mechanism.
   2. Motor starter for each pump:
      a. Motor circuit protector circuit breaker.
      b. Full voltage non-reversing magnetic starter.
      c. Thermal or electronic overloads.
   3. Control power transformer:
      a. Primary voltage: 230/460 VAC, 3-phase, 60 hertz.
      b. Secondary voltages:
         1) Control and status points: 24 VDC.
      c. Sized for all panel components plus 10 percent spare capacity.
      d. Primary and secondary fuses.
   4. Control components:
      a. Terminal strips:
         1) For landing all external wiring.
      b. Relays, timers, and other components as required for the specified functionality and remote monitoring connections.
   5. Simplex operation:
      a. Front panel controls:
         1) HAND/OFF/AUTO switch.
         2) START pushbutton.
         3) STOP pushbutton.
         4) Momentary LOW-LEVEL OVERRIDE pushbutton.
         5) Running pilot light.
         6) Stopped pilot light.
         7) Power pilot light.
         8) Pump fault pilot light.
         9) High-High-level alarm.
      b. Remote monitoring and control:
         1) Provide dry relay contact outputs for the following:
            a) Pump fault alarm.
            b) Pump run status.
            c) High-High-Level Alarm.
      c. Operation:
         1) HAND:
            a) START pushbutton starts pump.
            b) STOP pushbutton stops pump.

c) LOW-level switch activation stops pump.
(1) Momentary LOW-LEVEL OVERRIDE pushbutton overrides.
2) OFF: Pump stops operation and alarm conditions are re-set.
3) AUTO: Pump operates automatically in response to level switch signals.
a) Start when the HIGH-level switch is activated.
b) Stop when the LOW-level switch is activated.
d. Alarm: High-High alarm with activation of HIGH-HIGH-level switch.
6. Duplex operation:
a. Front panel controls:
1) HAND/OFF/AUTO switch.
2) LEAD-STANDBY selector switch:
a) Designates the lead pump automatic operation.
3) START pushbutton for each pump.
4) STOP pushbutton for each pump.
5) Momentary LOW-LEVEL OVERRIDE pushbutton.
6) Running pilot light for each pump.
7) Stopped pilot light for each pump.
8) Power pilot light.
9) Pump fault pilot light for each pump.
10) High-High-level alarm.
b. Remote monitoring and control:
1) Provide dry relay contact outputs for the following:
a) Pump fault alarm: Each pump.
b) Pump run status: Each pump.
c) High-High Level Alarm.
c. Operation:
1) HAND:
a) START pushbutton starts pump.
b) STOP pushbutton stops pump.
c) LOW-level activation stops pump:
(1) Momentary LOW-LEVEL OVERRIDE pushbutton overrides.
2) OFF: Pump stops operation and alarm conditions are re-set.
3) AUTO: Pumps operate automatically in response to level switch signals.
a) Lead pump starts when HIGH-level switch is activated.
b) Lead pump stops when LOW-level switch is activated.
c) When lead pump fault alarm is activated, standby pump becomes the lead pump.
d) Activation of HIGH-HIGH-level switch activates HIGH-HIGH-level alarm and standby pump becomes the lead pump.

2.06 LEVEL SWITCHES

A. Type: Ball float as specified in Section 17201 - Level Measurement: Switches.

B. Cable length: Equal to sump depth to the VCP plus 5 feet.

2.07 ACCESSORIES

A. Lifting cables:
   1. Material: Type 304 stainless steel.
   2. Attached to balance point of pump.
   3. Suitable for lifting pump from sump.
   4. Extend from pump attachment to hanger.

B. Lifting hangars:
   1. Material: Type 304stainless steel.
   2. Suitable to provide storage of extra lift cable and electrical cables at wall sump.

2.08 SPARE PARTS AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

B. Special tools: For each type or size of pump, provide 1 set.

C. Touch-up paint: 1 pint of finish coating paint.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. In accordance with the manufacturer’s instructions.

C. Install lifting hanger 3 feet-6 inches above floor.

D. Remove any extra length of power and control cables at connection point (panel, junction box, or receptacle).

E. Repair damaged finish with the manufacturer’s supply of touch up paint.

3.03 PUMP SCHEDULE

Tag Numbers	PMP-4125	PMP-6852	PMP-3931, PMP-3941
Location	Backwash Valve Vault	PAC System	Filter Gallery Sump
General Characteristics:			
Sump Pump Type	Type 1	Type 2	Type 1
Rated Performance:			
Design Head, feet	25	60	60
Minimum Flow at Design Head, gpm	18	10	10
Motor:			
Maximum, hp	1/2	1/2	½
VCP Required	No	Yes	No

END OF SECTION

SECTION 11312K

SUBMERSIBLE MEDIUM CAPACITY CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Submersible pump with features scheduled in the Pump Schedule.
   2. Tag numbers: As specified in Pump Schedule.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   5. B148 - Standard Specification for Aluminum-Bronze Sand Castings.
   6. B505 - Standard Specification for Copper Alloy Continuous Castings.
   7. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
   8. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   9. F594 - Standard Specification for Stainless Steel Nuts.

C. CSA International (CSA).

D. FM Global (FM).

E. Food and Drug Administration (FDA).

F. Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 11.6 - Rotodynamic Submersible Pump Tests.
   3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   4. 14.3 - Rotodynamic Pumps for Design and Application.

G. Insulated Cable Engineer’s Association (ICEA).

H. National Electrical Code (NEC).

I. National Electrical Manufacturers Association (NEMA).

J. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
   1. Allowable Operating Region (AOR): The region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   2. Preferred Operating Region (POR): The region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   3. Pump head (total dynamic head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 11.6,14.1-14.2, 14.3, and as modified in this Section.
   4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; when multiple suction pressure taps are used, average pressure shall be suction head regardless of variation in individual taps.
   5. Tolerances: As stipulated in the listed HI standards, unless specified more restrictively.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

C. Rotordynamic analysis.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

C. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer's representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.
      c. Test Plans:
         1) Test requirements as specified in this Section.
      d. Test Reports.

e. Manufacturer's representatives field notes and data.
f. Owner Training.

D. Product Submittals:
1. As specified in Section 01600 - Product Requirements.
2. Product data.
3. Shop Drawings.
4. Manufacturer's instructions.
5. Calculations.
6. Schedules.

E. Operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.
2. Include a list of configurable parameters and the final values for each.
3. Include a troubleshooting chart covering the complete pump and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Dry pit, vertical submersible pumps: One of the following, or equal:
1. Sulzer ABS.
2. ITT Flygt: NT series.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Submersible sump pumps with components: Pumps, drivers, motors, base elbows, guide rails and lifting devices, electrical devices internal to pump housing, submersible cabling for power and control conductors, and other items as required for a complete and operational system.
1. The submersible pumps shall be provided for vertical, dry pit installation. The pump shall be secured to a steel support stand of suitable strength to support the weight of the pump and resist any expected torsion, bending, or vibration forces.

B. Design requirements:
1. Pump performance characteristics:
a. As specified in the Pump Schedule.

b. Rotordynamic analysis level: As scheduled and as specified in Section 15050 - Common Work Results for Mechanical Equipment.
   1) Vibration analysis expert: Provide when scheduled.
c. Required conditions (flow/head) shall be within the pump manufacturer's Allowable Operating Range (AOR).
d. Performance tolerances shall be the same as the test tolerances specified in Section 15958 - Mechanical Equipment Testing.

2. Motor characteristics: As specified in Pump Schedule.

C. Product requirements: As specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 MATERIALS

A. General: When materials are referenced in this Section or on the pump schedule, the compositions shall be the UNS Alloys, Types, or Grades in this Article unless specified or scheduled otherwise.

B. Cast iron: ASTM A48, Class 35 B minimum.

C. Nickel cast iron: ASTM A48, Class 35 minimum with 3 percent nickel added.

D. Steel: ASTM A108, Grade or UNS Alloy as specified or scheduled.

E. Stainless steel: ASTM A276 or ASTM A582, Type or UNS Alloy as specified or scheduled.

F. Bronze: ASTM B505 or ASTM B584, UNS Alloy C83600.

G. Zincless bronze: ASTM B505 or ASTM B584, Leaded Tin Bronze, UNS Alloy C92700.

H. Aluminum bronze: ASTM B148, ASTM B505 or ASTM B584, UNS Alloy C95200.

I. Fasteners: Stainless steel, ASTM F593 or ASTM F594, type or grade as specified.

2.04 GENERAL PUMP CONSTRUCTION

A. Pump shall be an overhung impeller, close-coupled, single-stage, volute-style, end-suction submersible unit, capable of handling raw unscreened sewage, stormwater and other solids-laden fluids without clogging.

2.05 PUMP AND MOTOR CASING

A. Type: Watertight, air-filled.

B. Material: Cast iron (minimum).

C. Design working pressure: Minimum 1.10 times maximum shutoff total dynamic head with maximum diameter impeller at maximum operating speed plus maximum suction static head or minimum 20 pounds per square inch gauge.

D. O-ring seals: Capable of sealing mated surfaces (major components) watertight; with the following features:
   1. Machined surfaces and grooves.
   2. O-ring contact on 4 surfaces and O-ring compression on 2 surfaces.
   3. Does not require specific fastener torque or tension to obtain watertight joint.
   4. Does not require secondary sealing compounds, gasket, grease, or other devices.

E. Testing: Perform 5-minute hydrostatic test of pump casing at minimum 1.5 times Design Working Pressure.

2.06 IMPELLERS

A. General:
   1. Water passages: Smooth enough to prevent clogging by stringy or fibrous materials.
   2. Passage sizes: Large enough to pass solids with sphere size of 3 inches or smaller for motors larger than 2 horsepower.
   3. Casting: 1 piece, free of cracks and porosity.
   4. Balance vanes: On impeller back shrouds.
   5. Method for securing impeller to shafts:
      a. For pumps 5 horsepower and less, secured by bronze nut or Allen head bolt locked in place, but readily removable without the use of special tools.
      b. For pumps greater than 5 horsepower, keyed to the shaft and secured by bronze nut or Allen head bolt locked in place, but readily removable without the use of special tools.

B. Rotation: As indicated on the Drawings; clockwise looking from top when not indicated.

C. Balance: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

D. Vibration criteria: As specified in Section 15958 - Mechanical Equipment Testing.

E. Type: As specified in the Pump Schedule:
   1. Standard impeller:
      a. Material: Cast iron (minimum).
      b. Dynamically balanced, double-shrouded, multi-vane, non-clog design.
   2. Flygt-supplied pumps:
      a. N-style impeller:
         1) Material: Cast iron, Class 35B.
         2) Dynamically balanced, semi-open, multi-vane, backswept, non-clog design.
         3) Impeller vane leading edges shall mechanically self-clean as they pass a spiral groove located on the volute section.
         4) Impeller vanes shall have a screw-shaped leading edge hardened to Rockwell HRc 45.
   3. ABS-supplied pumps:
      a. ContraBlock style:
         1) Material: Cast iron, Class 40.

2) Dynamically balanced, semi-open, single-vane, non-clog design.
3) Cast iron, Class 40 front plate shall be mounted to the volute by 4 stainless steel adjusting screws.
4) Front plate shall be designed with a wave-shaped inlet and outward-spiraling V-shaped groove on the impeller side.

2.07 WEAR RINGS

A. Provide one of the following systems:
   1. Wear ring system:
      a. General: Used to provide efficient sealing between the volute and suction inlet of the impeller.
      b. Volute wear ring:
         1) Material: Brass.
         2) Fitted to the volute inlet.
      c. Impeller wear ring:
         1) Material: Type 316 stainless steel.
         2) Heat-shrunk fitted onto the suction inlet of the impeller.
         3) Flygt N impeller: Part of replaceable suction cover.
   2. Wear plate system:
      a. Material: Cast iron, ASTM A48, Class 40, with a minimum Brinell Hardness of 250.
      b. Attached to the pump volute to prevent rotation.
      c. Replaceable and adjustable to maintain proper clearances between the wear plate and the impeller.

2.08 PUMP SHAFTS

A. Material: Type 420 stainless steel; turned, ground, and polished.

B. Features:
   1. Strength: Able to withstand minimum of 1.5 times maximum operating torque and other loads.
   2. Resonant frequency: As specified in Section 15050 - Common Work Results for Mechanical Equipment and Section 15958 - Mechanical Equipment Testing.
   3. Maximum deflection: Minimum 0.002 inches under operating conditions.

C. Tapered to fit at impeller with key and bolt for securing impeller.

D. Pump and motor shaft shall be a solid continuous shaft.

2.09 BEARINGS

A. Pump shaft shall rotate on a minimum of 2 permanently sealed, grease-lubricated bearings:
   1. Upper bearing for radial forces shall be self-aligning spherical roller type.
   2. Lower bearing for combined axial and radial forces shall be angular contact ball type.

B. Bearing type: Anti-friction in accordance with ABMA standards.

C. Bearing lubrication system shall be sized to safely absorb heat energy normally generated in bearing under maximum ambient temperature of 60 degrees Celsius.

D. Bearing life: One of the following, whichever provides longer bearing life in intended service:
   1. Minimum ABMA 9 or 11, L10 bearing life of 50,000 hours at rated design point.
   2. Minimum 24,000 hours at bearing design load imposed by pump shutoff with maximum sized impeller at rated speed.

2.10 SHAFT SEALS

A. Upper seal unit material: 1 stationary tungsten-carbide ring and 1 positively driven rotating carbon ring or tungsten-carbide ring.

B. Lower seal unit material: 1 stationary and 1 positively driven rotating tungsten-carbide ring.

C. Features:
   1. Tandem arrangement running in an oil chamber.
   2. Design oil chamber to ensure that air is left in the oil chamber to absorb the expansion of the oil due to temperature variations.
   3. Oil in oil chamber shall be FDA approved, paraffin-type, colorless, odorless, and non-toxic.
   4. Independent spring system between seal interfaces able to withstand maximum suction submergences.
   5. Does not require pressure differential to effect sealing.
   6. Does not use pumped media for lubrication.
   7. Lower mechanical seal effectively lubricated from oil chamber housings.
   8. Not damaged when pump is run dry (unsubmerged) for extended periods.
   9. Springs and other hardware: Stainless steel, Type 300 or 400 series.

2.11 DISCHARGE BASE AND ELBOW

A. Materials: Same as pump casing.

B. Features:
   1. Structurally capable of firmly supporting guide rails, discharge piping, and pumping unit under operating conditions.
   2. Integral support legs or pads with bolting to sump floor provisions: 1 or more.
   3. Incorporates 90-degree flanged elbow that receives horizontal flow from pump and discharges flow vertically.
   4. Discharge interface:
      a. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal-to-metal watertight contact.
      b. Self-aligning without having to enter the wet well.
      c. Discharge elbow to mate to pump discharge and transition to discharge piping.

2.12 GUIDE RAILS, BRACKETS, FASTENERS, AND LIFTING CHAIN FOR EACH PUMP

A. Material: Type 316 stainless steel, with the following features:
   1. Dual pipes or dual rails that extend from discharge base to upper bracket unless scheduled otherwise.
   2. Rail wall thickness sufficient to suspend pump unit between brackets plus minimum 50 percent safety factor.
   3. Sized to fit discharge base and sliding bracket of pump.
   4. Integral, self-aligning, guide rail sliding brackets that seal pump to discharge base under operating conditions.
   5. Upper guide rail bracket.
   6. Intermediate guide rail brackets where indicated on the Drawings or at 10-foot maximum intervals.
   7. Lifting chain of sufficient strength and length to permit safe removal of pump unit from sump.

2.13 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.
      a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
      b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
      c. Make structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors:
   1. Revolutions per minute: As scheduled:
   2. Enclosure: As scheduled.
   3. Electrical characteristics: As scheduled.

C. Motor construction:
   1. Squirrel cage induction motor, shell type design.
   2. If explosion-proof motor is scheduled, provide motor that is UL or FM listed for NEC Class I, Division 1, Groups C and D service, whether submerged or unsubmerged.
   3. NEMA design type: B.
   4. Motor insulation, either one:
      a. Class F, moisture resistant, rated for 155 degrees Celsius.
      b. Class H, moisture resistant, rated for 185 degrees Celsius.
   5. Designed for continuous duty handling pumped media of 40 degrees Celsius and capable of a minimum of 15 evenly spaced starts per hour.
   6. Capable of continuous operation under load with the motor submerged, partially submerged, or exposed, without derating the motor.

7. Motor cooling, one of the following:
    a. Motor cooled by the surrounding media.
    b. Cooling jacket:
        1) Non-clogging ports and channels that use pumped fluid as the cooling media.
        2) Functional with motor submerged, partially submerged, or exposed.
        3) Provide capability to relieve entrapped air from the system.
    c. Spray systems, air moving equipment or other secondary cooling systems are not acceptable.
8. Motor sealing: Design motor case and seals to withstand 65 feet of submergence.
9. Coordinate motors with the variable frequency drive manufacturer to ensure compatibility between the motor and variable frequency drive. Other drivers: As scheduled and as specified in sections listed in the Pump Schedule.

D. Power and control cables:
1. Submersible to same water depth as motor casing.
2. Type SPC with Hypalon/Buna N or chloroprene rubber jacket.
3. Insulation rated for 90 degrees Celsius.
4. Non-wicking fillers.
5. Length: Sufficient to connect to surface junction box (without the need of splices) as indicated on the Drawings or 30 feet, whichever is greater.
6. Power and control conductors shall terminate at terminal blocks in the local control panel or junction box.
7. Sized in accordance with NEC, ICEA, and CSA specifications.
8. Provide stainless steel cable and stainless steel wire braid sleeve to support power cable from underside of wet well roof slab or access frame.

E. Cable entry/junction chamber:
1. Cable entry seal design shall not require specific torque requirements to insure a watertight and submersible seal.
2. Cable entry seal shall consist of a single cylindrical elastomer grommet, flanked by stainless steel washers.
3. Entry body shall perform compression and strain relief that is separate from the sealing function.
4. Cable entry junction chamber shall be separate from the motor chamber to prevent foreign material from gaining access to the motor interior through the top of the pump.

F. Control/protection module:
1. Each pump shall be supplied with its own self-contained control/protection module to provide for the direct connection to internal pump monitoring devices, including:
    a. Thermal protection: Provide automatic reset motor stator temperature detectors, 1 switch in each phase winding. If any detector is activated, the sensor shall activate an alarm and shut down the motor. Thermal detectors shall activate when the stator temperature exceeds 125 degrees Celsius.
    b. Moisture detection: One of the following:
        1) Provide capacitive type leakage sensor for the detection of water in the oil chamber or a moisture sensor in the lower motor chamber to detect any fluid in the motor. Sensor shall have an explosion-proof rating.

2) Provide a small float to detect the presence of water in the stator chamber.

2. Module shall signal an alarm condition if any of the internal monitoring devices is activated.
3. Furnish the modules to Contractor for installation in control panels not provided by the manufacturer.

2.14 FINISHES

A. Pump manufacturer to factory prime and coat pump/motor and discharge elbow as specified in Section 09960 - High-Performance Coatings.

B. Contractor to provide touch-up field coatings as specified in Section 09960 - High-Performance Coatings.

2.15 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts: Deliver the following as specified in Section 01600 - Product Requirements.

B. Deliver 1 set of special tools required for complete assembly or disassembly of pump system components for each type or size of pump specified.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.
3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing (Factory Acceptance Tests):
1. Witnessed, virtual only.
2. Furnish test reports and Manufacturer’s Certificate of Source Testing.
3. Equipment Testing:
   a. Pump:
      1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
4) Pump casing: Hydrostatic pressure tests if specified in this Section.

C. Installation Verification:
1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
1. Equipment testing:
a. Pump:
1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

E. Owner Training:
1. Perform Owner training as specified in Section 01756 - Commissioning. Training topics should focus on maintenance
2. Number of sessions:
a. Operations and maintenance: 1.

3.04 PUMP SCHEDULE

Tag Numbers	**PMP-3911** **PMP-3921**
General Characteristics:	
Service	Filtered Water (Process Drain)
Quantity	2
Maximum Noise, dBA at 3 Feet	Not required
Minimum Pumped Fluid, Degrees Fahrenheit	40
Normal Pumped Fluid, Degrees Fahrenheit	65
Maximum Pumped Fluid, Degrees Fahrenheit	852
Rotordynamic Analysis Level	1
Vibration Analysis Expert	Not required
Installation Configuration	Dry Pit
Pump Characteristics:	
Impeller Type	N or ContraBlock
Pass Minimum Sphere Size, Inch	2
Speed Control	Fixed
Maximum Pump Speed, rpm	1200
Minimum Pump Speed, rpm	N/A

Tag Numbers	PMP-3911 PMP-3921
Rated Design Point (at Maximum Revolutions per Minute):	
Flow, gpm	600
Head, Feet	16.5
Minimum Hydraulic Efficiency, Percent	65
Maximum Active Input Horsepower	5
Required Condition 2 (at Maximum Revolutions per Minute):	
Flow, gpm	635
Head Range, Feet	15 to 20
Minimum Hydraulic Efficiency, Percent	60
Required Condition 3 (at Maximum Revolutions per Minute):	
Flow Range, gpm	775
Head, Feet	10 to 15
Minimum Hydraulic Efficiency, Percent	55
Other Conditions:	
Maximum Shutoff Head, Feet	40
Maximum NPSHr at Every Specified Flow, Feet	15
Minimum Suction Static Head, Feet	0
Maximum Suction Static Head, Feet	25
Minimum Discharge Size, Inches	4
Motor Characteristics:	
Minimum Submergence	Exposed
Maximum Driver Speed, rpm	1200
Motor Horsepower, Minimum	5
Voltage/Phases/hertz	460/3/60
Service Factor	1.3
Starting Current, Amps	6
Rated Current, Amps	34
Motor Efficiency (At 100-Percent Load), Minimum	65
Enclosure Type	Submersible, Explosion-Proof
NEMA Design Type	B
Accessories:	
Basin Cover	Not required
Hoist	Not required

Tag Numbers	PMP-3911 PMP-3921
Source Testing:	
Performance Test Level	1
Vibration Test Level	1
Noise Test Level	1
Functional Testing:	
Performance Test Level	1
Vibration Test Level	None
Noise Test Level	None

END OF SECTION

SECTION 11312S

HORIZONTAL MAGNETIC DRIVE CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Centrifugal, close coupled, magnetic drive, end-suction, sealless pumps with drivers and features as scheduled.
   2. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
   3. B73.1 - Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process.

B. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A108 - Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   5. A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
   6. A494 - Standard Specification for Castings, Nickel and Nickel Alloy.
   7. A743 - Standard Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   8. B367 - Standard Specification for Titanium and Titanium Alloy Castings.
   9. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   10. F594 - Standard Specification for Stainless Steel Nuts.

C. Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   3. 14.3 - Rotodynamic Pumps for Design and Application.
   4. 14.4 - Rotodynamic Pumps for Installation Operation and Maintenance.

D. National Electrical Code (NEC).

E. Occupational Safety and Health Administration (OSHA).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
   1. Allowable Operating Region (AOR): The region over which the service life of the pump is not seriously compromised by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   2. Preferred Operating Region (POR): The region over which the service life of the pump will not be significantly affected by hydraulic loads, vibration, or flow separation where the pump's vibration, noise, and cavitation are within acceptable limits.
   3. Pump head (Total Dynamic Head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 14.1-14.2, 14.3, 14.4, and as modified in this Section.
   4. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.
   5. Tolerances: In accordance with HI 9.1-9.5, 14.1-14.2, 14.3, and 14.4, unless specified more restrictively.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

C. Rotordynamic analysis.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

C. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer's representative qualifications.
      b. Certificates:
         1) Requirements as specified in this Section.
      c. Test Plans:
         1) Test requirements as specified in this Section.
      d. Test Reports.

e. Manufacturer's representatives field notes and data.
f. Owner Training.

D. As specified in Section 01600 - Product Requirements.
1. Product data.
2. Shop Drawings.
3. Manufacturer's instructions.
4. Calculations:
a. Torsional analysis.
5. Schedules.

E. Operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.
2. Include a list of configurable parameters and the final values for each.
3. Include a troubleshooting chart covering the complete pump and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Pump:
1. The following, or equal:
a. Iwaki America, MXM Series.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide the same pump for all applications. See Pump Schedule.

B. Supply horizontal, centrifugal, ASME B73.1 end suction, magnetic-drive pump. non-metallic, lined magnetic drive pumps shall utilize ductile cast iron outer shell with injection molded liner and encapsulated inner rotating assembly, including a set of inner magnets within a containment shell or rear casing.
1. Inner magnets are magnetically coupled or driven by outer magnet ring or drive magnet coupled to a conventional drive motor.
2. Liquid end is hermetically sealed by static O-ring or gasket(s).
3. Provide components as specified and other items as required for a complete and operational system.

4. Pumps shall comply with the latest additions of the following codes and standards:
    a. ASME B73.1.
    b. HI.
    c. NEC.
    d. OSHA Rules and Regulations.

C. Design requirements:
1. Pump performance characteristics:
    a. As specified in the Pump Schedule.
    b. Rotordynamic analysis level: As scheduled and as specified in Section 15050 - Common Work Results for Mechanical Equipment.
    c. All required conditions (flow/head) shall be within the pump manufacturer's Allowable Operating Region (AOR).
    d. Performance tolerances shall be the same as the test tolerances specified in Section 15958 - Mechanical Equipment Testing.
2. Motor characteristics: As specified in the Pump Schedule.

D. Product requirements as specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 MATERIALS

A. General: Materials in the Pump Schedule shall be the type and grade as specified in this Section.

B. Cast iron: ASTM A48, Class 30 minimum.

C. Ductile iron: ASTM A395.

D. Steel: ASTM A108, Grade as scheduled.

E. Stainless steel: ASTM A276, type as scheduled.

F. Iron-chromium alloy: ASTM A743, Grade CA40.

G. Structural steel: ASTM A283, Grade D.

H. Hastelloy C: ASTM A494, Grade CW-12M-2.

I. Titanium: ASTM B367, Grade C-3.

2.04 GENERAL PUMP CONSTRUCTION

A. Type: Centrifugal, close coupled, magnetic drive, end-suction, sealless pumps manufactured in accordance with ASME standards.

B. Discharge flange: ASME B16.1 or B16.5 drilled; rated for 1.2 times the pump shutoff head at 150 degrees Fahrenheit.

C. Suction flange: ASME B16.1 or B16.5 drilled.

D. Fasteners: Provide Type 316 stainless steel fasteners in accordance with ASTM F593 or ASTM F594.

E. Vibration: As specified in Section 15958 - Mechanical Equipment Testing.

F. Permanent alignment of the pump to motor shall be provided.

2.05 PUMP CASINGS

A. Type: 2-piece volute type with a minimum 1/8-inch thick liner, integral suction, and discharge nozzles.

B. Material: As scheduled.

C. Design working pressure: Minimum 1.10 times maximum shutoff total dynamic head with maximum installable impeller diameter at maximum operating speed plus maximum suction static head.

D. Hydrostatic test: 10-minute hydrostatic test at minimum 1.5 times design working pressure.

E. Pump lining shall be applied to the casing and not rely on a mechanical locking method.

2.06 IMPELLERS

A. Type: As scheduled.

B. Material: As scheduled.

C. Radial bearings and spacers shall be supplied and manufactured of silicon carbide with carbon coating for run dry protection.

D. Thrust bearings and rear wear ring shall be supplied and manufactured of silicon carbide with carbon coating for run dry protection.

E. Bearings shall be lubricated by a pumpage recirculation circuit.

F. Balance: As specified in Section 15050 - Common Work Results for Mechanical Equipment and vibration criteria as specified in Section 15958 - Mechanical Equipment Testing.

2.07 PUMP SHAFTS

A. Material: As scheduled.

B. Strength: Able to withstand minimum 1.5 times maximum operating torque and/or other loads as applicable.

C. Pump shaft shall be a solid shaft design.

2.08 MAGNETS

A. Provide drive magnets suitable for the entire pump curve performance range to ensure that the pump will not de-couple.

B. Impeller magnets to be encased in the same material as the impeller.

2.09 PUMP FRAME

A. Material: As scheduled.

B. Provide a 1-piece rigid construction frame with a machined face for a “C” face mounted motor at the driver end and gasketed at pump end.

C. Frame shall have drain and vent connections.

2.10 EQUIPMENT GUARDS

A. Provide equipment safety guards as specified in Section 15050 - Common Work Results for Mechanical Equipment.

2.11 DRIVERS

A. Horsepower:
   1. As scheduled.
   2. Listed driver horsepower is the minimum to be supplied.
      a. Increase driver horsepower if required to prevent driver overload while operating at any point of the supplied pump operating head-flow curve including runout.
      b. When scheduled driver is a motor, increase motor horsepower if required to prevent operation in the service factor.
      c. Make structural, mechanical, and electrical changes required to accommodate increased horsepower.

B. Motors: Provide motors as specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower and as specified in this Section:
   1. Revolutions per minute: As scheduled.
   2. Enclosure: As scheduled.
   3. Electrical characteristics: As scheduled.
   4. Efficiency, service factor, insulation, and other motor characteristics: As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower.
   5. Motor accessories: As specified in Section 16222 - Low Voltage Motors Up to 500 Horsepower and in this Section.

C. Drivers: As scheduled and as specified in sections listed in the Schedule.

2.12 ANCHOR BOLTS

A. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.13 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts:
   1. Pump thrust bearing set.
   2. Pump radial bearing set.
   3. One set of gaskets, seals, and O-rings.

B. Special tools: Deliver 1 set for each furnished pump type and size needed to assemble and disassemble pump system.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.
   2. Furnish test reports and Manufacturer's Certificate of Source Testing.
   3. Equipment testing:
      a. Pump:
         1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         4) Pump casing: Hydrostatic pressure tests if specified in this Section.

C. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. Pump:
         1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

E. Owner Training:
1. Perform Owner Training as specified in Section 01756 - Commissioning. Training topics should focus on maintenance
2. Number of sessions:
a. Operations and Maintenance 1.

3.04 PUMP SCHEDULE

Tag Numbers	PMP-6511 PMP-6521	PMP-6201 PMP-6202	PMP-7103 PMP-7104
General Characteristics:			
Service	Sodium Hydroxide (Caustic Soda) 25 - 50 percent	Aluminum Chlorohydrate (ACH)	Cationic Polymer (PEC)
Quantity	2	2	2
First Named Manufacturer's Model	Iwaki MXM	Iwaki MXM	Iwaki MXM
Minimum Pumped Fluid, degrees Fahrenheit	60	32	32
Normal Pumped Fluid, degrees Fahrenheit	70	70	70
Maximum Pumped Fluid, degrees Fahrenheit	200	100	100
Rotordynamic Analysis Level	None	None	None
Vibration Analysis Expert	Not Required	Not Required	Not Required
Pump Characteristics:			
Impeller Type	Enclosed	Enclosed	Enclosed
Bearing Lubrication	Pumpage	Pumpage	Pumpage
Drive Type	Magnetic	Magnetic	Magnetic
Speed Control	Fixed	Fixed	Fixed
Maximum Pump Revolutions per Minute	3,500	3,500	3,500
Suction Flange Size, minimum (in.)	1	1	1
Discharge Flange Size, minimum (in.)	1	1	1

Tag Numbers	PMP-6511 PMP-6521	PMP-6201 PMP-6202	PMP-7103 PMP-7104
Rated Design Point (at Maximum Revolutions per Minute):			
Flow, Gallons per Minute	43	44	28
Head, Feet	44	43	56
Minimum Efficiency, Percent	50	50	45
Required Condition 2 (at Maximum Revolutions per Minute):			
Flow, Gallons per Minute	28	35	23
Head, Feet	55	51	58
Minimum Efficiency, Percent	45	45	37
Other Conditions:			
Maximum Shut Off Head, Feet	63	63	63
Maximum NPSHr at Specified Flow, Feet	20	20	20
Minimum NPSHa at Specified Flow, Feet	7	9	7
Minimum Suction Static Head, Feet	-13	-6	5
Maximum Suction Static Head, Feet	17	14	13
Pump Materials:			
Pump Casing	CFRETFE	CFRETFE	CFRETFE
Impeller	CFRETFE	CFRETFE	CFRETFE
Pump Frame	Cast Iron	Cast Iron	Cast Iron
Radial and Thrust Bearings	Silicon Carbide	Silicon Carbide	Silicon Carbide
Shaft	Silicon Carbide	Silicon Carbide	Silicon Carbide
Liner and Containment Shell	CFRETFE	CFRETFE	CFRETFE
Driver Characteristics:			
Driver Type	Motor	Motor	Motor
Drive Arrangement	Horizontal, C Face Mounted, Solid Shaft	Horizontal, C Face Mounted, Solid Shaft	Horizontal, C Face Mounted, Solid Shaft
Non-reverse Ratchets	None	None	None
Minimum Driver Horsepower	1	1	1

Tag Numbers	PMP-6511 PMP-6521	PMP-6201 PMP-6202	PMP-7103 PMP-7104
Motor Characteristics (when motor is driver type):			
Inverter Duty Rated	Yes	Yes	Yes
Motor Voltage/Phases/Hertz	460/3/60	460/3/60	460/3/60
Enclosure Type	TEFC	TEFC	TEFC
Source Testing:			
Performance Test Level	2	2	2
Vibration Test Level	1	1	1
Noise Test Level	None	None	None
Functional Testing:			
Performance Test Level	1	1	1
Vibration Test Level	1	1	1
Noise Test Level	1	1	1
Hydrostatic Pressure Test	As specified in this Section	As specified in this Section	As specified in this Section

END OF SECTION

SECTION 11312V

SUBMERSIBLE CHEMICAL LIQUID SUMP PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Packaged submersible sump pumps.
   2. Tag numbers: As specified in the Pump Schedule.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Hydraulic Institute (HI):
   1. 9.1-9.5 - Pumps - General Guidelines.
   2. 11.6 - Rotodynamic Submersible Pump Test.
   3. 14.1-14.2 - Rotodynamic Pumps for Nomenclature and Definitions.
   4. 14.3 - Rotodynamic Pumps for Design and Application.

C. International Organization for Standardization (ISO).

D. National Electrical Code (NEC).

E. NSF International (NSF).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section have the indicated meaning.
   1. Pump head (Total Dynamic Head, TDH), flow capacity, pump efficiency, net positive suction head available (NPSHa), and net positive suction head required (NPSHr): As defined in HI 9.1-9.5, 11.6, 14.1-14.2, 14.3, and as modified in this Section.
   2. Suction head: Gauge pressure available at pump intake flange or bell in feet of fluid above atmospheric; average when using multiple suction pressure taps, regardless of variation in individual taps.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer’s representative qualifications.

b. Certificates:
    1) Requirements as specified in this Section.
c. Test Plans:
    1) Test requirements as specified in this Section.
d. Test Reports.
e. Manufacturer's representatives field notes and data.
f. Owner Training.

C. Product Submittals:
1. As specified in Section 01600 - Product Requirements.
2. Product data.
3. Shop Drawings.
4. Manufacturer's instructions.
5. Calculations.
6. Schedules.

D. Operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Pumps: One of the following, or equal:
1. BJM Pumps. Perfecta Series, Model TIGF 32-9NL.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Submersible chemical resistant pumps. Driven by a close coupled electric motor with nominal rating of 115 volts, 1 phase, 60 hertz, and 3,450 revolutions per minute.

B. Design requirements:
1. Pump performance characteristics: As specified in the Pump Schedule, Pump Characteristics:
    a. As specified in the Pump Schedule.
    b. Rotordynamic analysis level: As scheduled and as specified in Section 15050 - Common Work Results for Mechanical Equipment.
    c. Performance tolerances shall be the same as the test tolerances specified in Section 15958 - Mechanical Equipment Testing.
2. Motor characteristics: As specified in the Pump Schedule.

C. Product requirements:
    1. As specified in Section 01600 - Product Requirements and Section 15050 - Common Work Results for Mechanical Equipment.

2.03 PUMP HOUSING

A. Material: As specified in the Pump Schedule.

B. Discharge flange:
    1. Material: Glass filled PPO.
        a. 1.5 inch NPT-F discharge screwed connection.

C. Upper housing and motor housing should be molded as 1 piece constructed of glass filled PPO.

2.04 IMPELLERS

A. Multi-vane impeller:
    1. Material: As specified in the Pump Schedule.

B. Method of securing to shafts: Threaded lock nut or similar connection.

2.05 STRAINER

A. Replaceable strainer constructed of PPO and screwed directly to the pump housing and suction cover made of glass filled PPO that is press fit into place.

B. Strainer equipped to pass solids up to 0.25 inch.

2.06 PUMP SHAFTS

A. Materials: As specified in the Pump Schedule.

B. Rotor will be dynamically balanced.

2.07 BEARINGS

A. Upper bearing: Single row; deep groove.

B. Lower bearing: Single row; deep groove.

C. Lubrication: NSF approved ISO 32 mineral oil.

D. Minimum bearing L10 life shall be 30,000 hours in accordance with ABMA 9 or ABMA 11.

2.08 SEALS

A. Lip seals:
    1. 2 lip seals, 1 upper and 1 lower for each pump.
    2. Material: FKM.

B. O-rings:
   1. Material: FKM.

2.09 DRIVERS

A. Motors:
   1. As specified in Section 16222 - Low Voltage Motors.
   2. Oil filled submersible motor.
   3. Insulation: Class F.
   4. Power: 115 volt, 1 phase, 60 hertz.
   5. 1.10 service factor.
   6. Pumps shall be able to operate continuously without exceeding pumps service capacity when immersed in water up to 135 degrees Fahrenheit.
   7. Power cable:
      a. Supplied with 22 foot power cord connected to motor lead wires in a water and oil resistant sealed cable entry.
      b. Cable will be sized in accordance with NEC standards.
      c. Outer jacket will l be oil resistant and capable of submergence in water to 135 degrees Fahrenheit.
         1) Material: EPDM outer jacket.

2.10 SPARE PARTS AND SPECIAL TOOLS

A. Spare parts: Deliver the following as specified in Section 01600 - Product Requirements:
   1. O-ring set for each pump.
   2. Seal set for each pump.

B. Special tools: For each type or size of pump specified, provide 1 set of special tools required for complete assembly or disassembly of the pump system components.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.03 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.
   2. Furnish test reports and Manufacturer's Certificate of Source Testing.
   3. Equipment testing:
      a. Pump:
         1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         4) Pump casing: Hydrostatic pressure tests if specified in this Section.

C. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
   1. Equipment testing:
      a. Pump:
         1) Performance test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         2) Vibration test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.
         3) Noise test: Test level as scheduled; test as specified in Section 15958 - Mechanical Equipment Testing.

E. Owner Training:
   1. Not required.

3.04 PUMP SCHEDULE

A. Pump characteristics:

Tag Numbers	PMP-6319
Location	Chlorine Building
Service	Sump Pump
Service Material	General
Pump Type	Simplex
Rotordynamic Analysis Level	None
Vibration Analysis Expert	Not Required

Tag Numbers	PMP-6319
Capacity, gpm	25
Total Dynamic Head (TDH), Feet	5
Motor Horsepower, minimum	0.5
Min. Shutoff Head, feet	27
Motor Speed, revolutions per minute	3,450
Pump Shaft/Hardware Material	Titanium
Level Switch Supplied	No
Max. Submergence Depth, ft.	3

END OF SECTION

SECTION 13206A

FIBERGLASS REINFORCED PLASTIC ABOVEGROUND STORAGE TANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Fiberglass reinforced plastic aboveground storage tanks.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
   3. RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.

B. ASTM International (ASTM):
   1. D2240 - Standard Test Method for Rubber Property-Durometer Hardness
   2. D3299 - Standard Specification for Filament-Wound Glass Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
   3. D4097 - Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.

1.03 SUBMITTALS

A. Submit as specified in Section 06608 - Fiberglass Reinforced Plastic.

B. Calculations
   1. Calculations for anchoring equipment to structures.
      a. Indicate anchor type, layout, number, size, and embedment requirements to resist dead, live, seismic, and other applicable loads specified in Section 01850 - Design Criteria.
         1) Number of anchor bolts not less than 8, nor less than the tank diameter divided by one foot.
      b. Calculations shall be prepared and sealed by a Professional Engineer licensed in the state where the Work will be installed.
      c. Design anchors in accordance with the structural design criteria specified in Section 01850 - Design Criteria, and the requirements of this Section.

C. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds

B. Special Warranty:
   1. Provide an additional 4 years full warranty issued in the name of the owner. Prorated warranties are not acceptable.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacturer of proposed corrosion-resistant fiberglass reinforced plastic structures for a minimum of 5 years with satisfactory performance record as specified in Section 06608 - Fiberglass Reinforced Plastic.

B. The manufacturer-approved installer shall have installed products of similar fiberglass reinforced plastic equipment on a minimum of 5 projects with a satisfactory performance record.

C. Manufacturer shall be ASME RTP-1 certified.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Ershigs, Inc.
   2. Belco Manufacturing Co., Inc.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design tanks in accordance with ASTM D3299, follow the procedures and methods, utilize the equations and formulas, and incorporate safety factors and allowable design stresses and strains set forth in ASME RTP-1 and other design requirements as specified in Section 06608 - Fiberglass Reinforced Plastic.

B. Tank filling: Design shall include any necessary accommodations to allow for pneumatic unloading of chemicals from tanker truck. This unloading process involves pressurizing the tanker truck to 15 psi and pushing chemical into the storage tank to fill it. At the end of the filling operation, as the truck empties, the tank may be exposed to this pressurized vessel for a brief period of time.

C. Roof live load:
   1. Personnel access/maintenance: Load of 250 pounds distributed over a 12-inch by 12-inch area.

D. Static head of contents.

E. Nozzle locations as indicated on the Drawings.

F. Fire retardancy not required.

G. Design tank(s) and anchoring to withstand the following loads:
   1. Tank self-weight (dead load).
   2. Roof live loads specified in this Section.
   3. Weight of tank contents.

4. Loads specified in Section 01850 - Design Criteria:
    a. Seismic load of tank and tank contents.

H. Tank wall structural design shall not include corrosion barrier thickness in design calculations for the structural wall thickness required to meet design loads as specified in this Section.

I. Support conditions as indicated on the Drawings.

J. Caustic Soda (CS) Storage Tanks
1. General: Suitable for storage of caustic soda (sodium hydroxide) solution, delivered at 25 to 50 percent concentration. Design tanks for liquid specific gravity up to 1.6 and pH 12 with a minimum internal pressure rating of 0.5 inches WC.
2. Bulk Storage Tanks: TNK-6501, TNK-6502, TNK-6503.
    a. Number of units: 3.
    b. Required Storage Volume (each tank): 18,000 gallons (nominal).
    c. Diameter: 12 feet.
    d. Straight Shell Length: 22 feet.
    e. Orientation: Vertical
    f. Access manway and nozzles, as indicated on the Drawings.
    g. Tank Connections:
        1) Drain: One 3-inch on tank bottom.
        2) Outlet: One 3-inch on tank bottom.
        3) Overflow: One 4-inch.
        4) Inlet: One 3-inch with downcomer to 6 inches above tank bottom and anti-siphon hole. Shall be installed in the factory before shipment.
        5) Vent: One 6-inch.
    h. Appurtenances:
        1) Access manway on top: 24 inch.
        2) Access manway on side: 30 inch.
        3) 6-inch radar level sensor flanged port.
        4) Welded clips for attachment of overflow pipe and ladder.
        5) Internal downcomer supports
    i. Level gauge.
        1) 3-inch flanged port reserved for the sight level.
    j. Slope bottom of tank to the outlet drain to allow for full drainage of tank contents.
    k. Include railings and 5,000-pound fall arrest anchors on top of tanks for instrument maintenance and manway access.
3. Day Tank: TNK-6531.
    a. Number of units: 1.
    b. Required Storage Volume (each tank): 1,500 gallons (nominal).
    c. Diameter: 6 feet.
    d. Straight Shell Length: 7 feet.
    e. Orientation: Vertical
    f. Access manway and nozzles, as indicated on the Drawings.
    g. Tank Connections:
        1) Drain: One 3-inch on tank bottom.
        2) Outlet: One 3-inch on tank bottom.
        3) Overflow: One 4-inch.

4) Inlet: One 3-inch with downcomer to 6 inches above tank bottom and anti-siphon hole. Shall be installed in the factory before shipment.
5) Vent: One 6-inch.

h. Appurtenances:
1) Access manway on top: 20 inch.
2) 6-inch radar level sensor flanged port.
3) Welded clips for attachment of overflow pipe and ladder.
4) Internal downcomer supports.

i. Level gauge.
1) 3-inch flanged port reserved for the sight level.

j. Slope bottom of tank to the outlet drain to allow for full drainage of tank contents.

k. Include 5,000-pound fall arrest anchors for instrument maintenance and manway access.

2.03 MATERIALS

A. Materials as specified in Section 06608 - Fiberglass Reinforced Plastic.
1. Submit manufacturer's data sheets for each resin used to verify compatibility of the resin with the product the tank will be storing.

B. Resin:
1. For non-fire-retardant applications: Premium grade vinyl ester resin as recommended by the resin manufacturer for the specific operating environment.
a. Manufacturers: One of the following or equal:
1) Derakane, 411-350.
2) Reichhold Dion, VER 9100.
b. Interplastic, VE 8300.
2. For fire-retardant applications:
a. Premium grade vinyl ester resin as recommended by the resin manufacturer for the specific operating environment.
b. Add antimony trioxide or pentoxide for Class I fire rating to the structural laminate only.
c. Manufacturers: One of the following or equal:
1) Derakane, 510C-350.
2) Ashland, Hetron 992FR.
3) Interplastic, VE 8440.
4) Reichhold Dion, VER 9300FR.

C. Minimum corrosion liner:
1. One "C" or synthetic veil.
2. In addition to 1 ”C” or synthetic veil, include 1-1/2 ounces per square foot mat to a total minimum thickness of 0.096 inches on surfaces exposed to the service environment.

D. Ultraviolet stabilizer: Add to the resin used in the wax coat for exterior surfaces in the type and amount recommended by the resin manufacturer.

2.04 FABRICATION

A. Fabrication method: Hand lay-up or filament wound at construction with integral molded bottom knuckle in accordance with applicable portions of Section 06608 - Fiberglass Reinforced Plastic:
   1. Follow manufacturer's recommendations for BPO/DMA and post cures.

B. Structural section with internal veil: Prohibited.

C. Color: To be selected from standard color options.

D. Legs and tie-down lugs: Components laminated onto tank wall shall be Type 316 stainless steel.

E. Anchor bolts: Type 316 stainless steel, of size and length recommended by tank manufacturer.

F. Flanges:
   1. All flange dimensions, except thickness, and bolting shall conform to the following standards:
      a. 2 inches through 24 inches: ASME B16.5 Class 150.
      b. 30 inches through 42 inches: ASME B16.1 Class 125.
   2. Flange faces shall be perpendicular to the centerline of the duct within 1 degree and shall be flat to plus or minus 1/32-inch up to and including 18-inch equivalent diameter and plus or minus 1/16-inch for equivalent diameters greater than 18 inches.
      a. The minimum flange shear thickness shall be 4 times the flange thickness.
      b. The flange thickness shall be 25 pounds per square inch pressure-rated flanges.
   3. Flanges shall be made by hand lay-up construction with nozzle neck and flange made integrally in 1 piece as specified in Section 06608 - Fiberglass Reinforced Plastic.
   4. Press molded or filament-wound flanges not allowed.
   5. Use 1/8-inch thick full-faced elastomeric gaskets having a Shore A Durometer hardness of 60, within plus or minus 5, in accordance with ASTM D2240 for flanged joints.
   6. Elastomer specified by Fabricator to be resistant to chemical environment.

G. Gussets:
   1. Reinforce nozzles, except manways, with plate or conical gussets to match piping.
   2. Conical gussets having comparable strength may be substituted for plate gussets.

H. Reinforcement of nozzle and manhole openings in vessel walls:
   1. In accordance with ASTM D3299 for filament wound vessels or ASTM D4097 for contact-molded, hand lay-up vessels as specified in Section 06608 - Fiberglass Reinforced Plastic.
   2. When reinforcing materials are cut to facilitate placement around an installed nozzle or opening, stagger joints in successive reinforcing layers to avoid

overlapping and do not place so that the joints are parallel to the axis of the tank.

a. The principal fiber direction of the woven roving reinforcement (0 degree/90 degree) shall be parallel to the tank axis.

I. Cover: Hinged lid.
   1. Platforms and ladders: As indicated on the Drawings.

J. Fall protection:
   1. Provide a minimum of two safety harness tie-off points at each tank.

2.05 VESSEL ASSEMBLY

A. All cutouts from the equipment shall be marked, indicating their original location, and retained. All cutouts shall become the property of the Owner.

B. Do not remove centerlines marked on the equipment for use in assembly until after inspection by the Engineer.

C. Install flanged nozzles with boltholes straddling principal centerlines of the vessel.
   1. For tank tops, nozzle boltholes straddle radial centerlines.

D. When requested, Fabricator shall supply to the Owner, at the earliest possible time, a template which locates anchor boltholes within plus or minus 1/8 inch for each vessel.

E. Where specified, a non-skid surface shall be provided on the exterior surface of the cover.
   1. Silica grit may be applied in conjunction with the final resin coat.
   2. Other methods may be submitted.

F. Furnish and overlay on the outside of the equipment a plastic nameplate showing the following information:
   1. Name of manufacturer.
   2. Date of manufacture.
   3. Owner's purchase order number.
   4. Equipment name/number.
   5. Resin number and manufacturer.
   6. Design pressure and temperature.
   7. Vessel diameter, height, and weight.

G. Butt joints or shell joints shall be in the number and location(s) as indicated on the fabrication drawings.
   1. Additional joints are not allowed.
   2. Slip joints, "mod joints," or other methods not conforming to the fabrication drawings are not allowed.
   3. If joint locations are not indicated on the fabrication drawings, Fabricator shall submit number and location.

H. Allowable tolerances shall be in accordance with ASTM D3299 or ASTM D4097, except as modified in this Section or on the fabrication drawings.

I. When joining components, gaps at mating edges shall be limited to 1/4-inch maximum, and misalignment of inside surfaces shall not exceed 1/3-inch of the lesser wall thickness.

J. The outside surface of vessel flat bottoms after assembly shall be flat within plus or minus 1/2-inch. In addition, localized indentations or protrusions shall not exceed plus or minus 1/4-inch within 2 feet.

2.06 TANK HEATING AND INSULATION

A. Heating
   1. Provide tanks with heater pads or tape for freeze protection.
   2. Pads or tape shall be waterproof with low-watt density, suitable for use with FRP tanks.
   3. Pads or tape shall provide the heating power designated in the table below depending on tank size.

Tag Numbers	**TNK-6531**	**TNK-6501 TNK-6502 TNK-6503**
Tank Size	1,500 gallons	18,000 gallons
Power Requirement	350 W	1,100 W

   4. Provide 1 heating controller for each tank. Controller shall be capable of controlling all heating pads or tape for that tank.
      a. Controller shall be housed in a NEMA 4X enclosure.
      b. A single 120 VAC, 20A power supply will be provided to each controller for powering pads/tape.
      c. Alarms will be indicated with LEDs on the controller face.
      d. Signal Output:
         1) Alarms for low temp, high temp, and low current.
         2) 4-20 mA signal for indication of temperature
   5. Manufacturers, or equal:
      a. HTD Heat Trace.

B. Insulation
   1. Two-inch polyisocyanurate with 3/16 inch FRP skin.

2.07 ACCESSORIES

A. Level gauge:
   1. Level indicator shall be a clear PVC sight tube.
   2. Materials: All wetted components shall be compatible with stored chemical.
   3. Tank level staff gauge:
      a. Resistant to abrasion and corrosion.
      b. Mounted on the tank adjacent to the indicator.
      c. Calibrated in nominal 100-gallon increments.

B. Cushioning Mat:
   1. Provide cushioning mat between tank and concrete pad to prevent point loads on bottom of tank. Mat shall extend entirely beneath tank.
   2. Materials: 1/2-inch thick sheets of 2-pound density polyurethane foam

C. Labels: Provide for each tank the following shop finishing:
   1. Shipping label identifying:
      a. Tank tag number.
      b. Chemical service.
   2. Permanent labels: in accordance with Section 10400 - Signage.
      a. Identification label, including the following information:
         1) Name of manufacturer.
         2) Date of manufacture.
         3) Owner's purchase order number.
         4) Equipment name/number.
         5) Resin number and manufacturer.
         6) Design pressure and temperature.
         7) Vessel diameter, height, and weight.
      b. NFPA label specifically coded for the tank contents in accordance with NFPA 30.
      c. Paint or affix label onto the tank wall to be clearly visible from outside the tank enclosure.

D. Provide flanged flexible connectors for each of the following fittings:
   1. The flanged outlet nozzle on each tank.
      a. Wetted materials shall be selected by the tank manufacturer or vendor for the chemical service.
      b. Provide all mounting hardware and supports.
      c. Manufacturers: One of the following or equal:
         1) Red Valve, Redflex expansion joints with 3 arches.
         2) Flexijoint Expansion joint.

PART 3 EXECUTION

3.01 TANK INSTALLATION

A. For flat bottom vessels without legs, the foundation must provide full non-elastic support to the flat bottom, preferably through the use of grout, which will allow continuous support even though surfaces may not be flat.

B. All anchor lugs or leg pads shall be set on a 1-inch thick layer of non-shrink grout.
   1. Do not use hard shim to fill void between the lugs and foundation.

C. Unless otherwise agreed, independently support all piping so as not to apply loads to the vessel nozzles.

D. Isolate potential load due to thermal expansion of piping from the vessel.

E. During installation, do not force piping into alignment, which can create excessive stresses in the tank.

F. Do not mate raised-face flanges or ring gaskets to full-faced fiberglass reinforced plastic nozzles.

A. Vertically support ladders at the tank foundation or platform, as indicated on the Drawings.
   1. Ladder lugs attached to the vessels shall provide lateral support only.

B. Where tank foundations are cut out to accommodate full bottom drains, fill the cutout area after tank installation with grout or other material that will provide localized support.

3.02 OWNER TRAINING

A. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
      a. Training topics should focus on maintenance
   2. Number of sessions:
      a. Operations and Maintenance: 1.

END OF SECTION

SECTION 13207

STRAND-WOUND CIRCULAR PRESTRESSED CONCRETE TANK WITH A TYPE I CORE WALL AND DOMED ROOF

PART 1 GENERAL

1.01 SUMMARY

A. Work includes:
   1. Design and construction of an AWWA D110, Type 1, strand-wrapped circular prestressed concrete tank, furnishing, installation, and testing.
      a. The tank shall consist of: foundation, underdrain system, concrete membrane floor slab, cast-in-place concrete core wall, cast-in-place concrete domed roof, and all associated appurtenances.
      b. The core wall shall be vertically post-tensioned with thread bars, prestressed circumferentially with machine-wrapped 7-wire galvanized strand, and protected with several coats of shotcrete.
      c. The foundation shall be constructed with continuous shallow concrete spread footings below the perimeter wall.
      d. The concrete floor shall be constructed with a concrete slab on grade.
   2. In the event of a discrepancy between this section of the Specifications and any other section of the Specifications, this section shall govern.
   3. The Tank Contractor shall furnish all labor, materials, tools, and equipment necessary to design, construct, and test the prestressed concrete tank.

1.02 REFERENCES

A. Abbreviations:
   1. cfm - cubic feet per minute.
   2. f'c - specified compressive strength of concrete.
   3. g - gravitational constant, equal to 32.2 feet per second squared.
   4. gpm - gallons per minute.
   5. ksi - kips per square inch.
   6. MG - million gallons.
   7. mph - miles per hour.
   8. pcf - pounds per cubic foot.
   9. psf - pounds per square foot.
   10. psi - pounds per square inch.
   11. PVC - polyvinyl chloride.
   12. sec - seconds.

B. Definitions:
   1. Core Wall - That portion of the concrete tank wall that is vertically post-tensioned and circumferentially pre-stressed.
   2. Prestressed Concrete - Concrete in which internal compressive stresses of such magnitude and distribution have been introduced through post-tensioning to offset tensile stress development from service loads.

3. Prestressing Reinforcement - High-strength steel used to circumferentially prestress the concrete tank wall.
4. Rebound - The shotcrete material that ricochets off of the receiving surface and falls.
5. Shotcrete - Pneumatically applied wet mortar or concrete used for embedment protection of the circumferential prestressed wall reinforcement.
6. Strand - A symmetrically arranged and helically twisted assembly of 7 high-strength galvanized, steel wires used for prestressing reinforcement or as nonprestressed seismic cables.
7. Stressing Machine - May refer to the automated wrapping machinery used to pre-stress the strand around the tank circumference or vertical post-tensioning equipment used to post-tension vertical thread bars.
8. Tank Prestressor - A contractor or sub-contractor that specializes in the design of an AWWA D110 type of tank and specializes in the construction of the prestressed elements of the tank, such as the strand/wire wrapping and the vertical post-tensioning of the wall.
9. Tendon - High-strength thread bar, including end anchorages, used to impart vertical prestressed forces to the tank wall.
10. Wire - High-strength, cold-drawn steel wire used to assemble strands.

C. Reference Standards:
   1. American Concrete Institute (ACI):
      a. ACI 301-16 - Specifications for Structural Concrete, 2016.
      b. ACI 305.1-14 - Specification for Hot Weather Concreting, 2014.
      c. ACI 306.1-90 - Standard Specification for Cold Weather Concreting, 1990.
      d. ACI 350-06 - Code Requirements for Environmental Concrete Structures and Commentary, 2006.
      e. ACI 350.1-10 - Specification for Tightness Testing for Environmental Engineering Concrete Containment Structures and Commentary, 2010.
      f. ACI 350.3-06 - Seismic Design of Liquid-Containing Concrete Structures and Commentary, 2006.
      g. ACI 350.5-12 - Specifications for Environmental Concrete Structures, 2012.
      h. ACI 372R-13 - Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures, 2013.
      i. ACI 506R-16 - Guide to Shotcrete, 2016.
      j. ACI 506.2-13 - Specification for Shotcrete, 2013.
   2. ASTM International (ASTM):
      a. A 416 - Standard Specifications for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
      b. A 475 - Standard Specification for Zinc-Coated Steel Wire Strand.
      c. A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      d. A 706 - Standard Specification for Low-Alloy Deformed and Plain Bars for Concrete Reinforcing.
      e. A 722 - Standard Specification for Uncoated High-Strength Steel Bars for Prestressed Concrete.
      f. C 33 - Standard Specification for Concrete Aggregates.
      g. C 150 - Standard Specification for Portland Cement.
      h. C 171 - Standard Specification for Sheet Materials for Curing Concrete.

i. C 618 - Type F Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
j. D 570 - Standard Test Method for Water Absorption of Plastics.
k. D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
l. D 638 - Standard Test Method for Tensile Properties of Plastics.
m. D 746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
n. D 747 - Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
o. D 792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
p. D 1056 - Standard Specification for Flexible Cellular Materials- Sponge or Expanded Rubber.
q. D 2000 - Standard Classification System for Rubber Products in Automotive Applications.
r. D 2240 - Standard Test Method for Rubber Property-Durometer Hardness.

3. American Society of Civil Engineers (ASCE):
   a. 7-16 - Minimum Design Loads for Buildings and Other Structures.
4. American Water Works Association (AWWA):
   a. C652 - Standard for Disinfection of Water-Storage Facilities.
   b. D110-13 - Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, 2013.
5. NSF International (NSF):
   a. 61 - Drinking Water System Components - Health Effects.
6. Code of Federal Regulations (CFR):
   a. Part 1910 - Occupational Safety and Health Standards (OSHA).
7. U. S. Army Corps of Engineers (USACE):
   a. CRD C 572 - Corps of Engineers Specifications for Polyvinylchloride Waterstop.

1.03 SUBMITTALS

A. Product data:
   1. Admixtures:
      a. Submit evidence of NSF 61 compliance for all concrete admixtures.
   2. Waterstops:
      a. Submit samples, prints, and complete physical property data covering waterstops.
      b. Laboratory test reports: Submit reports indicating that average properties of polyvinyl chloride waterstops material and finish conform to requirements specified in this Section.
   3. Epoxy grouting equipment: Submit product information.
   4. Neoprene bearing pads: Submit product information.
   5. Stressing machine:
      a. Submit a description of the proposed equipment.
      b. Submit calibration reports for force recording equipment used installation of vertical thread bars and circumferential prestressing.

B. Shop drawings:
   1. Drawings showing all plan views, sections, and details of the tank construction, including, but not limited to, all structural elements, all appurtenances, connections, joints, waterstop, roof hatches, vents, ladders, fall arrest and protection systems, guardrails, piping, pipe penetrations, pipe supports, sub-grade preparation, base liners, tank instrumentation, and materials for roof drainage and conductance.
   2. Drawings of entire prestressing operation showing vertical thread bar and circumferential strand placement with associated schedules and intermediate lock-off elevations, prestressing bar and strand size, ducts for vertical thread bars, and anchorage details.
   3. Drawings for placement and detailing of all reinforcing steel.
   4. Drawings showing:
      a. Neoprene bearing pads and methods of pad installation.
      b. Waterstop and methods of installation.
      c. Sponge filler pads or sleeves and methods of installation.
      d. Exterior coating system.
   5. All shop drawings shall be signed and sealed by a registered Utah structural engineer.

C. Design Submittals:
   1. Structural calculations for all aspects of the structural design of the tank, along with calculations for prestressing reinforcement, elongation estimates, soil capacity checks, and calculations for any other structural design aspect, suitable for contractor to attain building permit.
   2. Concrete mix designs in accordance with Specification 03300 - Cast-in-Place Concrete and additional provisions specified herein.
   3. Shotcrete mix designs in accordance with the provisions specified herein.
   4. Admixtures to be used in the concrete and/or shotcrete and their purpose.
   5. All design submittals shall be signed and sealed by a registered Utah structural engineer.

D. Tank responsibility statement:
   1. The Tank (Sub)Contractor shall submit a statement attesting that they have assumed responsibility for the tank design, building permit acquisition, and construction. No other submittal items will be reviewed until a satisfactory statement has been received.

E. Qualifications of Tank (Sub)Contractor statement:
   1. Failure to submit a qualifications statement package will be deemed an irregularity, which will cause bid to be rejected as nonresponsive.
   2. Submit pertinent information that demonstrates conformance with Quality Assurance requirements specified herein.
   3. To include:
      a. Company history, contact person(s), address, and telephone number.
      b. Project references with owner and engineer's contact information.
      c. Name and work history of the on-site project manager to be assigned to the project.

F. Quality control submittals:
   1. Certificates of Compliance:
      a. Thread Bars: Submit certified test reports that verify bars and anchorage meet specified material standards.
      b. Waterstop: Submit certificates certifying that waterstops provided on this project meet or exceed physical property requirements of current USACE CRD C 572.
      c. Circumferential prestressing: Submit certified test reports for each size, heat, and reel that verify conformance to applicable ASTM standards for materials, strength, and yield properties.

G. Test reports:
   1. Strand and vertical thread bar prestressing records.

H. Operation and Maintenance Manuals
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

I. Manufacturers instructions:
   1. Tank appurtenances: Submit manufacturer's installation instructions.

1.04 NON-RESPONSIVE BID

A. Qualifications statement package:
   1. Submit a qualifications statement package with the bid. The package shall contain information as required per Section 1.03.E.
   2. Failure to submit a qualifications statement package will be deemed an irregularity that may cause bid to be rejected as non-responsive.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Singular Responsibility:
      a. It is the intent of these Specifications to create singular responsibility for design, construction, and performance of the prestressed concrete tank. The design and construction of all aspects of the foundation, floor slab, core wall, prestressing, shotcrete, and domed roof of the tank shall be performed by the Tank Contractor.
         1) The Tank (Sub)Contractor may subcontract with a Tank Prestressor as required for the design and construction of the tank.
         2) The Tank (Sub)Contractor shall have a working agreement with the Tank Prestressor in which the Tank (Sub)Contractor is approved by the Tank Prestressor to perform all construction of the specified tank except the presstressing and post tensioning.
         3) The Tank (Sub)Contractor agrees to meet the minimum standard of care required by the Tank Prestressor and their design or as specified herein, whichever is more stringent.
         4) The Tank Contractor has successfully teamed with the Tank Prestressor to successfully construct at least 5 tanks within the last 10 years.

5) The Tank Contractor may subcontract labor for reinforcing steel installation and for concrete slab finishing under the Tank Contractor's direct supervision.

b. The Tank (Sub)Contractor's on-site project managershall supervise the work of any subcontractors and their personnel.

c. If the Tank (Sub)Contractor believes that any requirement of this Section represents a departure from its normal recommendations that will affect the quality or performance of the tank, notify the Engineer in writing of such concerns. For each provision of concern, cite the relevant paragraphs of this Section and indicate the Tank Contractor's recommended modifications or alternatives to those provisions.

1) Acceptance of Tank (Sub)Contractor's alternatives shall be at the discretion of the Engineer, and the decision of the Engineer shall be final.

2. The specified tank shall be constructed by the Tank (Sub)Contractor. The Tank (Sub)Contractor shall be experienced in the construction of circumferentially prestressed tanks with cast-in-place concrete core wall sections using freed neoprene bearing pad connections at the base of the wall, PVC waterstops, seismic cables placed between the wall and the foundation, and a domed concrete roof.

a. No Tank (Sub)Contractor is considered qualified unless it has successfully built the following projects:

1) At least 5 circumferentially prestressed concrete tanks conforming to AWWA D110, Type I that are 1.0 MG or larger and used for water storage in the last 10 years.

b. The Tank (Sub)Contractor shall have in its employ for this project a team, comprised of staff of both the Tank Contractor and Tank Prestressor, consisting of an on-site project manager, concrete foreman, shotcrete foreman, and prestressing foreman, each of whom shall have constructed in the last 10 years a minimum of 5 AWWA D110 Type I tanks with domed concrete roofs having a capacity of 1.0 MG or greater.

3. The specified tank shall be designed by the Tank(Sub)Contractor. The Tank (Sub)Contractor shall have in its employ a design engineer with a minimum of 10 years of experience in the design of AWWA D110 Type I tanks with domed or flat-slab concrete roofs. The design engineer shall have been the engineer of record for a minimum of 10 AWWA D110 Type I tanks designed by the Tank Prestressor in its own name. The design engineer shall be licensed as a structural engineer in the state of Utah. The design engineer shall be licensed as a Professional Engineer in the state of Utah with adequate experience in design of the tank.

a. No Tank Prestressor is considered qualified unless it has designed the following projects:

1) At least 10 circumferentially prestressed concrete tanks with domed concrete roofs conforming to AWWA D110, Type I in the last 20 years.

2) At least 5 circumferentially prestressed concrete tanks with domed concrete roofs conforming to AWWA D110, Type I used for water storage that have been in successful operation for at least 5 years.

3) At least 5 circumferentially prestressed concrete tanks with domed concrete roofs conforming to AWWA D110, Type I that are 1.0 MG or larger in the last 10 years.

4. Experience in the design and construction of AWWA D110 Type II, Type III, or Type IV tanks will not be accepted as demonstrating the qualifications required by the preceding paragraphs.

1.06 DESIGN CRITERIA

A. Except as modified herein, the prestressed concrete tank shall be designed and constructed in compliance with the provisions of AWWA D110 for strand-wound circular, prestressed concrete water tanks with Type I core wall.
   1. The prestressed concrete tank core wall shall be of cast-in-place concrete construction. Shotcrete or precast core walls are not permitted under the provisions of this Section.

B. Standards/Codes:
   1. The prestressed concrete tank shall be designed and constructed as specified herein, and in accordance with provisions of the following standards and codes:
      a. AWWA D110-13(R18).
      b. IBC, 2021.
      c. ACI 350-06 with modifications per ASCE 7-16 §15.7.7.3.
      d. ACI 350.3-06.
      e. ASCE 7-16.
   2. Where conflicts between the requirements of this Section and of these standards and codes occur, the more restrictive provisions shall apply.
      a. Exception: Requirements for concrete cover and member thickness shall be as specified in this Section.

C. Utah Department of Health:
   1. Contractor is advised that the prestressed concrete tank specified herein will be used in potable water service and all components shall be NSF61 certified.
   2. All admixtures used in the concrete mix design for the prestressed concrete tank shall be certified in compliance with NSF 61.

D. Design criteria and requirements to be used by the Tank (Sub)Contractor in the design calculations:
   1. Capacity: 1 MG usable storage below the maximum operating water elevation shown on the Drawings.
      a. Inside Diameter: 74 feet.
   2. Dead Load: shall be the estimated weight of all permanent imposed loads.
      a. Unit weight of concrete shall be taken as 150 pounds per cubic foot.
      b. Unit weight of steel shall be taken as 490 pounds per cubic foot.
   3. Fluid Load: shall be the lateral pressure and weight of the water when the tank is filled to a level that is 6 inches above the elevation of the top of the overflow elevation as indicated on the Drawings (to allow for overflow conditions).
      a. Unit weight of water shall be taken as 62.4 pounds per cubic foot.
   4. Dome Live Load:
      a. Uniform: 40 pounds per square foot, non-reducible.
      b. Any concentrated reactions due to the use of fall protection equipment.
      c. Application of fall protection equipment reaction loads shall be applied concurrently with uniform roof live load. However, load factors for the load

case where the combination of uniform and fall protection reactions are considered simultaneously may be taken as unity.

5. Construction Loads:
   a. Loads applied to the tank during construction shall be accounted for in the design of the tank.
6. Geotechnical Report: See Section 00800 - Supplementary Conditions.
7. Foundation Loads: the tank foundation shall be proportioned so that the net foundation bearing pressure shall be less than the net allowable soil bearing pressure specified in the Geotechnical Report.
   a. The allowable soil bearing pressure may be increased by 33 percent for load combinations that include wind or seismic loads.
   b. Settlement Loads: the tank shall be designed to resist the effects of total and differential settlement indicated in the Geotechnical Report.
8. The final design for wind and seismic loads shall consider a reduced capacity to resist sliding due to membranes placed between the bottom of the concrete foundation and the soil.
9. Wind Load: determined in accordance with ASCE 7-16.
   a. Exposure Category C.
   b. Basic Wind Speed V = 115 mph (3-sec gust).
   c. Importance Factor, I_W = 1.00.
10. Seismic Design Criteria: seismic design shall be based on the applicable sections of AWWA D110-13, ASCE 7-16, and ACI 350.3-06. The seismic forces shall be calculated using each code separately. The total base shear used for design shall be the maximum value obtained from the 3 codes used.
    a. When comparing force and base shear values, those obtained from ASCE and ACI shall be based on service level loads.
    b. AWWA D110-13 Design Criteria:
       1) Occupancy Category, IV.
       2) Importance Factor, I = 1.50.
       3) Design Spectral Acceleration for Short Period, S_{DS} = 0.937g.
       4) Design Spectral Acceleration for 1-second Period, S_{D1} = 0.424g.
       5) Site Class D.
       6) Impulsive Structure Coefficient, R_I = Tank Design Engineer to select based on design.
       7) Convective Structure Coefficient, R_C = Tank Design Engineer to select based on design.
       8) Overstrength Factor,Ω_o, Designer to select based on design .
    c. ASCE 7-16 Design Criteria:
       1) Risk Category IV.
       2) Design Spectral Acceleration for Short Period, S_{DS} = 0. 937g.
       3) Design Spectral Acceleration for 1-second Period, S_{D1} = 0.424g.
       4) Site Class D.
       5) Basic system force resisting system:
          a) Flat-bottom ground-supported tank, prestressed concrete, anchored flexible base.
       6) Response Modification Factor, R = Tank Design Engineer to select based on design .
       7) Overstrength Factor,Ω_o = Tank Design Engineer to select based on design .
       8) Long-period Transition Period, T_L = 8 sec.
       9) Importance Factor, I_e = 1.50.

d. ACI 350.3-06 Design Criteria:
    1) Design Spectral Acceleration for Short Period, S_{DS} = 0. 937g.
    2) Design Spectral Acceleration for 1-second Period, S_{D1} = 0.424g.
    3) Site Class D.
    4) Basic system force resisting system:
        a) Flat-bottom ground-supported tank, prestressed concrete, anchored flexible base.
    5) Impulsive Structure Coefficient, R_I = Tank Design Engineer to select based on design .
    6) Convective Structure Coefficient, R_C = Tank Design Engineer to select based on design .
    7) Long-period Transition Period, T_L = 8 sec.
    8) Importance Factor, I = 1.50.
e. The sloshing wave height shall be taken as the larger of the values calculated in accordance with AWWA D110-13, ASCE 7-16, and ACI 350.3-06.
    1) In the event that the calculated height of the “sloshing wave” exceeds the freeboard of the tank (distance from the maximum operating water surface elevation to the bottom of the dome at the wall), the tank and the dome shall be designed to accommodate the dynamic effects as follows:
        a) Any portion of the convective sloshing wave that extends above the bottom of the dome at the wall shall be calculated and applied to the dome as an uplift pressure in accordance with section 15.7.6.1.2.e of ASCE 7-16.
        b) Additionally, the mass of any confined portion of the convective sloshing wave shall be included with the impulsive mass used in the estimation of the hydrodynamic forces applied to the tank for design, also in accordance with section 15.7.6.1.2.e of ASCE 7-16.
        c) Any revisions to the tank, including but not limited to, the dome elevation, and water overflow level, that are required to meet the specified provisions to resist sloshing loads and its effect on the hydrodynamic design shall not result in additional costs to the Owner.

11. Temperature and moisture gradients: effects due to changes in temperature and due to temperature and moisture gradients across structural members shall be considered in the design. Refer to Section 01850 - Design Criteria.
12. Prestressing application: forces applied to the wall shall be considered in the design of the wall, especially where wall penetrations result in locally increased prestressing force application to the wall.
13. Vent Capacity Requirements (after accounting for resistance to air flow based on screen mesh size and screen open area):
    a. The vent shall be sized for a minimum rate of 750 cfm or the rate of volumetric withdrawal assuming the outlet pipe has ruptured, whichever is greater.

E. Floor Slab and Wall Footing Requirements:
    1. The floor slab shall be designed as a membrane floor slab as defined in ACI 372R, Section 3.2.2 that is not less than 6.5 inches thick; or the floor slab

may be designed as a slab-on-ground with a thickness not less than 6.5 inches.

2. Construction joint locations shall be submitted to the Engineer for review.
    a. Where construction joint spacing exceeds 50 feet, provide means for reducing shrinkage below the limit specified in Section 03300 - Cast-In-Place Concrete in proportion to the extent the spacing limit of 50 feet is exceeded.
    b. Use of construction joints in the floor slab shall be minimized.
3. Minimum ratio of floor slab reinforcement area to concrete area shall be 0.5 percent for each orthogonal direction, with bars spaced no greater than 12 inches on center or 2 times the slab thickness, whichever is less.
4. Minimum concrete cover over reinforcing steel shall be in accordance with Table 3.3.2.3 of ACI 350.5.
5. Wall footings shall bear below floor sub-grade and shall be placed monolithically with the floor slab.
    a. The bottom of the wall footing shall be embedded a minimum of 18 inches below the lowest finish grade elevation over the outside edge of the footing or as indicated on the Drawings, whichever is greater.
6. Design of the floor and wall footing shall consider the differential base stiffness and at concrete encasements or hard points below the floor and wall footing.

F. Wall Design Requirements:
1. The prestressed concrete tank wall shall be constructed with a cast-in-place core wall that is circumferentially wrapped with 7-wire galvanized strand prestressing reinforcement at the exterior and encapsulated within protective shotcrete layers. The core wall is to be vertically prestressed with post-tensioned thread bars.
2. The thickness of the core wall shall not be less than 10 inches thick.
3. The minimum average vertical compressive axial prestress in the core wall provided by the vertical prestressing reinforcement shall be 200 psi after deduction for all losses.
    a. Vertical prestressing reinforcement shall be spaced on average no greater than 50 inches on center or 7 times the thickness of the core wall, whichever is less.
4. The minimum average circumferential residual prestress compression in the wall shall not be less than 200 psi.
5. The connection between the base of the wall and the foundation shall be an anchored flexible connection in accordance with Section 4.2.1 and Figure 4B of AWWA D110-13.
    a. The joint at the base of the wall shall permit unrestrained radial expansion and contraction of the wall relative to the foundation.
    b. The joint at the base of the wall shall provide restraint against lateral seismic loads acting tangentially to the wall.
    c. Restraint cables shall be provided between the core wall and the foundation to resist seismic loads. The cable installation shall be detailed in a manner that does not introduce radial restraint between the wall and the foundation.
6. The minimum concrete cover over non-prestressed reinforcing shall be in accordance with Table 3.3.2.3 of ACI 350.5 with the following exception:
    a. Provide minimum 2-inch concrete cover on inside face of concrete wall exposed to liquid for non-prestressed reinforcing.

7. Vertical non-prestressed reinforcing:
    a. Provide vertical non-prestressed reinforcing over the full height of the wall.
    b. The tensile stress shall be limited to a maximum of 18,000 psi.
    c. Reinforcing size shall not exceed 3/4-inch in diameter.
    d. Reinforcing spacing shall not exceed 12 inches on center.
8. Horizontal non-prestressed reinforcing:
    a. Provide horizontal non-prestressed reinforcing around the entire perimeter of the wall. The reinforcing shall be continuous through vertical joints in wall.
    b. Reinforcing size shall not exceed 3/4-inch in diameter.
    c. Reinforcing spacing shall not exceed 12 inches on center.

G. Domed Roof Design Requirements:
1. The roof shall be a domed, cast-in-place concrete structure. Columns or interior supports will not be allowed.
2. The minimum thickness of the domed roof shall be 4 inches.
3. The dome shall be fixed to the tank wall.
4. Minimum concrete cover over reinforcing steel shall be in accordance with Table 3.3.2.3 of ACI 350.5.
5. The reinforcing steel for the roof structure shall be sized in accordance with ACI 350 with the environmental durability factor, S_d, applied to limit flexural stress. Reinforcing steel shall be proportioned and distributed to control cracking for normal environmental exposure.
6. The effects of thermal expansion and contraction shall be accounted for in the design of the roof structure. Appurtenances and roof connections shall be detailed to limit restraint to thermal radial movement.
7. The Tank (Sub)Contractor shall submit, for the Engineer's approval, a plan showing the roof configuration that includes construction joints. Construction joints shall incorporate a 6-inch PVC waterstop.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Prestressing steel shall be adequately packaged for protection against corrosion and physical damage during shipping and storage.

B. Prestressing steel that has rusted or has otherwise sustained damage will be rejected.

C. Prestressing material and appurtenances delivered to project site: Store off ground on planks, supported by 4-by-4 timber. Cover with polyethylene sheeting or treated paper to prevent exposure to moisture.

1.08 PROJECT CONDITIONS

A. Environmental requirements:
1. Cold weather epoxy grouting of tendons:
    a. In cold weather, and especially during frosts, take special precautions to avoid freezing of epoxy.
    b. In event that grouting procedure cannot be postponed, keep wall temperature above freezing point with hot blankets or by other means acceptable to Engineer.

B. Site safety precautions:
   1. Take every precaution to keep personnel and visitors outside the area of danger from breaking prestressing strands or bars, during wrapping process.
   2. At no time shall anyone be allowed to stand in the line of stressed circumferential strand during the wrapping process.
   3. No work shall be performed by anyone, other than the prestressing crew within 50 feet of the tank during the circumferential wrapping operation or vertical bar stressing operation.
   4. Where access to the site by unauthorized persons cannot be controlled while prestressing work is in progress, or where property lines are less than 100 feet from the wrapping operation, erect protective fencing to prevent breaking strands from endangering such persons.

C. Welding:
   1. Perform no welding to anchor plates after prestressing tendons have been assembled.
   2. Do not use prestressing steel as ground for welding operations.

1.09 SEQUENCING AND SCHEDULING

A. Polyvinyl chloride waterstops:
   1. Welding of polyvinyl chloride waterstops: Prior to installing waterstops in forms, contractor shall demonstrate to the engineer, the ability to weld acceptable joints in waterstops.
   2. Quality of welded joints: Are to be subject to acceptance of the Engineer.

B. Restrictions on shotcrete operations:
   1. Abrasive Blasting:
      a. Do not commence prior to the completion date of curing period of tank corewall.
      b. Do not commence until all form tie holes have been drypacked.
   2. Wind conditions: Do not apply shotcrete under such strong wind conditions that considerable amount of cement and moisture is removed by wind from mortar spray between nozzle and surface on which shotcrete is applied.
   3. Temperature requirements:
      a. Peak temperature during day must be expected to rise to at least 55 degrees Fahrenheit.
      b. Night temperature of first night after shotcrete application must not be expected to drop below 33 degrees Fahrenheit.
   4. Cold weather conditions:
      a. Application of shotcrete under cold weather conditions is solely at the Tank (Sub)Contractor's risk.
      b. Shotcrete may be applied in cold weather provided surfaces are not frozen.
      c. Damage to shotcrete: Whenever rain or frost damages shotcrete which has not had chance to take set:
         1) Remove and replace such shotcrete.
         2) Remove damaged shotcrete before applying any new layers of shotcrete.
      d. Type III Portland cement may be utilized for shotcrete for cold weather application.

C. Ultimate initial prestressing force for vertical thread bars: Do not apply until concrete compressive strength in walls reaches specified strength.

D. Wrapping of circumferential prestressing strands:
   1. May start when core wall concrete has reached a compressive strength of 3,000 pounds per square inch and intermediate layers of shotcrete coats over prestressing strands has reached a compressive strength of 250 pounds per square inch or 12 hours after the shotcrete coat was applied, whichever is greater.
   2. The compressive stress in the concrete due to wrapping shall not exceed 55 percent of f'_c at any time.

1.10 WARRANTY

A. Provide warranty as specified in section 01783 - Warranties and Bonds

B. Special warranty
   1. The Tank (Sub)Contractor shall guarantee the structure against defective materials and/or workmanship for a period of 2 years from the final date of substantial completion. If any materials or workmanship prove to be defective within 2 years, those materials shall be replaced or repaired by the Tank Contractor at the expense of the Tank (Sub)Contractor.
   2. Access hatches and manways (through-roof and wall access) warranty: Manufacturer is to warranty proper operation and against defects in material or workmanship for a period of 5 years from the date of final completion.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:
   1. Materials of construction for the strand-wound prestressed concrete tank shall be selected by the Tank Contractor, subject to the limitations of this Section.

B. Concrete:
   1. Concrete shall conform to Section 03300 - Cast-In-Place Concrete and ACI 301, except as modified herein.
   2. Unless otherwise specified, all concrete for tank construction shall have a minimum 28-day compressive strength of 4,000 psi.
   3. The concrete for the tank floor, footings, and pipe encasement shall conform to the following requirements.
      a. Concrete shall not be air-entrained.
      b. The coarse and fine aggregate shall meet the requirements of ASTM C33 and sized to meet member thickness and clearance requirements of ACI 350.
      c. Superplasticizer and water-reducing admixtures shall be incorporated into the concrete for the floor slab and wall footing.
   4. Proportioning for concrete shall be in accordance with ACI 301.
   5. All concrete shall have a maximum water-soluble chloride ion concentration of 0.06 percent by weight of cement.

6. Cement shall conform to ASTM C 150, Type I or Type II.
7. Accelerating and retarding admixtures shall not be incorporated into the any concrete mix without prior acceptance by the Engineer.

C. Reinforcing Steel:
   1. Reinforcing steel shall be new billet steel Grade 60 meeting the requirements of ASTM A 615.
   2. Reinforcing steel that is to be welded shall be ASTM A 706, Grade 60.
   3. Reinforcing steel shall be accurately fabricated and shall be free from loose rust, scale, and contaminants.
   4. Reinforcing steel shall be accurately positioned on supports, spacers, hangers, or other reinforcement and shall be secured in place with wire ties or suitable clips. Rebar chair supports shall be provided in accordance with Section 03200 - Concrete Reinforcing.
   5. Minimum reinforcing steel lap splice length shall be as indicated on Drawings.

D. Prestressing Materials:
   1. Seven-wire strand:
      a. Prestressing strand shall be in accordance with ASTM A 416 prior to hot-dip galvanizing.
      b. Individually hot-dip galvanize each wire of strand before forming the wires into a strand.
      c. Hot-dip galvanized 7-wire strand shall meet following minimum requirements:

Physical Characteristics	Required Results
Nominal Strand Diameter Before Galvanizing	3/8 inch
Nominal Area After Galvanizing	0.089 square inch
Nominal Weight Per 1,000 Linear Feet	303 pounds
Pitch of Strand	12 to 16
Minimum Yield Strength At 1 Percent Extension	180,000 psi
Minimum Ultimate Strength After Galvanizing	240,000 psi
Elongation In 24 Inches At Fracture	4.5 percent
Weight Of Zinc Coating per ASTM A475	0.85 ounces per square foot

   2. High strength thread bars:
      a. Thread bars and deformations: Hot rolled.
         1) Thread bars with cold rolled threads or with quenched or tempered steels will not be permitted.
      b. Deformations of thread bars:
         1) Provide deformations that form screw-thread suitable for mechanically coupling lengths of thread bar and provide positive attachment of anchor assemblies.
         2) Provide deformations that are in accordance with ASTM A 722, Type II requirements and are uniform such that any length of bar may be cut at any point and internal threads of coupler designated for that size of bar can be freely screwed on bar.

c. Tensile and physical properties: Bars manufactured in accordance with ASTM A 722, Type II requirements are to comply with following minimum requirements:

Physical Characteristics	Required Results
Nominal Diameter	1.25 inches or 1.375 inches
Nominal Cross-sectional Area	1.245 square inches or 1.577 square inches
Nominal Bar Weight	4.39 pounds per foot or 5.56 pounds per foot
Minimum Tensile Stress	150 ksi
Minimum Yield Stress at 0.2 Percent Offset	120 ksi
Elongation At Rupture In Gauge Length of 20 Bar Diameters	4 percent minimum
Maximum Carbon Content of Bar	0.55 percent

d. Nuts: Minimum ultimate strength shall be 95 percent of minimum ultimate strength of thread bar.

3. Anchorages for vertical post-tensioned thread bars:
   a. All post-tensioned prestressing shall be secured at the ends by means of approved permanent anchoring devices, which shall hold the prestressing steel at a force not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.
   b. The load from the vertical prestressing anchoring device shall be distributed to the concrete through steel bearing plates and shall not exceed the values specified by the Post-Tensioning Institute (PTI), Guide Specifications, Paragraph 3.1.7.
   c. Fully-threaded anchor connections shall be used at both ends of the vertical prestressing bar, which shall, when necessary, incorporate a spherical-shaped bearing surface to match the conical surface in the bearing plate.
   d. Wedge anchors shall not be used for permanent anchor hardware.
4. Testing of Prestressing Material:
   a. Provide mill certificates.
   b. Prior to preparation of shop drawings and installation of vertical thread bars, provide proof that the thread bar anchorage system meets the requirements specified herein.
   c. Before any prestressing operations may be started, the Tank Contractor shall calibrate all recording equipment at an approved testing laboratory to the satisfaction of the Engineer.
   d. All continuous force readings for either the vertical or the circumferential prestressing operations shall be developed with electronic (or the substantial equivalent) force (strain gauge method) sensing transducers, all having a maximum nonlinearity error of +/- 0.5 percent and a maximum hysteresis error of +/- 0.25 percent.

5. Anchor pockets for vertical thread bars:
    a. Consist of steel cans fabricated from steel tubing, hot-dip galvanized after cutting and subsequently welded to the top bearing plate.
    b. Provide adequate means for flushing of vertical ducts during concrete placement.
6. Ducts for vertical thread bars:
    a. Duct enclosures shall be standard 1.25-inch or 1.375-inch diameter PVC pipe class 160 or class 200, respectively, unless otherwise specified on the Drawings.
    b. Threaded hose connections shall be provided at the top of each duct for water flushing.
    c. All ducts shall be provided with expandable valves to facilitate the injection of epoxy grout after prestressing.
7. Epoxy grout for vertical thread bars:
    a. The vertical thread bar system shall offer complete 2-part epoxy protection of the prestressing steel inside ducting and anchors.
    b. Portland cement grout will not be accepted.

E. Seismic Cables and Sleeves:
1. Seismic cables:
    a. Hot-dipped galvanized 7-wire strand:
    b. Prestressing strand shall be in accordance with ASTM A 416 prior to galvanizing and ASTM A 475 after galvanizing.
    c. Individually hot-dip galvanize each wire of strand before forming the wires into a strand.
    d. The galvanized strand shall have a minimum ultimate tensile strength of 240,000 psi.
    e. The cables shall be installed to connect the wall and the foundation.
    f. The minimum weight of zinc galvanic coating shall be 0.85 ounces per square foot.
    g. Only 7-wire strand will be allowed. Single wire will not be allowed.
2. Neoprene sleeves for seismic cables shall conform to SCE-43 of ASTM D 1056 and as further modified by the following:

Physical Characteristics	Required Results
Compressive deflection	9 to 13 psi
Shore 00 durometer	60 to 80 pcf
Density	12 to 28 pcf
Water absorption by weight	5 percent
Temperature range: Low (flex without cracking) High continuous High intermittent	-40 degrees Fahrenheit 150 degrees Fahrenheit 250 degrees Fahrenheit
Compressive set (average): 1/2-inch sample compressed at 50 percent for 22 hours at 70 degrees Fahrenheit and 24 hour recovery	15 to 35 percent
Maximum linear shrinkage during heat aging (7 days at 158 degrees Fahrenheit)	5 percent
Minimum tensile strength	175 psi

Physical Characteristics	Required Results
Minimum elongation	180 percent
Resilience (bayshore - percent rebound average 1/2-inch thickness at 72 degrees Fahrenheit)	20 to 40 percent

F. Shotcrete:
1. General:
   a. Shotrcrete shall conform to ACI 506.2, except as modified herein.
   b. Minimum compressive strength of shotcrete shall be 4,500 psi at 28 days.
   c. Shotcrete used in the tank construction shall have a maximum water soluble chloride ion concentration of 0.06 percent by weight of cement.
   d. Rebound materials shall not be reused in any form for shotcrete.
2. Portland cement shall meet the general requirements in Section 03300 - Cast-In-Place Concrete.
3. Fine aggregates:
   a. Fine aggregates shall meet the requirements as specified in Section 03300 - Cast-In-Place Concrete and the following paragraphs.
   b. Coarse sand:
      1) Shotcrete applications: Use well graded coarse sand, unless otherwise noted.
      2) Gradations:

Sieve Size	Percent Passing by Weight
3/8 inch	100
Number 4	95-100
Number 8	80-100
Number 16	50-85
Number 30	25-60
Number 50	10-30
Number 100	2-10

   c. Fineness modulus shall be between 2.7 and 3.0.
4. Water shall be in accordance with Section 03300 - Cast-In-Place Concrete.
5. Class F fly ash shall conform to ASTM C618 and shall not make up more than 20 percent of the cementitious material in the shotcrete mix.

G. Elastomeric Materials:
1. Bearing pads shall be natural rubber or neoprene:
   a. Natural rubber bearing pads shall contain only virgin natural polyisoprene as the raw polymer and the physical properties shall comply with ASTM D 2000 Line Call-Out M4AA414A13.
   b. Neoprene bearing pads shall have a hardness of 40 to 50 durometer, a minimum tensile strength of 1,500 psi, a minimum elongation of 500 percent, and a maximum compressive set of 50 percent. Pads shall

meet the requirements of ASTM D 2000 Line Call-Out M2BC410 A14 B14 or 2 BC 415 A1 4 B14 for 40 durometer material.

2. Sponge filler shall be closed-cell neoprene or rubber conforming to ASTM D 1056, Type 2, Class A, and Grade 3. Compression deflection limited to 25 percent at 2 to 5 psi.

H. Waterstops:

1. Requirements:
   a. Material: Polyvinyl chloride.
   b. Size and type:
      1) Centered at construction joints in cast-in-place concrete: 6-inch flat ribbed type.
      2) At tank walls to tank wall-footing joints: 9-inch wide with 1-inch diameter hollow bulb ribbed type.
      3) Type not allowed: Dumbbell type.
   c. Physical characteristics:

Physical Characteristics	Test Method	Required Results
Specific Gravity	ASTM D 792	Not less than 1.3
Hardness	ASTM D 2240	70 to 90 Type A Shore durometer
Tensile Strength	ASTM D 638	Not less than 2,000 pounds per square inch
Ultimate Elongation	ASTM D 638	Not less than 300 percent
Alkali Extraction	CRD C 572	7 day weight change between minus 0.1 percent and plus 0.25 percent. Hardness change within 5 points.
Low Temperature Brittle Point	ASTM D 746	No sign of cracking or chipping at minus 35 degrees Fahrenheit
Water Absorption	ASTM D 570	24 hours, not more than 0.15 percent
Accelerated Extraction Tensile	CRD C 527	Not less than 1,600 pounds per square inch
Stiffness in Flexure	ASTM D 747	Not less than 600 pounds per square inch
Tear Resistance	ASTM D 624	225 pounds per square inch
Weight Requirements		
Thickness		3/8 inch
Center Bulb Outside Diameter		1 inch nominal
Allowable Tolerances		
Width		Plus or minus 3/16 inch
Thickness		Plus or minus 1/32 inch

d. Manufacturers: One of the following or equal:
    1) Burke Concrete Accessories, Inc.
    2) Greenstreak PVC Waterstops, Sika Corporation.
    3) Kirkhill Rubber Company.
    4) Williams Products, Inc.
    5) Vinylex Corporation.

I. Tank Appurtenances:
1. General:
    a. Provide and install all appurtenances as shown on the Drawings and as specified herein.
2. Piping:
    a. Inlet: As indicated on the Drawings.
    b. Outlet: As indicated on the Drawings.
    c. Overflow piping and overflow cone: As indicated on the Drawings.
    d. Drain piping: As indicated on the Drawings.
3. Pipe Supports:
    a. Provide as required to adequately support piping under all load and operating conditions.
    b. Refer to Section 15061 - Pipe Supports.
4. Conduits:
    a. As indicated on Drawings.
5. Conduit Supports:
    a. Proivde as required to adequately support conduits under all load and operating conditions.
    b. Refer to Section 16070 - Hangers and Supports.
6. Ladders:
    a. Conforming to all requirements of OSHA and as indicated on the Drawings.
        1) Provide brackets and fasteners required for support and secure mounting to tank structure.
        2) Rungs: solid bar stock.
        3) Welds: fillet or full penetration as appropriate to the condition.
        4) Fasteners Ladder bolts, concrete anchors, nuts, washers, and flush steel inserts: Type 316 stainless steel.
    b. Interior:
        1) Materials: Type 304/304L stainless steel.
        2) Fall protection: Fall arrest device as specified in the following paragraphs. Material to match that of ladder. Provide removable center rail extension projecting at least 48 inches above top rung of ladder.
    c. Exterior:
        1) Materials: As indicated on the Drawings.
        2) Fall protection: “Saf-T-Climb” as indicated on the Drawings.
        3) Anti-climb door: Per ladder manufacturer. Material to match that of the exterior ladder.
    d. Horizontal lifeline fall protection system: As indicated on the Drawings.
    e. Fall arrest device consisting of sliding/locking mechanism with safety belt and belt attachment to center climbing rail.
        1) Device material: Type 304 stainless steel.

2) Devices: To include following items, all fabricated of device material unless otherwise accepted by the Engineer:
    a) Rails: Lengths as required.
    b) Brackets: Complete with brackets necessary for attaching rail to ladders.
    c) Removable rail extension: 48-inch long.
3) Sleeve assemblies and safety belts: 2.
4) Manufacturers: The following or equal:
    a) Norton Company, Air Space Device Division, Cerritos, CA, Saf-T-Climb with SAF-T-NOTCH RAIL and SAF-T-LOCK SLEEVE.

7. Access hatches (through-roof access):
    a. Sizes: Nominal size(s) as indicated on the Drawings.
    b. Material and construction:
        1) Door leaf/leaves: Aluminum diamond pattern plate with reinforcement if required for spans provided.
        2) Frame: Minimum 1/4-inch thick, aluminum channel with anchor flange around perimeter.
        3) Door hardware: Equip doors with following:
            a) Hinges: Minimum 2 heavy forged stainless steel hinges and pins for each leaf.
            b) Operators, hold-open and handle: Spring operators and automatic hold-open arm with release handle for each leaf.
            c) Lock: A Type 316 stainless steel snap lock with fixed handle shall be mounted on the underside of one cover. In addition, the lock shall be a cylinder style with a threaded security cover plug.
            d) Seals: Leaf seals shall be dust and water tight.
            e) Drainage coupling: 1-1/2-inch coupling located in front right corner of frame. Drain shall be installed to drain to the exterior side of the tank, adjust curb height as required.
        4) Finish: Manufacturer's standard mill finish.
        5) Manufacturers: One of the following or equal:
            a) Bilco Co., Type JD-AL.
            b) Babcock-Davis Associates, Inc., Type AM or GT.
            c) Nystrom, Inc.
8. Hinged manway(s) (through-wall access):
    a. Sizes: Nominal clear opening size(s) as indicated on the Drawings.
    b. Materials and construction:
        1) All Type 304 stainless steel components, unless otherwise accepted by the Engineer.
        2) Lock: Provide stainless steel padlocks on the hand wheel and yoke.
    c. Manufacturers: The following or equal:
        1) Chase Associates, Edgecomb, Maine, CM-1.
9. Grating, Guardrail, and Miscellaneous Fabrications:
    a. Refer to Section 05500 - Metal Fabrications.
    b. Materials: As indicated on the Drawings.
10. Roof Ventilator:
    a. Size: As required to meet the air flow design requirements, but not less than indicated on the Drawings.
    b. Materials and construction:
        1) Aluminum components.

2) Stainless steel anchors.
3) Flashing shall wrap over the edge of the concrete curb and extend down a minimum of 2 inches.
4) Two-inch aluminum filters.
5) Insect screens.
6) Twelve-inch tall base.
7) Fiberglass hood insulation.

c. Manufacturers: The following or equal:
1) Greenheck Fabra Hood.

d. Finish: Manufacturer's standard mill finish.

11. Downspouts and conductor heads:
a. Minimum 22 gauge steel.
b. Galvanized in accordance with ASTM A 653 to G90 designation.
c. Fastened to the tank wall with stainless steel anchors.
d. Field painted. Color to be selected by Owner.

J. Form ties:
1. General: The requirements of this Section supplement the form ties requirements stated in Section 03102 - Concrete Formwork.
2. Requirements:
a. Form ties for forming system selected for concrete other than corewall: Cone-snap tie or flat bar type with waterstops.
b. Form ties for forming system selected for tank corewall: Tapered ties.

K. Wall Forms: As specified in Section 03102 - Concrete Formwork, SYMONS, ALUMA, and regular plywood forms may be used for forming of circular walls, as long as there are no straight sections longer than 36 inches at any place around the outside circumference of such walls.
1. Forms shall be designed to resist the construction loads for full height wall pours.

L. Polyethylene sheeting:
1. Minimum 6-mils thick and in accordance with ASTM C 171.

M. Granular leveling base:
1. Material shall meet the requirements for aggregate base course specified in Section 02050 - Soils and Aggregates for Earthwork.

N. Epoxy injection materials: As specified in Section 03931 - Epoxy Injection System and the following products:
1. Grout injection pipes: Provide with positive mechanical shutoff valves.

O. Materials for repair of chipped out concrete areas:
1. Epoxy bonding agent: As specified in Section 03071 - Epoxies.

P. Membrane Liner:
1. Thickness: Minimum 30 mil.
2. Material: Impermable PVC.
3. Manufacturers: One of the following or equal:
a. York Manufactuing, Inc., Wasco Seal.
b. Watersaver Co., Inc. equivalent product.

c. Palco Linings, Inc. equivalent product.

4. Install liner per manufacturer's recommendations to provide a waterproof layer below the tank foundation as indicated on the Drawings.

2.02 SOURCE QUALITY CONTROL

A. Concrete testing:
   1. As specified in Section 03300 - Cast-In-Place Concrete.

PART 3 EXECUTION

3.01 SUPERVISION

A. The Tank Contractor shall provide a full-time on-site project manager during all aspects of tank construction.

3.02 INSTALLATION

A. Waterstops:
   1. General: The requirements of this Section supersede the waterstop requirements stated in Section 03150 - Concrete Accessories.
   2. Requirements:
      a. Install in concrete joints where indicated on the Drawings.
      b. Connect the ends of the radial waterstop in the wall footing joints to the circumferential waterstop in the wall to wall footing joint and to the circumferential waterstops in the floor to wall-footing joints if they should exist.
      c. Provide waterstop in each joint in water-bearing structures, whether indicated on the Drawings or not.
      d. Provide waterstops that are continuous.
      e. Set accurately to position and line indicated on the Drawings.
      f. Hold and securely fix edges in position at intervals of not more than 12 inches and secure in manner that they cannot move during placing of concrete.
      g. A hog-ring or nail may be driven through both ends of the waterstop to facilitate placing and tying of waterstops to reinforcing steel forms or form-ties.
      h. Tank Contractor's option: One of the following:
         1) Use waterstop tie wires at not more than 12 inches on centers, near outer ribs, to tie waterstops into position.
         2) Use special clips.
      i. Waterstop terminations: Terminate 3 inches from top of finished surfaces of walls and slabs unless otherwise specified or indicated on the Drawings.
      j. Installation of waterstops:
         1) Install so that joints are watertight.
         2) Provide field welded polyvinyl chloride waterstop joints such as unions, crosses, ells, and tees.
         3) Make all splices to waterstop in accordance with manufacturer's recommendations.

4) Clean waterstops of all concrete, dirt, and foreign matter.

B. Form and accessories removal:
   1. General: The requirements of this Section supercede the form and accessories removal requirements stated in Section 03102 - Concrete Formwork.
   2. Requirements:
      a. Other forms supporting concrete and shoring: Remain in place as follows:
         1) Sides of footings, sides of slabs, and columns: 24 hours minimum.
         2) Core walls: 12 hours minimum.

C. Neoprene bearing pads:
   1. General:
      a. Secure bottom surface of pads by positive attachment to structure such that horizontal crawling is prevented.

D. Closed cell neoprene joint fillers and sleeves (“sponge filler”):
   1. When joint filler pads or sponge filler sleeves are indicated on the Drawings or specified, place materials in correct position before concrete is placed against them.
   2. Holes and joints in pads are to be filled with caulking to prevent passage of mortar or concrete from one side of the joint to the other.

3.03 FLOOR

A. Prior to placement of the floor reinforcing, a 6-mil polyethylene moisture barrier shall be placed over the leveling base material. Joints in the polyethylene shall be overlapped a minimum of 6 inches.

B. Prior to placement of the floor concrete, all piping that penetrates the floor shall be set and encased in concrete to the limits indicated on the Drawings. Provide waterstops at the joints between the encasement and the concrete floor slab where indicated on the Drawings.

C. The vertical waterstops between the wall and footing shall be placed and supported to locate the center bulb within the joint as indicated on the Drawings and as required by the Tank Contractor. The waterstop shall be continuously connected and spliced using a thermostatically controlled sealing iron and each splice shall be successfully spark tested prior to encasement in concrete.

D. The floor shall be poured without construction joints, except as otherwise allowed by the Engineer. There shall be no construction joints between the floor and wall footing.

3.04 CONCRETE

A. All concrete shall be conveyed, placed, finished, and cured as specified in Section 03300 - Cast-In-Place Concrete, except as modified herein.

B. Requirements:
   1. Cold joints:
      a. Cold joints in floors, dome, and wall footings are not allowed.
      b. Continuously cover joints with new concrete, and thoroughly integrate through vibration, even if it means that horizontal passes of only 6 inches in width can be made until additional concrete and equipment becomes available to permit wider passes in concrete placement.
   2. Blockouts or other types of wall openings: Do not provide openings other than those indicated on the Drawings.

C. Weather Limitations:
   1. Unless specifically authorized in writing by the Engineer, concrete shall not be placed without special protection during cold weather when the ambient temperature is below 35 degrees Fahrenheit and when the concrete is likely to be subjected to freezing temperatures before initial set has occurred and the concrete strength has reached 500 psi. Concrete shall be protected in accordance with ACI 306.1. The temperature of the concrete shall be maintained in accordance with the requirements of ACI 301 and ACI 306.1. All methods and equipment for heating and for protecting concrete in place shall be subject to the approval of the Engineer.
   2. During hot weather, concreting shall be in accordance with the requirements of ACI 305.1.
   3. Placement of concrete during periods of low humidity (below 50 percent) shall be avoided when feasible and economically possible, particularly when large surface areas are to be finished. In any event, surfaces exposed to drying wind shall be covered with polyethylene sheets immediately after finishing, or flooded with water, or shall be water cured continuously from the time the concrete has taken initial set. Curing compounds may be used in conjunction with water curing, provided they are compatible with coatings that may be applied later and if they are degradable.

D. Finishes:
   1. Provide manufacturer’s standard finish unless otherwise noted.

E. Curing:
   1. Except where specified herein, concrete curing shall be as specified in Section 03300 - Cast-In-Place Concrete.
   2. Requirements:
      a. Any concrete surface that is designated to receive paint or upon which any material is to be bonded: No curing compound shall be used.
      b. Concrete designated to be painted: Water or plastic membrane cure.
      c. Tank core walls: Water curing.
      d. Floor slab:
         1) The floor shall be cured by flooding with water, and shall remain saturated for a minimum of 7 days after placement.
         2) Alternatively, the floor slab may be cured with a sprayed on curing compound and prepared as follows:
            a) After the surface is dry to the touch, a 6-mil thick polyethylene sheet shall be carefully taped and sealed to the concrete surface and kept on such surface for as long as possible, but not less

than 7 days, to minimize the loss of moisture trapped between the polyethylene sheet and the concrete.

b) Alternatively, heavy curing blankets may be used in lieu of the polyethylene sheet.

e. Dome: Water or plastic membrane cure.

f. Other concrete surfaces: Water curing.

F. Testing Cast-in-Place Concrete:

1. All concrete testing shall be in accordance with Section 03300 - Cast-In-Place Concrete, except as noted herein.
2. Special Inspection Testing shall be at the expense of the Owner as specified in Section 01455 - Regulatory Quality Assurance.

3.05 SEISMIC CABLES

A. Requirements:

1. Provide seismic cables to connect wall and wall footing.
2. Quantity and spacing of seismic cables shall be as indicated on the Shop Drawings.
3. Where necessary, seismic cables shall be pre-bent before placing units in wall and wall footing.
4. Tie seismic cables to lower horizontal circumferential tie-bar for vertical prestress tendons as indicated on the Drawings.
5. In wall-footing, tie seismic cables to radial footing bars.

3.06 PRESTRESSING

A. Circumferential Prestressing Equipment:

1. The circumferential stressing system shall produce a continuously, electronically (or substantial equivalent) monitored permanent stress or force recording along its full length as it is being applied and the stress variation in any strand at any point around the circumference shall not be greater than +/- 1.5 percent of the ultimate strength of the steel.
   a. In addition to this recording, any system which deflects the tensioned prestressing material between the tensioning device and the wall after it has left the tensioning device, shall provide a similar continuously monitored stress or force record along its full length as it is being applied to the wall.
   b. These recordings shall show that either before or after deflection that the stress variation in the prestressing material at any point around the circumference shall not be greater than +/- 1.5 percent of the ultimate strength of the steel.
2. Due to prior instances of force measurement inaccuracies and the inherent problems associated with hand-held stressometers, no manually recorded force readings will be accepted.
   a. This requirement shall be strictly followed.
3. Any wrapping that does not meet the stress tolerances specified and/or cannot meet the requirements of above will not be accepted and will be removed at the expense of the Tank Contractor.
   a. The Tank Contractor is responsible for all costs associated with meeting the specified tolerances.

4. Since intermittent force applications can result in an unequal stress distribution around the wall (due to friction losses), the prestressing system shall be capable of applying a continuous wrapped force at any point around the circumference within the specified tolerances.
    a. Circumferential stressing systems based on jack-operated cable or rod-type tendons (such as those placed inside of ducts incorporated in the corewall or placed manually around the exterior of the corewall) will not be allowed.
5. Since wrapping systems which utilize single solid prestressing material will not provide the desired bond between the prestressing material and the shotcrete and since single solid prestressing material will not provide an adequate safety factor against failure, only machine wrapping systems which utilize 7-wire prestressing strandwrapping will be allowed.

B. Circumferential Prestressing Application:
1. All cracks in the core wall and floor slab shall be repaired as specified following the circumferential prestressing of the tank walls.
2. Wrapped strand shall be anchored to the wall at least once for every coil or reel.
3. Permanently anchoring one strand to a previously wrapped strand will not be permitted. Wrapped strand ends shall be joined by suitable splicing methods that shall develop 90 percent of the full strength of the strand.
4. Use of different alloys in the splicing material shall not be permitted.
5. The clear vertical spacing between any 2 wrapped strands shall be 1.5 strand diameters or 3/8-inch, whichever is larger. A 1/4-inch construction tolerance shall apply to strand spacing, as well as to this minimum spacing requirement.
6. All wrapped strand not meeting the spacing requirements shall be spread by approved methods or shall otherwise be removed.

C. Vertical Prestressing Equipment:
1. The Tank Contractor shall provide a continuously, electronically (or substantial equivalent), monitored permanent force elongation record from zero to full force at the final lock-off for all of the vertical prestressing work.
2. The ordinate of the permanent recording shall show the elongation in inches and the abscissa shall show the force in pounds or kips.
3. Manually recorded force and elongation readings will not be accepted.
4. The vertical prestressing machinery shall have automatic electronic tensioning cut-off devices or equivalent means to ensure that the specified force and elongation is not exceeded at any time during any thread bar stressing operation.
5. The force readings at the stressed bar ends, immediately after lock-off, for any stressing operation, on any thread bar, shall not fluctuate more than +/- 1.5 percent (of the minimum ultimate strength of the steel) from the desired average force setting.
6. The applied force, immediately after lock-off for the final stressing operation on any thread bar, shall be no less than 72 percent of the ultimate strength of the steel and the applied force before lock-off shall be no greater than 75 percent of the ultimate strength of the steel.

D. Vertical Prestressing Application:
   1. Where necessary, all permanent anchor hardware shall have a ball-shaped threaded nut that can be screwed down on to a matching cone-shaped bearing surface in the bearing plate after the desired tension on the anchor hardware and/or prestressing steel has been applied.
   2. The number and spacing of the thread bars shall not be altered under any condition.
   3. High-strength thread bars shall be used for vertical prestressing.
   4. All ducts shall be clean and free of water and deleterious materials that would impair bonding of the grout or interfere with grouting procedures.
   5. Grout injection pipes shall be fitted with positive mechanical shutoff valves, which shall not be removed within the first 24 hours.
   6. Grouting of thread bars shall begin at the lowest grout connection.
   7. Each vertical thread bar duct shall be pumped until the entire nut at the top anchor has been covered with epoxy.
   8. In cold weather, and especially during frosts, special precautions must be taken to avoid the freezing of grout. In the event that the grouting procedure cannot be postponed, the wall temperature must be kept above the freezing point with hot blankets or by other approved means.
   9. Upon completion of the vertical stressing and grouting operation, all anchor pocket areas above the anchor nuts shall be dry packed with a 1 part cement to 2 parts sand mortar mix immediately after the epoxy coating on the inside can surface has become tacky, or alternatively, the metal can may be filled with concrete aggregates and epoxy.
   10. The inside surfaces of any metal cans to be dry packed shall be coated with a 2-part epoxy. Dry packing shall not proceed until the epoxy coat has become tacky. The dry pack surface shall be finished flush with the adjoining concrete surface.
   11. Damaged PVC tubing shall be replaced unless repairs are made and approved by the Engineer.
   12. Vertical thread bar components shall be assembled off the ground and as detailed on the Shop Drawings. All vertical thread bars must be fully assembled before they are installed in the forms.
   13. Vertical thread bars shall be accurately placed and fastened securely in place to reinforcing steel and form ties to prevent movement during placement of concrete.
   14. All vertical thread bars must be flushed with water from the top immediately upon completion of the concrete vibrating operation. Water shall be introduced through a taped-off hole in the wooden lids on the anchor pockets and be permitted to drain through the bottom grout tube. Flushing shall not be accomplished by introducing water through the bottom connection. Should a thread bar duct not flush properly, the Engineer shall be notified immediately.
   15. Cleaning of ducts with air only (not water), or removal of water with air from the bottom connection, will not be permitted.
   16. Placing of vertical thread bars shall be done to proper locations, elevations, and alignments, with a maximum tolerance of plus or minus 1/4 inch.
   17. All vertical thread bars shall be properly tied at the anchor plates and shall be tied with No. 4 bars at intervals of 24 inches or less between the anchor plates. The maximum permissible misalignment of the anchor plate to the vertical thread bar is +/- 2.5 degrees.

18. Anchor plates must be installed at right angles to the thread bar alignment near the anchor. Anchor plates must be installed with long sides, aligned parallel with the wall forms and secured to prevent their rotation while concrete is placed.
19. Unless indicated otherwise on the Plans, the minimum concrete cover around steel anchor pockets and bearing plates shall be 1.5 inches.
20. The vertical clearance between bottom anchor plate and the waterstop at the base of the tank walls shall be no less than 2 inches nor more than 4 inches.

E. Circumferential and Vertical Prestressing Operations:
1. The maximum initial electronically recorded steel stress shall not exceed 75 percent of the guaranteed minimum ultimate strength of the steel at any time during or after stressing.
2. An automatic, continuously electronically (or substantial equivalent) monitored permanent recording of the applied force, at any point on the strand, at any point on and around the tank wall, must be made during the entire circumferential prestressing application. All such recordings must be based on a continuous sensing of the applied force on the strand between the tensioning drum and the wall when, and as, the strand is being wrapped and laid on the wall.
3. The force setting on wrapping and vertical thread bar stressing machinery shall be such that the applied forces fall within the specified minimum or maximum stress or force limitations; the force setting shall be corrected immediately when the applied force falls outside the required force tolerance limitations.
4. In the event that the stressing machinery is incapable of holding the applied forces within the specified stress or force limitations, the Engineer will order, at the expense of the Tank Contractor, the removal and replacement of such machinery in favor of a different unit capable of maintaining such tolerance requirements.
5. The loss in stress in post-tensioned prestressing steel due to creep and shrinkage of concrete and sequence stressing is to be assumed as 25,000 psi. The final stress is the average initial stress reduced by the stress loss of 25,000 psi.
6. The final force is the steel section multiplied by the final stress.
7. The final force for the vertical thread bars shall be no less than the required final force shown on the Shop Drawings.
8. The initial force for the circumferential wrapped strand shall be no less than the required initial force shown on the Shop Drawings.
9. The continuous, electronically-produced force application chart during the wrapping application becomes the property of the Owner.
10. An automatic, continuously electronically (or substantial equivalent) monitored and simultaneously recorded force-elongation reading must be made for each vertical stressing application.
11. The force-elongation reading must represent the true relationship between the elongation at any given point of the vertical stressing operation and the applied force on the prestressing steel at that same point.
12. The force-elongation relationship must be constantly maintained from the beginning, starting with the removal of the slack to the point of lock-off and complete release of the force on the vertical prestressing steel after retraction of the stressing piston or equivalent stressing device.

13. All electronically produced force-elongation readings during the vertical thread bar stressing operations become the property of the Owner.
14. After the concrete core wall has reached the specified 28-day compressive strength, the vertical thread bars shall be stressed.
15. Circumferential wrapping shall not start until the vertical thread bars have been stressed.
16. In the event gaps between concrete core wall and wrapped strand develop that exceed 3/8 inch, discontinue wrapping. Before resuming any wrapping, either:
    a. Build-up walls with shotcrete to provide proper curvature before resuming any wrapping.
    b. If acceptable to Engineer, drypack gaps after wrapping is completed and before shotcreting is started.
17. Wrapping over intermediate shotcrete coats or built-up shotcrete areas may commence 12 hours after shotcrete has been applied, or when the shotcrete has reached a strength of 250 psi, whichever duration is longest.
18. Prestressing strand exposed to excessive temperatures greatly increases the possibility of irrevocable damage to the strand such as steel embrittlement, stress corrosion, and strand splitting.
    a. The temperature of the prestressed strand during wrapping shall not be allowed to increase by more than 50 degrees at any time during application due to stressing technique.
19. All vertical thread bar ducting and anchors (both vertical and circumferential prestressing) shall be pressure grouted with an approved 2-part water insensitive epoxy and approved epoxy grouting equipment.

3.07 ABRASIVE BLASTING

A. Exterior surfaces of concrete walls shall be prepared prior to the commencement of any shotcreting or strand wrapping, to remove all deteriorated concrete and bond-inhibiting contaminants.
    1. The surface preparation shall achieve a minimum profile of International Concrete Repair Institute (ICRI) CSP5 over a minimum of 90 percent of the surface area required to be prepared.
    2. The prestressing operator who is performing the abrasive blasting shall make available to the inspector an ICRI surface preparation sample to assist with evaluation of the surface preparation.

B. The concrete surface shall have no traces of laitance, form-oil, original surface smoothness, or surface color.

C. In order to mitigate environmental concerns, conform to environmental constraints, and achieve the desired profile, the Tank Contractor shall utilize either a self-contained mechanical etching or shot blast system, combined with a vacuum recovery system, or a high pressure water jetting system.
    1. Abrasive blasting systems which rely on sandblasting or steel shot without a vacuum recovery system, or systems that have not been used successfully in the past to prepare surfaces for shotcreting and standwrapping, will not be permitted.

3.08 SHOTCRETING

A. Shotcrete Equipment:
   1. Shotcrete mixing shall be in conformance with the requirements of Section 03300 - Cast-In-Place Concrete.
   2. The delivery equipment shall be of an approved design and size that has given satisfactory results in similar previous work.
   3. The equipment must be capable of discharging mixed materials into the hose under close control and it must be able to deliver a continuous smooth stream of uniformly mixed material at the proper velocity to the discharge nozzle, free from slugs of any kind.
   4. The nozzle shall be of a design and size that will insure a smooth and uninterrupted flow of materials.
   5. Delivery equipment shall be thoroughly cleaned at the end of each shift.
   6. Equipment parts shall be regularly inspected and replaced as required.
   7. The capacity of the compressor shall be large enough that the minimum amount of air to be available at the nozzle shall be no less than 400 cfm, irrespective of whether or not air from the same air supply is used for other purposes.

B. Placement and Testing of Shotcrete:
   1. Shotcrete shall be applied by an ACI 506 certified nozzleman.
   2. Manually applied shotcrete shall be applied with the nozzle held at a small upward angle not exceeding 5 degrees and constantly moving during application in a smooth motion with the nozzle pointing in a radial direction toward the center of the tank.
      a. The nozzle distance from the prestressing shall be such that shotcrete does not build up or cover the front face of the wire or strand until the spaces behind and between the prestressing elements are filled.
   3. Unless applied by an automated shotcrete process, total cover coat thickness shall be controlled by shooting guide wires. Vertical wires shall be installed under tension and spaced no more than 2 feet apart to establish uniform and correct coating thickness. Monofilament line (100 pound test) or 18 or 20 gauge high tensile strength steel wire shall be used. Guide wires shall be removed after placement of the cover coat.
   4. Shotcrete applied by an automated shotcrete process shall be applied using the wet mix only.
      a. Nozzles shall be kept mounted on power driven machinery enabling the nozzle to travel parallel to the surface to be sprayed at a uniform linear or bi-directional speed.
      b. The nozzle shall be kept at a uniform constant distance from the surface, always maintaining a right angle spray of the material to the surface.
      c. The high velocity impact shall be developed pneumatically by injecting compressed air at the nozzle.
   5. Testing:
      a. Testing shall be by an independent testing laboratory, acceptable to Engineer, and engaged by and at the expense of the Tank Contractor.
      b. Test shotcrete in accordance with ACI 506, except as specified herein. One test panel shall be made for each of the following operations: core wall, cove, wire cover, and cover coat.

1) Test panels shall be made from the shotcrete as it is being placed, and shall, as nearly as possible, represent the material being applied. The method of making a test sample shall be as follows:
    a) A frame of wire fabric (one foot square, 3 inches in depth) shall be secured to a plywood panel and hung or placed in the location where shotcrete is being placed.
    b) This form shall be filled in layers simultaneously with the nearby application.
    c) After 24 hours, the fabric and plywood backup shall be removed and the sample slab placed in a safe location at the site.

c. The sample slab shall be moist cured in a manner identical to that used for the regular surface application.
    1) The sample slab shall be sent to the testing laboratory.
    2) Nine 3-inch cubes shall be cut from the sample slab and subjected to compression tests in accordance with current ASTM Standards.
    3) Three cubes shall be tested at the age of 7 days, 3 shall be tested at the age of 28 days, and 3 shall be retained as spares.

C. Shotcrete Placing and Finishing:
1. Shotcrete shall be applied in a steady, uninterrupted flow. Should the flow become intermittent for any cause, the machine operator shall direct the nozzle away from the work until it again becomes constant, or shut off the flow of materials.
2. The nozzle shall be held at approximately right angles to the surface and shall be kept at the proper and the same distance from the surface dictated by good practice standards for the type of application, type of nozzle and air pressure employed.
3. Sufficient time shall be allowed for each layer of shotcrete to set up so it may take the next layer without sagging.
4. The shotcrete shall be started at the bottom of the wall until all wrapped strand has been covered. Subsequent shotcrete layers may be applied from the top down or from the bottom up at the discretion of the Tank Contractor.
5. While the nozzle travels around the wall, the nozzle shall be raised or lowered at a uniform rate in such a manner that an adequate overlapping of coatings and a uniform finish will develop.
6. The nozzle shall be spiraled up or down around the tank to either the top or the bottom of the wall or to the termination of the intermediate strand layer.
7. To ensure proper penetration around the strand and proper conveyance of the material through the hose, a 5- to 7-inch slump of the mortar at the pump is recommended.
8. The application of the shotcrete in the number and thickness of layers specified herein is mandatory for proper penetration of shotcrete behind prestressing material and to reduce shrinkage due to more uniform in-depth drying of the shotcrete.
9. Each layer of wrapped prestressing steel shall be covered with shotcrete until a minimum clear cover of 3/8-inch or the diameter of the strand, whichever is greater, has been placed over the prestressing steel.
10. The final cover coat, to make up for the full thickness of shotcrete over the final strand layer, shall be applied in at least 3 layers of equal thickness.

11. Each layer of shotcrete shall be completed for the full circumference of the tank and substantially the full height of that layer before the next layer of shotcrete may be applied.
12. All shotcrete coatings shall be built up in layers of approximately 3/8-inch in thickness until the final required thickness has been obtained. The Tank Contractor shall demonstrate by a reliable means that the proper thickness of shotcrete has been obtained with each layer applied.
13. Unless otherwise specified on the Drawings, the minimum shotcrete cover over all wrapped steel shall not be less than the following:
    a. For shotcrete in contact with soil: 2 inches.
    b. For other shotcrete exposures: 2 inches.
14. The Tank Contractor shall make provisions to protect adjacent structures, equipment, vehicles, etc., from being damaged by overshooting shotcrete and rebound materials. Overshot shotcrete deposited onto the dome shall be removed before it adheres to the concrete surface.
15. After the minimum shotcrete cover specified over the wrapped prestressing strand has been completed by the automated shotcrete procedure, and if such finish requirements are shown on the Drawings, the exterior surface shall be given an acceptable float finish true to line and curvature and to details shown on the Drawings.
16. If a float finish is required on the Drawings, plaster or hand-applied shotcrete may be used to build up and level the surface and to obtain the desired surface finish and projections.
17. The finish coat mix (if a smooth float finish is required on the Drawings), shall consist of a minimum of one sack of cement for each 3-1/2 cubic feet of moist plaster sand.
18. The Tank Contractor shall be responsible for all damages caused by shotcreting operations and shall bare the cost for making repairs.

D. Hand Placed Shotcrete for Repairs Only:
    1. To ensure a high quality shotcrete, the Tank Contractor shall satisfy the Engineer that the nozzleman has had sufficient and acceptable experience in the application of structural shotcrete and is a certified nozzleman in accordance with ACI 506.
    2. Experience gained on shotcrete pool and ditch construction will not be considered as experience for qualifying the nozzleman.
    3. The nozzleman shall be capable of applying thin coats of even and uniform thickness.
    4. The nozzleman's skill shall be tested and the results of such tests shall be acceptable to the Engineer before that nozzleman may start any work.

E. Restrictions on Shotcrete Operation:
    1. Shotcrete shall not be applied under such strong wind conditions that a considerable amount of cement and moisture will be removed by the wind from the mortar spray between the nozzle and the surface on which the shotcrete is applied.
    2. Shotcrete may be applied in cold weather provided the surfaces are not frozen.
    3. The temperature during the day must be expected to rise to at least 40 degrees Fahrenheit and the night temperature of the first night after the

shotcrete application must not be expected to drop below 27 degrees Fahrenheit.

4. The use of Type 3 Portland cement is required (when readily available) in the event shotcrete is applied at temperatures below 40 degrees Fahrenheit.
5. The Tank Contractor may apply shotcrete under the conditions specified herein solely at his own risk.
6. Whenever rain or frost has damaged shotcrete which has not had a chance to set up, such shotcrete must be removed and replaced.
7. The Tank Contractor shall consult with the Engineer to determine whether or not he will accept the shotcrete damaged by rain or frost before applying any new layers of shotcrete.

F. Shotcrete Curing:
   1. Intermediate layers of shotcrete shall be kept damp by hand curing or other means no sooner than 12 hours after the shotcrete has been applied.
   2. Watercuring is not required should additional shotcrete be applied on the entire wall surface within the following 12 hours.
   3. Indiscriminate use of continuous watercure for intermediate layers should be avoided.
   4. Complete shotcrete surfaces, which do not receive any additional shotcrete coatings, shall be membrane cured with plastic for a period of at least 7 days. Plastic membrane used shall contain and prevent loss of moisture from shotcrete as much as possible. Membrane curing methods utilizing curing compounds or wax-based residuals will not be permitted.

3.09 CLEANING

A. After construction is completed, the interior of the tank shall be completely cleaned of debris and flushed with clean water to remove all dirt and loose material.

3.10 FILLING AND WATERTIGHTNESS TESTING

A. Filling:
   1. The water used for the first filling of the tank will be furnished by the Owner. If the leakage test fails, the Tank (Sub)Contractor shall repair the tank, refill the tank and retest it. The Tank (Sub)Contractor shall be responsible for the cost of refilling the tank for subsequent tests.
   2. The tank shall be filled in approximately 8-foot increments with 8 working hours between each increment for observation of possible leaks through ring drains, wall, and wall-footing connection.

B. Testing:
   1. If only damp spots are observed during filling, the filling of tank can continue. If leaks are large enough to potentially pool water and/or fail the leakage test specified in Section 01759 - Water Leakage Test for Concrete Structures are observed, the filling process shall cease, and those leaks shall be thoroughly investigated and possibly repaired prior to continuing to fill the tank.
   2. Fill tank with water and hold water level at 3 inches below the overflow level for a period of 24 hours.
   3. Test tank for leakage in accordance with the provisions of Section 01759 - Water Leakage Test for Concrete Structures.

4. Examine the tank and soil at the perimeter of the tank footings for evidence of leaks.
    a. Acceptance criteria shall be as specified in Section 01759 - Water Leakage Test for Concrete Structures.

C. Repairing tank leaks:
    1. Repair leaks to satisfaction of the Engineer.
    2. Any areas that, in opinion of the Engineer, are exposed to contamination during repair work shall be sprayed with disinfection water mix.
    3. Leakage through joints, which may have resulted from bent over waterstops or honeycomb under or around waterstops, may require removal of concrete around waterstops in suspected areas.
    4. Repair of chipped out concrete areas:
        a. Coat chipped out concrete surface with epoxy bonding agent.
        b. Properly drypack with drypack mix for repair of concrete tank areas.
    5. Any cracks, voids, honeycomb, or cold joints showing or causing running leaks of water, shall be repaired by epoxy injection as specified in Section 03931 - Epoxy Injection System until such cracks and voids have been completely sealed.

D. Disinfecting:
    1. Follow disinfection protocol as outlined in section 01757 - Disinfection

END OF SECTION

SECTION 13208

POLYETHYLENE TANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Type 1 and Type 2 polyethylene storage tanks. Type 1 tank shall be made from crosslinked polyethylene resin and Type 2 shall be made from linear (non-crosslinked) polyethylene resin.

1.02 REFERENCES

A. American Society for Mechanical Engineers (ASME):
   1. B16.4 - Gray Iron Threaded Fittings.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. ASTM International (ASTM):
   1. D638 - Standard Test Method for Tensile Properties of Plastics.
   2. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   3. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
   4. D1525 - Standard Test Method for Vicat Softening Temperature of Plastics.
   5. D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
   6. D1998 - Standard Specification for Polyethylene Upright Storage Tanks.
   7. D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.

C. National Fire Protection Association (NFPA):
   1. 30 - Flammable and Combustible Liquid Code.

D. National Electrical Manufacturer's Association (NEMA).

E. Occupational Safety and Health Administration (OSHA):
   1. 29 CRF Part 1910 - Occupational Safety and Health Standards.

1.03 SUBMITTALS

A. Fabrication drawings for each tank including:
   1. Dimensions.
   2. Tank wall thickness.
   3. Materials of construction.
   4. Tank fittings.
   5. Tank appurtenances.
   6. Tank restraint system.

7. Tank resin and hoop stress data.

B. Chemical compatibility sheet to include:
   1. Chemical to be stored.
   2. Percentage of chemical.
   3. Temperature of chemical.

C. Engineering design calculations of restraint and anchoring system signed by a structural engineer registered in the state where the project is located.

D. Installation instructions.

E. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

F. Certification to certify that each tank is suitable for the specified chemical service, no degradation within warranty period, including tank fittings and gasket material.

G. Proof of qualification: Provide lists of installation and contact information with same type of application and chemical used.

H. Color charts for proposed coating systems.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds

B. Special Warranty
   1. Provide an additional 4 years full warranty issued in the name of the owner. Prorated warranties are not acceptable.

1.05 QUALITY ASSURANCE

A. Qualification of manufacturer: Manufacturer with experienced personnel, physical facilities, and management capacity sufficient to produce custom-made rotationally molded polyethylene tanks of the size, exposure, and chemical services specified for minimum 5 years with satisfactory performance record.

PART 2 PRODUCTS

2.01 SCOPE OF SUPPLIES

A. Provide all materials, labor, equipment, and hardware to provide all polyethylene storage tanks with specified fittings and accessories, seismic and wind load restraint systems, anchor bolts, and flange flexible connectors for complete installation in the positions and orientations indicated on the Drawings.

2.02 MANUFACTURERS

A. One of the following or equal:
   1. Poly Processing Co.
   2. Snyder Industries, Inc.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Tanks: As scheduled.

B. Tank wall thickness: Calculated in accordance with ASTM D1998 using design specific gravity as scheduled. Note that design specific gravity may be higher than specific gravity of tank contents.

C. Design requirements:
   1. The minimum required wall thickness of the cylindrical shell at any fluid level shall be determined by the following equation, but shall not be less than 0.187 inches thick:

      T = P x O.D./2 SD = 0.433 x S.G. x H x O.D./2 SD
      T = wall thickness, in.
      SD = hydrostatic design stress, psi
      P = pressure (.433 x S.G. x H), psi
      H = fluid head, ft.
      S.G. = specific gravity, g/cm^3
      O.D. = outside diameter, in.

D. The hydrostatic design stress shall be determined by multiplying the hydrostatic design basis, determined by ASTM D2837 using rotationally molded samples, with a service factor selected for the application.
   1. The hydrostatic design stress is 600 pounds per square inch at 73 degrees Fahrenheit for Type I and Type II materials.
   2. The tank shall have a stratiform (tapered wall thickness) wall.

E. The hydrostatic design stress shall be derated for service above 100 degrees Fahrenheit and for mechanical loading of the tank.

F. The minimum design specific gravity shall be as Scheduled.

G. The minimum required wall thickness for the cylinder straight shell must be sufficient to support its own weight in an upright position without any external support.
   1. Flat areas shall be provided to allow locating large fittings on the cylinder straight shell.

H. The top head must be integrally molded with the cylinder shell.
   1. The minimum thickness of the top head shall be equal to the top of the straight wall.
   2. The top head of tanks with 2,000 or more gallons of capacity shall be designed to provide a minimum of 1,300 square inches of flat area for fitting locations.

I. Tanks with 2,000 or more gallons of capacity shall have a minimum of 3 lifting lugs integrally molded into the top head.
   1. The lifting lugs shall be designed to allow erection of an empty tank.

J. Tank shell thickness:
   1. In accordance with ASTM D1998, Section 6.1.
   2. Design tank wall thickness for liquid with specific gravity as specified.
   3. Provide adequate thickness at all fittings and connection points for mounting of fittings to the tank without damage to the tank or causing excessive deflection.
   4. Maximum allowable hoop stress used in tank wall thickness calculations per ASTM D1998 shall be based on test data in accordance with ASTM D2837.

K. Seismic load restraint system:
   1. Seismic design criteria: Design tank restraint system for seismic design criteria as specified in Section 01850 - Design Criteria.
   2. Consist of stainless steel angles or brackets equally spaced around the tank perimeter anchored into the concrete tie down cable.
   3. If the restraint system includes the use of tensioning and adjustment devices, such as turnbuckles, provide easy adjustment of the cables at the time of construction and as required in the future.
      a. Hardware shall be provided to attach cables to anchored brackets at the base of the tank.
   4. The tank shall be designed to provide a minimum of 4 tie-down lugs integrally molded into the top head.
      a. The tie-down lugs shall be designed to allow tank retention in seismic loading situations without tank damage.
      b. Anchor bolts shall be provided by the Contractor per the instructions and the base plates for the system.

2.04 TANK MATERIALS

A. Type 1 high-density crosslinked polyethylene (XLPE) or Type 2 high-density linear polyethylene (HDLPE).

B. Resin:
   1. Manufacturers: One of the following or equal:
      a. PAXON, grade 7204 resin for crosslinkable polyethylene.
      b. Exxon, 8660-8661 or SURPASS RMs245-U (UG) Octene Copolymer HDPE Rotational Modeling Resin for linear polyethylene.

C. The material used shall be virgin polyethylene resin as compounded and certified by the manufacturer.
   1. Type 1 tanks shall be made from crosslinked polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.
   2. Type II tanks shall be made from high-density linear polyethylene resin as manufactured by ExxonMobil Chemical, or resin of equal physical and chemical properties.
   3. Resin choice would be based on the specific application, chemical to be stored and concentration.

D. Ultraviolet stabilizer:
   1. The polyethylene resin material shall contain a minimum of a UV 8 stabilizer as compounded by the resin manufacturer.
   2. Pigments may be added but shall not exceed 0.25 percent (dry blended) of the total weight.

E. Free of holes, blisters, crazing, cracking, delamination, undispersed raw materials, and any sign of contamination from foreign matter.
   1. The finished tank wall shall be free of visual defects such as foreign inclusions, air bubbles, pinholes, pimples, crazing, cracking, and delaminations.
   2. All cut edges where openings are cut into the tanks shall be trimmed smooth.

F. Resin shall meet or exceed the following properties:
   1. Mechanical Properties of Type 1 of Tank Material: Current XLPE Resin:

Property	ASTM	Value
Density (Resin)	D1505	0.938-0.946 g/cc
Tensile (Yield Stress 2"/min)	D638	3,000 psi
Elongation at Break (2"/min.}	D638	>300%
ESCR (100% Igepal, Cond. A, F50)	D1693	>1000 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	>1000 hours
Vicat Softening Temperature,	D1525	250
Flexural Modulus	D790	100,000 psi

   2. Mechanical Properties of Type II tank material: Current HDLPE Resin:

Property	ASTM	Value
Density (Resin)	D1505	0.942-0.948 g/cc
Tensile (Yield Stress 2"/min)	D638	2,950 psi
Elongation at Break (2"/min.)	D638	>1,000%
ESCR (100% Igepal, Cond. A, F50)	D1693	550 hours
ESCR (10% Igepal, Cond. A, F50)	D1693	48 hours
Vicat Softening Temperature	D1525	235
Flexural Modulus	D790	129,000 psi

G. Gel test: This test does not apply to Type II linear resins.
   1. Inner portion of tank wall:
      a. Not less than 65 percent.
      b. ASTM D1998 requirements.
   2. Entire wall thickness: Not less than 80 percent.

H. Restraint system:
   1. Metal components, including anchor bolts:
      a. Type stainless steel.
      b. The Anchor bolts shall be supplied by the tank manufacturer.
      c. The drawings and calculations for the seismic system shall be submitted for review.
   2. Concrete anchors or flush shells shall not be used.

2.05 FITTINGS

A. Terminate in socket, threaded, or flanged connections:
   1. Flanges: 150 pound ASME B 16.5.
   2. Double flanged CPVC bolted fittings with encapsulated stainless steel or Hastelloy bolts.
   3. Threaded connections: ASME B 16.4.

B. Fittings at upper tank sidewall or top:
   1. Compression threaded type, long shank, polyvinyl chloride flanged fittings with deep cut threads (not injection molded thread) and with dual wide nuts.
   2. The bulkhead fittings shall be constructed of PVC, PP, or other specified material.
   3. Gaskets shall be a minimum of 1/4 inch thickness and constructed of 40-50 durometer EPDM, 60-70 durometer Viton™ or other specified material.

C. Fittings on tank top:
   1. Fittings shall be vertical.
   2. The top head shall be integrally molded with the cylinder shell.
   3. The minimum thickness of the top head shall be equal to the top of the straight wall.
   4. The top head of tanks with 2,000 or more gallons of capacity shall be designed to provide a minimum of 1,300 square inches of flat area for fitting locations.

D. Flanged outlet drain fitting in the lower tank sidewall: Integrally molded flanged outlet must be an integral part of the tank and of the same material as the tank. Metal and alloy inserts shall not be used.

E. Fittings and appurtenances for each tank as Scheduled.

2.06 ACCESSORIES

A. Ladder and platform:
   1. Provide a fiberglass reinforced plastic ladder and landing platform for each storage tank for access to the top manway. Provide a minimum of 2 safety harness tie-off points at each tank with 2,000 or more gallons of capacity.
   2. In accordance with OSHA standards.
   3. Fasteners: Type 304 stainless steel.

4. Anchor bolts: Type 304 stainless steel.
5. Secure ladder to the tank using encapsulated stainless steel or Hastelloy bolts.
6. Support ladder directly on the concrete foundation and from the tank wall.

B. Level gauge:
1. Provide each tank with 2,000 or more gallons of capacity with:
   a. Clear polyvinyl chloride sight tube.
2. Materials: Suitable for the specified chemical service for the individual tanks.
3. Tank level staff gauge:
   a. Resistant to abrasion and corrosion.
   b. Mounted on the tank adjacent to the indicator.
   c. Calibrated in nominal 500 gallon increments.

C. Tank vents:
1. Each tank shall be properly vented for the type of material and flow rates expected.
2. Vents must comply with OSHA Part 1910 normal venting for atmospheric tanks or other accepted standard, or shall be as large as the filling or withdrawal connection, whichever is larger but in no case less than 2 inches nominal inside diameter with screening.

D. Provide flanged flexible connectors for each of the following fittings:
1. The flanged outlet nozzle on each tank.
   a. Wetted materials shall be selected by the tank manufacturer or vendor for the chemical service.
   b. Provide all mounting hardware and supports.
   c. Manufacturers: One of the following or equal:
      1) Red Valve, Redflex expansion joints with 3 arches.
      2) Flexijoint Expansion joint.

2.07 TANK FABRICATION

A. Rotationally molded construction in accordance with ASTM D1998.

B. Provide for each tank the following shop finishing:
1. Shipping label identifying:
   a. Tank tag number.
   b. Chemical service.
2. Color: Selected by the Engineer.
3. Permanent labels:
   a. Identification label.
   b. NFPA label specifically coded for the tank contents in accordance with NFPA 30.
   c. Paint or affix label onto the tank wall to be clearly visible from outside the tank enclosure.

2.08 TESTING

A. Each tank shall be leak tested by the manufacturer prior to shipment by filling with clean water for a period of at least 4 hours with all fittings installed and blinded.
1. There shall be no measurable drop in liquid surface.

2. Any leaks shall be noted and repaired and the tank shall be re-tested for an additional 4 hours minimum.
    a. Reason for leak and method of repair shall be recorded and submitted to the Engineer.
3. Any defects or leaks that have not been adequately repaired will be cause for rejection of the tank.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Transportation, handling, storage of the tanks, and installation shall be in accordance with the manufacturer's printed instructions.
2. Repair any damage to tank components or the insulation due to transportation or installation.
3. Install piping to tank with sufficient flexibility to allow tank movement of 1 inch in any direction without damage to piping.

B. All tank fitting attachments shall be equipped with flexible couplers or other movement provisions provided by the tank customer.
1. The tank will deflect based upon tank loading, chemical temperature and storage time duration.
2. Tank piping flexible couplers shall be designed to allow 4 percent design movement.
3. Movement shall be considered to occur both outward in tank radius and downward in fitting elevation from the neutral tank fitting placement.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's field service:
1. Inspect the installed tanks for proper installation.
2. Instruct Owner's personnel on operations and maintenance of the tanks.

3.03 OWNER TRAINING

A. Owner Training:
1. Perform Owner training as specified in Section 01756 - Commissioning.
    a. Training topics should focus on maintenance
2. Number of sessions:
    a. Operations and Maintenance: 1.

3.04 SCHEDULE

A. As specified in Attachment A - Tank Schedule.

END OF SECTION

ATTACHMENT A - TANK SCHEDULE

TANK SCHEDULE

Tag Number	TNK-7101, TNK-7102	TNK-7105	TNK-6211
Service	Cationic Polymer (PEC)	Cationic Polymer (PEC)	Aluminum chlorohydrate (ACH)
Chemical pH	5.0 - 8.0	5.0 - 8.0	3.0 - 5.0
Chemical Specific Gravity	1.05	1.05	1.39
Tank Design Specific Gravity	1.5	1.5	1.5
Number of Tanks	2	1	1
Usable Capacity, each	4,600 gal	550 gal	900 gal
Type of Tank	Cross-Link Polyethylene	Cross-Link Polyethylene	Cross-Link Polyethylene
General Design	Flat bottom, dished top	Flat bottom, dished top	Flat bottom, dished top
Installation	Vertical	Vertical	Vertical
Diameter (feet)	10	4	5.5
Height (feet)	10 (max)	7 (max)	7 (max)
Inlet Nozzle Size (inches)	3	3	3
Outlet Nozzle Size (inches)	3	2	2
Drain Nozzle Size (inches)	3	2	2
Overflow Nozzle Size (inches)	4	4	3
Vent Nozzle Size (inches)	6	4	4
Roof Nozzle Size (inches)	6-inch nozzle for mounting ultrasonic level sensor	6-inch nozzle for mounting ultrasonic level sensor	6-inch nozzle for mounting ultrasonic level sensor
Bottom Manway (inches)	NA	NA	NA
Top Manway (inches)	24	17	17
Ladder	Required	Required	Required
Lifting Lugs	Required	Required	Required

Tag Number	TNK-7101, TNK-7102	TNK-7105	TNK-6211
Level Indicator	Required	Required	Required
Pipe and Conduit Supports	Required	Required	Required

SECTION 13224

FILTER UNDERDRAIN SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Existing filter underdrain system:
      a. Filters 1-6: Remove and dispose existing filter media and underdrain system (gravel, precast slab panels, grout between the panels, grout between the panels and the walls, concrete support piers, and plastic nozzles), and prepare the existing filter basins for the new underdrain system as indicated on the Drawings and required by underdrain supplier.
      b. Filters 7-16: Remove and dispose existing filter media and existing plastic nozzles, and prepare the existing filter basins for the new underdrain nozzle system as indicated on the Drawings. Protect the existing underdrain concrete slab.
   2. New filter underdrain system:
      a. Filters 1-6:
         1) Furnish and install the new nozzle filter underdrain system, as specified and indicated on the Drawings.
         2) The new underdrain system shall include all items and materials within the filter cell to collect filtered water, uniformly distribute backwash air and water, retain the filter media, and to retain, support, and seal the filter underdrain system to make it complete and operable.
         3) The bottom of the underdrain GRC panel forms shall be 10 inches above the filter slab to match the existing heigh of the filter plenum.
      b. Filters 7-16:
         1) Furnish and install new replacement nozzles, as specified and indicated on the Drawings.

1.02 REFERENCES

A. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Structural design of new underdrain system for Filters 1-6, including connection to existing filter box exterior walls and gullet walls.

1.04 SUBMITTALS

A. Shop drawings:
   1. Submit complete and explicit details of the design, construction, and operating characteristics of the filter underdrain system prior to commencing any work on the system as specified in Section 01330 - Submittal Procedures. Submittal data shall include:
      a. Complete structural design calculations showing conformity with all specification requirements signed and stamped by a Structural Engineer or Civil Engineer registered in the State of Utah.
      b. Materials of construction.
      c. Installation details and leveling requirements.
      d. Mathematical proof or test data to demonstrate maximum percentage of flow maldistribution within a filter cell for water backwash, air scour only, and combined air/water backwash.
         1) Domain of model shall include backwash water inlet pipe and filter effluent box, lower gullet, gullet wall openings, air scour entrance, underdrain nozzles including tailpipes, and underdrain plenum.
         2) Diagrams shall be prepared illustrating circulation, flow and fluid velocity distribution patterns (in color) throughout the basins with a report summarizing approach and results from the modeling effort.
      e. Certification of compatibility of the underdrain system with the filter media specified in Section 13226 - Filter Media.
      f. Submit full and complete hydraulic test results and design calculations showing conformity with all flow design requirements to the Engineer for review and acceptance.
         1) Separate tests and design calculations shall be based on the filter cell design employed for this project.
         2) Include the full range of flow conditions specified, and indicate pertinent physical relationships between the metering orifices, cross-sectional flow areas for water transport to the flow metering elements, relative magnitudes of entrance, transport, metering, and discharge losses; and such other data as may be required by the Engineer.
         3) All test setups, procedures, and instrumentation shall be capable of providing data accuracy of plus or minus 2 percent.
      g. Recommended detailed concrete specifications for the concrete false floor slab by the underdrain system manufacturer (nozzle underdrain system only).
      h. 2 sample(s) of each component of the complete underdrain system intended for the project. Proper documentation showing NSF 61 certification of all underdrain components including sealing compound, caulks, and other materials.
      i. The manufacturer's proposed method of testing the installed underdrain flow distribution.
      j. All other data which in the judgement of the Engineer is necessary to demonstrate conformance with all specification requirements.

B. Delegated Design Submittals:
   1. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment.

2. Structural calculations for underdrain system for Filters 1-6, stamped by a Professional Engineer Licensed in the State of Utah.
    a. Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.

C. Field test reports: Submit to the Engineer 3 copies of full and complete test reports for all tests, describing the units tested; the type of test; test setups, procedures, and instrumentation; and test flow rates, pressures, levels, and all other data and results as required to demonstrate that all items tested meet specified requirements.

D. Operation and maintenance manuals:
    1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.05 PRODUCT HANDLING, STORAGE, AND DELIVERY

A. Place or store underdrains and specialties only in designated staging areas as indicated on the Drawings and approved by the Engineer.

B. Store underdrains and specialties off the ground, under ultraviolet-resistant tarps from time of delivery on-site until final installation in the filters.

C. Replace underdrains and specialties damaged during storage and delivery.

D. Underdrains and specialties are subject to inspection at the Engineer’s request if visual evidence of damage is observed.

1.06 QUALITY ASSURANCE

A. Certifications:
    1. Provide a manufacturer's certificate of proper installation that states the underdrain system has been installed in accordance with the manufacturer's requirements and has been supervised by an authorized representative of the manufacturer and that all of the specified testing has been conducted to insure proper performance.
    2. Provide a Certificate of Compliance with each shop drawing submittal, as specified in Section 01330 - Submittal Procedures, certifying that the item covered is in compliance with the Contract Documents and identification of all deviations from the Contract Documents.

B. Nozzle underdrain system: Polyvinyl chloride support column forms, glass reinforced concrete (GRC) false floor forms, nozzle inserts, nozzles, and any specialties required for installation such as special anchorage, leveling shims, temporary sealing caps, pressure relief system, access manway, etc., shall be the products of a single supplier.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nozzle Underdrain System:
   1. The following or equal:
      a. Orthos Liquid Systems, Inc.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General:
   1. Design the filter underdrain system to ensure long-term stability in its operating characteristics.
   2. It shall be resistant to changes in head loss, flow uniformity, corrosion, and any other effects which would in time cause loss of efficiency or effectiveness of its operation.
   3. Design the filter underdrain system to meet all requirements specified for delivery, storage, handling, installation, and operation.
   4. Underdrain system shall be compatible with existing air scour system, as shown in the Drawings, that delivers air into the lower gullet.

B. Flow design requirements:
   1. Design the filter underdrain system to produce uniform air and water flows throughout the filter cell over the full range of normal backwash flow rates.
   2. Flow uniformity per square foot of filter area shall be as required to permit efficient and effective filtration and backwashing.
   3. The installed filter underdrain system shall satisfy both of the following criteria for acceptable flow uniformity:
      a. Maldistribution of air and water flows during backwash, for specified flow conditions, shall not exceed:
         1) Plus or minus 10 percent of average standard cubic feet of air per minute per square foot of filter area.
         2) Plus or minus 5 percent of average gallons per minute per square foot of filter area.
      b. Visual tests shall reveal no evidence of maldistribution or disturbance of filter media.
   4. In addition to the uniformity requirements specified above, the maximum headloss for the nozzle system for the backwash water from the filter basin floor to the top of the underdrain system shall not exceed 30 inches of water when backwashing at 21 gallons per minute per square foot of filter area.
   5. The filter underdrain systems shall be furnished and installed to perform satisfactorily and as specified when operated under the following flow conditions:
      a. Downflow of filtered water at 3-10 gallons per minute/square foot (gpm/sf).
      b. Upflow of backwash air at 3 to 4 standard cubic feet per minute per minute/square foot average (scfm/sf).
      c. Upflow of backwash water at 4 to 21 gpm/sf.
      d. Upflow of combined backwash air at 4 scfm/sf and water at 9gpm/sf.

C. Structural design requirements:
   1. The filter underdrain system, including the concrete false floor and related appurtenances, anchorage, and supports, shall be designed to safely withstand the specified loadings. This includes connection to existing filter box exterior walls and gullet walls
   2. The nozzle underdrain system, when installed, shall be designed for the greater of an uplift force of 1,600 pounds per square foot or 200 percent of the maximum internal plenum pressure at maximum possible backwash rate.
   3. Headloss through the filter media shall be included in the calculation of the maximum pressure.
   4. There shall be no leakage from the seals, joints, or gaskets at the design pressure at maximum backwash rates.
   5. The filter underdrain system shall be designed to withstand a net downward loading of not less than 1,400 pounds per square foot to account for the weight of the media, and the in-service hydraulic loading, plus its own dead weight and the force of vertical seismic accelerations as specified in Section 01850 - Design Criteria.
   6. Adequate safety factors to account for dynamic loading (such as during the initiation and termination of backwash) and seismic loads as specified in Section 01850 - Design Criteria shall be included in the design to account for any dynamic loading above and beyond that described above.
   7. The design shall adequately provide for all loads incurred during shipment, handling, and installation.

D. Performance requirements: Furnish such installation details and recommendations as are necessary to acceptably interface the filter underdrain system with all surrounding structures, including requirements for leveling, grouting keys and pockets, dowels, support ledges and piers, and anchorage.

2.03 MATERIALS

A. General:
   1. Materials used in the filter underdrain system shall conform to specified requirements unless more stringent requirements are specified by the underdrain supplier.
   2. All materials shall, at the time of shop drawing submittal, have received NSF 61 certification.

B. Grout:
   1. Nonshrink grout conforming to the applicable requirements as specified in Section 03600 - Grouting.
   2. All grout associated with the installation of the underdrains shall be nonshrink grout.
   3. Underdrain manufacturer shall certify compatibility between the underdrain material and the nonshrink grout.

C. Structural concrete: As specified in Section 03300 - Cast-in-Place Concrete, except that coarse aggregate shall not be larger than 1/2-inch maximum diameter in slabs 3 inches in depth or less, and shall not be larger than 3/4-inch maximum diameter in slabs greater than 3 inches in depth.

D. Concrete reinforcement: As specified in Section 03200 - Concrete Reinforcing.

E. Metals:
   1. As specified in Section 05500 - Metal Fabrications.
   2. All exposed (not embedded in concrete) or partially exposed metals, including but not limited to anchor bolts and anchorage, fasteners, washers, etc., shall be Type 316 stainless steel.

F. Grout stops, cover plates, and concrete retaining strips shall be high-impact plastic, or polyvinyl chloride, properly keyed or mechanically restrained to prevent the strips from working loose with time.
   1. They shall also be completely sealed with caulking to prevent water, air, or grout from leaking around them.
   2. Plastics shall be high-strength, completely inert, resistant to erosion, corrosion, and degradation from chlorine up to 150 milligrams per liter, and suitable for use with backwash temperatures from 34 to 150 degrees Fahrenheit.

2.04 NOZZLE UNDERDRAIN SYSTEM (FILTERS 1-6)

A. Support system:
   1. The false floor shall be made up of reinforced concrete cast in place over prefabricated glass reinforced concrete (GRC) false floor forms.
      a. The forms remain in place as the underside of the floor slab and provide preformed holes for locating and supporting the cast-in-place flow element inserts.
      b. The false floor forms shall be installed onto PVC support columns inside the filter cell, and onto ledges along the perimeter walls of the filter cell.
   2. The ledges and columns shall be carefully leveled to within plus or minus 1/8 inch before installing the false floor forms.
      a. The level tolerance of the ledges and columns shall be checked by a laser to ensure compliance with the Specifications.
   3. The support system shall adequately provide for both longitudinal and transverse flow under the false floor to ensure uniformity of flow distribution.
      a. The false floor and support columns shall be designed to the criteria specified under Structural Design Requirements.

B. False floor forms:
   1. The forms shall be constructed of NSF 61 certified GRC.
   2. They shall have approximate plan dimensions of 2 feet by 2 feet.
   3. The false floor forms shall contain an array of plastic nozzle sleeves cast in the concrete, uniformly spaced at not more than 6-inch centers both ways, and designed to accept a nozzle sleeve which shall screw into place at each nozzle location
   4. The forms shall become a permanent part of the finished false floor.
   5. The forms shall be designed to carry stresses due to the placement of concrete and with minimal deflection under the load imposed by the concrete.
   6. The manufacturer shall provide filler forms, as indicated on the Drawings, to close the area along the perimeter walls where a full form cannot fit.
      a. The filler forms shall be cut to the appropriate size by the manufacturer prior to delivery.

C. Flow nozzles and inserts:
   1. The GRC forms shall accept a NSF 61 certified polypropylene nozzle insert which shall screw into place at each nozzle location.
      a. The nozzle insert shall contain a disposable seal which shall prevent concrete from passing through or fouling the threaded portion.
   2. Each media retaining underdrain nozzle shall be molded of NSF certified polypropylene.
      a. They shall screw into the nozzle insert adapters and shall have narrow, vertical slot openings suitably sized for compatibility with the filter media.
      b. The slots shall be designed to prevent clogging from small particles.
      c. The nozzles shall be designed to uniformly distribute washwater during the backwash cycle, and collect filtered water during the filtration cycle.
      d. The nozzles shall not require epoxy or metal fasteners for installation.
      e. All materials should be compatible with backwash water up to 150 mg/L of free residual chlorine without embrittlement.
   3. Nozzle:
      a. Designed to allow the direct placement of filter media (as specified) on top of the nozzle.
      b. Designed to withstand the same loadings as the monolithic pour.
      c. The nozzles shall provide for collection of water in the filter basin and provide for the uniform distribution of backwash water without permitting media to enter the plenum.
      d. Easily installed (screwed into) and removed from the top side of the underdrain.
      e. Tail piece:
         1) Designed to provide for the uniform distribution of air scour and backwash water.
         2) Provided by the manufacturer of the correct length of tailpipe as an integral part of the distributor nozzle.
         3) Each nozzle to have a hole in the tailpiece so placed to bleed off trapped air in the plenum.
   4. The manufacturer shall supply torque and other installation instructions and requirements to account for the variation in temperature from installation to service and other effects that may cause the nozzles to loosen in service.

2.05 REPLACEMENT NOZZLES (FILTERS 7-16)

A. General
   1. Shall be a direct replacement of the existing nozzles as manufactured by Orthos Liquid Systems, Inc., Model K1.0.35.3”PCI.X350.PP, without exception.
   2. Nozzles shall be NSF 61 certified.

B. Construction
   1. Nozzle shall be two parts: screen assembly and stem.
   2. Screen assembly shall screw into the upper thread section of the existing underdrain floor nozzle sleeves.
   3. Screen nozzle slots shall be suitably sized for compatibility with the filter media and designed to prevent clogging from small particles.
   4. Nozzle stems shall be one piece and screw into the lower thread section of the existing underdrain floor nozzle sleeves.

5. Nozzle stems shall have identically-sized and -located air holes and slots as the original stems to be replaced.
6. Nozzle components shall be easily installed from the top side of the underdrain.

PART 3 EXECUTION

3.01 PRE- INSTALLATION

A. General:
   1. At least 2 weeks prior to underdrain construction commencing, a 3-hour construction kickoff meeting shall be held at the project site.
      a. The kickoff meeting shall be facilitated by the Contractor, and attended by the underdrain manufacturer's technical representative, Contractor, Owner's Representative, and Owner.
      b. The meeting shall discuss project schedule and coordination activities, as well allow the manufacturer's technical representative to present installation instructions and lessons learned from other projects.
      c. The meeting shall be scheduled at a mutually agreeable time, with a minimum of 2 weeks' notice provided to all parties.
      d. All costs for the Contractor and underdrain manufacturer's technical representative to attend the meeting shall be the responsibility of the Contractor.
   2. Install the filter underdrain systems in strict accordance with the manufacturer's installation drawings and printed recommendations, and as manufactured and indicated on the Drawings.
      a. Obtain from the underdrain supplier such written installation details, recommendations, and training required to acceptably interface the filter underdrain system with all surrounding structures.
      b. The Contractor is cautioned that such installation details are not indicated on the Drawings, as they will vary according to the underdrain supplier's specific requirements.
   3. Sequence the installation of underdrains as specified in the Contract Documents.

3.02 EXISTING FILTER UNDERDRAIN REMOVAL

A. Filters 1-6:
   1. Remove and dispose of the existing filter media, precast concrete panels and related grout material, plastic nozzles, concrete support piers and anchor bars as indicated on the Drawings. Care shall be exercised so that no damage occurs to the remaining filter basin walls, floor, handrail, access ladders, level probes, or flume.
   2. Allow an inspection period of no less than 48 hours after the media has been removed and before demolition of the precast concrete panels.
      a. After the underdrain system has been removed, allow an inspection period of no less than 48 hours.
      b. Coordinate the inspection periods with the Engineer.
      c. Both inspection periods shall occur during working days only.

3. After removal of the underdrains and media, grind the filter floor and walls to a height of 18 inches above the floor to the original concrete providing an even surface for the new underdrain.
    a. The grinding shall remove all grout, laitance, loose coatings, and foreign material.
    b. The resultant surface shall be clean, sound, and (for the plastic block underdrain system only) intentionally roughened to a full amplitude of plus or minus 1/8 inch.
    c. All necessary repairs shall be made by the Contractor after grinding is complete.
    d. The filter, including the filter flume and related backwash piping, shall be thoroughly cleaned; all grinding material and debris shall be vacuumed out of the filter before any filter underdrain installation can begin.
    e. The filters shall be kept clean during installation of the filter underdrain.
    f. Precautions shall be taken to prevent any foreign material from entering the filter flumes.
4. Before the new underdrains are installed, clean the flume of any debris.
    a. Do not allow the debris to enter the plant drain system.
    b. After the debris has been separated and removed, the water from the flume cleaning operations may then pass to the plant drain system.
    c. Control the drainage flow so that the plant drain system is not flooded.

B. Filters 7-16:
1. Remove and dispose of the existing filter media and plastic nozzles as indicated on the Drawings. Care shall be exercised so that no damage occurs to the remaining filter basin walls, floor, handrail, access ladders, level probes, or flume.

3.03 INSTALLATION

A. General:
1. Install the filter underdrain systems in strict accordance with the manufacturer’s installation drawings and printed recommendations, and as manufactured and indicated on the Drawings.
    a. Obtain from the underdrain supplier such written installation details, recommendations, and training required to acceptably interface the filter underdrain system with all surrounding structures.
    b. The Contractor is cautioned that such installation details are not indicated on the Drawings, as they will vary according to the underdrain supplier's specific requirements.

B. Physical requirements:
1. There are 16 filters:
    a. Each filter comprises of 2 filter cells.
    b. Each filter cell is of nominal internal dimensions 64 feet long by 11 feet wide.

C. Cleaning and placement:
1. Take all necessary precautions recommended by the underdrain manufacturer’s published instructions and as specified to ensure the underdrain system and piping is completely clean and free of any debris, dirt,

or other foreign materials which could clog the underdrain system or interfere with flow.
    a. Backwash water piping shall be thoroughly flushed clean.
    b. All loose debris and dirt within the filter cell and flume shall be removed by sweeping and vacuuming.
    c. Care shall be taken during installation to prevent grout from extruding into any of the flow passages or ports or into the underdrain system itself. Any evidence of grout intrusion witnessed during installation shall require that the affected section be removed and replaced.
2. As installation progresses, underdrain sections partially completed shall be protected with heavy building paper, masking tape, or other acceptable means to maintain cleanliness and protect the underdrain. Any damage or debris shall be promptly remedied.
3. Cleanliness shall be maintained through final placement of filter media.

D. Nozzle underdrain system installation (Filters 1-6):
1. The reinforced concrete false floor underdrain system shall be a monolithic, cast-in-place, concrete structural slab that shall be finished to a true level plane within the lesser of plus or minus 1/8 inch or the tolerance specified by the manufacturer of the filter underdrain.
    a. Prepare the false floor support ledges and piers as necessary to enable installation within the required level tolerance.
    b. Reinforcing steel shall be placed to accurately fit in place without bending of the reinforcing bars in the field.
    c. Flood the underdrain with water to ascertain that the level tolerance is met.
    d. Failure of the filter underdrain system to meet the level tolerance shall require removal of the failed sections and replacement with new underdrain sections to within level tolerances.
2. Should any underdrain materials including the false floor forms, nozzle inserts, and nozzles become chipped, plugged, bent, or damaged in any way they shall be removed and replaced before the false floor is poured.

E. Replacement nozzle installation (Filters 7-16):
1. Install replacement nozzles per manufacturer’s instructions.
2. Nozzle stems shall be installed to a true level plane within plus or minus 1/16 inch.

3.04 FIELD QUALITY CONTROL

A. Tests:
1. Conduct all specified testing and provide all material, instrumentation, personnel, etc., for the tests specified. The Engineer shall be given sufficient advance notice of the testing to enable the Engineer to witness the tests.
2. A manufacturer's representative shall inspect and supervise the filter underdrain testing.
3. All test set-ups, procedures, and instrumentation shall be designed by the underdrain manufacturer as required to provide data accuracy of plus or minus 2 percent.
4. Perform each test on every filter unless otherwise noted.

5. All testing shall be coordinated with Owner and specific consideration shall be given to disposal/recycling of testing water.
6. Testing shall be repeated until criteria is achieved and approved by the Owner's Representative.

B. Preliminary structural integrity and flow distribution tests:
   1. Perform this test prior to the placement of any filter media or support gravel.
   2. After sufficient curing time, as defined by the underdrain manufacturer, has elapsed to permit the installation to develop adequate strength, test each filter underdrain system to verify underdrain integrity.
   3. Water backwash only testing:
      a. Flood filter cell with approximately one foot of clean water above the underdrain.
      b. Introduce backwash water slowly in the filter, increasing in stages as follows:
         1) 10 gallons per minute/square foot.
         2) 15 gallons per minute/square foot.
         3) 19 gallons per minute/square foot.
         4) 21 gallons per minute/square foot.
         5) Hold rate at each stage for sufficient visual observation.
      c. During this test, flow from each nozzle as well as any sign of dead spots or boils shall be visually observed. Any evidence of flow maldistribution such as a water mounds or boils in any area of the filter will constitute a failed test.
      d. After this initial test, the filter shall be drained and the underdrain system shall be inspected for any damage or leaks.
      e. Correct and retest underdrain systems that fail to meet the test criteria. Repeat test until all deficiencies are corrected.
      f. Follow underdrain manufacturer's specific instructions for repairing damage to the underdrain system caused by test procedure.
   4. Air testing:
      a. Flood filter cells with clean water to approximately 6 inches above the underdrain.
      b. Conduct air scour at a rate of 3.9 scfm/ft.
      c. During this test, air flow from each nozzle and any sign of dead spots shall be visually observed. Any evidence of unusual airflow and maldistribution will constitute a failed test.
      d. After this test, the filter shall be drained, and the underdrain system shall be inspected for any damage or leaks.
      e. Correct and retest underdrain system until all deficiencies are corrected.
      f. Follow underdrain manufacturer's specific instructions for repairing damage to underdrain system caused by test procedure.
   5. Air/Water testing:
      a. Flood filter cells with three feet of clean water above the underdrain.
      b. Initiate air scour rate of 3.9 scfm/ft.
      c. Introduce water backwash slowly increasing to a rate of 8 to 10 gpm/ft.

C. Underdrain flow distribution test:
   1. Perform this test prior to the placement of any filter media or support gravel.

2. The filter underdrain system in each filter shall be given a flow distribution test to verify that both air and water flow from the installed system is distributed uniformly in the filter basin.
3. The test shall be conducted using methods specified by the manufacturer and approved by the Engineer.
4. Flood filter cells with clean water approximately 6 inches above the underdrain at the beginning of each test. Sustain test flow rates for approximately 3 minutes while making visual observations.
5. Extend or repeat test when additional time is needed to make observations, as directed by the Engineer.
6. The test shall be as follows:

Test Number	Water, gallons per minute	Air, standard cubic feet per minute
1	0	4,200
2	0	5,300
3	2,400	4,200
4	8,500	4,900
5	12,400	0
6	26,750	0
7	29,600	0
During each test, the water surface shall present a uniformly turbulent appearance without dead spots or boils.		

D. Equal Distribution Test of Backwash Water (Manometer Test):
1. This test shall be completed on all 16 filters. However, corrections and retesting will only apply to any deficiencies in Filters 1-6.
2. The demonstration must be completed before the installation of media.
3. Since pressure is directly related to flow in a flooded filter, this test measures the pressure in the plenum during a backwash. To measure the pressure, the Contractor shall install 16 supplier-provided piezometric adapters in the false floor as indicated on the plans. Four adapters shall be placed near each corner of the filter and 3 across the centerline of the filter from the backwash entrance(s).
4. From the piezometric adapters on the nozzle sleeves, the Contractor shall route Supplier-provided transparent vinyl tubing of equal length from the installed piezometric adapters to a supplier -provided piezometer panel that contains a scale for each sample tube. Contractor to adjust the panel and the scales with the water level during backwashing and assist with measurements as directed by the Supplier.
5. The panel shall be installed in a place far from the troughs. Figure 3.24 of "Filter Troubleshooting and Design Handbook" by R.P. Beverly of the AWWA shall serve as a reference for performing this test.
6. Pressure readings representing the pressure drop of the underdrain are measured as the height of the water in each tube above the wash water level during a backwash. Using the highest and lowest values, the maldistribution can be calculated as follows:

$$Maldistribution\ (\%) = \left[1 - \sqrt{\frac{(P\ Highest)}{(P\ Lowest)}}\right] \times 100$$

7. Testing shall be performed at 21 gallons per minute/square foot of backwash water.
8. The test shall demonstrate equal distribution of the backwash water. A maldistribution variation of up to ± 5% between different measurement points is acceptable. If the variation is found to be greater than ± 5%, the Contractor must make all corrections required to meet the maximum prescribed variation. No work will be allowed in any subsequent filters until the problem is corrected.
9. After testing, the Contractor shall remove the piezometric taps and replace with approved nozzles. The Contractor shall also remove the vinyl tubing and manometer board and assist the Supplier for clean-up and storing of the piezometric equipment. The piezometric equipment provided by the SUPPLIER for the testing shall remain the property of the Supplier.
10. Correct and retest underdrain systems that fail to meet the test criteria.
11. Repeat test until all deficiencies are corrected.
12. Follow underdrain manufacturer's specific instructions for repairing damage to the underdrain system caused by test procedure.

E. Sand flow distribution tests:
   1. These tests shall be completed on all 16 filters. However, corrections and retesting will only apply to any deficiencies in Filters 1-6.
   2. After the underdrain system has been installed and has passed the underdrain flow distribution test, the filter sand media may be placed.
   3. Perform the sand flow distribution test after the media has been placed, washed, and skimmed, but before placement of anthracite filter media.
   4. Sand tests shall consist of at least 5 backwash cycles and shall be as follows:
      a. Flood filter cell approximately 6 inches above the sand media with clean water.
      b. Air backwash at 5,480 standard cubic feet of air per minute for 4 minutes (3.9 standard cubic feet of air per minute/square foot).
      c. Simultaneous air and water backwash at 5,480 standard cubic feet of air per minute and 8,500 gallons per minute for 4 minutes (3.9 standard cubic feet of air per minute/square foot and 6 gallons per minute/square foot, respectively).
      d. Water backwash at 26,750 gallons per minute for 4 minutes (19 gallons per minute/square foot).
      e. Drain down to initial level and repeat.
      f. At the conclusions of the 5 backwash cycles, inspect the sand surface.
   5. Results:
      a. Deviations more than plus or minus 1/4 inch from the average level plane indicates failure.
      b. Media boiling shall constitute a failed test.
      c. Media movement from one area of the filter to the other shall constitute a failed test.
   6. Correct and retest underdrain systems that fail to meet the test criteria.
   7. Repeat test until all deficiencies are corrected.

F. Final filter flow distribution tests: Follow underdrain manufacturer's specific instructions for repairing damage to the underdrain system caused by test procedure:
   1. These tests shall be completed on all 16 filters. However, corrections and retesting will only apply to any deficiencies in Filters 1-6.
   2. After the underdrain system has been installed and has passed the sand flow distribution tests, the filter anthracite media may be placed.
      a. After the media has been placed, washed, and skimmed, the final filter flow distribution test shall be performed.
      b. This test shall be conducted for each layer of media placed in each filter cell.
   3. The final flow distribution tests shall consist of at least 10 backwash cycles on each filter, and shall be as follows:
      a. Flood filter cell approximately 6 inches above the filter media with clean water.
      b. Air backwash at 5,480 standard cubic feet of air per minute for 4 minutes (3.9 standard cubic feet of air per minute/square foot).
      c. Stop all air scour flow and allow media to settle for approximately 1 to 2 minutes.
      d. Water backwash at 8,500 gallons per minute for 4 minutes (6 gallons per minute/square foot).
      e. Water backwash at a rate sufficient to achieve 25 percent expansion. Consult Engineer for flow rate.
      f. Water backwash at 8,500 gallons per minute for 4 minutes (6 gallons per minute/square foot).
      g. Slow the backwash flow gradually, so as to allow the media to restratify.
      h. Slowly drain the filter down to the initial level and repeat.
      i. At the conclusion of the 10 backwash cycles, inspect the filter media surface.
   4. Results: Deviations of more than 1/2 inch from the average level plane indicates failure.
   5. At 5 places per filter designated by the Engineer, determine the sand layer thickness by means of hydraulic testing.
      a. Insert a probe into the media while backwashing at 4 gallons per minute/square foot.
      b. The sand height shall be within plus or minus 1/4 inch from the average level plane.
   6. Correct and retest underdrain systems that fail to meet the test criteria.
   7. Repeat test until all deficiencies are corrected.
   8. Follow underdrain manufacturer's specific instructions for repairing damage to the underdrain system caused by test procedure.

3.05 MANUFACTURER'S FIELD SERVICES

A. Provide services of manufacturer's field representative to ensure proper installation, testing, and start-up of the filter underdrain. Minimum of eight trips and 20 days.

B. The manufacturer's representative shall have 5 years of experience in the installation of similar underdrain systems and provide a list of 10 facilities at which he has inspected the installation and testing of underdrain systems.

C. The filter underdrain system manufacturer's representative shall be present at the jobsite for whatever period is necessary to ensure proper installation. At a minimum, the manufacturer's representative shall be present during all underdrain installation operations and testing.

END OF SECTION

SECTION 13226

FILTER MEDIA

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Removal and disposal of the existing support gravel and filter media as indicated on the Drawings and as specified in this Section.
      a. Filters 1-6:
         1) Media consisting of approximately 20 inches of anthracite, 10 inches of silica sand, 6 inches of support gravel shall be removed from 6 filters.
      b. Filters 7-16:
         1) Media consisting of approximately 20 inches of anthracite, 10 inches of silica sand shall be removed from 10 filters.
      c. Each filter has an approximate area of 1408 square feet.
   2. Installation of new filter media in each of the filters indicated on the Drawings and as specified in this Section. Including:
      a. Anthracite: 42 inches
      b. Sand: 12 inches

B. Media Responsibility: The Media Supplier has sole responsibility for furnishing granular filter media meeting the requirements of the specification.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. B100 - Standard for Granular Filter Material.

B. ASTM International (ASTM):
   1. C33 - Standard Specification for Concrete Aggregates.
   2. C40 - Test Method for Organic Impurities in Fine Aggregates for Concrete.
   3. C117 - Test Method for Materials Finer Than 75-um (No. 200) Sieve in Mineral Aggregates by Washing.
   4. C123 - Standard Test Method for Lightweight Particles in Aggregate.
   5. C127 - Test Method for Specific Gravity and Absorption of Coarse Aggregate.
   6. C128 - Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate.
   7. C136 - Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   8. D409 - Standard Test Method for Grindability of Coal by the Hardgrove-Machine Method.
   9. C702 - Standard Practice for Reducing Samples of Aggregate to Testing Size.
   10. D75 - Practice for Sampling Aggregates.
   11. D388 - Standard Classification of Coal by Rank.
   12. D3174 - Standard Test Method for Ash in the Analysis Sample of Coal and Coke from Coal.

13. D3175 - Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke.
14. E11 - Standard Specification for Wire Cloth and Sieves for Testing Purposes.

C. Food Chemical Codex.

D. NSF International (NSF):
1. Standard 61 - Drinking Water System Components - Health Effects.
a. U.S. EPA Test Methods 200.7, 200.8, and 245.1 - Regulated Metals.
b. U.S. EPA Test Method 625 - Base Neutral Analysis (Semi-Volatile Organic Compound).
c. U.S. EPA Test Method 900.0 - Radionuclides.

1.03 DEFINITION

A. Determination of particle size distribution:
1. Determine particle size distribution by screening through standard sieves, Tyler square root of 2 series or equivalent U.S. series.
2. Determine percent sizes from a plot, on semilog or probability paper, of the percentages of the material passing each sieve against the rated opening of the sieve or the equivalent diameter of the grains. Sieve dimensions shall conform to ASTM E11 and Table B.1 of the Appendix to AWWA B100.
3. Define percent size as the size of the theoretical opening of a sieve through which that percentage of the filter media, by weight, will pass. For example, if the size distribution of the filter media particles is such that 10 percent of the sample is finer than 0.50 millimeters, the filter media shall be said to have a 10 percent size of 0.50 millimeters.
4. Define uniformity coefficient as the ratio of the 60 percent size to the 10 percent size of the filter media.

1.04 SUBMITTALS

A. All submittals shall be as specified in Section 01330 - Submittal Procedures.

B. Submit the following:
1. Sand quality information:
a. Sieve analysis (particle size distribution), effective size, and uniformity coefficient.
b. Acid solubility.
c. Specific gravity.
d. Hardness based on the Mohs scale.
e. Shape.
2. Anthracite quality information:
a. Sieve analysis (particle size distribution), effective size, and uniformity coefficient.
b. Acid solubility.
c. Specific gravity.
d. Hardness based on the Mohs scale.
e. Ash content in accordance with ASTM D3174.
f. Volatiles content in accordance with ASTM D3175.
g. Grindability Index in accordance with ASTM D409.

h. Shape.

3. Any other information as requested by the Engineer.

C. Submit qualifications of the independent testing laboratory for approval.
   1. Independent testing laboratory shall be accredited by the American Association for Laboratory Accreditation or be able to provide 25 references for similar projects using anthracite and sand filter media in drinking water or wastewater filtration applications

D. Media Submittal: For each type of media submit the following:
   1. Media Benchmark.
      a. Purpose: To establish the agreed upon benchmarks for the material that is to be manufactured.
      b. Schedule: Submittal approval is required prior to beginning manufacturing.
      c. Requirement:
         1) Certified test results of complete media analysis (1.04.B), from an approved independent testing lab employed by the Media Supplier, for the proposed media.
         2) Media Samples:
            a) Submit one sample of each type of media.
            b) Shipped in durable, non-glass containers of not less than 5-pound capacity, clearly labeled with Project name, media source, effective size, uniformity coefficient and specific gravity.
            c) Engineer reserves the right to retest (at Owner's expense) the samples to confirm that the samples reasonably match certified test results submitted.
   2. Manufactured Media Testing and Samples.
      a. Purpose: To demonstrate that media produced during the manufacturing process is reasonably similar to the approved benchmark submittal.
         1) It is anticipated that there may be a reasonable variation in the effective size and uniformity coefficient between different media lots produced during the manufacturing process for the Project.
         2) Although such variation may be acceptable, the Engineer reserves the right to use the test results to direct the Contractor to install individual production lots of sand and anthracite media in different filters to provide the best possible media compatibility matches at no additional cost to the Owner.
         3) Engineer may reject any or all individual media lots produced during the manufacturing process that do not meet the requirements of the specification. Rejected lots will not be shipped to the Project site without additional remanufacturing or reprocessing and subsequent approval of test results by the Engineer.
      b. Schedule:
         1) Media samples and test result approval is required prior to shipping.
         2) Separate submittals for individual production lots are required for large media quantities involving production runs over an extended duration. It is anticipated that individual lot test results will be submitted to the Engineer as soon as they are available during the production of media.

c. Requirement:
    1) Filter medias shall be sampled and tested for effective size and uniformity coefficient. The media producer may use in-house testing capabilities or an independent laboratory for the manufactured testing, but only after laboratory acceptance and approval by the Engineer.
    2) Sample collection and frequency for individual production lots shall be in accordance with AWWA B100. All test results shall be identified by traceable production lot identification.
    3) Manufactured Media Samples:
        a) Submit one sample of each production lot and type of media.
        b) Sample collection in accordance with AWWA B100.
        c) Shipped in durable, non-glass containers of not less than 5-pound capacity, clearly labeled with Project name, media source, effective size, uniformity coefficient and specific gravity.
        d) Engineer reserves the right to retest (at Owner's expense) the samples are to confirm that the samples reasonably match certified test results submitted.

3. Delivered Media Testing.
    a. Purpose: To demonstrate that media delivered to the Project site matches the manufactured media.
        1) The Engineer reserves the right to test the media received at the Project site at the Owner's expense.
        2) Media that does not comply with the specified requirements, certified test results, or acceptance criteria may be rejected at the sole discretion of the Engineer and shall be replaced with approved media at no additional cost to the Owner.
        3) If the delivered media is rejected by the Engineer, an independent laboratory, acceptable to the Engineer, may be employed by the Contractor to sample and test disputed material. For material that is not in compliance with the specified requirements, the Contractor shall bear the cost of testing the delivered media and any retesting required by the Engineer to demonstrate compliance. Otherwise, the Owner is responsible for costs of testing the delivered media.
    b. Schedule: After delivery to the Project site and before installation.
    c. Requirement:
        1) Sample collection in accordance with AWWA B100.
        2) Test results provided by an independent lab, acceptable to the Engineer.
4. Installed Media Testing.
    a. Purpose: To document the characteristics of the installed media in each filter for the use of the Owner in tracking changes in media characteristics over time and to assess the impacts of the backwash/skimming procedure. It is understood that the effective size and uniformity coefficient of the installed media, after washing and skimming, may differ from values prior to installation. Therefore, acceptance of media will be based upon the results of the delivered media testing, not installed media testing.

b. Schedule:
    1) Sand media shall be sampled after complete installation, washing and skimming of all sand layers to the required depth and prior to the installation of anthracite media.
    2) Anthracite media shall be sampled after complete installation, washing and skimming of all anthracite layers to the required depth.
c. Requirement:
    1) Collect media samples using a clean trowel or sampling tube to provide a representative sample from the entire media depth.
    2) Store samples in clean clear plastic bags, securely sealed and labeled with location, media type and collection date using indelible marker.
    3) Provide test results of effective size, uniformity coefficient and specific gravity for each sample.
    4) Sampling Locations:
        a) Collect one sample from each quarter quadrant and combine the four samples to make one composite sample per each filter cell.
        b) Sampling and testing is the responsibility of the Contractor using a laboratory approved by the Engineer.
            (1) Sand and anthracite mix in media samples shall be separated using a high density liquid separation process as called for in AWWA B100.

E. Submit media installation instructions from the Media Supplier.

1.05 QUALITY ASSURANCE

A. Perform certified material testing of new filter media by an Owner approved independent testing laboratory employed by the Contractor.

B. Certified test results shall cover all physical, gradation, size, and chemical characteristics specified in this Section. All tests shall be made in accordance with test procedures as described in AWWA B100 and AWWA B604.

C. After approval, all shipments shall meet the Specifications. Approved samples shall meet the requirements of AWWA B100 including any addenda and AWWA B604, including any addenda.

D. Perform field samples and testing in accordance with the requirements of AWWA B100 and AWWA B604.

E. The supplier of the filter media shall supervise the media installation in the first filter.

F. The sand media and anthracite media manufacturing plants are to provide documentation that their respective site-specific manufacturing facilities are independently certified to be in compliance with the NSF/ANSI 61 Standard.

1.06 PRODUCT HANDLING, STORAGE, AND DELIVERY

A. Packaging: Package filter media in ultraviolet-resistant polyethylene bags (super sacks with bottom pour spout) on pallets. Clearly mark each bag of material with the

following information: Effective size, uniformity coefficient, source, date of bagging, and the lot or stockpile identification.

B. Place or store all filter media only in designated staging areas indicated on the Drawings and approved by the Engineer.

C. Store all filter media at the jobsite off the ground, protected from weather, and covered with a suitable membrane to prevent contamination of the media from windblown debris and soil.

D. Conveying of the new filter media by compressed air through ducts, pipes, or hose is not to be permitted. Placement of filter media in the filters shall comply in all respects with AWWA B100 and AWWA B604, except as modified or supplemented in this Section.

PART 2 PRODUCTS

2.01 FILTER SAND

A. Quality:
   1. Filter sand:
      a. Silica sand composed of hard, durable, uncoated grains.
      b. Thoroughly wash, screen, and free of clay, loam, dust, dirt, organic matter, and other foreign material from filter sand.
   2. Acid solubility of the filter sand: Not to exceed 2.5 percent.
   3. Specific gravity of the filter sand: Not to be less than 2.50.
   4. Not more than 1 percent by weight of the filter sand shall be flat or micaceous particles.
      a. Define flat as a ratio of the longest axis to the shortest axis of the circumscribing rectangular prism for a particle of sand media that exceeds 5.

B. Size:
   1. The silica sand shall meet the following requirements:
      a. Effective size (millimeters): 0.65 (±0.05).
      b. Uniformity coefficient - less than 1.4 before and after skimming.
   2. The installed filter sand shall be in compliance with the Specifications when, after hydraulic classification in place by backwashing and removal of the finer material by skimming, the media meets the physical, gradation and size characteristics specified in this Section.

C. Excess media:
   1. Provide sufficient excess sand media to anticipate media settlement, compaction during installation, and skimming requirements.
   2. The final media depth after skimming, backwashing, and testing is complete shall be 12 inches, unless otherwise indicated on the Drawings.

2.02 FILTER ANTHRACITE

A. Quality:
   1. The anthracite:
      a. Composed of hard durable grains.
      b. Processed from anthracite coal.
      c. Free from any significant amounts of iron sulfides, clay, shale, dust, dirt, or other foreign matter.
   2. The solubility of the filter anthracite in a 1:1 mixture of concentrated hydrochloric acid (approximately 37 percent) shall be less than 2.5 percent. The solubility of the filter anthracite shall be less than 5 percent by weight in 1 percent hot (190 degrees Fahrenheit) sodium hydroxide solution.
   3. The filter anthracite shall have a hardness of not less than 2.7 on the Mohs scale.
   4. Average apparent specific gravity shall be determined by the procedure set forth in ASTM C128, which provides for soaking the sample in water for 24 hours. The filter anthracite shall have a specific gravity of not less than 1.40, nor more than 1.70.
   5. The filter anthracite shall not have more than 1 percent by weight flat and sliver-like (combined) particles. Flat and sliver-like shall be defined as a ratio of the longest axis to the shortest axis of the circumscribing rectangular prism for a particle of anthracite media that exceeds 5.
   6. The filter anthracite shall have an ash (dry) content of less than or equal to 15 percent as determined by ASTM D3174.
   7. The filter anthracite shall have a volatiles (dry ash free) content of less than or equal to 7 percent as determined by ASTM D3175.
   8. The filter anthracite shall have a Hardgrove grindability index of less than or equal to 38 as determined by ASTM D409.

B. Size:
   1. The anthracite shall meet the following requirements:
      a. Effective size (millimeters): 1.2 (±0.05).
      b. Uniformity coefficient - less than 1.40 before and after skimming.
      c. Maximum particle diameter (millimeters) - 2.00.
      d. Minimum particle diameter (millimeters) - 0.65.
   2. The installed filter anthracite shall be in compliance with the Specifications when, after hydraulic classification in place by backwashing and removal of the finer material by skimming, the media meets the physical, gradation and size characteristics specified in this Section.

C. Excess media:
   1. Provide sufficient excess anthracite media to anticipate media settlement, compaction during installation, and skimming requirements.
   2. The final media depth after skimming, backwashing, and testing is complete shall be 42 inches, unless otherwise indicated on the Drawings.

D. Packaging: Package filter anthracite in 1-ton ultraviolet-resistant polyethylene bags (super sacks with bottom pour spout) on pallets. Each bag of material shall be clearly marked with the following information: Effective size, uniformity coefficient, source, date of bagging, and the lot or stockpile identificationn.

2.03 MEDIA COMPATIBILITY

A. The Media Supplier shall provide filter sand media and anthracite media that are compatible when backwashed. Media compatibility between sand and anthracite shall be determined from the following formula:

$$Q_{BW}=17.67 \times D_{60} (S.G.-1.0)^{2/3}$$

Where:
Qbw = Media Backwash Rate In gallons per minute per square foot
D60 = Effective Size In Millimeters Multiplied By Uniformity Coefficient
S.G. = Apparent Specific Gravity

B. The QBW calculated for the sand media shall be greater than or equal to the QBW calculated for the anthracite media, but not more than 2.0 gallons per minute per square foot greater.

C. Due to the variability and physical nature of media size, uniformity coefficient, and apparent specific gravity, and as necessary to improve results for media compatibility, the Media Supplier shall produce either the sand or anthracite media first to establish the backwash characteristics of that media and shall then produce the second media to match the backwash compatibility of the first.

2.04 SUPPLIERS

A. Filter sand: One of the following or equal:
   1. Unifilt Corp.
   2. Northern Gravel Co.

B. Filter anthracite: One of the following or equal:
   1. Unifilt Corp.
   2. F.B. Leopold Co., Inc.

C. Approved equal:
   1. In order to be approved as an equal, a prospective Media Supplier shall submit the following:
      a. Documentation demonstrating that the supplier has been continuously engaged in the business of manufacturing either sand or anthracite filter media for potable water treatment plants for a period not less than five years.
      b. References for a minimum of 5 similar projects for which the supplier has successfully furnished either sand or anthracite filter media within the last 10 years. Similar projects are defined as potable water treatment plant filters of equal or greater size to those of the Project.
      c. A letter signed by an authorized officer of the company certifying that the supplier will comply with all requirements of the specification including the requirement to accept sole responsibility for all filter media and to provide compatible sand and anthracite media as specified.
      d. Documentation that the site-specific manufacturing facilities are in compliance with the latest version of the ANSI/AWWA B100 Standard and are independently certified with the NSF/ANSI 61 Standard.

2. Approval of a prospective Media Supplier is at the sole discretion of the Engineer.

PART 3 EXECUTION

3.01 FILTER MEDIA REMOVAL

A. Sequence the removal, replacement, and installation of filter media as specified in Section 01140 - Work Restrictions.

B. Remove existing gravel, sand, and anthracite from the filters. Methods used shall not damage the existing filter units, washwater troughs, handrail, access ladders, level probes, nor any other structural, electrical, instrumentation, architectural, and mechanical appurtenances of the filters.

3.02 FILTER MEDIA INSTALLATION

A. Before placing filter media:
   1. Verify that all nozzle slots are open and free of obstructions, and that the area around the filter underdrains is swept clean and vacuumed.
   2. Remove all debris from filters.
   3. Thoroughly wash down all parts of the filter units with clear water.
   4. Maintain the cleanliness of the filters throughout the media placement operation.
   5. The underdrain system shall have passed the specified structural integrity and flow distribution testing before any media is placed. The underdrain is considered to have passed these tests upon the Engineer's acceptance of the test results.

B. Media Placement - General
   1. Prevent contamination during transporting and placing the filter media. Any filter media which has become contaminated, either before or after placement in the filters, shall be removed and replaced with new or washed and cleaned material in a manner approved by the Engineer.
   2. Based upon submitted test results of manufactured media and media matching parameters, the Engineer reserves the right to use the test results to direct the Contractor to install individual production lots of sand and anthracite media in different filters to provide the best possible media matching compatibility at no additional cost to the Owner. Each layer of filter media shall be brought up to the required elevation and made level over the entire filter bed area. The placement of each layer of sand and anthracite shall be accepted by the Engineer before the next layer is placed.
   3. Do not damage any equipment or piping in the filter units.
   4. Workers shall not stand or walk directly on the filter materials. The workers shall walk on plywood mats that will sustain their weight without displacing the material (minimum dimensions 2 feet by 2 feet by 1/2 inch thickness).
   5. The filter may be flooded with water to use as a leveling gauge for each layer of material.

6. Each media level shall be thoroughly washed, and have passed the specified in-place media tests before the next layer is placed. The media is considered to have passed these tests upon the Engineer's acceptance of the test results.
7. Place each layer evenly throughout the filter. Do not place in one area and then spread to the rest of the filter.
8. Initial placement shall include sufficient depth to account for skimming and removal of media and fine particles.

C. Filter media washing - General:
   1. Plant staff shall operate all filter backwash controls when washing the new filter media installed in the filter basins.
   2. The Contractor is responsible for coordinating the scheduling of filter media washing through the Engineer with plant operations.
      a. Plant operations shall govern scheduling the use of the backwash system.
      b. The Contractor is responsible for this coordination to avoid delays to his schedule.
   3. Filter media washing will be allowed as determined by the Engineer so as not to interrupt operation of the plant.
      a. At no time shall the plant's reclaim ponds overflow from the media washing operations.
      b. Filter media washing shall be terminated before reaching a liquid level that would affect plant operations regardless of the status of the media washing operation.
   4. Verify separation of the media washing residuals from the backwash water sufficient for returning the water to the treatment plant. Remove and dispose of the residuals from the media washing operation.

D. Filter sand:
   1. Before placing the sand, remove all plywood panels used by the construction personnel to walk on the media support system or on the filter media.
      a. Fill the filters to a water depth 12 to 15 inches above the surface of the filter media support system.
      b. The sand shall then be placed into the water in a uniform manner over the entire surface area of the filter. This may require hand placement of the initial layer of filter sand.
         1) Transport and place the sand carefully to prevent contamination of any sort, and replace sand made dirty before or after placing with clean sand.
         2) Any indication during sand placement that the underdrain has been displaced or damaged shall require the sand to be removed and the underdrain replaced in accordance with the underdrain manufacturer’s specific instructions for repairing damage.
   2. After placing the filter sand, backwash the filter at an initial rate of not more than 2 gallons per minute/square foot of filter area (approximately 3 inches per minute rate of rise), and increase the rate gradually over a period of 3 minutes to a maximum rate of 19 gallons per minute per square foot.
      a. Maintain this maximum rate for a minimum of 5 minutes.
      b. Close the filter backwash rate valve slowly to allow for hydraulic media segregation.

3. Using hand trowels and laser level, skim the top surface of the media to remove all fine-grained sized materials. Dispose of the sand particles removed during this skimming.
    a. Fine-grained materials are defined as all material passing a No. 50 sieve (0.295 millimeters).
4. At the discretion and direction of the Engineer, skimming that is not of uniform depth shall be redone.
5. Conduct filter sand washing and skimming operations described above three separate times as follows:
    a. Wash and Skim No. 1: Depth of skimming and removal shall be approximately 2.0 percent of sand media depth.
    b. Wash and Skim No. 2: Depth of skimming and removal shall be approximately 2.0 percent of sand media depth.
    c. Wash and Skim No. 3: Skim and remove media to final depth. (Remove minimum 1/4 inch of media.)
6. After final skimming operation is finished, wash the media a final time as described above and drain the filter.
    a. Under direction of Engineer, inspect the media surface for fine material. If in the opinion of the Engineer excessive fines are present, the Contractor shall physically skim and remove the fines from the media surface. The media shall be washed once again for final inspection and media depth measurements.
    b. Measure depth of filter media. Final depth shall not be less than 1/4 inch nor greater than 1/2 inch from the requirement. Otherwise, Contractor shall add or remove media and wash and skim as directed by Engineer.

    Upon approved completion, collect and test representative sand media sample from the filter as indicated herein. Test results shall be submitted to the Engineer.
    c. The installed sand must pass the specified gradation test before the anthracite layer is installed.
    d. The media is considered to have passed these tests upon the Engineer's acceptance of the test results.

E. Filter anthracite:
1. Remove all plywood panels used by the construction personnel to walk on the media before placing any anthracite.
2. Fill the filters to a water depth 12 to 15 inches above the surface of the filter sand media. The anthracite shall be placed into the water in a uniform manner over the entire surface area of the filter.
    a. Transport and place the anthracite carefully to prevent contamination of any sort, and replace anthracite made dirty before or after placing with clean anthracite.
    b. Do not place anthracite filter media in any filter cell until the filter sand in that cell has been skimmed to final depth and accepted.
3. After placing each filter anthracite lift and soaking it in clean water in the filter box for 24 hours, backwash the filter media at an initial rate of not period of 3 minutes to a maximum rate of 19 gallons per minute per square foot, or as directed by the Engineer.
    a. Maintain this maximum rate for a minimum of 5 minutes and until the waste washwater becomes clear.

b. Close the filter backwash flow control valve slowly down to 5 gpm/sf to allow for hydraulic media segregation.
c. Backwash at 5 gpm/sf for an additional 4 minutes.
d. Slow the backwash flow gradually, so as to allow the media to stratify.
e. This backwash sequence, or similar sequence as directed by the Engineer, shall be conducted before each skimming.

4. Using hand trowels and laser level, skim the top surface of the media to remove all fine-grained sized and flat materials. Dispose of the anthracite particles removed by skimming.
   a. Fine-grained and flat anthracite particles from the top surface are defined as all material passing a Number 30 sieve (0.594 millimeters).
5. At the discretion of the Engineer, skimming that is not of uniform depth shall be redone.
6. Conduct anthracite media washing and skimming operations described above three separate times as follows:
   a. Wash and Skim No. 1: Depth of skimming shall be approximately 2.0 percent of anthracite media depth.
   b. Wash and Skim No. 2: Depth of skimming shall be approximately 2.0 percent of anthracite media depth.
   c. Wash and Skim No. 3: Skim and remove media to final depth (remove minimum 1/4 inch of media).
7. After final skimming operation is finished, wash the media a final time as described above and drain the filter.
   a. Under direction of Engineer, inspect the media surface for fine material. If in the opinion of the Engineer excessive fines are present, the Contractor shall physically skim and remove the fines from the media surface. The media shall be washed once again for final inspection and media depth measurements.
   b. Measure depth of filter media. Final depth shall not be less than 1/4 inch nor greater than 1/2 inch from the requirement. Otherwise, Contractor shall add or remove media and wash and skim as directed by Engineer. Upon approved completion, collect and test representative sand media sample from the filter as indicated herein. Test results shall be submitted to the Engineer.
      1) The media is considered to have passed these tests upon the Engineer's acceptance of the test results.

3.03 DISINFECTION

A. As specified in Section 01757 - Disinfection.

3.04 FIELD QUALITY CONTROL

A. Tests:
   1. Acid solubility tests, specific gravity tests, and sieve analysis tests shall be made in accordance with Test Procedures as described in AWWA B100 and AWWA B604.
   2. Media with a particle size distribution not meeting the specified size and quality values will be subject to rejection.
   3. Conduct all specified testing and furnish all material, instrumentation, and personnel for conducting tests as specified in this Section. Give the Engineer

sufficient advance notice of the testing to enable the Engineer to witness the tests.

4. Do not place filter media in any filter basin before the Engineer has reviewed the media's test results and completed a visual inspection of the media. Any media placed in the filter without the Engineer's acceptance shall be subject to rejection.
5. Furnish an independent commercial testing laboratory, acceptable to the Engineer, to sample, conduct, and certify the tests specified in this Section.

B. Testing filter media:
   1. Media manufacturer's testing: Furnish for the Engineer's review and acceptance, certified laboratory tests of the new filter media including the filter sand, and filter anthracite proposed for the filters.
      a. These tests shall show the analysis of all specified physical characteristics, gradation, and size including acid solubility, shape, specific gravity, and sieve analysis tests.
      b. Make the tests upon samples obtained in accordance with the sampling procedures of AWWA B100 which are representative of that proposed to furnish and place in the filters.
      c. The filter media shall not be shipped before the Engineer has reviewed and accepted the manufacturer's test report of the media to be shipped.
   2. Testing of new filter media stored on-site:
      a. All filter media is subject to gradation and retesting at the Engineer's direction if visual evidence of contamination is observed or suspected.
      b. All media shall be predesignated for each filter and a representative sample is gradation tested by the Contractor prior to placement in each filter basin.
   3. Testing of installed filter sand:
      a. After completion of backwashing and skimming of the filter sand, 3 random samples selected by the Engineer shall be taken from each filter by the Contractor and shall be sieve analyzed for compliance with the Specifications.
      b. The Contractor's testing laboratory shall determine the percent by weight of the flat or micaceous sand media on a minimum of 3 randomly selected 1 gram (0.035 ounce) samples from each filter.
         1) The longest and shortest axis of the media particles shall be determined using calipers or a proportional divider.
         2) Suspected flat or micaceous particles can be checked by comparing the minimum thickness of the particle as measured at its approximate midpoint with the maximum length dimension.
   4. Testing of installed filter anthracite:
      a. After completion of backwashing and skimming of the filter anthracite, 3 random samples selected by the Engineer shall be taken from each filter by the Contractor and shall be sieve analyzed for compliance with the Specifications.
      b. The full depth of installed anthracite shall be sampled. The testing laboratory shall remove all sand intermixed with the anthracite before performing any analysis.
         1) The testing laboratory shall first wash the media sample with clean water to remove any loose or foreign matter from the media grains.

The testing laboratory shall then separate the anthracite from the sand using the procedure outlined in ASTM C123.

2) The heavy liquid may be prepared with portions of bromoform and 1,1,2,2 tetrachloroethane (TCE) to create a liquid with a specific gravity of 1.9.
3) The laboratory shall be responsible for taking all safety precautions when working with these toxic chemicals, including the safety precautions outlined in their respective Material Safety and Data Sheets (MSDS) and in ASTM C123.

c. The Contractor's testing laboratory shall determine the percent by weight of the flat and sliver-like anthracite media on a minimum of 3 randomly selected 1-gram (0.063 ounce) samples from each filter cell.
1) The longest and shortest axis of the media particles shall be determined using calipers or a proportional divider.
2) Suspected flat or sliver-like particles can be checked by comparing the minimum thickness of the particle as measured at its approximate midpoint with the maximum length dimension.

3.05 CLEANING

A. Backwashing: At all times. The Contractor shall utilize plant operators, in coordination with the Engineer, to operate all filter controls.

B. Filter structure cleaning: Once all filter testing and skimming operations are completed, remove all debris and media from all backwash drain conduits, troughs, pipelines, and structures.

END OF SECTION

SECTION 13270

PAC STORAGE AND HANDLING SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Complete and operational powdered activated carbon (PAC) storage and handling system for unloading, storing, handling, metering and delivering PAC.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Welding Society (AWS):
   1. D1.1 - Structural Welding.

C. ASTM International (ASTM):
   1. B88 - Standard Specification for Seamless Copper Water Tube.

D. International Building Code (IBC).

E. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

F. National Electrical Code (NEC).

G. National Electrical Manufacturers Association (NEMA).

H. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

I. UL Solutions (UL).

J. National Fire Protection Association (NFPA)

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

C. Silo structure and auxiliary building.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   1. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and over-current protective devices, short circuit ratings, dimensions, and enclosure details for all Supplier-furnished electrical items.
   2. Manufacturer's Installation Instructions: Include instructions for storage, handling, protection, examination, preparation, and installation of system.
   3. Instrument Data Sheets: Provide fully completed data sheets for each instrument as specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

C. Shop Drawings: As specified in Section 15050 - Common Work Results for Mechanical Equipment:
   1. Certified dimensional drawings: Submit drawings of each item of equipment and auxiliary apparatus to be furnished including installation drawings and details:
      a. Include front and side views.
      b. Anchorage details including:
         1) Anchor locations, diameters, and dimensions.
         2) Anchor chair details, if anchor chairs are required by this Section for moderate to high seismic resistance:
         3) Anchor reinforcement details, if anchor reinforcement is required by this Section for moderate to high seismic resistance.
      c. Conduit entrance locations for all electrical equipment.
      d. Include nameplate legends and bill of materials.
   2. Schematics: Submit detailed loop drawings and schematic electrical and control wiring diagrams as specified in Section 16050 - Common Work Results for Electrical and Section 17050 - Common Work Results for Process Control and Instrumentation Systems for all Supplier-furnished electrical items as required for a complete installation.

D. Delegated Design Submittals:
   1. Calculations: As specified in Section 15050 - Common Work Results for Mechanical Equipment.
   2. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
   3. Structural calculations for silo structure stamped by a Professional Engineer Licensed in the State of Utah.

E. Commissioning Submittals:
   1. As specified in Section 01756 - Commissioning, including the following:
      a. Manufacturer's representative qualifications.
      b. Certificates.
         1) Requirements as specified in this Section.
      c. Test Plans.
         1) Test requirements as specified in this Section.
      d. Test Reports.
      e. Manufacturer's representatives field notes and data.
      f. Owner training.

F. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete system and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

B. Special warranty:
   1. The system shall be dust and watertight from the truck fill line adapter to the discharge of the wetting system.
   2. The system dust collector emissions shall meet or exceed a discharge of 0.020 grains per dry standard cubic feet of air when pneumatically offloading trucks conveying PAC.
   3. Bulk storage, transfer, and wetting without bridging, blockage, “rat-holing”, or stoppage.
   4. Duration of special warranty: 1 year.
      a. If the PAC storage and handling system fails to meet the performance guarantee requirements the Supplier shall modify, change, or add equipment as necessary to meet performance requirements at Supplier’s sole expense.
      b. Replace all devices and components that fail in service within the first year of operation.

1.06 ADMINISTRATIVE REQUIREMENTS

A. Schedule two instrumentation and control coordination meetings with the Supplier, Owner, Instrumentation and control system contractor (ICSC) and Engineer.
   1. Meeting requirements are specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

B. Compliance with NFPA 652 and Coordination with Owner’s Dust Hazard Assessment:
   1. The Owner will conduct a Dust Hazard Analysis (DHA), based on the requirements of NFPA 652, using Contractor submittals, Contract Documents, existing conditions, and other materials as required for a complete assessment.
   2. Findings from DHA will be reviewed by the Engineer, Owner, Fire Marshal, Contractor, and PAC System Supplier to determine the best course of action for compliance with NFPA 652.
      a. Contractor and PAC System Supplier shall be available for a 3-hour workshop to discuss requirements and opportunities for efficient compliance.
      b. Owner and Fire Marshal shall make final determination on design changes for dust hazard mitigation.

c. Contractor shall assume a duration of 8 weeks after complete submittal of PAC Storage and Handling system for development of DHA and determination of mitigation measures.
    1) Submittal completeness shall be as determined by Engineer.
d. Required changes to PAC Storage and Handling system will be returned to Contractor as submittal comments.
    1) Contractor and PAC System supplier shall incorporate requested changes and resubmit as required before submittal approval will be given.

3. Costs for changes to PAC system and appurtenances shall be as submitted by Contractor at bid time in the Powdered Activated Carbon Dust Hazard Mitigation Allowance Schedule, see Bidding Documents, section C.
    a. Owner will direct dust hazard mitigation improvements based on results of DHA.
    b. Improvements are not limited to items from the Powdered Activated Carbon Dust Hazard Mitigation Allowance Schedule. Owner reserves the right to negotiate alternative mitigation measures using the available allowance.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following
    1. Chemco Systems.
    2. Integrity Municipal Systems.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design criteria:
    1. PAC density:
        a. 35 pounds per cubic foot for structural calculations.
        b. 18 pounds per cubic foot for volume calculations.
    2. PAC mesh size:
        a. Passing 100 mesh = 99 percent minimum.
        b. Passing 200 mesh = 95 percent minimum.
        c. Passing 325 mesh = 90 percent minimum.

B. The PAC storage and handling system shall meet the following minimum requirements:
    1. The system layout and all interconnecting chutes, pipes, controls, control panels, feeder and supports will provide adequate maintenance clearance including electrical control panel stand back clearance as per the NEC.
    2. Structural design conforms to IBC latest edition.
    3. All welders are certified per AWS D1.1.
    4. Furnish all electrical control panels with UL label.
    5. All parts and components within the system that will be in contact with PAC and carrier water shall meet the requirements of NSF 61.
    6. All parts and components of the system shall be designed to meet NFPA 652 requirements for combustible dust hazard mitigation.

2.03 GENERAL

A. All electrical and instrumentation/control systems shall conform to Divisions 26 and 40 of the Specifications.

B. The supplier shall furnish a complete, fully functional system for unloading PAC from a bulk truck transport truck trailer, storing in a bulk dry silo and feeding PAC. Equipment identification shall be per Drawing 00N01 through 00N03.
   1. The PAC storage and dosing system shall include a PAC storage silo, silo vent filter, feeder skid, power and control panels, and ancillary equipment as required for a complete operating system.
   2. The system shall be pre-assembled, pre-wired and tested to the maximum extent practical at the factory and delivered to the site ready for installation and start-up.
      a. The Contractor shall be responsible for all final field assembly, field interconnecting piping and conduit, field electrical and mechanical terminations, and adjustments necessary to provide a complete operating system.

2.04 GENERAL SYSTEM DESCRIPTION

A. Unloading and storage:
   1. Dry PAC shall be pneumatically unloaded from a bulk truck transport trailer, utilizing the truck's compressor and hoses to transport the PAC through a carbon steel pipeline tangentially into the PAC storage silo. The PAC shall be stored in a welded carbon steel silo until utilized.

B. Feeding:
   1. A combination of specially designed air fluidization nozzles, located in the conical discharge section of the silo, shall pulse compressed air into the bulk of the carbon, promoting mass flow from the flanged discharge connection.
      a. The fluidized PAC shall be fed from the silo into the volumetric feeder hopper by a rotary valve, where it is temporarily stored until conveyed by the feeder discharge screw into the wetting cone.
      b. The speed of the screw shall be directly proportional to the amount of carbon dropped into the wetting cone below.
      c. A variable speed motor shall provide a wide range of carbon delivery rates from the screw.

C. Wetting and transporting:
   1. Once in the wetting cone, the PAC shall be kept flowing by adding a sidestream from the motive water stream into the wetting cone tangentially. The swirling water shall form a vortex within the wetting cone to sweep the inner walls clean, preventing the carbon from setting up, which will ultimately lead to the formation of a stable arch, and system pluggage.
      a. The carbon/water mixture shall flow out of the wetting chamber into the mouth of a hydraulic eductor mounted below.
      b. The passing of a motive water stream through the eductor nozzle produces a slight vacuum in the mouth of the eductor, which helps draw the carbon/water mixture into the mixing zone directly downstream of the eductor mouth.

c. Pneumatically actuated valves shall be utilized to control the flow of the motive water, slurry, and to drain the system.

D. Package control system:
   1. The Control system shall utilize a programmable logic controller (PLC) based control panel.
      a. The vendor system shall communicate with the Plant PLC network using a dedicated network connection that shall be isolated from any vendor field control networks.
      b. The PLC shall control the sequence of events throughout the system. Interlocks, sensors, alarms and trips shall be provided to protect the system and identify upsets and/or failures.
      c. The PLC control panel shall be completely prewired, preprogrammed, and factory tested for proper operation prior to shipment.
      d. Supplier is responsible for providing all the necessary control hardware, software, and components as required for a fully functional and operational installation.

E. Hazardous location classification:
   1. The exterior of the silo shall be classified as non-hazardous. The silo storage section shall be classified as non-hazardous. The interior equipment room of the silo shall be rated Class II, Division 1, Group F. The air compressor auxiliary building shall be classified as non-hazardous.

2.05 EQUIPMENT

A. PAC storage silo:
   1. The 2 bulk storage silos shall be welded, carbon steel vertical cylinder with a conical bottom.
      a. Each silo shall have a minimum material storage capacity of 55,000 pounds.
      b. The storage silo shall be 14 feet diameter, 42 feet and 0 inches (maximum) in height to the highest part of the top of the silo, and 50 feet and 0 inches (maximum) in height to the top of the highest part of any attachment thereto.
      c. The silo shall be supported by a full height, full diameter structural skirt, complete with access door.
   2. The interior of the PAC silos, as well as upper exterior blower and ancillary systems shall be constructed in conformance with a Classification II, Division 1 location. Electrical installation shall comply with articles 500 and 502 of NFPA70 National Electric Code.
   3. Provide all signage required by IFC chapter 22 both inside and outside of the silo skirt.
   4. Design Loads: Design loads shall include the following loads acting separately or in combination:
      a. Seismic, wind, and snow loads as specified in Section 01850 - Design Criteria.
      b. Dead weight of the structure.
      c. Weight of powdered activated carbon based on 35 pounds per cubic foot for dead load.
      d. Transportation, handling, and erection loads.

e. A live load of 100 pounds per square foot on the silo deck plus a 300-pound point load on the silo deck.
f. A 1,000-pound dead load from the silo vent filter.
g. Dead load from the ladders, platforms, and ancillary equipment.

5. The silo and anchor bolt system shall be designed by the Supplier for the above noted loads acting in the load combinations required by the International Building Code.
6. Manufacture:
   a. Each silo shall be all welded, 1-piece construction design. Two-piece silos with bolted splice connections are not acceptable. All welds must be complete joint penetration. Fabrication shall comply with Section 01455 - Regulatory Quality Assurance.
   b. Each silo shall have 1 cone bottom outlet with a minimum slope of 60 degrees from horizontal. Each silo shall be fabricated of carbon steel plate with adequate thickness to withstand the full range of pressure or vacuum to which silo is to be subjected. Conical bottom plates shall be no less than 1/4-inch thick. Each silo shall include lifting lugs, welded ladder supports, welded pipe and conduit support brackets, and penetrations as required.
   c. The silos shall include a self-supporting roof with flanged openings for the silo vent filter, the vacuum/pressure relief valve, access manway, and a level monitoring device.
   d. The silos shall also include the following accessory items:
      1) Each silo shall be secured with steel anchor bolts and nuts as indicated on the drawings. Anchor bolts shall be designed to withstand both uplift and shear forces. Only ½ of the anchors shall be considered effective in resisting shear forces.
      2) In Seismic Design Categories C through F:
         a) The silo shall be fitted with anchor chairs to provide the gauge length of 8 bolt diameters required by ASCE 7-16, Section 15.7.5.
         b) Anchor chairs and their connections to the silo shall be designed for the overstrength factor as required by ASCE 7-16, Section 15.7.3.
         c) Anchor reinforcement sized to resist the steel tensile strength of the anchor shall be provided at each anchor. Anchor reinforcement shall conform to ACI 318-19 Section 17.5.2.1 and Figure 17.5.2.1a.
      3) Penetrations in silo wall for installation of point level probes to monitor the PAC level in the silo. The silo level switches shall be located such that the devices are readily accessible for maintenance from the ladder, intermediate platform(s), or the silo roof.
      4) A continuous level sensor on the silo roof to measure the level of powdered activated carbon within the storage area of the silo.
      5) Two level switches for sensing “High” and “Low” silo levels.
      6) A 24-inch minimum diameter access manhole located in the silo roof.
      7) A pressure/vacuum relief valve capable of venting the maximum pressure airflow which will occur in the PAC storage system including the airflow and surge that results when a delivery truck unloads. The valve shall relieve pressure and vacuum in order to protect the silo.

The pressure/vacuum relief valve shall be Knappco or approved equal.

8) A flanged penetration located on the silo deck for the silo vent filter.
9) Access to the top of the silo shall be provided via a vertical, galvanized, Occupational Safety and Health Administration (OSHA)-approved steel ladder extending from 2 feet above the finished grade at the base of the silo to the intermediate platform(s) and on to the top of the silo.
    a) The ladder assembly shall be supplied with a fall prevention system complete with 3/8-inch corrosion resistant galvanized cable lifeline, top bracket with energy absorber, bottom bracket with tensioner, cable guides as necessary, and 1 detachable cable sleeve with dual independent locking system.
10) The silos shall be equipped with handrail and toe plate for all platforms and stairs, including the top of the silo. The handrails shall be galvanized and shall meet OSHA standards.
11) Miscellaneous penetrations and supports as necessary for installation of conduits and piping to the devices mounted external to the silo.

e. Receptacles: Provide waterproof, ground fault interrupting, duplex convenience outlets on silo roof platform, as well as other interior areas requiring 120 VAC (volts AC) power for maintenance or troubleshooting.

7. Flange connections shall be 150-pound ANSI rating and shall have a minimum of 4 inches clearance from the silo shell.
8. Use conductive gaskets and hoses between equipment pieces e.g., flange attachments.
9. The silo shall be painted as specified later in this Section.
10. A lightning protection system shall be installed as specified in Section 16670 - Lightning Protection. Coordinate with installers.

B. Silo Utilities:
1. The system Supplier shall factory install and wire applicable silo utilities.
2. The Supplier shall furnish and install a silo exhaust fan located near the top of the equipment room. The exhaust fan shall have an adjustable louver, wire guard, and adjustable thermostat. Components rated Class II, Division 1, Group F as applicable.
3. The Supplier shall furnish a 10-kilowatt electric space heater with adjustable thermostat for the silo equipment room. Components rated Class II, Division 1, Group F as applicable.
4. The Supplier shall furnish and install LED, dust tight light fixtures for the silo interior equipment room. Include light switch. Components rated Class II, Division 1, Group F as applicable.
5. The Supplier shall furnish and install one 120-volt, 15A duplex receptacle in the silo equipment room. Components rated Class II, Division 1, Group F as applicable.
6. The silo skirt equipment room shall have insulation factory installed on the walls. The insulation shall be minimum 1-1/2 inches thick rigid extruded polystyrene and bonded to the walls with adhesive. The Supplier shall finish paint the insulation.

C. Silo dust collector:
   1. A pulse jet type dust collector shall be furnished for installation on the silo roof and shall be suitable for the continuous cleaning of the PAC conveying air vented from the storage silo during filling.
   2. The dust collector shall be equipped with the following:
      a. Approximately 300 square feet of pleated polyester filter media. The vent filter shall be Flex Kleen, C.P. Environmental, or equal.
      b. Schedule 40 carbon steel internal air piping.
      c. Carbon steel housing with quick opening access door.
      d. A pressure differential indicator and high differential pressure switch, which will alarm when the cleaning cycle no longer cleans the filters sufficiently and indicates the need to replace the filter.
      e. Blower assembly.
      f. An internal grid to prevent filter elements from dropping into the storage silo.
   3. The dust collector shall have a compressed air header assembly complete with aluminum diaphragm valves and brass solenoid valves pre-piped and wired to a solid-state sequencer mounted in a NEMA 4 enclosure.
   4. The dust collector blower shall be cast aluminum and equipped with a 2 horsepower, 460-volt, 3 phase, 60 hertz motor.
      a. The motor shall be totally enclosed, fan cooled (TEFC) and meet NEMA standards. Refer to specification 16222 - Low Voltage Motors up to 500 Horsepower.
   5. Furnish a dust collector airline assembly complete with a manually operated brass isolation ball valve, a combination filter/regulator assembly, a pressure gauge, and photohelic differential pressure gauge.
      a. Piping shall be suitably sized schedule 40 galvanized pipe.
      b. The silo shall be shipped to site with the dust collector airline, wire, and conduit factory installed on the exterior of the silo.

D. Silo fill line:
   1. A complete truck fill pipe assembly shall be furnished which will include 4-inch nominal diameter (4-1/2 inches outside diameter [OD]), schedule 40 carbon steel pipe to convey the PAC from delivery truck into the silo. All bends in the fill pipeline shall have a minimum 4-foot 0-inch radius.
   2. The fill pipe shall terminate on the silo at a target box at the silo roof. The target box shall be designed to dissipate the velocity of chemical being conveyed and allow it to drop into the silo in an even pattern. The target box shall be constructed of carbon steel plate and furnished with a removeable end plate to facilitate cleaning of the fill pipe.
   3. The inlet end of the conveying pipe shall be provided with a 4-inch nominal quick disconnect male adapter (bronze or cast iron) and lockable dust cap with chain connected to the limit switch.
   4. Mount a NEMA 4 limit switch on the side of the truck fill operator station panel for control of the dust collector. The limit switch shall have one set of normally open and normally closed contacts.

E. Silo discharge:
   1. Each silo shall be equipped with discharge cone with one 8-inch diameter, ANSI class 150 flanged outlet.

2. The discharge cone is to have multiple aeration nozzle openings. The quantity and size of the aeration nozzles shall be sized by the system Supplier.
    a. Furnish a 30-gallon air receiver tank with a safety, pressure relief valve.
    b. Furnish all valves, gauges, and hoses required to pipe the inlet dry air to and from the air receiver.
    c. Furnish all valves, gauges, regulators, hoses, fittings, and headers required to transfer compressed air from the air receiver to the silo discharge cone aeration nozzles.
    d. Furnish all couplings and aeration nozzles for operation of the aeration assembly.
3. The discharge shall be painted as specified later in this Section.
4. Applicable equipment to be rated to Class II, Division I.

F. Silo discharge isolation valve:
1. The PAC storage silo discharge cone shall be equipped with a manually actuated knife gate valve. All wetted parts shall be constructed of stainless steel and the valve shall be equipped with a manual chainwheel operator. The valve shall be manufactured by DeZurik, or equal.
2. Furnish a transition chute from the knife gate valve discharge to the airlock rotary feeder inlet. The chute shall have a flanged inlet and flanged outlet.
3. The chute shall have an aeration nozzle with required fittings, hose, isolation valves, and solenoid valve to provide a pulse of clean, dry compressed air to the feed chute to promote material flow.

G. Silo airlock rotary valve:
1. The silo discharge cone shall be equipped with a rotary valve that will isolate the surge hopper from the fluidized powdered activated carbon in the storage silo and will refill the surge hopper with PAC as required. The rotary feeder shall be capable of refilling the surge hopper within 5 minutes.
2. The valve shall be of cast iron or stainless steel construction with ANSI 125 pound, 8-inch flanged inlet and outlet connections. The rotor shall be machined steel with outboard bearings.
3. The design of the valve shall effectively isolate the rotor bearings from the process material. The valve shall be designed for use as a conveying valve or a feeder valve in a pneumatic conveying system.
4. The drive motor shall be a minimum of 1/2 horsepower, 1,750 rpm, 480 volt, 60 hertz, 3 phase, with a 1.15 service factor. The motor shall be TEFC and meet NEMA standards. Refer to Section 16222 - Low Voltage Motors Up to 500 Horsepower.
5. The rotary valve shall be Rotolok, ACS, or approved equal.
6. Applicable equipment to be rated to Class II, Division I.

H. Surge hopper:
1. Furnish 1 intermediate storage hopper per silo.
2. The PAC intermediate storage hopper shall be installed between the rotary valve and the volumetric feeder. The hopper shall be fabricated of 304L stainless steel and shall have a minimum capacity of 6 cubic feet. The hopper shall have a side slope minimum of 60 degrees. The hopper shall be furnished with a flanged top cover, with an 8-inch 150# ANSI pattern inlet and a flanged connection to the feeder.

3. The hopper shall be equipped with low level and high level switches to monitor the PAC level in the hopper.
4. Applicable equipment to be rated to Class II, Division I.

I. Volumetric feeder:
1. Furnish 1 volumetric feeder per silo. The feeder shall be of the variable speed control volumetric type utilizing a helical screw.
2. Each feeder shall be capable of feeding PAC at 18 pounds per cubic foot at a rate of 50 to 650 pounds per hour.
3. The feed screw shall be a helical design, constructed of 316 stainless steel and shall discharge the PAC through a stainless steel discharge tube.
   a. The screw shall require no mechanical seal. The feeder shall be stainless steel construction with stainless steel fasteners and fittings.
   b. All wetted parts shall be manufactured from stainless steel.
   c. All materials and design features shall be suitable for the material being handled.
4. The feeder shall be capable of a minimum 20:1 turndown ratio.
5. The drive motor shall meet NEMA standards, TEFC, and shall be variable speed. The motor shall be minimum 1/2 HP, 480 VAC, 1,750 rpm with a 1.15 service factor. The motor shall be powered and controlled from the main control panel. Additionally refer to Section 16222 - Low Voltage Motors up to 500 Horsepower.
6. The feeder discharge shall be equipped with a stainless steel or PVC removable drop tube which shall guide the PAC from the feeder discharge tube into the wetting cone.
7. The volumetric screw feeder shall deliver the powder activated carbon at calculated rates within plus or minus 2 percent of the desired set point value.
8. The feeder shall be manufactured by Chemco Systems, L.P., Integrity Municipal Systems, or approved equal.
9. Applicable equipment to be rated to Class II, Division I.

J. Wetting cone:
1. Furnish 1 wetting cone system per silo, capable of efficiently wetting powdered activated carbon at a dry chemical feed rate of 50 to 650 pounds per hour with a bulk density of 18 pounds per cubic foot.
2. The wetting cone shall be of stainless steel.
   a. The inlet to the wetting cone shall be flanged and the outlet shall be welded.
   b. The wetting cone shall be equipped with an overflow pipeline which shall contain an ultrasonic level switch to sense the presence of a slurry backup and initiate system shutdown.
3. The wetting cone shall be equipped with an eductor and motive water assembly to transfer the powdered activated carbon slurry.
4. The wetting cone shall have a tangential water inlet nozzle that is managed by the wetting cone water supply panel.
   a. The water supply panel shall possess valves and flow meters to provide sufficient water flow and pressure for the operation of the wetting cone, including pressure regulating valve and low-pressure switch to control and monitor water pressure to ensure sufficient water pressure is maintained to the wetting cone system.

b. The water panel arrangement shall be supplied with schedule 80 type 304 stainless steel piping.
c. Backflow preventors shall be supplied and installed upstream of the water supply panel.

K. Eductor:
1. Furnish an eductor constructed of type 304 stainless steel and capable of conveying 50 gallons per minute of PAC slurry with a minimum motive water pressure of 30 pounds per square inch inlet head and 15 pounds per square inch discharge head.
2. The eductor shall be equipped with a motive water line assembly complete with a manually operated isolation ball valve, a pressure reducing valve with integral strainer, a low-pressure switch, a pressure gauge, and booster pump.
3. The eductor motive water line shall be equipped with a pneumatically actuated, normally closed, spring return ball valve. The pressure switch shall be Ashcroft B7 or approved equal.
4. The eductor suction line shall be equipped with a pneumatically actuated, normally closed, spring return ball valve.
5. The eductor discharge line shall be equipped with a pneumatically actuated, normally closed, spring return ball valve, pressure sensor, pressure gauge, and low-pressure switch with an instrument isolation manual ball valve.
6. The eductor discharge shall have 2 discharge branches.
   a. One branch shall be piped to the process feed point and be the permanent delivery path of PAC slurry to process.
   b. The second branch shall be a tee-connection on the PAC slurry discharge with an isolation ball valve and quick-connect hose coupling.
   c. The system supplier shall include provisions (welded coupling with plug or ANSI flange with steel blind) at grade in the silo skirt for the plant to install a flexible hose from the second branch of one silo to the other, equivalent branch in the other silo.
   d. This configuration allows for emergency, cross-system PAC slurry feeding. The system supplier shall furnish one 40-foot coil of flexible, wire reinforced hose with quick-connect couplings to connect the systems.
7. Motive water piping shall be schedule 80 threaded type 304 stainless steel, minimum of ANSI 150# class. Manual motive water valves shall be stainless steel or bronze ball valves, threaded, with a minimum of ANSI 200# class.
8. Slurry piping shall be scheduled 80 threaded type 304 stainless steel, minimum of ANSI 150# class. Motive water valves shall be stainless steel ball valves, threaded, with a minimum of ANSI 200# class.

L. Compressed air system:
1. The system Supplier shall furnish one air compressor system for each silo, factory installed, piped, and wired within the auxiliary building. The compressor shall be a belt driven rotary screw compressor.
2. The compressed air system shall include a compressor/receiver skid, refrigeration air drier, air filters, and instruments, valves, regulators, coalescing filters, pressure switches, and appurtenances capable of providing the quantity and quality of air necessary to sustain operation of the PAC dosing system.
3. The Supplier’s compressed air system piping shall include a supply to the silo dust collector for reverse pulsing of the bags, to the storage silo cone for PAC

fluidization and to the hydraulic skid for operation of the pneumatic flow control valves.

4. Pressure control valves shall be provided as required for proper operation of the subsystems. Air pressure regulators shall be Fisher Model 627 or equal.
5. Compressed air piping shall be schedule 40 galvanized piping with 150# threaded fittings.
6. Solenoid valves shall be brass body, soft-seated, with 120 VAC solenoid coil. Solenoid operators shall be molded coil in NEMA 9 explosion-proof enclosure. Maximum operating pressure differential capability shall be 100 pounds per square inch gauge. Solenoid valves shall not require a minimum pressure to either open or close. Valves shall be 2-way or 3-way, energize-to-close or energize-to-open as required for the application. Valves shall be ASCO Red Hat or approved equal.

M. Structures and supports:
   1. The PAC feed equipment with associated piping, conduit, instruments, and junction boxes shall be mounted on a single support skid fabricated from A-36 structural steel members. The structural members shall be of sufficient size to support the equipment without excessive deflection or vibration. Skids, brackets, and conduit supports shall be fabricated in accordance with AISC. Pipe supports shall be in accordance with MSS SP-58.

N. Auxiliary building:
   1. Provide a prefabricated building to house the 480 VAC power panel, packaged power supply center (PPSC), 480 VAC motor controller panels, PLC panels, air compressors and air drier/filters.
      a. Design loads shall include the following loads acting separately or in combination: Seismic, wind, and snow loads as specified in Section 01850 - Design Criteria.
      b. The building anchor bolt system shall be designed by the Contractor per Section 01357 - Delegated Design Procedures for the above noted loads acting separately or in combination.
   2. The Supplier will determine the size of the building to house all the necessary equipment. It is anticipated that the building will be approximately 10 feet by 40 feet in length. The building will be equipped with 1 steel double door assembly with dimensions 6 feet and 0 inches width by 6 feet and 8 inches high.
   3. The walls shall be insulated with minimum 1-1/2-inch extruded polystyrene, fiberglass, or approved equal. The external walls shall be corrugated steel cladding, fiberglass reinforced plastic, or approved equal. The roof shall be sloped to one side and equipped with gutter and downspout.
   4. The building shall be equipped with a built-in air conditioner capable of offsetting the heat load from the equipment. The sidewall of the enclosure shall have an opening for an exhaust fan. Provide two 5-kilowatt space heaters.
   5. The supplier will provide all conduit and wire for power and control of electrical equipment.
   6. The supplier will provide lighting, light switches, and receptacles all pre-wired to the PPSC.
      a. Interior lighting:
         1) Industrial grade, totally enclosed, fully gasketed LED fixtures, UL listed for damp locations.

2) Provide light switches to control interior light fixtures.

b. Emergency lighting:
   1) Provide one of the following:
      a) Industrial grade emergency lighting fixture with thermoplastic enclosure, 12-volt nickel cadmium battery, and minimum 90-minute operating capacity, mounted above each exterior door.
      b) Battery backup within the overhead lighting to supply the required egress lighting.

c. Exterior lighting:
   1) Provide an industrial grade, LED wall pack fixture with IES cutoff distribution, UL listed for wet locations, mounted above each exterior door, with battery backup.
   2) Exterior lighting fixtures shall be automatically controlled by a photocell, with HAND-OFF-AUTO switch inside the prefabricated electrical building for photocell over-ride.

d. Receptacles:
   1) Provide receptacles installed and tested by the enclosure supplier.

7. The building will arrive on site with all the equipment installed, piped and wired to the greatest extent practical.
8. The building will be placed on a concrete foundation prepared by the Contractor.
9. The Contractor is responsible for the interconnected piping, wiring, and conduit to connect the booster pump, air compressor, and panels to the respective tie-in points within the silo system.
10. The Contractor shall provide security to building.

2.06 PAINTING AND COATING

A. Surface preparation: The PAC silo exterior and structural members shall be prepared for factory coatings by commercial blast cleaning (SSPC-SP6). The interior of the storage area shall be left unblasted and unpainted.

B. Painting: The silo exterior and associated equipment shall be factory coated. Purchased items shall be manufacturer's standard finish. All coatings shall be applied in accordance with the paint manufacturer's recommended application procedures. Color samples shall be submitted to the Engineer for final selection and approval.
   1. Primer: 4 to 6 mils dry film thickness (DFT) Carboline Carboguard 60 or equal.
   2. Finish Coat: 4 to 6 mils DFT Carboline Carbothane 8845 or equal.
   3. Total: 10 to 13 mils DFT.

2.07 POWER DISTRIBUTION AND CONTROL PANELS

A. General:
   1. The control panel and its internal and external components shall meet the requirements of the following specification sections:
      a. Section 17710 - Control Systems: Panels, Enclosures, and Panel Components
      b. Section 17720 - Control Systems: Programmable Logic Controllers.

c. Section 17721 - Control Systems: Local Operator Interface (LOI).
d. Section 17733 - Control Systems: Network Materials and Equipment.
e. Section 17710 - Control Systems: Panels, Enclosures, and Panel Components.
f. Section 17712 - Control Systems: Uninterruptible Power Supplies 10 kVA and Below.

2. Provide a separate control panel for each vendor-packaged system so that the control panels will have fully independent control of the functions and operations of their respective systems.
3. Provide components and equipment with a UL 508 listing.
4. Provide control panels labeled with UL 508A.
5. Provide intrinsically safe circuits and equipment in accordance with UL698A.
6. VCP shall be programmed, wired, and factory tested for proper operation prior to shipment.
   a. Factory-assemble and wire the control panel so that field wiring only requires connection to terminals.
   b. Additional testing requirements as specified in Section 17950 - Commissioning for Instrumentation and Controls.
7. Provide surge protection on the incoming power feed.
8. Provide necessary control hardware, software, and components as required for a fully functional and operational installation.
9. Provide heating and cooling devices to maintain instrumentation and control devices within their rated operational temperature range.

B. Power distribution:
1. The PAC system 480-volt power panel (PP-PAC) shall be provided, including the main breaker and feeder breakers. This power panel shall supply loads including but not limited to the motor controller panels, auxiliary building heaters, and PAC silo heaters.
   a. A 3-phase surge arrester shall be provided on the power panel 480 VAC distribution supply. The surge arrester shall be equal to a Square D SDSA3650.
2. Provide a 480 VAC to 120 VAC packaged power supply (PPSC-PAC) to supply miscellaneous 120 VAC loads (PNL-PAC) within the auxiliary building as well as PAC silos. Refer to specification 16472 - Packaged Power Supply Center.
3. Provide a typewritten schedule in each panelboard.

C. Starter Panels (VCP2-6802 & VCP2-6832):
1. Each starter cabinet shall have a main disconnect.
2. Provide 480 VAC motor controller panels (VCP-6802 and VCP-6832) which includes: motor circuit breakers, motor starters, power blocks, terminal blocks, 120 VAC control power transformer(s) and fuses.
   a. A main flange-mounted disconnect and associated main breaker shall be provided in the motor controller panel. This main breaker shall be utilized to protect and to de-energize the complete PAC system (except lighting and heating)
   b. A NEMA starter with motor circuit protector and solid-state overload protection shall be provided for each 480 VAC constant speed motor.

c. Provide variable frequency drive(s) for each load requiring variable speed operation as specified in Section 16262 - Variable Frequency Drives 0.50 - 50 Horsepower.
d. AC power shall be distributed to the various devices in the power panel via power distribution block(s).
e. Provide a control power transformer (480 VAC primary, 120 VAC secondary), with appropriately sized primary and secondary overcurrent protection. Ground the secondary of the transformer per NEC article 250.
f. A 3-phase power monitor shall be provided to monitor the phase balance of the 480 VAC power supply to the power panel. The power monitor shall be equal to a Time Mark model 252.
g. Provide each motor with a Local Off Remote (LOR) selector switch, with the controls in the LOR=Local mode able to operate the motor if the PLC fails. In the LOR=Remote mode, the motor is operated via PLC.

D. Truck unloading operator station (VCP-6801 & VCP-6831):
1. Provide a truck unloading operator station as described herein and located adjacent to the silo truck fill line assembly.
2. The components for the truck unloading operator station shall be housed in a NEMA 4X stainless steel enclosure. The panel shall include, but not limited to the following:
a. Selector switches:
1) Dust collector blower “hand/off/auto.”
2) Dust collector cleaning sequencer “hand/off/auto.”
b. Indicating lights:
1) Dust collector blower running status.
2) Dust collector cleaning sequencer.
3) Silo level “high-high.”
4) Silo level “high.”
5) Silo level “low.”
c. Silo level digital indicator.
3. Operation:
a. To start the unloading procedure, the dust collector blower and dust collector cleaning sequencer selector switches should be in the “auto” position.
1) When the operator removes the fill pipe adapter dust cap and allows it to hang from the chain, the limit switch is actuated, and the dust collector blower and sequencer will start and continue to run during the entire fill operation.
2) After the dust cap is replaced, the blower will stop, and the sequencer will continue to pulse the filter media for a pre-set time.
3) If “high” level is reached, the horn and silo “high” level light will be activated.
4) If “low” level is reached, the silo “low” level light will be activated.
5) Pressing the “alarm silence” push button will silence the horn.

E. Control panels (VCP-6800 & VCP-6830):
1. The PAC system PLC Control Panels shall be a dedicated panel for each silo, and shall include PLC, uninterruptible power supply (UPS), local operator interface (LOI), network communications equipment, 24 volts DC (VDC) power supplies, control relays, lights, terminal blocks, switches, etc.

2. Provide 120VAC 1P circuit to each PLC control panel.
3. Provide all components and equipment with UL 508 listing.
4. All control panels shall be UL 508A labeled.
5. Provide fuses for all equipment not UL or UR listed.
6. Perform and submit thermal management calculations for each control panel. Provide heating, cooling, and dehumidifying devices to maintain all instrumentation and control devices within their rated operational temperature range.
7. Control wiring philosophy shall meet the following requirements:
    a. The control wiring philosophy shall be such that all field control devices utilize normally closed contacts during normal operating conditions.
    b. A contact opening or an open circuit shall result in an alarm condition for the specific device.
    c. Loss of power to a control device shall result in an alarm condition.
8. Provide nonmetallic ducts for routing and organization of conductors and cables. Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring.
9. Provide 120 VAC to 24 VDC (or other voltages as required) power supply arrangement that is configured with several modules to supply adequate power in the event of a single module failure in either a 1+1 or N+1 configuration as required:
    a. Provide automatic switchover upon module failure.
    b. Alarm contacts monitored by the PLC.
    c. Design a power supply system so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.
10. Factory assembly and wiring of the control panel such that field wiring shall consist only of connections to terminals.
11. PLC:
    a. Modicon M340 with ethernet communication utilizing Modbus TCP communications.
12. Provide an unmanaged Phoenix Contact rail switch capable of connecting to multimode fiber SFP with SC connectors.
13. Provide a graphical Local Operator Interface (LOI) Schneider Electric HMIGTO6310.
14. All PLC and LOI programming shall be the Owner's property. Locking programming out of owner access is not acceptable.
15. Provide complete software documentation, including a ladder logic diagram printout with a complete set of comments and a narrative description of the sequence of operations.
16. Pilot devices buttons:
    a. Provide a white pilot light indicating Control Power On.
    b. PAC System Emergency Stop pushbutton.
    c. Alarm Silence pushbutton.
17. Provide all status and alarms and setpoints to the owner's control system:

F. Junction boxes:
    1. The PAC system shall be provided with all interior electrical devices pre-wired and terminated to terminal blocks in pre-wired junction boxes mounted to the silo structure:
        a. 480VAC junction box.

b. 120VAC control and receptacle/lightning junction box.
c. 4-20 mA analog signal junction box.

2. Interior of the silo and top-mounted equipment is assumed to be pre-wired to junction boxes mounted within the silo interior. The contractor shall provide the interior of the silo conduit and wire, where not pre-packaged, with the Vendor supplied silo equipment.
3. Terminals shall be clearly labeled, allowing ease of extension of wiring from the feeder skid to the auxiliary building.
4. Provide junction boxes to meet the requirements as specified in Section 16134 - Boxes.

G. Instrumentation and Monitoring devices:
1. Pressure indicators shall be Bourdon tube type with solid front, phenolic plastic case and 4-1/2-inch dial. Indicators shall be Ashcroft 1279 or approved equal.
2. The silo level sensor shall be guided radar type with NEMA 4X coated aluminum housing with local display, Endress + Hauser Levelflex FMP57 or approved equal.
3. The wetting cone high-level switch shall be of ultrasonic, gap type with 316 stainless steel sensors. The level switch shall operate on 120 VAC and provide a discrete output rated for 10A at 120V. The level switch shall be a VEGASWING 63 or approved equal.
4. Compressed air, motive water, and slurry pressure switches shall be Ashcroft B series, Square D Class 9012, or Allen Bradley Bulletin 836 as required to meet electrical area classification.
5. The 2-point level probes for the PAC storage silo level indication and the 2-point level probes for the feeder surge hopper level indication shall be oscillating tuning fork type of stainless-steel construction, VEGAWAVE 61 or approved equal.
a. Low level probe for silo shall automatically stop air fluidization operations.
6. The silo dust collector differential pressure switch shall be a Dwyer series 1950 or approved equal.

2.08 SPARE PARTS

A. The Supplier shall furnish, in accordance with Section 01782 - Operation and Maintenance Manuals, a list of recommended spare parts required for normal operation and maintenance of the equipment.
1. Owner will review this list with the Supplier and determine which spare parts are desired.
2. At Owner's discretion, any requested spare parts will be purchased under a separate contract or purchase order.

PART 3 EXECUTION

3.01 PREPARATION

A. Anchoring and bracing to structures:
   1. Locate and secure all anchors and anchor reinforcement prior to casting concrete.
   2. Prepare equipment anchor setting template(s) and use them to position anchors during the construction of supporting structure(s).
   3. Install anchors of type and material indicated on approved anchoring designs.
   4. Install anchors with embedment indicated on approved anchoring designs.

3.02 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.03 DELIVERY AND STORAGE

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Silo and all equipment shall be packaged, crated, and delivered to protect against damage.

C. All parts shall be properly protected so no damage or deterioration shall occur during a prolonged delay from shipment until installation is completed and the equipment is ready for operation.

D. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

E. The finished surfaces of all exposed flanges shall be protected by wooden blank flanges, strongly built and securely bolted thereto.

F. Factory-assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

A. Source Testing (Factory Acceptance Tests):
   1. Witnessed, virtual only.
   2. Furnish test reports and Manufacturer’s Certificate of Source Testing.

B. Installation Verification:
   1. Furnish Manufacturer’s Certificate of Installation Verification.

C. Functional Testing:
   1. Furnish Manufacturer’s Certificate of Functional Compliance.

D. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
   2. Number of sessions:
      a. Operations and Maintenance: 1 session.

E. Manufacturer services:
   1. As specified in Section 01756 - Commissioning.
   2. Manufacturer shall provide a representative who has complete knowledge of the proper operation and maintenance of the equipment to instruct representatives of the Contractor and Owner on the proper installation and operation and maintenance. Representative shall assist in functional and operational testing of the system.
      a. To include, but not be limited to, 6 nonconsecutive 8-hour days with 2 trips.

END OF SECTION

SECTION 13446

MANUAL ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Valve and gate actuators.
   2. Handwheel actuators.
   3. Hand-cranked geared actuators.
   4. Floor Boxes.
   5. Floor stands.
   6. Key operated valves.
   7. Bench stands.
   8. Accessory equipment and floor boxes.

1.02 REFERENCES

A. Aluminum Association (AA):
   1. DAF-45 - Designation System for Aluminum Finishes.

B. American Water Works Association (AWWA).

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. National Electrical Code (NEC).

1.03 SUBMITTALS

A. Shop drawings: Include shop drawings and product data with associated gate or valve as an integrated unit.

B. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.04 QUALITY ASSURANCE

A. Provide valve actuators integral with valve or gate, except for valve actuators utilizing T-wrenches or keys, and portable gate actuators intended to operate more than 1 valve.

B. Provide similar actuators by 1 manufacturer.

C. Provide gates and hand operating lifts by 1 manufacturer.

D. Provide hydraulic gate lifts by 1 manufacturer.

E. Provide hydraulic valve actuators and motorized actuators by 1 manufacturer.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.06 MAINTENANCE

A. Extra materials:
   1. Key operated valve keys or wrenches: Furnish a minimum 4 keys with 4-foot shafts and 3-foot pipe handles or wrenches with 4-foot shafts and 3-foot handles for operating key operated valves.

PART 2 PRODUCTS

2.01 VALVE AND GATE ACTUATORS

A. Valve actuators:
   1. Motorized actuators are specified in Section, 13447 - Electric Motorized Actuators.
   2. Manual actuators:
      a. Material: Type 316 stainless steel.
      b. Design: Hand lever.
      c. Spring release handle: 12-inch.
      d. Notch plate: 10 position.
      e. Secure with mounting bolts.
      f. Locking device so that valve can be locked in any position with a wing nut.
   3. Stem and cover:
      a. For submerged valves, provide extension stem as indicated on the Drawings.
   4. Limit switches: Provide limit switches on manually actuated valves where indicated on the Drawings:
      a. Limit switches: Heavy-duty, industrial grade, oiltight, with not less than 2 auxiliary contacts.
      b. Rating: Rated for 10 amps, 120 volts alternating current.
      c. Enclosure: NEMA Type 4X enclosure and with stainless steel levers and arms. Provide switch with NEMA Type 7 enclosure when switch is located within areas with NEC Class 1, Division 1 or Class 1, Division 2 designations as indicated on the Drawings.

B. Stem covers:
   1. Aluminum pipe:
      a. Threaded cap on top.
      b. Bolted aluminum flange on bottom.
      c. Slots cut 1- by 12-inch at 18 inches on center in front and back of pipe.

d. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.

2. Ultraviolet light resistant, clear butyrate plastic or polycarbonate pipe:
   a. Capped on the upper end.
   b. Either threaded into the top of the gate operators or held in place by bolt-down aluminum brackets.
   c. Capable of covering threaded portion of greased stems that project above actuators when gates or valves are opened or closed.
3. Staff gauges:
   a. Adhesive-backed mylar, suitable for outdoor service.
   b. Calibrated in hundredths of feet.
   c. Read the weir crest elevations directly.
   d. Gauge range: 1.5 feet minimum.
   e. Indicate the following elevations on each staff gauge:
      1) -0.75, -0.50, -0.25, 0.0, 0.25, 0.50, 0.75.
   f. Supplement with a stem-mounted pointer or indicator that permits direct observation of the weir gate crest elevation.
   g. Apply staff gauges to each stem cover after installation of the cover and after calibration and testing of the weir gates.
   h. Set gauges precisely by a survey crew using instruments acceptable to the Engineer.

C. Stem cover flanges, pipes and caps:
   1. After fabrication, etch and anodize to produce the following chemical finishes in accordance with AA publication DAF-45:
      a. A 41 - Clear Anodic Coating.
      b. C 22 - Medium Matte Finish.

D. Gate stem covers: Concentric with stem.

E. Position indicators:
   1. For all aboveground worm gear or traveling nut manual actuators, provide position indication on the actuator enclosure.
   2. Tail rods on hydraulic cylinders, or dial indicators with clear full-open and closed position indicators, calibrated in number of turns or percentage of opening.

F. Manual or power actuator size:
   1. Sized to deliver maximum force required under most severe specified operating condition, including static and dynamic forces, seat and wedge friction, and seating and unseating forces with safety factor of 5, unless otherwise specified.

G. Actuator size: Capable of supporting weight of suspended shafting unless carried by bottom thrust bearings; shaft guides with wall mounting brackets.

H. Provisions for alternate operation: Where specified or indicated on the Drawings, position and equip crank or handwheel operated geared valve actuators or lifts for alternate operation with tripod mounted portable gate actuators.

I. Operation: Counterclockwise to open with suitable and adequate stops, capable of resisting at least twice normal operating force to prevent overrun of valve or gate in open or closed position.

J. Open direction indicator: Cast arrow and legend indicating direction to rotate actuator on handwheel, chain wheel rim, crank, or other prominent place.

K. Buried actuator housing: Oil and watertight, specifically designed for buried service, factory packed with suitable grease, completely enclosed space between actuator housing and valve body so that no moving parts are exposed to soil; provide actuators with 2-inch square AWWA operating nut.

L. Worm gear actuators: Provide gearing on worm gear actuators that is self-locking with gear ratio such that torque in excess of 160 foot-pounds will not need to be applied to operate valve at most adverse conditions for which valve is designed.

M. Traveling nut actuators: Capable of requiring maximum 100 foot-pounds of torque when operating valve under most adverse condition; limit stops on input shaft of manual actuators for fully open and closed positions; non-moving vertical axis of operating nut when opening or closing valve.

2.02 HANDWHEEL ACTUATORS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Coating: Handwheel as specified in Section 09960 - High-Performance Coatings.

C. Mounting: Floor stand or bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

D. Bearings above and below finished threaded bronze operating nut: Ball or roller.

E. Wheel diameter: Minimum 24 inches.

F. Indicator: Counterclockwise opening with arrow, and word OPEN cast on top of handwheel indicating direction for opening.

G. Pull to operate: Maximum 40 pounds pull at most adverse design condition.

H. Stem travel limiting device: Setscrew locked stop nuts above and below lift nut.

I. Grease fittings: Suitable for lubrication of bearings.

2.03 HAND-CRANKED GEARED ACTUATORS

A. Type: Single removable crank; fully enclosed.

B. Mounting: Floor and bench stand. Unless otherwise indicated on the Drawings position actuator 36 inches (nominal) above top of walkway surface.

C. Operating nut: When scheduled for portable gate actuators.

D. Geared lifts: Single speed with minimum ratio of 2 to 1.

E. Teeth on gears, spur pinions, bevel gears, and bevel pinions: Cut.

F. Lift nuts: Cast manganese bronze.

G. Exterior surfaces on cast-iron lift parts: Smooth.

H. Bearings above and below flange on lift nuts: Ball or roller; capable of taking thrust developed by opening and closing of gates under maximum operating head; with bronze sleeve bearings and sufficient grease fittings for lubrication of moving parts, including bearings and gears.

I. Crank rotation indicator: Cast arrow with word OPEN in prominent location readily visible indicating correct rotation of crank to open gate.

J. Hand cranks: 15-inch radius; requiring maximum 25 pounds pull to operate gate at maximum operating head; with:
   1. Revolving brass sleeves.
   2. Gears, spur pinions, bevel gears, and bevel pinions with cut teeth.
   3. Cast manganese bronze lift nuts.
   4. Cast-iron lift parts with smooth exterior surfaces.

K. Indicator: Dial position type mounted on gear actuator; enclosed in cast-iron or aluminum housing with clear plastic cover; marked with fully open, 3/4, 1/2, 1/4, and closed positions.

2.04 FLOOR BOXES

A. Manufacturers: The following or equal:
   1. Waterman Industries, Inc.

B. Floor boxes: Cast-iron; with:
   1. Counter type indicator.
   2. Hinged, lockable lid with directional arrow.
   3. 2-inch square AWWA operating nut.
   4. Packing gland providing drip-tight seal around valve shaft.

2.05 FLOOR STAND

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Floor stand assemblies: Heavy-duty cast-iron, suitable for mounting specified actuator.

2.06 BENCH STANDS

A. Manufacturers: One of the following or equal:
   1. Rodney Hunt Co.
   2. Waterman Industries, Inc.

B. Bench stands: Handwheel actuators or hand crank, geared actuators conforming to hand-cranked geared actuator requirements, except capacity to be mounted on haunch, wall bracket, or self-contained gate yoke.

2.07 ACCESSORY EQUIPMENT

A. Wall brackets or haunches: As indicated on the Drawings.

B. Stems: Stainless steel; sized to match output of actuator; minimum gate or valve operating stem diameter; maximum 200 slenderness ratio.

C. Stem couplings: Stainless steel; internally threaded to match stem; lockable to stem by set screw.

D. Stem guides: Cast-iron with silicon bronze bushing; maximum 200 slenderness ratio; capable of being mounted with wall bracket; adjustable in 2 directions.

E. Wall brackets: Cast-iron, capable of withstanding output of actuator, adjustable in 2 directions.

F. Stem stuffing boxes: Cast-iron, with adjustable gland and packing.

G. Fasteners: Type 316 stainless steel.

H. Anchor bolts: As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry except that the material shall be Type 316 stainless steel.

I. Geared valve actuators: Provided with cut gears, either spur or worm; sized to operate valves at most adverse design condition; with maximum 40-pound pull at handwheel or chain wheel rim.

J. Geared valve traveling nut actuators: Acceptable only where specified or indicated on the Drawings.

K. Accessory equipment for valves and gates requiring remote actuators: Operating stems, stem couplings, stem guides, wall brackets, and stem stuffing boxes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install floor boxes in concrete floor with lid flush with floor.

B. After installation of gate and stem covers, mark stem covers at point where top of stems are at full-open position and at closed position.

C. Attach floor stand to structure with anchor bolts.

D. Install stem stuffing boxes where operating stems pass through intermediate concrete floor slabs.

3.02 SCHEDULES

A. Geared actuators: Provide geared actuators for following valves:
   1. Butterfly valves larger than 6 inches, nominal size, on liquid service.
   2. Butterfly valves larger than 10 inches, nominal size, on gas and air service.
   3. Plug valves 6 inches, nominal size, and larger.

B. Handwheel actuators: Provide handwheel actuators for valves mounted 6 feet or less above floors.

C. Chain wheel actuators: Provide chain wheel actuators for valves mounted more than 6 feet to centerline above floors.

3.03 OWNER TRAINING

A. Owner Training:
   1. Perform Owner training as specified in Section 01756 - Commissioning.
      a. Training topics should focus on maintenance
   2. Number of sessions:
      a. Operations and Maintenance 1.

END OF SECTION

SECTION 13447

ELECTRIC ACTUATORS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electric motor-driven actuators for valves and gates.

B. Equipment tag numbers:
   1. As scheduled.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C504 - Standard for Rubber-Seated Butterfly Valves.
   2. C542 - Standard for Electric Motor Actuators for Valves and Slide Gates.

B. International Organization for Standardization (ISO):
   1. 12944 - Paints and Varnishes.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01600 - Product Requirements.

B. Provide a complete list/schedule of actuators being provided with their associated tag names, as indicated on the Drawings and/or Specifications, service process area and the size of the valve they are actuating.

C. Product data:
   1. Electrical ratings:
      a. Voltage and number of phases.
      b. Starting and running current.
      c. Voltage levels and source for control and status.
   2. Description of integral control interface.
   3. Remote control station components (If applicable).
   4. Environmental ratings, including NEMA enclosure rating and submergence capabilities.
   5. Gear ratios for both manual and motorized actuation.
   6. Opening and closing directions.
   7. Electric motor data.
   8. Allowable starts per hour.
   9. List of included options and accessories.

10. Full travel times.
11. Gearbox data including gear ratio, and gearbox efficiency.

D. Shop Drawings:
   1. Wiring diagrams:
      a. Include options and expansion cards furnished with each actuator.
   2. Dimensioned drawings of each valve and actuator combination.
      a. Include valve and actuator orientation for each valve. Contractor and Supplier are responsible to confirm orientation, accessibility, reachability for all actuators.
      b. Submitted actuator orientation shall be approved by Engineer.
   3. Dimensioned drawings of each valve gearbox.
      a. Include gearbox orientation for each valve.

E. Calculations:
   1. Operating torque.
   2. Maximum torque calculations for seating and unseating.
   3. Maximum operating torque at starting and normal operation.

F. Installation instructions:
   1. Detail the complete installation of the equipment including rigging, moving, and setting into place.
   2. Provide manufacturer's installation instructions.

G. Quality Control Submittals:
   1. Manufacturer's representative qualifications.
   2. Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   3. Manufacturer's Certificate of Installation as specified in Section 01756 - Commissioning.
   4. Manufacturer's Certificate of Functional Compliance as specified in Section 01756 - Commissioning.

H. Owner Training Submittals:
   1. As specified in Section 01756 - Commissioning.

I. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.04 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

1.05 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.06 MAINTENANCE

A. As specified in Section 01600 - Product Requirements.

B. Spare parts:
   1. Provide the following (minimum 10 percent of total number of actuators of each model type furnished, but not less than 1 for each model of actuator furnished):
      a. Stem nut.
      b. Worm shaft subassembly.
      c. Drive sleeve subassembly.
      d. Complete actuator seal kit.
      e. Actuator gearbox oil (sufficient quantity to fill 4 gearboxes).
      f. Encoder.
      g. Control module.

C. Setting tool:
   1. If required for setting or configuring the actuator, provide a handheld setting tool. Furnish 1 setting tool for every 10 actuators.
      a. Capable of communicating with PC-based configuration software and transferring the following in either direction between the computer and programmer and setting tool, and between the setting tool and actuator.
      b. Actuator configurations:
         1) Capable of storing up to 10 different configurations.
      c. Diagnostic data:
         Capable of storing 4 complete sets of diagnostic data.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Lines 3 inches and smaller:
   1. The following or equal:
      a. Rotork Controls Inc.
         1) ROMpak (Quarter-turn).

B. Lines 4 inches and larger:
   1. One of the following, or equal:
      a. Auma:
         1) SA/GK (multi-turn) with Aumatic AC controls.
         2) SA/GS (quarter-turn) with Aumatic AC controls.
      b. Limitorque Corp.:
         1) Accutronix MX for multi-turn applications.
         2) Accutronix QX quarter-turn applications.
      c. Rotork Controls Inc. IQ3 Range:
         1) IQ for multi-turn applications.
         2) IQT for quarter-turn applications.

2.02 MATERIALS

A. Enclosures:
   1. Constructed of materials suitable for the environment where the actuator will be installed.
   2. Stainless steel external fasteners.
   3. Provide O-ring seals for each of the following areas:
      a. Between the terminal compartment and the internal electrical elements.
      b. Between the mechanical and electrical portions to protect from the ingress of oil, and to protect the mechanical components of oil from dust and moisture when the electrical terminal is open.
   4. Ratings
      a. As scheduled and specified:
      b. NEMA Type 6P: Double sealed and IP68 rated for prolonged submergence.
      c. XP: Factory Mutal (FM) approved for Class I, Division 1 and Division 2 locations.

B. Coatings:
   1. Material requirements:
      a. Factory prime and coat with an ISO 12944 classification coating of C5M (Marine, offshore estuaries with high salinity) coating with 15 year durability.
      b. Touch-up damaged coatings with manufacturer provided coating repair kit.
   2. Application requirements:
      a. Painting shall commence within 4 hours of blast cleaning.
      b. Each paint coat within the system is to be applied in accordance with the paint manufacturer's instructions.
      c. Paint thickness shall be checked for each coat on each actuator.
   3. Qualification requirements:
      a. Operators shall be experienced and proficient in surface preparation and coating application techniques.
      b. Personnel shall have relevant knowledge of health and safety hazard, use of protective equipment, coating materials, mixing and thinning coatings, coating pot life, surface requirements, etc.
      c. Personnel carrying out inspection or verification shall be certified as NACE coating inspector or equivalent such as ICorr.

2.03 CHARACTERISTICS FOR ACTUATORS ON LINES 3 INCHES AND SMALLER

A. Actuators for valves 3 inches and smaller:
   1. Complete and operable with all components and accessories required for operation.
   2. Power supply:
      a. Valve motion independent of power supply phase rotation.
      b. Power supply as shown on Electrical Drawings
   3. Size actuator to move valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
      a. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.

4. For outdoor or vault installations, provide an integral anti-condensation heater when available as an option.
5. Control inputs:
    a. Capable of using discrete 24 VDC.
    b. Controls the valve when local-stop-remote is in REMOTE.
    c. Material: Type 316 stainless steel.
    d. Provide the following inputs at the actuator:
        1) OPEN.
        2) CLOSE.
6. Status outputs:
    a. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
        1) FULLY CLOSED.
        2) FULLY OPEN.
        3) REMOTE.
    b. Output contacts rated for 5 amps, 120 VAC.
7. Analog input:
    a. Provide a 4 to 20 analog input for analog modulating valves when indicated on the Drawings.
    b. Modulate valve to maintain position based on analog input value.
    c. Maximum input impedance 250 ohms.
8. Analog output:
    a. Provide an isolated 4 to 20 mA analog output when indicated on the Drawings.
9. Components:
    a. Motors:
        1) Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
        2) Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
            a) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
            b) 60 starts per hour minimum for open/close service.
    b. Manual actuation:
        1) Hand wheel for manual operation.
    c. Gearing: Self-locking, high-alloy steel gears.

2.04 CHARACTERISTICS FOR ACTUATORS ON LINES 4 INCHES AND LARGER

A. Provide actuators complete and operable with all components and accessories required for operation.

B. Power supply:
1. Voltage and phases as indicated in the Motorized Actuator Schedule.
2. Valve or gate motion independent of power supply phase rotation.
3. Provide an internal backup power source or mechanical indicator to maintain settings and track valve position when main power is off.
4. Actuators shall incorporate major components such as the motor, starter, local controls, terminals, etc., housed within a self-contained, sealed enclosure.

C. Size actuator to move gates or valves from full open to closed position within the time indicated in the Motorized Actuator Schedule:
    1. If an operating time is not indicated on the Motorized Actuator Schedule, size the actuator to move gates or valves at minimum 12 inches per minute under maximum load. Measure rate of closure for valves at maximum diameter of disc, plug, or ball.
    2. Size actuators so that gear boxes are not required where possible.

D. Control interface:
    1. Configuration:
        a. Provide a non-intrusive, non-contacting interface for configuring input and output settings, control values, ranges, torque switch settings, valve positions switch settings, and options.
            1) Configurable from a handheld configuring tool or input devices on the actuator.
    2. Local interface, integral to actuator:
        a. Non-intrusive, non-contacting selector switches:
            1) LOCAL-STOP-REMOTE:
                a) Motor actuator operation is prevented with the switch in STOP.
            2) OPEN-CLOSE:
                a) Controls the valve when LOCAL-STOP-REMOTE is in LOCAL.
                b) Spring return to center.
                c) Configurable between maintained (actuator runs until end of travel, high torque, or a LOCAL-STOP-REMOTE is switched to STOP) and momentary (actuator stops when lever is released).
        b. Local display:
            1) Valve fully open and fully closed indicators.
            2) Numerical display showing actual valve or gate position in percent of travel.
    3. Remote control station - (LCP):
        a. For actuators located more than 5 feet above finished floor/grade or where indicated on the Drawings in the Schedule.
            1) NEMA rating to match those to the associated Actuator Schedule.
                a) Where the rating is not listed, use NEMA Type 4X enclosures for non-hazardous areas, and explosion-proof (XP) Class I Division 1 for hazardous areas.
                b) Pilot devices shall be 30 millimeters and pilot lights shall be illuminated by LEDs.
            2) LOCAL-STOP-REMOTE selector switch.
            3) LOCAL mode control devices:
                a) Operate valve when LOCAL-STOP-REMOTE integral to actuator is in REMOTE and LOCAL-STOP-REMOTE on remote control station is in LOCAL.
                b) OPEN-STOP-CLOSE maintained switch or OPEN, STOP, and CLOSE pushbuttons where Maintained operation is indicated in the Actuator Schedule.
                c) OPEN-CLOSE spring-return switch or OPEN and CLOSE pushbuttons where momentary operation is indicated in the Valve and Gate Schedule.
            4) Pilots' lights to indicate valve position:
                a) Fully open.

b) Fully closed.

4. Control inputs:
   a. Capable of using discrete 24 VDC.
   b. Controls the valve when LOCAL-STOP-REMOTE is in REMOTE.
   c. Isolated inputs capable of operating from external control voltage source or internal power supply:
   d. Provide the following inputs:
      1) OPEN.
      2) CLOSE.
      3) STOP.
   e. OPEN and CLOSE inputs configurable between maintained (actuator runs until end of travel, high torque, or a STOP input) and momentary (actuator stops when command is removed).
5. Status outputs:
   a. Monitor relay output: Dry contact, normally closed, opens when actuator is not in REMOTE or in the event of any internal fault or alarm condition.
   b. Dry contact outputs configured for the functions indicated on the Drawings. Provide the following outputs for all actuators:
      1) Fully closed.
      2) Fully open.
      3) LOCAL-STOP-REMOTE in REMOTE position.
   c. Output contacts rated for 5 amps, 120 VAC, and 24 VDC.
6. Analog input:
   a. Provide a 4 to 20 mA analog input for analog modulating valves when indicated on the Drawings.
   b. Modulate valve to maintain position based on analog input value.
   c. Maximum input impedance 250 ohms.
7. Analog output:
   a. Provide an isolated 4 to 20 mA analog output when indicated on the Drawings.
      1) Loop power sourced from the actuator power supply.
      2) Capable of driving into a load up to 500 ohms.
      3) Output proportional to process value(s) indicated on the Drawings.
      4) Valve or gate position.
      5) Operating torque.

E. Features:
   1. Time delay on reversal: Incorporate time delay between stopping actuator and starting in opposite direction to limit excessive current, torque, and heating from instantaneous reversal.
   2. Data logging:
      a. Store diagnostic data and reference data.
      b. Time-stamped historical operating data, including number of operations and most recent operations.
      c. At a minimum, starting torque, maximum running torque, and end of travel torque.
         1) Store reference data (recorded during commissioning) and data from last operation.
   3. Provide display of logged data on the actuator, or provisions to download to a personal computer.

F. Components:
    1. Motors:
        a. Specifically designed for valve actuator service with high starting torque, totally enclosed non-ventilated construction.
        b. Torque ratings equal to or greater than that required for valve seating and dynamic torques with a 25 percent factor of safety.
            1) Design requirements for rubber-seated AWWA butterfly valves:
                a) Design actuators for maximum gate or valve operating torque, in accordance with and using safety factors required in AWWA C504 and AWWA C542.
                    (1) Valve actuator torque requirement for open-close service: Not less than the required valve-seating and dynamic torques under design operating conditions in accordance with AWWA C504.
                    (2) Valve actuator torque requirement for modulating service: Not less than twice the required valve dynamic torque under design operating conditions in accordance with AWWA C504.
            2) Design requirements for slide gates, gate valves, knife gate valves, globe valves, and diaphragm valves:
                a) Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C542.
                b) Design for the maximum torque and thrust running load over the full cycle.
                c) Maximum torque or thrust rating: Actuator stall torque or maximum thrust output shall not exceed the torque or thrust capability of the valve or gate, as determined by the valve or gate manufacturer.
        c. Capable of being removed and replaced without draining the actuator gear case.
        d. Motor bearings shall be amply proportioned of the anti-friction type and permanently lubricated.
        e. Rated for operating under the following conditions without exceeding temperature limits with ambient temperature of 40 degrees Celsius.
            1) Continuous operation for 15 minutes or twice the open-to-close operating time (whichever is greater) at normal operating torque or 33 percent of maximum torque (whichever is greater).
            2) 60 starts per hour for open/close service or 1,200 starts per hour for modulating service.
        f. Provide the following motor protection features:
            1) Jammed valve (no valve motion detected through a time delay).
            2) High motor temperature (sensed by an embedded thermostats).
            3) High torque.
            4) Single phasing protection.

G. Position sensing:
    1. Electronic and adjustable using a solid-state encoder wheel.
        a. Mechanical limit switches and potentiometers are not acceptable.
    2. Capable of retaining position and monitoring valve or gate motion when valve is manually actuated and when main power is not present.

3. Valve range and position switch outputs field adjustable.

H. Torque sensing:
   1. Torque shutdown setting: 40 percent to 100 percent rated torque:
      a. Adjustable in 1 percent increments.
   2. Torque display: 0 to 100 percent-rated torque.
   3. Capable of interrupting control circuit during both opening and closing and when valve torque overload occurs.
   4. Independent of variations in frequency, voltage, or temperature.
   5. Actuator shall store actual operational torque curves for retrieval by plant maintenance staff.
   6. Provide a temporary inhibit of the torque sensing system during unseating or during starting in mid-travel against high inertia loads.
   7. Provide visible verification of torque switch status without any housing disassembly.

I. Manual actuators:
   1. Hand wheel for manual operation.
      a. Maximum 80-pound pull on rim when operating gate or valve under maximum load.
      b. Provide pull chain when motorized actuator is located more than 6 feet above floor surface.
         1) Chain shall be of sufficient length to reach approximately 4 feet above the operating level.
         2) Where the chain obstructs an aisle or walkway, provide holdback or other means to ensure chain does not create a nuisance or hazard to operating personnel.
         3) Provide Type 316 stainless steel.
   2. Declutch lever: Padlockable, capable of mechanically disengaging motor and related gearing and freeing hand wheel for manual operation.

J. Gearing: Hardened alloy steel spur or helical gears and self-locking, alloy bronze worm gear set.
   1. Accurately cut to ensure minimum backlash.

K. Bearings:
   1. Anti-friction bearing with caged balls or rollers throughout.
   2. Sealed-for-life type thrust bearings housed in a separate thrust base.

L. Drive bushing:
   1. Easily detachable for machining to suit the valve stem or gearbox input shaft.
   2. Positioned in a detachable base of the actuator.

M. Lubrication:
   1. Provide totally enclosed actuator gearing with oil or grease filled gear case suitable for operation at any angle.
   2. Actuators requiring special or exotic lubricants are not acceptable.

2.05 ACCESSORIES

A. Software:
   1. Furnish PC-based diagnostic and configuration software to display diagnostic data and configure actuators.
   2. Provide software communications to the valve actuator and handheld setting tool.
      a. Provide accessories and drivers required for operation and communications with a standard personal computer running Microsoft Windows.
      b. Where infrared communications are used, furnish an IrDA to USB adapter with a mounting device to secure the infrared element to the valve actuator IrDA port:
         1) Provide with a minimum cable length of 3 feet, capable of being extended with a standard USB extension cable.

B. Termination module cover:
   1. For actuators on a valve network, provide a means to keep the valve network in service, in the event where the actuator must be removed.
   2. Provide sunshades for outdoor installations of remote control stations that use an LCD or similar screen. Regular pushbutton, sector switches, and pilot light control stations will not require a sunshade.

2.06 SOURCE QUALITY CONTROL

A. Source Testing:
   1. Design and performance test reports in accordance with AWWA C542.
   2. Test each actuator with a simulated load.
      a. Simulate a typical valve load.
   3. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Install the equipment in accordance with the manufacturer's instructions.

C. Position visual indicators so that they are most easily visible.

D. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

3.02 FIELD QUALITY CONTROL

A. As specified in Section 01756 - Commissioning, Section 15958 - Mechanical Equipment Testing, and this Section.

B. Functional Testing:
    1. Installed actuator:
        a. Test witnessing: Witnessed.
        b. Conduct Level 2 General Equipment Performance Tests.
        c. Conduct Level 2 Vibration Tests.
        d. Conduct Level 2 Noise Tests.
    2. Electrical Instrumentation and Controls:
        a. Test witnessing: Witnessed.
        b. Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.
    3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.03 OWNER TRAINING

A. Owner Training:
    1. Perform Owner training as specified in Section 01756 - Commissioning.
        a. Training topics should focus on maintenance
    2. Number of sessions:
        a. Operations and Maintenance: 1.

3.04 ACTUATOR SCHEDULE

A. Provide actuators indicated on the Drawings:
    1. Major process valves and actuator requirements are listed in the Valve Schedule in the Drawings.
        a. The Valve Schedule does not include all number and types of actuators required for the Project.

END OF SECTION

SECTION 14634

TOP RUNNING SINGLE GIRDER BRIDGE CRANE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Top running single girder traveling bridge crane.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE).

B. Crane Manufacturers Association of America, Inc. (CMAA):
   1. Specification No. 74 - Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist.
   2. Specification No. 78 - Standards and Guidelines for Professional Services Performed on Overhead and Traveling Cranes and Associated Hoisting Equipment.
   3. Specification No. 79 - Crane Operator's Manual.

C. Hoist Manufacturers Institute (HMI).

D. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

E. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Calculations.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Parts, devices, and accessories, including special safety and control devices.
   2. Motor Submittals as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

C. Shop Drawings:
   1. Dimensional drawings and other construction details, including materials of construction, equipment weights, electrical connection diagrams, and schematics showing electrical control.

D. Delegated Design Submittals:
   1. Structural calculations for runway beams, hoists, rails, bridge beams, and anchorage.

E. Installation instructions:
   1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
   2. Provide manufacturer's installation instructions.

F. Quality Control Submittals:
   1. Manufacturer's representative qualifications.
   2. Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   3. Manufacturer's Certificate of Installation Verification as specified in Section 01756 - Commissioning.
   4. Manufacturer's Certificate of Functional Compliance as specified in Section 01756 - Commissioning.

G. Certificates:
   1. Certificate of tests conducted by the crane manufacturer in accordance with industry standards and federal regulations.
   2. Load test certificate.

H. Owner Training Submittals:
   1. As specified in Section 01756 - Commissioning.

I. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include CMAA Specification No. 79.
   3. Include a troubleshooting chart covering the complete system and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.05 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements, Section 15050 - Common Work Results for Mechanical, and the manufacturer's instructions.

B. Unload and store cranes under the manufacturer's supervision.

1.06 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 15050 - Common Work Results for Mechanical Equipment.

B. Top running, single girder, bridge crane as indicated on the Drawings.

2.02 MANUFACTURERS

A. One of the following:
   1. ACCO.
   2. Heco Pacific Manufacturing.
   3. Milwaukee Crane.
   4. P&H.
   5. ProservCrane Group.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Design in accordance with CMAA Specification No. 74.

B. Cranes shall be in accordance with CMAA Service Class A2 for infrequent use.

C. Top running, single-girder traveling bridge crane system with electric motor-driven bridge and electric motor-driven trolley and hoist, bridge crane girders, girders cross bracing, end trucks, runways, rails, end stops, complete electrification and reels, and accessories based on the following values:

Capacity	3 tons
Span (center to center crane runway)	See Drawings
Elevation of hook in highest position, not lower than	4785.0
Elevation of hook in lowest position, not higher than	4773.75
Elevation of operating floor (floor slopes), approximate position	4773.75
Approximate hoisting speed, (minimum/maximum for range of speed)	2 - 20 feet per minute
Approximate travel speed of trolley (minimum/maximum for range of speed)	8 - 80 feet per minute
Approximate travel speed of bridge	20 - 100 feet per minute
Hoist motor, minimum	7 horsepower
Trolley motor, minimum	1 horsepower
Bridge motors, minimum	2 at 0.75 horsepower

D. Arrange working parts for convenient inspection, lubrication, adjustment, repair, or replacement.

2.04 RUNWAYS AND BRIDGE

A. Runways:
   1. Structural steel as specified in Section 05120 - Structural Steel Framing, capable of supporting crane components. Designed for a maximum deflection of 1/600 of span.
   2. Crane rails:
      a. ASCE crane rails designed by the manufacturer in accordance with the Specifications and criteria indicated on the Drawings.
         1) Splice using light splice joints by bolting.
      b. Rail:
         1) Arranged so that joints on opposite sides of the runway will be staggered with respect to each other and with respect to the wheelbase of the crane.
         2) Rail joints shall not occur at crane girder splices.
   3. Rail clamps:
      a. Use steel plates with eccentric fillers for adjustment of rail location.
      b. Double-hole fixed clamps at 2 feet apart on each side of rail in staggered position.

B. Bridge:
   1. Top running, single girder type, rigidly supported by end trucks on crane rail:
   2. End trucks:
      a. Structural steel members capable of distributing loading equally to each wheel.
      b. Shall carry the rated load between end truck wheels while the rated load is lifted at one end of the crane bridge.
   3. Wheels: Minimum 5-inch diameter; double flanged with rotating axles and safety lugs; forged steel, hardened to 425 Brinell, fitted with anti-friction bearings with seals and grease fittings.
   4. Bearings: Fitted with seals to exclude dust and moisture and shall be lubricated for life.
   5. Stops and bumpers: Permanent to prevent trolley overrun and capable of absorbing energy and stopping moving bridge at end of travel.
   6. Motorized.

2.05 BRIDGE DRIVE UNIT

A. Type:
   1. Variable-speed, adjustable torque cushioned start, motor-driven CMAA-4 units at ends of bridge.
   2. Tractor type drives are not acceptable.

B. Speed reducers: Oil-lubricated with oiltight cases.

C. Shaft bearings: Anti-friction.

D. Holding brakes: Cushioned stop rated at 100 percent of full load motor torque.

E. Motors:
   1. Designed and constructed for crane service.
   2. Horsepower: As scheduled.
   3. Revolutions per minute: 1,800.
   4. Enclosure: TENV.
   5. Electrical characteristics: 460 volt, 3 phase, 60 hertz.
   6. Class F insulation with Class B temperature rise.
   7. Reversible.

2.06 TROLLEY AND HOIST

A. Trolley drive:
   1. Provide with variable-frequency drive and variable motor and direct current cushioned stop holding brakes.
   2. Tractor drive units are not acceptable.
      a. Double-flanged wheels with rotating axles: Forged steel, hardened to 425 Brinell, fitted with anti-friction bearings with seals and grease fittings.
      b. Drive units: Separate for each runway or one that drives wheels on runway through a common shaft.
      c. Trolley head wheels: Minimum 4-inch diameter wheels with safety lugs. Hardened steel, mounted on permanently lubricated anti-friction bearings.
      d. Stops and bumpers: Capable of absorbing energy and stopping moving trolley when at end of travel.

B. Hoist:
   1. HMI Duty Service Classification H2; dual-speed, electric motor-driven, with load break, lower limit switch and an overload device.
   2. Load break: Mechanical Weston multiple disc type running in an oil bath and automatically holding loads indefinitely and permitting lowering without acceleration under full control, and direct current operated motor brake acting directly on the motor pinion shaft the instant power is shut off, capable of sustaining a load equal to 125 percent of hoist capacity, at least 15 operations per minute, and controlled smooth inching for both directions in vertical plane.
   3. Hoisting drum: Steel or cast iron with machined grooves to depth equal to 1/2 rope diameter; capable of retaining at least 2 complete wraps of rope with hook in lowest position and accommodating full rope length without overlapping when hook is in highest position.
   4. Hoisting rope: Specifically designed for specified service loads; preformed, improved plow steel with fiber core; double-reeved.
   5. Hoisting block: Steel with hook supported on ball or roller bearings.
   6. Hoisting block hook: Forged or rolled steel freely rotating on bearing support and with heavy-duty type safety latches.

C. Drive speed reducers: Oil-lubricated heat-treated steel helical gears with oiltight cases, and shafts running in anti-friction bearings.

D. Drive motors:
   1. Designed and constructed for crane service.
   2. Horsepower: As scheduled.
   3. Revolutions per minute: 1,800.
   4. Enclosure: TENV.

5. Electrical characteristics: 460 volt, 3 phase, 60 hertz.
6. Class F insulation with Class B temperature rise.
7. Inverter duty rated in accordance with NEMA MG-1, Part 31.

2.07 ELECTRICAL AND CONTROL

A. Electrification:
   1. Electric power: 480 volt, 3 phase, 60 hertz electric service with junction boxes for connection of field services and ground pad.
   2. Runway: Insulated bar electrification 3 power, 1 ground.
   3. Bridge: Industrial rigid track festoon system.
   4. Control voltage: 120 volts alternating current, supplied from a transformer on the crane.

B. Control:
   1. Capable of controlling hoist speed, trolley travel, and bridge travel.
   2. Radio controlled wireless, momentary-contact, maintain-pressure type, automatically de-energizing, and 2-speed pushbuttons.
   3. Pushbuttons:
      a. Start-stop.
      b. 2 pushbuttons for hoisting, 1 for each direction.
      c. 2 pushbuttons for trolley travel, 1 for each direction.
      d. 2 pushbuttons for crane travel, 1 for each direction.
      e. Directions of horizontal motions clearly marked on the bridge or trolley and on the control pendant.
   4. Provide 2 wireless controllers.
   5. Limit switches: Geared to limit the up and down travel and by hook to stop hoist at highest safe point.

C. Control and electrical enclosures: NEMA Type 4.

2.08 FINISHES

A. Products with a factory or shop applied coating system:
   1. Coat products with the manufacturer’s standard surface preparation and applied permanent coating system.
   2. Equipment subject to sunlight shall have a ultraviolet stable topcoat.
   3. Color and gloss: Manufacturer’s standard.
   4. Unexposed surfaces that require coating, such as the interior of cabinets, enclosures, and equipment shall be given the manufacturer’s standard permanent coated finish.
   5. The following shall not be coated:
      a. Running surfaces of beams and wheels.

2.09 SOURCE QUALITY CONTROL

A. Source Testing (Factory Acceptance Tests):
   1. Not witnessed.
   2. As specified in Section 01756 - Commissioning.
   3. Tests required to comply with CMAA standards and federal regulations.
   4. Test as specified in Section 15958 - Mechanical Equipment Testing.

5. Furnish test reports and the Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 GENERAL

A. Do not use cranes to handle loads until the load test certificate has been received.

B. Do not use cranes for construction.

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install equipment as indicated on the Drawings and the manufacturer's written installation instructions.

B. Tolerances:
   1. In accordance with CMAA Specification No. 74.

C. Repair damaged areas of coated surfaces with compatible materials to equal thickness and color match of undamaged areas.

D. Ensure overhead and lateral clearance between the crane and obstructions in accordance with CMAA Specification No. 74.

E. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

A. Functional Testing:
   1. Witnessed by:
      a. The Engineer.
   2. Testing requirements:
      a. Test with not less than 110 percent or more than 125 percent of rated load capacity.
      b. Provide load and slings for tests. Remove loads and slings after tests are complete.
      c. Operate crane through a full lift and lowering cycle, and travel of bridge and trolley to demonstrate functions of hoisting, braking, and traveling.
         1) Crane shall function quietly, smoothly, and safely.
   3. Furnish test reports and the Manufacturer's Certificate of Functional Compliance.

3.05 OWNER TRAINING

A. Perform Owner Training as specified in Section 01756 - Commissioning.
   1. Number of sessions:
      a. Operations and Maintenance: 1.

END OF SECTION

SECTION 15050

COMMON WORK RESULTS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mechanical equipment requirements for:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation requirements.

1.02 REFERENCES

A. American Bearing Manufacturers Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. American Gear Manufacturers Association (AGMA) Standards.

C. ASTM International (ASTM):
   1. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   2. A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   3. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   4. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   5. F594 - Standard Specification for Stainless Steel Nuts.

D. Hydraulic Institute (HI):
   1. 9.6.8 - Guideline for Dynamics of Pumping Machinery.

E. International Concrete Repair Institute (ICRI):
   1. Guideline No. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

F. International Organization for Standardization (ISO):
   1. 21940 - Mechanical Vibration - Rotor Balancing - Part 1: Introduction.

G. National Electrical Manufacturers Association (NEMA):
   1. MG-1 - Motors and Generators.

H. Society for Protective Coatings (SSPC):
   1. SP-1 - Solvent Cleaning.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Definitions used in this specification and equipment Submittals for terms related to rotor-dynamic pumps shall be in accordance with HI 9.6.8, Appendix A, as clarified below.
   2. These definitions shall be applied to equipment other than pumps, unless otherwise specified in Technical Sections.
   3. Rotordynamic analysis level:
      a. The level of detail required for rotordynamic analysis is indicated in the Technical Sections schedules as None (no analysis required), Analysis Level 1, Analysis Level 2, or Analysis Level 3, which correlate to increasing levels of required detailed equipment design analysis. Analysis Levels 1, 2, and 3 are based on HI 9.6.8.
      b. Where these specifications differ from HI the more stringent shall apply.
   4. Resonant frequency:
      a. The frequency of a periodic excitation force that is close to the natural frequencies of an object. Also known as critical frequency, critical speed, or resonant speed.
      b. An undamped resonant frequency within the separation margin is always considered harmful under Level 1 analysis.
      c. A resonant frequency that occurs within a separation margin of 15 percent above or below the operating speed range and has a log decrement greater than +0.3 is considered harmful under Level 2 and Level 3 analysis.
   5. Separation margin:
      a. The span of operating speeds within which interference between excitation orders and resonant frequencies indicate the possibility of harmful vibrations.
      b. The separation margin for a specific application extends 15 percent above and 15 percent below the span of operating speed required for the specified performance conditions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination.
   1. Show roof penetrations for mechanical equipment on roof drawing Submittal and include mechanical equipment information:
      a. Type.
      b. Size.
      c. Location.
      d. Configuration of penetration and the surround.
      e. Weight.
      f. Anchoring and support details.

1.05 SUBMITTALS

A. Items in this Section are components of equipment or systems specified in other sections.
   1. Include data for this Section's components with the equipment or system Submittal.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General:
   1. Equipment manufacturer's responsibility extends to selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries to provide a complete, operable unit.
   2. Manufacturer shall analyze rubber-bearing vertical-column pumps and equipment identified as non-reversing in the Technical Sections for reverse rotation and provide non reversing motor ratchets.
   3. Equipment that prevents reverse rotation shall be capable of both:
      a. Handling 150 percent of the maximum torque at maximum operating speed.
      b. 150 percent of torque that will be generated in reverse direction due to equipment shutoff head as calculated by the manufacturer.
   4. Motor shall be designed to run safely in the reverse direction at up to 140 percent times the reverse runaway speed under shutoff head conditions.

B. Rotordynamic analysis and vibration testing:
   1. Submit information for the Rotordynamic Analysis Level specified for each piece of equipment as shown in the Technical Sections prior to manufacture of the equipment.
   2. Rotordynamic analysis shall be performed on "like-new" and "as-worn" conditions, representing conditions when first installed and conditions when parts wear to the manufacturer's maximum allowable operating tolerances. Conditions assumed for the "as-worn" condition shall be 2 times the "like-new" tolerances unless specified otherwise.
   3. Rotordynamic analysis criteria:
      a. Torsional excitation forcing function magnitudes shall be no less than 1 percent of the maximum transmitted torque at given speed.
      b. Motor mass elastic information in accordance with NEMA MG-1 shall be obtained from the original equipment manufacturer and included in the analysis. Motors shall be precision balanced to ISO 21940 grade G2.5.
      c. Bearings:
         1) At maximum bearing loads an L-10 life of 100,000 hours in accordance with ABMA 9-11 to be proven.
   4. Submit factory and field testing requirements as specified in the Technical Sections and specified in Section 15958 - Mechanical Equipment Testing after manufacture and installation respectively.
   5. Repair, replace, and modify equipment exhibiting vibration performance that does not meet criteria specified in this Section at no additional cost to Owner.
      a. Acceptable remedies include adjustments to equipment component geometry, materials, energy absorbing couplings, etc.

b. Locking out speed interval(s) within equipment specified operating range is unacceptable.

6. Vibration analysis expert:
   a. Provide when specified in the equipment Technical Sections.
      1) Must be a 3rd party, unaffiliated with the equipment vendor or Contractor.
   b. Vibration analysis expert and analysis shall be provided by one of the following or equal:
      1) Engineering Dynamics Inc. (EDI, Texas).
      2) Mechanical Solutions, Inc. (MSI, New Jersey).
   c. Analysis shall be:
      1) Stamped by a registered professional mechanical engineer.
      2) Verified in-situ by the vibration analysis expert including certification that installation conforms to field conditions assumed in the reports.
      3) Verified in-situ by the vibration analysis expert including witness of at least 1 field vibration test, and certification that vibration measurements corroborate the rotordynamic analysis.
      4) Supplemented with additional field investigation and analysis should conditions during field vibration testing activity indicate non-compliance with these specifications; supplemental field investigation and analysis shall indicate remedies to comply with the specifications and shall be stamped by a registered professional mechanical engineer.
7. Rotordynamic Analysis Level 1:
   a. Before the equipment is released for manufacture it shall be determined that the equipment/motor structures do not have any harmful resonant frequencies in the lateral and torsional modes. Representative analysis results for identical equipment may be submitted.
   b. Calculate rotor lateral and torsional and equipment structural components' lateral frequencies with a spreadsheet calculation or finite element analysis software.
      1) Equipment structure lateral frequency shall include the motor.
      2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
   c. Determine the equipment system components (rotor and structure) resonant frequencies.
   d. An intersection of an equipment component resonant frequency with the 1x run speed excitation order that occurs within separation margin is unacceptable.
8. Rotordynamic Analysis Level 2:
   a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
   b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
      1) Equipment structure lateral frequency shall include the motor.
      2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
      3) Rotational inertia of water within the impeller, in the wet well and inside the equipment structure, e.g., the column of a vertical pump,

shall be included in the calculation at both the high level and low level conditions.

c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.

d. Forced damped analysis:
   1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
   2) Forced torsional analysis shall include not less than 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
   3) Equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
      a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
      b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
      c) Submit documentation of material fatigue limit.

e. Report Submittals:
   1) Confirmation of compliance with this Section, or detailed exceptions taken.
   2) Software used for analysis.
   3) Results with interpretation.
   4) Preparer's professional engineering stamp and seal.
   5) Input data including component properties, materials and connectivity to other components.
   6) Schematic diagram of model mode shapes, nodes and elements.
   7) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
   8) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
      a) Include equipment operating range; excitation lines at 1x, 2x run speed, and vane pass (or equivalent); and critical speeds associated with equipment system components including the rotor, each major equipment structural component and the motor.
   9) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.

9. Rotordynamic Analysis Level 3:
   a. Before the equipment and motor are released for manufacture it shall be determined that the equipment/motor structures do not have any harmful critical speeds in the lateral and torsional modes.
   b. Calculate rotor lateral and torsional and structure lateral frequencies with finite element analysis software.
      1) Equipment structure lateral frequency shall include the motor.

2) Speed changing drive systems (belt, gear) effects on rotational inertia and stiffness shall be incorporated.
3) Rotational inertia of water within the impeller, in the wet well and inside the equipment structure, e.g., the column of a vertical pump, shall be included in the calculation at both the high level and low level conditions.

c. Potentially harmful critical speeds shall be investigated further with a forced, damped analysis to determine component stresses do not exceed material properties.

d. Forced damped analysis:
1) Forced lateral analysis shall include forcing function magnitudes at least 10 percent of rotor disc weight at each disc position and hydraulic imbalance at 5 operating conditions spaced equally over the equipment operating range. If synchronous motors are used ensure that the rotor analysis includes startup, shutdown, and motor control transients.
2) Forced torsional analysis shall include 1 percent of the maximum permitted torque at any given speed. Damping shall be 1 percent of critical at all shaft elements.
3) Equipment rotor total stress (steady-state and alternating torque components plus lateral-bending stresses) shall not exceed:
a) Constant torque: Total stress limited to 30 percent of the material fatigue limit and to a maximum of 18 percent of ultimate tensile strength.
b) Variable torque (including variable speed equipment): Total stress limited to 50 percent of the material fatigue limit and to a maximum of 4 percent of the material ultimate tensile strength.
c) Submit documentation of material fatigue limit.

e. Report Submittals:
1) Report 1: Executive Summary including:
a) Confirmation of compliance with this specification section, or detailed exceptions taken.
b) Software used for analysis.
c) Results with interpretation.
d) Preparer's professional engineering stamp and seal.
e) Campbell diagrams showing the system natural frequencies, excitation orders, and operating speed range for both lateral and torsional analysis.
(1) Include equipment operating range; excitation lines at 1x, 2x run speed, vane pass (or equivalent), line- and twice-line frequency, motor-pole frequency, torsional harmonics from reciprocating drivers (including up to 6 times operating speed), control pulse frequencies induced by VFDs (with certification from VFD manufacturer of frequencies up to 24 times motor running speed), any torque harmonic greater than 1 percent of steady torque at primary excitation, and synchronous motor requirements; and critical speeds associated with equipment system components including the rotor and each major equipment structural component.

f) Report 1 shall not include detailed analysis elements listed for Submittal under Report 2 below, Submittal of full analysis details in Report 1 is unacceptable.
g) Following Submittal of Report 1, submit Report 2: Detailed Analysis including responses to comments made on Report 1: Rotor-dynamic Executive Summary.

2) Report 2: Rotordynamic detailed analysis including:
a) Input data including component properties, materials and connectivity to other components.
b) Schematic diagram of model mode shapes, nodes and elements.
c) Bearing stiffness and damping properties, impeller/diffuser interaction coefficients, and seal dynamic properties.
d) Forced, damped analysis indicating acceptable material stress limits are maintained at interference points shown on the Campbell diagram.
e) Synchronous motor information including time-integration study results showing transient peak stresses at startup, shutdown and motor control transient events. Provide tomographic diagrams including root and keyway stress concentration locations and the corresponding speeds that result in reported peak stresses.

2.02 POWER TRANSMISSION SYSTEMS

A. V-belts, sheaves, shaft couplings, chains, sprockets, mechanical variable-speed drives, variable frequency drives, gear reducers, open and enclosed gearing, clutches, brakes, intermediate shafting, intermediate bearings, and U-joints:
1. Rated for 24 hour-a-day continuous service, or for intermittent service with frequent stops-and-starts, whichever is most severe.
2. Sized with a service factor of 1.5 or greater:
a. Apply service factor to nameplate horsepower and torque of prime source of power and not to actual equipment loading.
b. Apply service factors in accordance with AGMA or as specified in the Technical Sections.

2.03 BEARINGS

A. Oil or grease lubricated, ball or roller antifriction type, of standard manufacture.
1. Design lubrication system based on the equipment location to operate in the temperatures as specified in Section 01850 - Design Criteria.
a. Design lubrication system to safely start after being shut off for 24 hours and operate safely:
1) Suitable for the outdoor winter temperature as specified in Section 01850 - Design Criteria.

B. Oil-lubricated bearings:
1. Provide either pressure lubricating system or separate oil reservoir splash-type system as specified in the Technical Section.

2. Design oil-lubrication system to safely absorb heat energy generated in bearings when equipment is operating in the following conditions:
    a. With the highest load and the temperature 15 degrees Fahrenheit above the outdoor summer temperature as specified in Section 01850 - Design Criteria.

C. Grease lubricated bearings, except those specified to be factory sealed:
    1. Fit with easily accessible grease supply, flush, drain, and relief fittings.
    2. Lubrication lines and fittings:
        a. Lines: Minimum 1/4-inch diameter stainless steel tubing.
        b. Multiple fitting assemblies: Mount fittings together in easily accessible location.
        c. Use standard hydraulic-type grease supply fittings:
            1) Manufacturers: One of the following or equal:
                a) Alemite.
                b) Zerk.

D. Ratings: Rated in accordance with ABMA 9 or ABMA 11 L10 life for bearings rating life of not less than 50,000 hours.

2.04 BELT DRIVES

A. Sheaves:
    1. Separately mounted on bushings by means of at least 3 pull-up bolts or cap tightening screws.
    2. When 2 sheave sizes are specified, provide separate belts sized for each set of sheaves.
    3. Statically balanced for all; dynamically balanced for sheaves that operate at a peripheral speed of more than 5,500 feet per minute.
    4. Key bushings to drive shaft.

B. Belts:
    1. Anti-static type when explosion-proof equipment or environment is specified.
    2. When spare belts are specified, furnish 1 spare belt for every different type and size of belt-driven unit:
        a. Where 2 or more belts are involved, furnish matched sets.
        b. Identify as to equipment, design, horsepower, speed, length, sheave size, and use.
        c. Package in boxes labeled with identification of contents.

C. Manufacturers: One of the following or equal:
    1. Dodge, Dyna-V belts with matching Dyna-V sheaves and Taper-Lock bushings.
    2. T.B. Woods, Ultra-V belts with matching Sure-Grip sheaves and Sure-Grip bushings.

2.05 FLANGED PIPING CONNECTIONS

A. Unless specified otherwise in the Technical Sections or indicated on the Drawings, provide flat face flanges.

2.06 ASSEMBLY FASTENERS

A. General service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM F593, Alloy Group 2.
   2. Nuts: In accordance with ASTM F594, Alloy Group 2.
   3. Washers: Alloy group matching bolts and nuts.

B. High-temperature service or high-pressure service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
   2. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
   3. Washers: Alloy group matching bolts and nuts.

C. Low-temperature service: Stainless steel, Type 316:
   1. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
   2. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
   3. Washers: Alloy group matching bolts and nuts.

2.07 GUARDS AT HIGH-TEMPERATURE SURFACES

A. Exposed surfaces having an external surface temperature of 120 degrees Fahrenheit or higher and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps or fixed ladders.

B. Cover with a thermal insulating material unless otherwise guarded against contact.
   1. Insulation thickness such that the insulation exterior temperature is below 120 degrees Fahrenheit.
   2. Insulation Type 3 and cover Type 5 as specified in Section 15082 - Piping Insulation.

2.08 GUARDS AT MOVING COMPONENTS

A. Provide guards on rotating components that are within 7.5 vertical feet of an operating floor or platform.

B. Allow visual inspection of moving parts without removal.

C. Allow access to lubrication fittings.

D. Easily removable for maintenance.

E. Prevent entrance of rain or dripping water for outdoor locations.

F. Size belt and sheave guards to allow for installation of sheaves 15 percent larger and addition of 1 belt.

G. Materials:
   1. Sheet metal: Carbon steel, 12-gauge minimum thickness, hot-dip galvanized after fabrication.
   2. Fasteners: Type 316 stainless steel.

2.09 SHOP FINISHES

A. Manufacturer's standard primer and finish coatings.
   1. Primer only if field coatings are to be applied.

2.10 GEAR MOTORS

A. Parallel shaft drives: Helical gearing.

B. Right-angle drives: Worm gearing.

C. Manufacturers: One of the following or equal:
   1. Baldor Electric Company.
   2. Bodine Electric Company.

2.11 GEAR REDUCTION UNITS

A. Design and performance criteria:
   1. Gear type:
      a. Helical or herringbone.
   2. AGMA Class II service:
      a. Use more severe service condition when such is recommended by unit's manufacturer.
   3. Cast-iron housing with gears running in oil.
   4. Anti-friction bearings.
   5. Thermal horsepower rating based on maximum horsepower rating of prime mover, not actual load.

2.12 MOUNTING AND LIFTING PROVISIONS FOR EQUIPMENT

A. Equipment bases and base plates:
   1. Provide equipment bases with machined support pads, dowels for alignment for mating of adjacent items, openings for electrical conduits, and openings to facilitate grouting.
   2. Provide jacking screws in bases and supports for equipment and for equipment weighing 500 pounds or more.
   3. Materials:
      a. Match equipment material or steel.
      b. Coating: Match equipment.

B. Steel support frames:
   1. Carbon steel:
      a. At exterior locations, and at interior wet or moist locations, provide continuous welds on both sides to close seams and edges between steel members.
      b. Grind closure welds smooth.

C. Lifting lugs or eyes:
   1. Equipment units weighing 50 pounds or more:
      a. Provide with lifting lugs or eyes to allow removal with lifting device.

2.13 NAMEPLATES

A. Fastened to equipment at factory in an accessible and visible location.

B. Metal engraved or stamped with text, holes drilled or punched for fasteners.

C. Material: Aluminum or stainless steel.

D. Fasteners: Number 4 or larger oval head stainless steel screws or drive pins.

E. Text:
   1. Manufacturer's name, equipment model number, equipment serial number, and identification tag number.
   2. Additional items indicated in the Technical Sections.
   3. Indicate the following additional information as applicable:
      a. Maximum and normal rotating speed.
      b. Service class in accordance with applicable standards.
   4. Include for pumps:
      a. Rated total dynamic head in feet of fluid.
      b. Rated flow in gallons per minute.
      c. Impeller, gear, screw, diaphragm, or piston size.
   5. Include for motors:
      a. Drive speed.
      b. Motor horsepower with rated capacity.
   6. Include for gear reduction units:
      a. AGMA class of service.
      b. Service factor.
      c. Input and output speeds.

2.14 PUMP SHAFT COUPLINGS

A. General:
   1. Type and ratings: Non-lubricated designed for not less than 50,000 hours of operating life.
   2. Sizes: Provide as recommended by manufacturer for specific application, considering horsepower, speed of rotation, balance, and type of service.
   3. Suitable for an ambient temperature range between -40 degrees to +200 degrees Fahrenheit.

B. Close couplings for electric-motor-driven equipment:
   1. Manufacturers: One of the following or equal:
      a. Lovejoy.
      b. T.B. Woods.
   2. Provide flexible couplings designed to accommodate angular misalignment, parallel misalignment, and end float.
   3. Manufacture flexible component of coupling from synthetic rubber or urethane.
   4. Provide service factor of 2.5 for electric motor drives and 3.5 for engine drives.
   5. Do not allow metal-to-metal contact between driver and driven equipment.

C. Flexible couplings for direct connected electric-motor-driven equipment:
   1. Manufacturers: One of the following or equal:
      a. Rexnord.
      b. T.B. Woods.
   2. Provide flexible couplings designed to accommodate shock loading, vibration, and shaft misalignment or offset.
   3. Provide flexible connecting element of rubber and reinforcement fibers.
   4. Provide service factor of 2.0.
   5. Connect stub shafts through collars or round flanges, firmly keyed to their shafts with neoprene cylinders held to individual flanges by through pins.

D. Spacer couplings:
   1. Where cartridge-type mechanical seals or non-split seals are specified, provide a spacer-type coupling of sufficient length to remove the seal without disturbing the driver or driven equipment.

2.15 PUMP SEAL CHAMBER AND SEALS

A. Seal chamber (stuffing box):
   1. Large enough to retrofit with double mechanical seal.

B. Seal types: Based on the following and as specified in the Technical Section:
   1. Type 1: Packing:
      a. Provide when specified in the Technical Section for wastewater, non-potable water, and sludge applications:
         1) Asbestos free.
         2) PTFE (Teflon™) free.
         3) Braided graphite.
         4) Manufacturers: One of the following or equal:
            a) Chesterton, 1400.
            b) John Crane.
      b. Provide when specified for drinking water service:
         1) Asbestos free.
         2) Material: Braided PTFE (Teflon™).
         3) Manufacturers: One of the following or equal:
            a) Chesterton, 1725.
            b) John Crane.
      c. Design:
         1) Packing gland to allow adjustment and repacking without dismantling pump except to open up stuffing box.
         2) Seal chamber (stuffing box) large enough to retrofit with double mechanical seal.
         3) Manufacturers: One of the following or equal:
            a) Chesterton, 1725.
            b) John Crane.
   2. Type 2: Mechanical seal, flushing, cartridge, single O-ring.
      a. Manufacturers: One of the following or equal:
         1) Chesterton, S10.
         2) John Crane, 5610 Series.

3. Type 3: Mechanical seal, flushing, cartridge, double O-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, S20.
        2) John Crane, 5620 Series.
4. Type 4: Mechanical seal, flushing, cartridge, double split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, S20.
        2) John Crane, 5620 Series.
5. Type 5: Mechanical seal, flushing, cartridge, single split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 442.
        2) John Crane, 5860.
6. Type 6: Mechanical seal, flushless, cartridge, single split-ring:
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 156.
        2) John Crane, 3740 Series.

C. Mechanical seals, Types 2 to 6:
1. Balanced hydraulically.
2. Spring:
    a. Stationary, out of pumping fluid.
    b. Material as specified in the Technical Section. Hastelloy C; Type Elgiloy or 17-7 PH stainless steel for split seals.
3. O-ring: Viton™ 747.
4. Gland: Type 316L stainless steel.
5. Set screws: Type 316L stainless steel.
6. Faces: Reaction bonded, silicon carbide/carbon.
7. Minimum differential pressures in either direction: 300 pounds per square inch gauge.
    a. Manufacturers: One of the following or equal:
        1) Chesterton, 1400.
        2) John Crane, equivalent product.
8. Drinking water service:
    a. Asbestos free.
    b. Material: Braided PTFE (Teflon™).
    c. Manufacturers: One of the following or equal:
        1) Chesterton, 1725.
        2) John Crane, equivalent product.

D. Flushing system:
1. Provide flushing connections:
    a. 3/4-inch size.
    b. Provide API Standard 682 seal water plan arrangement as specified in the Technical Section:
        1) Plan 11 - Product stream seal water from discharge thru seal.
        2) Plan 13 - Product stream seal water thru seal to suction.
        3) Plan 23 - Closed loop seal water with cooler and pumping ring.
        4) Plan 32 - Production seal water discharged to product stream.
        5) Plan 54 - Production Seal Water Excluded from Product Stream.

2.16 SAFETY SIGNS

A. Material, sign size, and text: As specified in Section 10400 - Signage.

2.17 SHIPPING

A. Prior to shipment of equipment:
   1. Bearings (and similar items):
      a. Pack separately or provide other protection during transport.
      b. Greased and lubricated.
   2. Gear boxes:
      a. Oil filled or sprayed with rust preventive protective coating.
   3. Fasteners:
      a. Inspect for proper torques and tightness.

PART 3 EXECUTION

3.01 PRE-INSTALLATION

A. Field measurements:
   1. Prior to Shop Drawings preparation, take measurements and verify dimensions indicated on the Drawings.
   2. Ensure equipment and ancillary appurtenances fit within available space.

B. Sequencing and scheduling:
   1. Coordinate details of equipment with other related parts of the Work, including verification that structures, piping, wiring, and equipment components are compatible.
   2. Equipment anchoring: Obtain anchoring material and setting drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

3.02 LUBRICATION LINES AND FITTINGS

A. Support and protect lines from source to point of use.

B. Fittings:
   1. Bring fittings to outside of equipment in manner such that they are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
   2. Mount fittings together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
   3. For underwater bearings: Bring fittings above water surface and mount on edge of structure above.

3.03 ALIGNMENT OF DRIVERS AND EQUIPMENT

A. Where drive motors or other drivers are connected to driven equipment by flexible coupling, disconnect coupling halves and align driver and equipment after driven equipment has been leveled on its foundation.

B. Comply with procedures of appropriate HI, AGMA Standards, alignment tolerances of equipment manufacturers and the following requirements to bring components into angular and parallel alignment:
   1. Maximum total coupling offset (not the per-plane offset): Not to exceed 0.5 mils per inch of coupling length for spacer couplings based on coupling length (not dial separation).
   2. Utilize jacking screws, wedges, or shims as recommended by the equipment manufacturer and as specified in the equipment sections.

C. Use reverse-indicator arrangement dial-type or laser-type alignment indicators: Mount indicators on the driver/coupling flange and equipment/coupling flange. Alignment instrumentation accuracy shall be sufficient to read angular and radial misalignment at 10 percent or less of the manufacturer's recommended acceptable misalignment.

D. Alignment and calculations shall include measurement and allowance for thermal growth, spacer coupling length, indicator separation, and axial spacing tolerances of the coupling.

E. When alignment satisfies most stringent tolerance of system components, grout between base and foundation.
   1. Allow minimum 48 hours for grout to harden.
   2. After grout hardens, remove jacking screws, tighten anchor bolts and other connections, and recheck alignment.
   3. Correct alignment as required.

3.04 EQUIPMENT SUPPORT AND ANCHORING TO STRUCTURES

A. Anchor equipment to structures as indicated on the Drawings and as specified.

B. Obtain final anchor bolt layouts for equipment prior to:
   1. Detailing reinforcement for equipment pads.
   2. Preparation of Shop Drawings for metal structures supporting equipment.

C. Anchor bolt templates:
   1. Provide templates as specified in the Technical Sections.
   2. Use final anchor bolt layout to construct templates for setting anchor bolts.
   3. Make templates:
      a. Rigid, and non-deformable during use.
      b. With longitudinal axes of anchors parallel.
      c. With longitudinal axes of anchors perpendicular to surface supporting the equipment.
   4. Templates may be reused for multiple locations of the same equipment only if:
      a. Templates are in "like-new" condition prior to each reuse.
      b. Anchor layout has not been deformed or damaged by previous installation, removal, or handling of templates.

5. Sequence:
    a. Set and support templates prior construction of structures surrounding anchors.
    b. Position anchors in templates to provide designated embedment in supporting structure, with required projection for installation of grout, base plates, and hardware for tightening.
    c. Construct concrete or masonry around anchors using methods that preserve required anchor positions and alignment, and clearances to edges of supports or structures.

D. Anchor adjustment sleeves:
    1. Use of adjustment sleeves around anchors:
        a. Is at the option of the Contractor.
        b. Does not relieve Contractor of obligation to construct and use templates for setting of anchors.
        c. May required increased anchor embedment length to develop the strength of the anchor in the embedded length below the adjustment sleeve.
    2. Submittal requirements for anchor adjustment sleeves:
        a. Provide within sufficient time for Engineer approval and not less than 10 working days before setting those items.
        b. Proposed locations of sleeves.
        c. Details and dimensions of sleeves.
        d. Sleeve materials of construction, and coatings.
        e. Information on sleeve filler material and means of filler removal.
        f. Type, details, and dimensions of anchor bolts or anchor rods to be used with sleeves.
        g. Calculations showing development of anchor load capacity below the bottom of the sleeve.
        h. Plan for removal of sleeve fillers, if any.
        i. Plan for placement and consolidation of flowable grout inside sleeves and to a level equal to top of concrete slab or equipment pad surrounding the sleeve.

3.05 GROUTING UNDER EQUIPMENT BASES, BASE PLATES, SOLE PLATES, AND SKIDS

A. General:
    1. Comply with equipment manufacturer’s installation instructions including:
        a. Tolerances for level.
        b. Tolerances for vertical and horizontal alignment.
        c. Requirements or recommendations for grouting spaces and grout installation.
        d. Recommendations for tightening of equipment anchors after grout has cured.
    2. Install equipment over grout as indicated on the Drawings or specified only after:
        a. Equipment is leveled and in proper alignment.
        b. Piping connections are complete and in alignment with no strain transmitted to equipment.

3. Install flowable grout, as specified in Section 03600 - Grouting, placed with forms and head boxes.
    a. Use flowable, non-shrink grout.
    b. Use flowable, non-shrink epoxy grout, only where indicated on the Drawings, where specified in Technical Sections, or when approved in advance by the Engineer.
    c. Grouting with dry-pack materials is not permitted.

B. Prepare equipment bases, base plates, soleplates, and skids for grouting:
    1. Concrete equipment bases:
        a. Roughen surface in accordance with ICRI, Guideline No. 310.2R, Surface Preparation Profiles CSP-3 and CSP-4.
        b. Clean roughened concrete surfaces.
    2. Base plates, soleplates, and skids:
        a. Clean surfaces in accordance with SSPC-SP-1-Solvent Cleaning, to remove dirt, dust, oil, grease, paint, and other material.

C. Level equipment for grouting:
    1. Use removable jack screws, or removable steel wedges and shims to support and level equipment bases, base plates, sole plates, and skids.
        a. Do not use leveling nuts placed on equipment anchors to support or level equipment bases, base plates, sole plates, and skids.
    2. Removable jack screws:
        a. Provide number, size, and locations of jack screws required to support and level equipment in accordance with manufacturer’s recommendations.
        b. Drill and tap equipment base plates, sole plates, and skids for jack screws.
        c. Support jack screws on circular steel plates that have been epoxy bonded to the equipment foundation.
            1) Provide plates fabricated from Type 316 stainless steel where edges of support plates will have grout side cover of 3 inches or less in the finished work.
        d. Make provision for removal of jack screws after grouting:
            1) Prevent grout from bonding to jack screws by wrapping jack screw threads that will be in contact with grout with multiple layers of tape or other material acceptable to the Engineer.
        e. Place and cure grout.
        f. After grout is placed and cured:
            1) Remove jack screws and material used to prevent grout from bonding to jack screws.
            2) Provide jack screws to Owner for future use.
            3) Fill jack screw holes with grout.
            4) Cure grout as specified.
    3. Removable steel wedges and shims:
        a. Use for equipment bases, base plates, sole plates, and skids where it is not practical to use jack screws.
        b. Provide number, size, and locations of wedges and shims required to support and level equipment in accordance with manufacturer’s recommendations.

c. Make provision for removal of wedges and shims after grouting:
    1) Prevent grout from bonding to wedges and shims by wrapping wedges and shims that contact grout with multiple layers of tape or other material acceptable to the Engineer.
    2) Locate and orient wedges and shims to allow for removal after grouting, and to facilitate placement of grout in the remaining voids.
d. Place and cure grout.
e. After grout is placed and cured:
    1) Remove wedges and shims, and material used to prevent grout from bonding to them.
    2) Fill jack screw holes with grout.
    3) Cure grout as specified.

D. Construct grout forms:
1. Provide forms:
    a. Rigid with adequate strength to withstand placement of grout.
    b. With surfaces that will produce a smooth, uniform finish for grout edges exposed in the finished work.
    c. That allow grout to flow horizontally beyond the perimeter of the equipment base plate a distance not less than the thickness of the grout, and not less than 1 inch.
2. Install forms:
    a. Seal form cracks and joints with elastomeric sealant to make form watertight.
    b. Line form surfaces in contact with grout with polyethylene film, or coat with 2 coats of heavy-duty paste wax.
3. Construct grout “head box” over entire length of one side of form.
    a. Make head box height sufficient to force grout to flow under full dimensions of equipment base and to the surrounding form faces.

E. Pre-grouting procedures:
1. Concrete surfaces receiving flowable, non-shrink grout:
    a. Saturate concrete surface in contact with grout and concrete surfaces extending not less than least 6 inches beyond limits of grout with clean water for a minimum of 24 hours prior to grouting.
    b. Just prior to grout placement, remove standing water using clean rags or oil-free compressed air. Provide “saturated surface dry” (SSD) concrete for grout placement.
2. Concrete surfaces receiving flowable, non-shrink epoxy grout:
    a. Do not saturate concrete prior to grout placement.

F. Grout placement and curing:
1. Place and cure grout as specified in Section 03600 - Grouting and in this Section.
2. Grouting:
    a. Keep level of grout in head box above bottom of equipment bases, base plates, sole plates, and skids always to drive flow under base.
    b. Maintain continuous grout flow from head box to opposite sides of forms without trapping air or forming voids.
    c. Vibrate, rod, or chain grout to facilitate grout flow, to consolidate grout, and to remove entrapped air.

3. After grout sets, remove forms and trim grout edges at 45-degree angle from bottom edge of equipment bases, base plates, sole plates, and skids.
4. Cure grout as specified in Section 03600 - Grouting.

G. After grout is cured:
1. Remove jack screws or wedges and shims, and material used to prevent grout from bonding to leveling devices.
2. Fill pockets from removed leveling devices with grout.
3. Cure filled voids as specified in Section 03600 - Grouting.
4. Tighten equipment anchors in accordance with equipment manufacturer requirements.

3.06 FIELD FINISHES

A. When touchup or repair is required, apply primer and coating systems as recommended by the equipment manufacturer.

END OF SECTION

SECTION 15052

COMMON WORK RESULTS FOR GENERAL PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Basic materials and methods for metallic and plastic piping systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard.

B. American Water Work Association (AWWA):
   1. C11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   4. C151 - Ductile-Iron Pipe, Centrifugally Cast.
   5. C207 - Standard for Steel Pipe Flanges for Waterworks Services-Size 4 In. Through 144 In.

C. ASTM International (ASTM):
   1. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   5. A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   6. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   7. B88 - Standard Specification for Seamless Copper Water Tube.
   8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
   9. D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing and Fittings.
   10. F37 - Standard Test Methods for Sealability of Gasket Materials.
   11. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   12. F594 - Standard Specification for Stainless Steel Nuts.

13. F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements of Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Buried pipes: Pipes that are buried in the soil with or without a concrete pipe encasement.
   2. Exposed pipe: Pipes that are located above ground, or located inside a structure, supported by a structure, or cast into a concrete structure.
   3. Pipes adjacent to a wet wall: Pipe centerline within 10 inches of the wet wall.
   4. Underground pipes: Buried pipes - see A. above.
   5. Underwater pipes: Pipes below the top of walls in basins or tanks containing water.
   6. Wet wall: A wall with water on at least one side.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials as specified in Section 01600 - Product Requirements including special requirements for materials in contact with drinking water.

B. Coatings and linings requirements stated in the Pipe Schedule, as modified in the individual pipe Technical Sections, and as specified in Section 09960 - High-Performance Coatings.

2.02 LINK TYPE SEALS

A. Characteristics:
   1. Modular mechanical type, consisting of interlocking neoprene or synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening.
   2. Links to form a continuous rubber belt around the pipe.
   3. Provide a nylon polymer pressure plate with Type 316 stainless steel hardware. Isolate pressure plate from contact with wall sleeve.
   4. Hardware to be Type 316 stainless steel.
      a. Provide anti-galling lubricant for threads.

B. One of the following or equal:
   1. Link-Seal.
   2. Pipe Linx.

2.03 FLANGE BOLTS AND NUTS

A. General:
   1. Washer:
      a. Provide a washer for each nut.
      b. Washer shall be of the same material as the nut.
   2. Nuts: Heavy hex-head.
   3. Cut and finish flange bolts to project:
      a. Face of the bolt shall exceed face of nut by 1/16-inch minimum.
      b. A maximum of 1/4 inch beyond outside face of nut after assembly.
   4. Tap holes for cap screws or stud bolts when used.
   5. Lubricant for stainless steel bolts and nuts:
      a. Chloride-free.
      b. Manufacturers: One of the following or equal:
         1) Huskey FG-1800 Anti-Seize.
         2) Weicon Anti-Seize High-Tech.

B. Ductile iron pipe:
   1. On exposed pipes with pressures equal to or less than 150 pounds per square inch gauge (psig):
      a. Bolts: In accordance with ASTM A307, Grade B.
      b. Nuts: In accordance with ASTM A563, Grade A.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   2. On exposed pipes with pressures greater than 150 psig:
      a. Bolts: In accordance with ASTM A193, Grade B7.
      b. Nuts: In accordance with ASTM A194, Grade 2H.
      c. Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.
   3. On underwater pipes and pipes adjacent to wet walls:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M.
   4. On buried pipes:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M for nuts.

C. Plastic pipe:
   1. On exposed pipes:
      a. Bolts: In accordance with ASTM A307, Grade B.
      b. Nuts: In accordance with ASTM A563, Grade A.
      c. Bolts and Nuts: Hot-dip galvanized in accordance with ASTM F2329.
   2. On underwater pipes and pipes adjacent to wet walls:
      a. Bolts: In accordance with ASTM A193, Grade B8M.
      b. Nuts: In accordance with ASTM A194, Grade 8M.

D. Steel pipe:
   1. On exposed pipes:
      a. For ASME B16.5 Class 150 flanges and AWWA C207 Class D flanges:
         1) Bolts: In accordance with ASTM A307, Grade B.
         2) Nuts: In accordance with ASTM A563, Grade A.
         3) Bolts and nuts: Hot-dip galvanized in accordance with ASTM F2329.

b. For ASME B16.5 and B16.47 Class 300 flanges and AWWA C207 Class E and F flanges:
1) Bolts: In accordance with ASTM A193, Grade B7.
2) Nuts: In accordance with ASTM A194, Grade 2H.

2. On underwater pipes and pipes adjacent to wet walls:
a. Bolts: In accordance with ASTM A193, Grade B8M.
b. Nuts: In accordance with ASTM A194, Grade 8M.

3. Low-temperature service: Stainless steel, Type 316:
a. Bolts: In accordance with ASTM A320, Grade B8M, Class 1, heavy hex.
b. Nuts: In accordance with ASTM A194, Grade B8M, heavy hex.
c. Washers: Alloy group matching bolts and nuts.

4. High-temperature service or high-pressure service: Stainless steel, Type 316:
a. Bolts: In accordance with ASTM A193, Grade B8M, Class 1, heavy hex.
b. Nuts: In accordance with ASTM A194, Grade 8, heavy hex.
c. Washers: Alloy group matching bolts and nuts.

2.04 MECHANICAL JOINTS BOLTS AND NUTS

A. Bolts, including T-bolts:
1. Type 316 stainless steel in accordance with ASTM F593.

B. Heavy hex nuts:
1. Type 316 stainless steel in accordance with ASTM F594.

2.05 GASKETS

A. General.
1. Suitable for the specific fluids, pressure, and temperature conditions.
2. Capable of being applied on surface of piping with cavities to provide for an improved seal with the internal piping pressure.

B. For flanged joints in ductile iron and steel piping for sewage service:
1. Suitable for pressures equal and less than 150 pounds per square inch gauge, temperatures equal and less than 250 degrees Fahrenheit, and raw sewage service.
2. Material:
a. SBR or neoprene elastomer with minimum Shore A hardness value of 70.
b. Reinforcement: Cloth or synthetic fiber.
c. Thickness: Minimum 3/32-inch thick for less than 10-inch pipe; minimum 1/8-inch thick for 10 inch and larger pipe.
3. Manufacturers: One of the following or equal:
a. Pipe less than 48 inches in diameter:
1) Garlock, Style 7797.
2) John Crane, similar product.
b. Pipe 48 inches in diameter and larger:
1) Garlock, Style 3760.
2) John Crane, similar product.

C. For flanged joints in polyvinyl chloride and polyethylene piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, with low flange bolt loadings, temperatures equal to and less than

120 degrees Fahrenheit, and polymer, chlorine, caustic solutions, and other chemicals, except chemicals which liberate free fluorine including fluorochemicals and gaseous fluorine.

2. Material:
   a. Chemical systems: 0.125-inch thick Viton™ rubber.
   b. Sewer and water: 0.125-inch thick SBR.
3. Manufacturers: One of the following or equal:
   a. Garlock.
   b. John Crane, similar product.

D. For flanged joints in gas or liquefied petroleum gas piping:
1. Liquefied petroleum, propane, and natural gas applications in black steel piping: Suitable for pressures equal to and less than 250 pounds per square inch gauge, temperatures equal to and less than 100 degrees Fahrenheit, and liquefied petroleum gas, propane gas, and natural gas application.
2. Material:
   a. Microcellular Teflon™ outer layers with rigid center layer.
   b. Sealability in accordance with ASTM F37, less than 0.55 millimeters per hour leakage of iso-octane at 1,000 pounds per square inch gasket load and 9.8 pounds per square inch fluid pressure.
3. Manufacturers: One of the following or equal:
   a. Garlock, Style 3545.
   b. John Crane, similar product.

E. For flanged joints in low pressure air piping:
1. Suitable for pressures equal to and less than 150 pounds per square inch gauge, temperatures equal to and less than 300 degrees Fahrenheit, and compressed air service.
2. Material: EPDM elastomer, 1/8-inch thick, 60 Shore hardness, smooth surface.
3. Manufacturers: One of the following or equal:
   a. Garlock, Style 8314.
   b. John Crane, similar product.

F. For flanged joints in ductile iron or steel water piping:
1. Suitable for hot or cold water, pressures equal to and less than 150 pounds per square inch gauge, and temperatures equal to and less than 160 degrees Fahrenheit.
2. Material:
   a. SBR or neoprene elastomer, compressed, with non-asbestos fiber reinforcement.
3. Manufacturers: One of the following or equal:
   a. Garlock, Bluegard 3300.
   b. John Crane, similar product.

G. For flanged joints in ductile iron or steel drinking water piping meeting NSF 61 requirements:
1. Suitable for hot or cold water, pressures equal to or less than 150 pounds per square inch gauge, and temperatures equal to or less than 160 degrees Fahrenheit.
2. Material:
   a. EPDM material with 80 Shore A durometer rating.

3. Manufacturers: One of the following or equal:
    a. Garlock, 98206.

H. John Crane, similar product.

I. For mechanical joints or wedge action joint restraints in ductile iron drinking water piping in accordance with NSF 61 requirements:
    1. In accordance with AWWA C110, C111, and C115.
    2. Material: Vulcanized styrene butadiene copolymer (SBR).
        a. Temperature range: 20 to 150 degrees Fahrenheit.
        b. Operating pressure: 250 psi.
        c. Durometer, Shore A (within 5): 75.
        d. ASTM D412 tensile strength: 1,500 psi.
        e. ASTM D412 elongation: 150 percent.
        f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 20.
        g. ASTM D573 minimum aging: 60 percent.
        h. ASTM D1149 resistance to surface ozone: No cracking.
    3. Manufacturers: One of the following or equal:
        a. American Cast Iron Pipe Co.
        b. EBAA Iron, Inc.
        c. Star Pipe Products.

J. For push-on joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
    1. In accordance with AWWA C110, C111, and C115.
    2. Material: Vulcanized styrene butadiene copolymer (SBR).
        a. Temperature range: 20 to 150 degrees Fahrenheit.
        b. Operating pressure: 250 psi.
        c. Durometer, Shore A:
            1) Main body: 50 to 65.
            2) Harder portion (if used): 80 to 85.
        d. ASTM D412 tensile strength:
            1) Main body: 2,000 psi.
            2) Harder portion (if used): 1,200 psi.
        e. ASTM D412 elongation:
            1) Main body: 300 percent.
            2) Harder portion (if used): 125 percent.
        f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 20.
        g. ASTM D573 minimum aging: 60 percent.
        h. ASTM D1149 resistance to surface ozone: No cracking.
    3. Manufacturers: One of the following or equal:
        a. American Cast Iron Pipe Co, Fastite Gasket.
        b. McWane Ductile, Tyton Gasket.
        c. U.S. Pipe.

K. For integrally restrained push-on joints in ductile iron drinking water piping in accordance with NSF 61 requirements:
    1. In accordance with AWWA C110, C111, and C115.

2. Material: Vulcanized styrene butadiene copolymer (SBR).
    a. Temperature range: 20 to 150 degrees Fahrenheit.
    b. Operating pressure: 250 psi.
    c. Durometer, Shore A:
        1) Main body: 50 to 65.
        2) Harder portion (if used): 80 to 85.
    d. ASTM D412 tensile strength:
        1) Main body: 2,000 psi.
        2) Harder portion (if used): 1,200 psi.
    e. ASTM D412 elongation:
        1) Main body: 300 percent.
        2) Harder portion (if used): 125 percent.
    f. ASTM D395 B, compression set, 25 percent deflection, maximum percentage 22 hours at 158 degrees Fahrenheit: 20.
    g. ASTM D573 minimum aging: 60 percent.
    h. ASTM D1149 resistance to surface ozone: No cracking.
3. Manufacturers: One of the following or equal:
    a. American Cast Iron Pipe Co, Fast-grip gasket.
    b. U.S. Pipe, Field Lok 350 Gaskets.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Piping drawings:
    a. Except in details, piping is indicated diagrammatically. Not every offset and fitting, or structural difficulty that may be encountered has been indicated on the Drawings. Sizes and locations are indicated on the Drawings.
    b. Perform minor modifications to piping alignment where necessary to avoid structural, mechanical, or other type of obstructions that cannot be removed or changed.
        1) Modifications are intended to be of minor scope, not involving a change to the design concept or a change to the Contract Price or Contract Times.
2. Piping alternatives:
    a. Provide piping as specified in this Section, unless indicated on the Drawings or specified otherwise.
    b. Alternative pipe ratings:
        1) Piping with greater pressure rating than specified may be substituted in lieu of specified piping without changes to the Contract Price.
        2) Piping of different material may not be substituted in lieu of specified piping.
    c. Valves in piping sections: Capable of withstanding specified test pressures for piping sections and fabricated with ends to fit piping.
    d. Grooved joints: Use couplings, flange adapters, and fittings of the same manufacturer.
        1) Manufacturer's factory trained representative:
            a) Provide on-site training for Contractor's field personnel.

b) Periodically visit the jobsite to verify Contractor is following best recommended practices.

2) Distributor's representative is not considered qualified to conduct the training or jobsite visits.

e. Flanged joints: Where one of the joining flanges is raised face type, provide a matching raised face type flange for the other joining flange.

3. Unless otherwise indicated on the Drawings, piping at pipe joints, fittings, couplings, and equipment shall be installed without rotation, angular deflection, vertical offset, or horizontal offset.

B. Wall and slab penetrations:

1. Provide sleeves for piping penetrations through aboveground masonry and concrete walls, floors, ceilings, roofs, unless specified or otherwise indicated on the Drawings.
2. For piping 1 inch in nominal diameter and larger, provide sleeves with minimum inside diameters of 1 inch plus outside diameter of piping. For piping smaller than 1 inch in nominal diameter, provide sleeve of minimum twice the outside diameter of piping.
   a. Arrange sleeves and adjacent joints so piping can be pulled out of sleeves and replaced without disturbing the structure.
   b. Cut ends of sleeves flush with surfaces of concrete, masonry, or plaster.
   c. Conceal ends of sleeves with escutcheons where piping runs through floors, walls, or ceilings of finished spaces within buildings.
   d. Seal spaces between pipes and sleeves with link-type seals when not otherwise specified or indicated on the Drawings.
   e. Seal openings around piping running through interior walls and floors of chlorine rooms and chlorine storage rooms gastight with synthetic rubber sealing compound.
3. Provide flexibility in piping connecting to structures to accommodate movement due to soil settlement and earthquakes. Provide flexibility using details indicated on the Drawings.
4. Core drilled openings:
   a. Do not damage or cut existing reinforcing bars, electrical conduits, or other items embedded in the existing concrete without acceptance by the Engineer.
   b. Determine location of reinforcing bars or other obstructions with a non-destructive indicator device.
   c. Remove dust and debris from hole using compressed air.

C. Exposed piping:

1. Install exposed piping in straight runs parallel to the axes of structures, unless otherwise indicated on the Drawings:
   a. Install piping runs plumb and level, unless otherwise indicated on the Drawings.
      1) Slope plumbing drain piping with a minimum of 1/4-inch per foot downward in the direction of flow.
2. Install exposed piping after installing equipment and after piping and fitting locations have been determined.

3. Support piping: As specified in Section 15061 - Pipe Supports, Section 15062 - Preformed Channel Pipe Support System, and Section 15063 - Non-Metallic Pipe Support System:
    a. Do not transfer pipe loads and strain to equipment.
4. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, flanged coupling adapters, and other types of joints or means which are compatible with and suitable for the piping system, and necessary to allow ready assembly and disassembly of the piping.
5. Assemble piping without distortion or stresses caused by misalignment:
    a. Match and properly orient flanges, unions, flexible couplings, and other connections.
    b. Do not subject piping to bending or other undue stresses when fitting piping.
    c. Do not correct defective orientation or alignment by distorting flanged joints or subjecting flange bolts to bending or other undue stresses.
    d. Flange bolts, union halves, flexible connectors, and other connection elements shall slip freely into place.
    e. Alter piping assembly to fit when proper fit is not obtained.
    f. Install eccentric reducers or increasers with the top horizontal for pump suction piping.

D. Buried piping:
1. Bury piping with minimum 3-foot cover without air traps, unless otherwise indicated on the Drawings.
2. Where 2 similar services run parallel to each other, piping for such services may be laid in the same trench.
    a. Lay piping with sufficient room for assembly and disassembly of joints, for thrust blocks, for other structures, and to meet separation requirements of public health authorities having jurisdiction.
3. Laying piping:
    a. Lay piping in finished trenches free from water or debris. Begin at the lowest point with bell ends up slope.
    b. Place piping with top or bottom markings with markings in proper position.
    c. Lay piping on an unyielding foundation with uniform bearing under the full length of barrels.
    d. Where joints require external grouting, banding, or pointing, provide space under and immediately in front of the bell end of each section laid with sufficient shape and size for grouting, banding, or pointing of joints.
    e. At the end of each day’s construction, plug open ends of piping temporarily to prevent entrance of debris or animals.
4. Concrete encase buried pipe installed under concrete slabs or structures.

E. Venting piping under pressure:
1. Lay piping under pressure flat or at a continuous slope without air traps, unless otherwise indicated on the Drawings.
2. Install plug valves as air bleeder cocks at high points in piping.
    a. Provide 1-inch plug valves for water lines and 2-inch plug valves for sewage and sludge lines, unless otherwise indicated on the Drawings.
3. Provide additional pipe taps with plug cocks and riser pipes along piping as required for venting during initial filling, disinfecting, and sampling.

4. Before piping is placed into service, close plug valves and install plugs. Protect plugs and plug valves from corrosion as specified in Section 09960 - High-Performance Coatings.

F. Restraining buried piping:
   1. At valves and at fittings where piping changes direction, changes sizes, and at ends:
      a. When piping is underground, use concrete thrust blocks, mechanical restraints, or push-on restraints.
      b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
   2. All buried piping specified to be pressure tested shall be fully restrained all joints. Concrete thrust blocks shall be provided only at connections to existing piping systems or where shown on the drawings.
   3. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
      a. During testing, provide suitable temporary restraints where piping does not require permanent restraints.
   4. Place concrete thrust blocks against undisturbed soil.
   5. Place concrete so piping joints, fittings, and other appurtenances are accessible for assembly and disassembly.
   6. Provide underground mechanical restraints where specified in Piping Schedule.

G. Restraining above ground piping:
   1. At valves and at fittings where piping changes direction, changes sizes, and at ends:
      a. When piping is aboveground or underwater, use mechanical or structural restraints.
      b. Determine thrust forces by multiplying the nominal cross-sectional area of the piping by design test pressure of the piping.
   2. Provide restraints with ample size to withstand thrust forces resulting from test pressures:
      c. During testing, provide suitable temporary restraints where piping does not require permanent restraints.

H. Connections to existing piping:
   1. Expose existing piping to which connections are to be made with sufficient time to permit, where necessary, field adjustments in line, grade, or fittings:
      a. Protect domestic water/potable water supplies from contamination:
         1) Make connections between domestic water supply and other water systems in accordance with requirements of public health authorities.
         2) Provide devices approved by owner of domestic water supply system to prevent flow from other sources into the domestic supply system.
   2. Make connections to existing piping and valves after sections of new piping to be connected have been tested and found satisfactory.
   3. Provide sleeves, flanges, nipples, couplings, adapters, and other fittings needed to install or attach new fittings to existing piping and to make connections to existing piping.
   4. For flanged connections, provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

I. Connections between ferrous and nonferrous metals:
   1. Connect ferrous and nonferrous metal piping, tubing, and fittings with dielectric couplings especially designed for the prevention of chemical reactions between dissimilar metals.
   2. Nonferrous metals include aluminum, copper, and copper alloys.

J. Flanged connections between dissimilar metals such as ductile iron pipe and steel pipe:
   1. Provide stainless steel bolts with isolation bushings and washers, and full-face flange gaskets.

3.02 CLEANING

A. Piping cleaning:
   1. Upon completion of installation, clean piping interior of foreign matter and debris.
   2. Perform special cleaning when required by the Contract Documents.

B. Chlorine piping:
   1. General:
      a. Coordinate with the Owner and attend a pre-cleaning meeting with Owner before cleaning chlorine piping.
      b. Work with the Owner during cleaning and conform to plant operational and shut down constraints.
      c. Clean chlorine piping in accordance with the requirements of the Chlorine Institute-Pamphlet 6 and meet the following requirements.
   2. PVC piping:
      a. Cleaning chlorine gas vacuum piping:
         1) Blow pipe clean of loose debris with instrument-grade clean and dry compressed air.
         2) Ensure that pipe is open and not valved off at the end of the section to be cleaned so that pipe does not become pressurized.
         3) Do not pressurize PVC with compressed air.
         4) Do not flush chlorine gas vacuum piping with water.
      b. Cleaning chlorine solution piping:
         1) Flush with potable water to clear loose debris.

C. Destination testing shall be conducted on all chemical piping prior to placing back in service. Destination testing is testing to confirm that water is being delivered to appropriate location when injected at the metering pump location. Only one destination test shall be conducted at a time to avoid confusion or incorrect interpretation of results.

D. Conduct pressure and leak test, as specified.

3.03 PIPE SCHEDULE

A. As indicated on the Drawings.

END OF SECTION

SECTION 15061

PIPE SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Supports for pipe, fittings, valves, and appurtenances.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   3. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

B. Manufacturers Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Design features.
   2. Load capacities.
   3. Material designations by UNS alloy number or ASTM Specification and Grade.
   4. Data needed to verify compliance with the Specifications.
   5. Catalog data.
   6. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.

C. Submit sealed and signed calculations for all pipe supports. Calculations shall meet the requirements as specified in Section 01850 - Design Criteria.

1.04 SYSTEM DESCRIPTION

A. Contractor shall provide final design, inspection, and certification for supports, seismic restraints, and provisions for control of expansion for all piping on this project that is 24 inches in diameter and smaller.
   1. The design of these systems shall be the product of a qualified professional engineer licensed to practice in the State of Utah retained by Contractor, as specified in Section 01357 - Delegated Design.

2. The hanger and support design drawings and calculations shall be prepared and signed by the Contractor's professional engineer (Design Professional) and shall bear the Design Professional's registration seal.
3. Design Professional shall have no less than 5 years of experience in type of piping work required for this project.
4. These requirements, however, shall not be construed as relieving Contractor of overall responsibility for this portion of the work.

B. In some cases, pipe/ductwork supports and expansion controls are shown on the Drawings. In other cases, they are not shown, but are required. In general, seismic restraints are not shown, but are required. Contractor is responsible to supply complete pipe/ductwork supports, seismic restraints, and expansion control systems whether they are shown on the Drawings or not.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

2.02 MATERIALS

A. General:
   1. Hot dip galvanized:
      a. Fabricate as specified in Section 05500 - Metal Fabrications.
      b. Hot dip after fabrication of support in accordance with ASTM A123.
      c. Repair galvanized surface as specified in Section 05500 - Metal Fabrications.
   2. Stainless steel:
      a. Fabricate as specified in Section 05500 - Metal Fabrications.
      b. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.
      c. At the shop, perform pickling and passivation on all surfaces inside and out in accordance with ASTM A380 or ASTM A967.
      d. Field welding is prohibited unless specifically allowed by the Owner. All field welds shall be passivated.

B. Outdoor areas: Areas exposed to the natural outdoor environment:
   1. Hot Dip Galvanized.

C. Indoor areas: Areas exposed to an indoor environment including galleries and tunnels:
   1. Hot Dip Galvanized.

D. Submerged, 3 feet or less above water level in a structure, or inside a water bearing structure:
   1. Type 316 Stainless Steel.

E. Stainless steel piping system:
   1. Type 304 Stainless Steel or Type 316 Stainless Steel.

F. Chemical containment areas and chemical piping:
   1. Type 316 Stainless Stee or FRP.

G. Fasteners:
   1. As specified in Section 05500 - Metal Fabrications.

2.03 PIPE SUPPORTS

A. Hanger rods: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 133.
         2) Nibco-Tolco, Figure 103.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 140.
         2) Bergen-Power, Figure 133.
         3) Cooper B-Line Systems, Inc., Figure B3205.

B. Hanger rods, continuously threaded: Sized to match suspended pipe hanger, or as indicated on the Drawings:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Bergen-Power, Figure 94.
         2) FM Stainless Fasteners.
      b. For steel and ductile iron piping:
         1) Anvil International, Figure 146.
         2) Bergen-Power, Figure 94.

C. Eye bolts:
   1. For stainless steel piping:
      a. Type 316 stainless steel, welded and rated equal to full load capacity of rod.
   2. For all other piping, unless indicated on the Drawings:
      a. Welded and rated equal to full load capacity of rod.

D. Welded eyebolt rod:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) FM Stainless Fasteners.
         2) Nibco-Tolco, Figure 101.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 278.
         2) Bergen-Power, Figure 93.

3) Cooper B-Line Systems, Inc., Figure B3210.

E. Adjustable ring hangers: MSS SP-58, Type 7 or Type 9 (system dependent):
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Bergen-Power, Figure 100SS.
2) Nibco-Tolco, Figure 1C.I.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 69.
2) Cooper B-Line Systems, Inc., Figure B3172.

F. Adjustable clevis hangers: MSS SP-58, Type 1:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure B3100 or B3102.
2) FM Stainless Fasteners, Figure 60.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 260 or Figure 590.
2) Bergen-Power, Figure 100.
3) Cooper B-Line Systems, Inc., Figure B3100 or B3102.

G. Adjustable clevis hangers for insulated pipe: Oversize:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 1A.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 300.
2) Bergen-Power, Figure 100EL.
3) Cooper B-Line Systems, Inc. Figure B3108.

H. Single rod hangers for steam pipe: MSS SP-58, Type 43; malleable iron or steel yoke and roller hangers; swivel to allow rotation of yoke on rod:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure B3110.
2) FM Fasteners, Figure 81.
3) Nibco-Tolco, Figure 324.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 181.
2) Cooper B-Line Systems, Inc., Figure B3110.

I. Double rod hangers for steam pipe: MSS SP-58, Type 41:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) FM Stainless Fasteners, Figure 71.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 171.
2) Cooper B-Line Systems, Inc., Figure B3114.

J. Brackets: MSS SP-58, Type 32 with back plate; rated for 1,500 pounds:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3066.
         2) FM Stainless Fasteners, Figure 98.
         3) Nibco-Tolco, Figure 30M.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 195.
         2) Cooper B-Line Systems, Inc., Figure B3066.

K. Brackets, heavy duty: MSS SP-58, Type 33 with back plate; rated for 3,000 pounds:
   1. Manufacturers: One of the following or equal:
      a. Anvil International, Figure 199.
      b. Cooper B-Line Systems, Inc., Figure B3067.

L. Standard U-bolt: MSS SP-58, Type 24:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3188.
         2) FM Stainless Fasteners, Figure 37.
         3) Nibco-Tolco, Figure 110.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 137.
         2) Bergen-Power, Figure 283.
         3) Cooper B-Line Systems, Inc., Figure B3188.

M. Riser clamps: MSS SP-58, Type 8:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3373.
         2) FM Stainless Fasteners, Figure 61.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 261.
         2) Bergen-Power, Figure 126.
         3) Cooper B-Line Systems, Inc., Figure B3373.

N. Pipe clamps: MSS SP-58, Type 4:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure 3140.
         2) Nibco-Tolco, Figure 4.
      b. For all other piping, unless indicated on the Drawings:
         1) Anvil International, Figure 212.
         2) Bergen-Power, Figure 175.
         3) Cooper B-Line Systems, Inc., Figure B3140.

O. Adjustable offset pipe clamp:
   1. Manufacturers: One of the following or equal:
      a. For stainless steel piping:
         1) Cooper B-Line Systems, Inc., Figure B3149.
         2) FM Stainless Fasteners, Figure 63.

3) Nibco-Tolco, Figure 4.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 100.
2) Cooper B-Line Systems, Inc., Figure B3149.

P. Offset pipe clamp:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure 3148.
2) Nibco-Tolco, Figure 8.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 103.
2) Cooper B-Line Systems, Inc., Figure B3148.

Q. Floor stand or stanchion saddles: MSS SP-58, Type 37. Provided with U-bolt hold down yokes:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) FM Stainless Fasteners, Figure 59.
2) Nibco-Tolco, Figure 318.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 259.
2) Bergen-Power, Figure 125.
3) Cooper B-Line Systems, Inc., Figure B3090.
c. Threaded pipe stand support stanchion. Match pipe support material:
1) Anvil International, Figure 63T.
2) Bergen-Power, Figure 138.
3) Cooper B-Line Systems Inc., Figure B3088ST.

R. Spring hangers:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Bergen-Power, Figure 920.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure B-268, Type G.
2) Bergen-Power, Figure 920.

S. One hole pipe clamps:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping: Engineer knows of no product.
b. For all other piping:
1) Anvil International, Figure 126.
2) Carpenter & Paterson, Figure 237S.

T. Welded beam attachment: MSS SP-58, Type 22:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Cooper B-Line Systems, Inc., Figure 3083.
2) Nibco-Tolco, Figure 304.

b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 66.
2) Bergen-Power, Figure 113A or 113B.
3) Cooper B-Line Systems, Inc., Figure B3083.

U. Heavy pipe clamp: MSS SP-58, Type 4:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 4H.
b. For all other piping, unless otherwise indicated on the Drawings:
1) Anvil International, Figure 216.
2) Bergen-Power, Figure 298.

V. PTFE pipe slide assembly: MSS SP-58, Type 35 with lateral and vertical restraint:
1. Manufacturers: One of the following or equal:
a. For stainless steel piping:
1) Nibco-Tolco, Figure 426.
b. For all other piping, unless indicated on the Drawings:
1) Anvil International, Figure 257, Type 3.
2) Cooper B-Line Systems, Inc., Figure B3893.

W. Anchor bolts, concrete anchors, concrete inserts, powder-actuated fasteners, and sleeve anchors: As specified in Section 05120 - Structural Steel Framing.

2.04 THERMAL PIPE HANGER SHIELD

A. Provided at hanger, support, and guide locations on pipe requiring insulation.

B. Consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer.

C. Same thickness as the piping system insulation specified in Section 15082 - Piping Insulation.

D. Standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems.

E. Stainless steel band clamps shall be used where specified to protect against slippage between the pipe wall and the thermal shield.

F. Standard shield:
1. Insulation:
a. Hydrous calcium silicate, high density, waterproof.
b. Compressive strength: 100 pounds per square inch average.
c. Flexural strength: 75 pounds per square inch average.
d. K factor: 0.38 at 100 degrees Fahrenheit mean.
e. Temperature range: 20 degrees Fahrenheit to 500 degrees Fahrenheit.
2. Steel jacket:
a. Jacket shall be galvanized steel.
b. Gauge shall be the manufacturer’s standard supplied for the given pipe size.

3. Connection:
    a. Shield shall have butt connection to pipe insulation.
    b. Steel jacket and insulation ends shall be flush.

G. Vapor barrier shield:
1. Insulation:
    a. Hydrous calcium silicate, high density, waterproof.
    b. Compressive strength: 100 pounds per square inch average.
    c. Flexural strength: 75 pounds per square inch average.
    d. K factor: 0.38 at 100 degrees Fahrenheit mean.
    e. Temperature range: 20 degrees Fahrenheit to 500 degrees Fahrenheit.
2. Steel jacket:
    a. Jacket shall be of galvanized steel.
    b. Gauge shall be the manufacturer's standard supplied for the given pipe size.
3. Connection:
    a. Shield shall have butt connection to pipe insulation.

H. Insulation shall extend 1 inch each side of steel jacket for vapor tight connection to the pipe insulation vapor barrier.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support, suspend, or anchor exposed pipe, fittings, valves, and appurtenances to prevent sagging, overstressing, or movement of piping; and to prevent thrusts or loads on or against connected pumps, blowers, and other equipment.

B. Field verify support location, orientation, and configuration to eliminate interferences prior to fabrication of supports.

C. Carefully determine locations of inserts. Anchor to formwork prior to placing concrete.

D. Use flush shells only where indicated on the Drawings.

E. Do not use anchors relying on deformation of lead alloy.

F. Do not use powder-actuated fasteners for securing metallic conduit or steel pipe larger than 1 inch to concrete, masonry, or wood.

G. Suspend pipe hangers from hanger rods and secure with double nuts.

H. Install continuously threaded hanger rods only where indicated on the Drawings.

I. Use adjustable ring hangers or adjustable clevis hangers for 4-inch and smaller diameter pipe.

J. Use adjustable clevis hangers for pipe larger than 4 inches in diameter.

K. Secure pipes with double nutted U-bolts or suspend pipes from hanger rods and hangers.
   1. For stainless steel piping, use stainless steel U-bolts.
   2. For all other piping, use galvanized U-bolts.

L. Support spacing:
   1. Support 2-inch and smaller piping on horizontal and vertical runs at maximum 5 feet on center, unless otherwise specified.
   2. Support larger than 2-inch piping on horizontal and vertical runs at maximum 10 feet on center, unless otherwise specified.
   3. Support exposed polyvinyl chloride and other plastic pipes at maximum 5 feet on center, regardless of size.
   4. Support tubing, PVC pipe 1-inch and smaller, copper pipe and tubing, fiber-reinforced plastic pipe or duct, and rubber hose and tubing at intervals close enough to prevent sagging greater than 1/4-inch between supports.
   5. Do not suspend or support valves, pipe and fittings from another pipe or conduit.

M. Install supports at:
   1. Any change in direction.
   2. Both sides of flexible pipe connections.
   3. Base of risers.
   4. Floor penetrations.
   5. Connections to pumps, blowers, and other equipment.
   6. Valves and appurtenances.

N. Securely anchor plastic pipe, valves, and headers to prevent movement during operation of valves.

O. Anchor plastic pipe between expansion loops and direction changes to prevent axial movement through anchors.

P. Provide elbows or tees supported from floors with base fittings where indicated on the Drawings.

Q. Support base fittings with metal supports or, when indicated on the Drawings, support on concrete piers.

R. Do not use chains, plumbers' straps, wire, or similar devices for permanently suspending, supporting, or restraining pipes.

S. Support plumbing drainage and vents in accordance with plumbing code as specified in Section 01410 - Regulatory Requirements.

T. Supports, clamps, brackets, and portions of support system bearing against copper pipe: Copper plated, copper throughout, or isolated with neoprene or polyvinyl chloride tape.

U. Where pipe is insulated, install over-sized supports and hangers.

V. Install thermal pipe shield in accordance with MSS SP-58, Type 40 on pipe supports for insulated pipes.

W. Install riser clamps at floor penetrations and where indicated on the Drawings.

X. Coat support system components as specified in Section 09960 - High-Performance Coatings.

END OF SECTION

SECTION 15062

PREFORMED CHANNEL PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Preformed channel pipe support system consisting of preformed channels, fittings, straps, and fasteners engineered to support piping.

1.02 REFERENCES

A. American Institute of Steel Construction (AISC).

B. American Iron and Steel Institute (AISI).

C. Manufacturer's Standardization Society (MSS):
   1. SP-58 - Pipe Hangers and Supports - Materials, Design, and Manufacture.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data.

1.04 QUALITY ASSURANCE

A. Design preformed channel pipe support system for loads in accordance with applicable provisions of:
   1. AISC Manual of Steel Construction.
   2. AISI Cold-Formed Steel Design Manual.

B. Product standards:
   1. Pipe support materials: In accordance with MSS SP-58.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fabricate preformed channel pipe support system using, as a minimum, parts specified below and meeting the requirements specified under Design Criteria.
   1. Manufacturers: One of the following or equal:
      a. Unistrut, Series P1000 or P1001; P5500 or P5501.

b. Allied Support Systems, Power Strut, Figure PS-200 or PS-200 2TS; PS-150 or PS-150 2TS.
c. Cooper Ind., B-Line, Channel Type B22 or B22A; B12 or B12A.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design responsibility:
1. The manufacturer of the preformed channel pipe support system is responsible for the design of the support system.
2. Prepare design calculations utilizing the design criteria included in these Specifications.
3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design criteria:
1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
2. Minimum gauge thickness: 12-gauge.
3. Allowable stress of channels:
a. Steel channels: The lesser of 25,000 pounds per square inch, or 0.66 times yield stress of steel.
b. Stainless steel channels: 0.66 times the yield stress of the stainless steel alloy.
4. Maximum deflection: 1/240 of span.
5. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
6. Future loads:
a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
7. Seismic design criteria: As specified in Section 01850 - Design Criteria as specified for mechanical equipment.
8. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

C. Supports below the top of walls of water bearing structures: Use Type 316 stainless steel for support system components.
1. Supports in other locations: Use hot-dipped galvanized components unless other materials are specifically indicated on the Drawings.

2.03 ACCESSORIES

A. Preformed channel concrete inserts: Minimum 12 inches long:
1. Manufacturers: One of the following or equal:
a. Unistrut, Series P-3200.
b. Allied Support Systems, Figure 282.

c. Cooper Ind., B-Line Series B32I.

B. 90-degree angle fittings:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P1026.
      b. Allied Support Systems, Power Strut, P603.

C. Pipe straps:
   1. For pipes 8 inches in diameter and smaller: Use 2-piece universal strap with slotted hex head screw and nut.
      a. Manufacturers: One of the following or equal:
         1) Unistrut, Series P1109 through P1126.
         2) Allied Support Systems, PS1100.
         3) Cooper Ind., B-Line Series B2000.
   2. For pipes greater than 8 inches in diameter: Unless different material is otherwise indicated on the Drawings use 1-piece 1-inch wide by 1/8-inch thick steel strap, hot-dip galvanized after fabrication.
   3. For stainless steel pipes: Use type of strap required for the pipe sizes specified above, but use Type 316 stainless steel materials.

D. Prefabricated double channel bracket:
   1. Manufacturers: One of the following or equal:
      a. Unistrut, P2542-P2546.
      b. Cooper Ind., B-Line Series B297.

E. Touch-up paint for galvanized surfaces:
   1. Manufacturers: The following or equal:
      a. Galvinox, Galvo-Weld.

F. Touch-up paint for painted surfaces: Same formulation as factory paint.

G. Cushion strip:
   1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to 275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets this criteria.
      a. Manufacturers: One of the following or equal:
         1) Anvil, AS 3795.
         2) Unistrut, P2600 Unicushion.

2.04 FABRICATION

A. Hot-dip galvanize support system components after fabrication to required length and shape.

B. Do not galvanize or paint stainless steel components.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install preformed channel concrete inserts for vertical support, quantity based on manufacturer's structural design calculations.

B. Fasten preformed channel pipe supports to existing walls using Z-fittings and concrete anchors as indicated on the Drawings.

C. Fasten preformed channel pipe supports to preformed channel concrete inserts embedded in ceiling using U-shaped fittings.

D. Suspend threaded rods from concrete inserts embedded in ceiling. Support preformed channel pipe supports with threaded rods.

E. Touchup cut or damaged galvanized surfaces.

F. Prevent contact between pipes and support components of dissimilar metals. Utilize rubber coated, plastic coated, or vinyl coated components, stainless steel components, or wrap pipe with PVC or polyethylene tape.

G. Install support as near as possible to concentrated loads.

H. Install support within 2 feet of horizontal and vertical changes in pipe alignment.

I. Adjust supports or install shims to obtain specified slope or elevation.

END OF SECTION

SECTION 15063

NON-METALLIC PIPE SUPPORT SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Non-metallic pipe support system including the following:
   1. Channel framing and components.
   2. Pipe clamps.
   3. Fittings.
   4. Fasteners.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings.

C. Calculations.

1.04 QUALITY ASSURANCE

A. Supply materials from a single manufacturer with sole responsibility for the pipe support system.

B. The supplied system, including pipe clamps, shall be interchangeable with industry standard 1-5/8-inch steel and fiberglass channel framing systems.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Transportation, handling, storage, and installation shall be in accordance with the manufacturers printed instructions.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. StrutTech.
   2. Unistrut.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design responsibility:
   1. The manufacturer of the non-metallic pipe support system shall be considered the designer of the support system.
   2. Prepare design calculations utilizing the design criteria included in these Specifications.
   3. Prepare detailed shop drawings illustrating the layout of the support system and identifying the components of the support system.

B. Design requirements:
   1. Include live, dead, and seismic loads associated with piping, valves, and appurtenances. Consider the content of the pipes in load calculations.
   2. Maximum allowable deflection: 1/240 of span.
   3. Allowable column loads: As recommended by manufacturer in published instruction for column's unsupported height and "K" value for calculating effective column length of not less than 1.0.
   4. Future loads:
      a. Support systems indicated on the Drawings may include spaces intended to accommodate future pipes.
      b. Assume such spaces are occupied by 6-inch diameter ductile iron pipes. Only the number of pipes that would physically fit into the space need be considered.
      c. Include the weight of the pipe contents in determining future loads. Assume pipe contents are water.
   5. Seismic design criteria: As specified in Section 01850 - Design Criteria as specified for mechanical equipment.
   6. Spacing of supports: As required to comply with design requirements but not more than 5 feet.

2.03 MATERIALS

A. Fiberglass resin: Corrosion-resistant premium grade vinylester.

B. Injection molded components: Polyurethane thermoplastics.

C. Flame spread of fiberglass:
   1. Vinylester fiberglass (Series VF): Class 1, ASTM E84.
   2. Polyurethane: V-O UL 94V.

D. Physical properties of fiberglass:

Physical Property	Longitudinal	Transverse
Tensile Strength	37,500 pounds per square inch (psi)	10,000 psi
Tensile Modules	3.0×10^6 psi	1.0×10^6 psi
Flexural Strength	37,500 psi	14,000 psi
Flexural Modules	2.0×10^6 psi	1.0×10^6 psi
Compressive Strength	37,500 psi	20,000 psi
Shear Strength	6,000 psi	5,500 psi
Izod Impact	30 foot-pounds per square inch	5 foot-pounds per square inch

E. Surface veil: Fiberglass channel shall have polyester surface veil over 100 percent of the surface to provide protection against degradation from ultraviolet light.

F. Touch-up resin:
   1. Manufacturers: The following or equal:
      a. Krylon, 7006-Satin Polyurethane Clear Finish.

2.04 COMPONENTS

A. Channel framing:
   1. All channel framing shall be supplied with integral notches 1 inch on center.
   2. Locate notches on interior flange to prevent slippage of pipe clamps and fittings after installation.

B. Pipe clamps:
   1. Adjustable type: Non-metallic and non-conductive.
   2. Fixed type:
      a. Pipe clamps for pipe less than 6 inches in diameter shall be non-metallic and non-conductive.
      b. Pipe clamps for pipe equal to and greater than 6 inches in diameter shall be fiberglass.

C. Channel fittings:
   1. Make fittings and post bases from glass-filled polyurethane or polyester.

D. Fasteners:
   1. Make fasteners from one of the following materials:
      a. Glass-filled polyurethane.
      b. Vinylester fiberglass.

E. Cushion strip:
   1. For solvent welded plastic pipes in elevated temperatures, use a thermoplastic elastomer, cushion wrap designed for use from -50 degrees Fahrenheit to

275 degrees Fahrenheit. Contractor to add a cushion strip at each pipe support strap that meets these criteria.

a. Manufacturers: One of the following or equal:
    1) Anvil, AS 3795.
    2) Unistrut, P2600 Unicushion.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Install in accordance with manufacturer's instructions, shop drawings, and as indicated on the Drawings.
2. Seal machined edges and holes with touch-up resin.

END OF SECTION

SECTION 15076

PIPE IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pipe identification including the following:
   1. Pipe identification markers, flow direction arrows, tags, and bands.
   2. Underground warning tape.
   3. Tracer wire.
   4. Witness markers.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. A13.1 - Scheme for the Identification of Piping Systems.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Submit following:
   1. Product data.
   2. Samples.
   3. Manufacturer's installation instructions.
   4. Submit following as specified in Section 01770 - Closeout Procedures:
      a. Operation and Maintenance Data.
      b. Warranty.

C. Color selection for all pipes and labels

PART 2 PRODUCTS

2.01 EXPOSED AND IN-CHASE PIPE IDENTIFICATION

A. For piping with outer diameter greater than or equal to 3/4 inch, provide lettered pipe markers and flow direction arrows:
   1. General requirements:
      a. Pipe markers shall include the following, minimum:
         1) Printed text identifying the pipe fluid.
            a) The text shall be all capital letters matching the text listed in the "Service" column of the Piping Schedule for the corresponding piping system.
         2) An arrow identifying the direction of fluid flow.
            a) The arrow can either be integral to the text marker or provided separately. If provided separately, the arrow must be placed immediately adjacent to each text marker, with the arrow aligned

with the text such that the text and arrow are both visible from the same viewpoint.

b) The arrow color shall match the text color, and the arrow background color shall match the text background color.

b. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.

c. Lettering:

Outside Pipe Diameter Including Covering	Lettering Height
Less than 0.75 inches	N/A
0.75 to 1.5 inches	1/2-inch
1.5 inches to 2 inches	3/4-inch
2.5 inches to 6 inches	1-1/4 inches
8 inches to 10 inches	2-1/2 inches
Over 10 inches	3-1/2 inches

d. Pipe and Marker colors:

1) Provide marker colors in accordance with Utah State Drinking Water Rules. Reference R309-525-8.
2) Lettering on labels shall be of a contrasting color (either black or white).
3) Submit all proposed pipe top coat and label colors to Owner for approval before painting.

2. Self-adhesive type markers:
   a. Manufacturers: One of the following or equal:
      1) Seton, (of Brady Corporation), Opti Code Pipe Markers.
      2) Marking Services, Inc.
      3) Duralabel.

   b. Materials:
      1) Self-adhesive vinyl.

B. For piping with outer diameter less than 3/4 inch, provide identification tags and flow direction arrows:
   1. Manufacturer: One of the following or equal:
      a. Seton (of Brady Corporation).
   2. Tag and chain materials:
      a. Copper piping: Brass.
      b. Ferrous piping: Type 316 stainless steel.
      c. Plastic piping: Stainless steel or Aluminum.
   3. Flow direction arrow colors shall adhere to the same requirements as for piping with outer diameter greater than or equal to 3/4 -inch, as specified in this Section.

C. Pipe bands:
   1. When bands are required by the Piping Schedule for a specific piping system, provide solid-colored 4-inch wide bands.
      a. Color as specified in the Piping Schedule.
   2. Self-adhesive type.
   3. Suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit.

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground warning tape:
   1. Manufacturer: One of the following or equal:
      a. Seton (of Brady Corporation).
      b. T. Christy Enterprises, Inc.
   2. Material:
      a. Polyethylene tape for prolonged underground use.
      b. Minimum tape thickness: 4 mils.
      c. Overall tape width: 4 inches.
      d. Message: “CAUTION” with the name of the service followed by “LINE BURIED BELOW.” in black lettering on colored background in accordance with approved APWA colors.

Service	**Color**
Potable water	Blue
Reclaimed water, irrigation, and slurry lines	Purple
Sewers and drain lines	Green
Gas, oil, steam, petroleum, chemicals, or other service	Yellow

B. Tracer wire:
   1. Manufacturers: One of the following or equal:
      a. Kris-Tech Wire.
      b. Aegion Corrpro.
   2. Materials: One of the following or equal:
      a. Solid copper conductor
      b. Thickness minimum: 10 gauge.
      c. Insulation:
         1) Match insulation color to the color of the pipe being installed.
         2) UF type, direct bury.
         3) 30 mil HMWPE.
   3. Splicing kit:
      a. Manufacturers: One of the following or equal:
         1) 3M, Model 82 A1N.
   4. Station box:
      a. Lid and collar materials: Cast iron.
      b. Lid type: Locking.
      c. Able to withstand heavy traffic loading.
      d. Manufacturers: One of the following or equal:
         1) CP Test & Valve Products, Inc., Glenn Test Station.
         2) Farwest Corrosion Control.

C. Witness markers:
   1. Manufacturers: One of the following or equal:
      a. Carsonite Composites, Utility Marker.
   2. Materials:
      a. Glass fiber and resin reinforced thermosetting composite material.
      b. UV resistant.
   3. Constructed as a single piece.
   4. Pointed at the bottom end.
   5. Information to be included on the marker:
      a. “Caution” (type of service) “Pipeline”.
      b. Phone number for Blue Stakes of Utah.
      c. Phone number for Owner in case of emergency.
      d. Station number: 1-800-662-4111.
      e. Offset:
         1) Only provide offset if marker is not directly over the pipe.
      f. Name of appurtenance or fitting (e.g. 45, BO, ARV, etc.)

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify satisfactory conditions of substrate for applying identification.

B. Verify that conditions are satisfactory for installation and application of products as specified in Section 01600 - Product Requirements.

3.02 PREPARATION

A. Prepare and coat piping with the coating systems defined in the Piping Schedule.

B. Prepare surface in accordance with identification product manufacturer's instructions.

3.03 EXPOSED AND IN-CHASE PIPING IDENTIFICATION

A. Identify exposed and in-chase piping with flow direction arrows and lettering (for piping with outer diameter greater than or equal to 3/4 inch) or tags (for piping with outer diameter less than 3/4 inch).

B. Provide lettering (or tags for pipes with outer diameter less than 3/4 inch) and flow direction arrows near equipment served, adjacent to valves, both sides of walls and floors where pipe passes through, at each branch or tee, and at intervals of not more than 50 feet in straight runs of pipe.
   1. Label all chemical tank fill pipelines at locations that are visible from chemical fill stations.
   2. Place markers on piping so they are visible from operator's position in walkway or working platform near piping. Locate markers on overhead pipes at 45 degrees below horizontal centerline of pipe, never directly at the bottom of a pipe. Print markers so that flow arrows are accurate when placed on either side of the pipe.

3. Do not apply markers, arrows, or tags to piping that is regularly submerged.

C. Where scheduled in the Piping Schedule, space solid-color bands along piping at 10-foot intervals.
   1. Do not apply bands to piping that is regularly submerged.

3.04 BURIED PIPING IDENTIFICATION

A. Underground warning tape:
   1. Non-detectable warning tape:
      a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe.
   2. Detectable warning tape:
      a. Place continuous run of warning tape in pipe trench, 12 inches above the pipe or a greater height if necessary to limit the tape bury depth to 36 inches. Do not bury detectable warning tape deeper than 36 inches.

B. Tracer wire:
   1. Install on all non-metallic pipe.
   2. Install an electrically continuous run of tracer wire along the entire length of the pipe with wire terminations in valve boxes, vaults, or structures.
   3. Install tracer wire on top of the pipe and secure to pipe with tape a minimum of every 10 feet.
   4. Where approved by the Engineer, splice sections of wire together using approved direct bury wire nuts.
      a. Twisting the wires together is not acceptable.

C. Witness markers:
   1. Install over pipe in unpaved open-space areas at intervals not greater than 200 feet.
   2. Place markers at appurtenances located in unpaved areas.
   3. Embed markers at least 18 inches into the soil.

END OF SECTION

SECTION 15082

PIPING INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Insulation for piping and related systems that are not plumbing systems.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded, and Seamless.
   2. C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   3. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   4. C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   5. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
   6. C552 - Standard Specification for Cellular Glass Thermal Insulation.
   7. C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
   8. C929 - Standard Practice for Handling, Transporting, Shipping, Storage, Receiving, and Application of Thermal Insulation Materials for Use in Contact with Austenitic Stainless Steel.
   9. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   10. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   11. D2310 - Standard Classification of Machine-Made "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe.
   12. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
   13. E96 - Standard Test Methods for Water Vapor Transmission of Materials.

1.03 DEFINITIONS

A. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.

B. Concealed: Piping above suspended ceilings and within walls, partitions, shafts, or service spaces and spaces not normally exposed to view but not buried.

C. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.

D. Flame Spread and Smoke Density: Burning characteristics determined in accordance with ASTM E84.

E. Interior: Piping that is installed inside a building.

F. K Factor: Thermal conductivity determined in accordance with ASTM C177 or C518.

G. Mineral Fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.

H. Water Vapor Permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section15050 - Common Work Results for Mechanical Equipment.
   1. Insulation properties: Include K factor, thickness, density, operating temperature limits, tensile strength, compressive strength, moisture absorption, flame spread, and smoke developed in accordance with ASTM E84 and corrosivity to stainless steel piping in accordance with ASTM C795.
   2. Jacket properties: Include covering material, cover thickness, tensile strength, tear strength, permeability in accordance with ASTM E96, flame spread, and smoke developed in accordance with ASTM E84, closure type or devices, and accessories.
   3. Insulating blankets: Include materials, performance characteristics, method of attaching to equipment, listing of locations where insulating blankets will be installed.
   4. Manufacturer's application instructions: Include assembly and application drawings and detailed instructions.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15050 - Common Work Results for Mechanical Equipment and Section 15500 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 15050 Common Work Results for Mechanical Equipment and Section 15500 - Common Work Results for HVAC.

B. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

TABLE 1. Required Insulation Thicknesses

Required Insulation Thicknesses (inches)					
Service Temperature Range as Designated in Insulation Schedule at End of this Section	**Nominal Pipe Diameters**				
	1 inch and Less	**1.25 to 2 inches**	**2.5 to 4 inches**	**5 to 10 inches**	**Over 10 inches**
Above 200 degrees Fahrenheit	2.0	2.5	3.0	3.5	3.5
100 to 200 degrees Fahrenheit	1.5	1.5	1.5	2.0	2.5
40 to 100 degrees Fahrenheit	0.5	1.0	1.0	1.5	2.0
Below 40 degrees Fahrenheit	1.0	1.0	1.5	2.0	2.0
Heat Traced Pipes	1.0	1.0	1.0	1.5	2.0
Aeration Air Pipes	0.5	0.5	1.0	1.0	1.0

2.03 PIPE INSULATION

A. Insulation types: Provide in accordance with the insulation types listed and scheduled.

B. Insulation, Type 1:
   1. Insulation material: Closed cell elastomeric insulation.
   2. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
   3. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
   4. Fire ratings:
      a. Flame spread: 25 or less.
      b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
   5. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.
   6. Manufacturers: One of the following or equal:
      a. Armacell, AP Armaflex.
      b. Aeroflex USA Inc., Aerocel® AC.

C. Insulation, Type 2:
   1. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
      a. In accordance with ASTM C547, Class 1.
      b. Provide with factory installed vapor barrier.
         1) Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type I.

2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
3) Circumferential butt seals: 4-inch wide tape or similar properties or 4-inch wide overlap with adhesive seal.
4) Vapor barrier permeability: 0.02 perms or lower.
5) Vapor barrier flame spread rating: 25 or less.

2. Minimum temperature range: Minus 0 degrees Fahrenheit to plus 850 degrees Fahrenheit.
3. K factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-inch/hour-square feet degrees Fahrenheit.
4. Maximum moisture absorption, volume percent: 5.
5. Manufacturers: One of the following or equal:
   a. Owens-Corning , Fiberglas™ FLEXWRAP® ASJ.
   b. Johns Manville, Micro-Lok® HP.
   c. Knauf Insulation, Earthwool® Redi-Klad® 1000° Pipe Insulation.

D. Insulation, Type 3:
1. Insulation material: Rigid cellular glass in accordance with ASTM C552, Type II.
2. Temperature range: Minus 450 degrees Fahrenheit to plus 900 degrees Fahrenheit.
3. K factor at 75 degrees Fahrenheit: Not more than 0.32 BTU-inch/hour-square feet-degrees Fahrenheit.
4. Minimum average density: 7.5 pounds per cubic foot.
5. Maximum moisture absorption, volume percent: 5.
6. Minimum compressive strength: 87 pounds per square inch.
7. Moisture permeability: 0.00 perm-inch.
8. Manufacturers: One of the following or equal:
   a. Owens- Corning, Foamglas® One™.

E. Insulation, Type 4:
1. Insulation material: Asbestos-free, rigid calcium silicate in accordance with ASTM C533; Type I for process temperatures up to 1,200 degrees Fahrenheit.
2. K factor at 500 degrees Fahrenheit: 0.55 for Type I.
3. Maximum average (dry) density: 14.5 pounds per cubic foot.
4. Compressive strength: 100 pounds per square inch, to produce a 5-percent compression.
5. Manufacturers: The following or equal: In accordance with ASTM C533 Type I:
   a. Johns Manville, Thermo-12 Gold.

2.04 INSULATION JACKETS

A. Jacket, Type 1:
1. Material: 28 ounces per square yard polyvinyl chloride on polyester fabric; total thickness 0.028-inch minimum.
2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: As selected by the Engineer from manufacturer's standard colors.
4. Overlap: 1-inch minimum at joints and fittings.
5. Joint seal: Self-sealing lap tape.
6. Fittings: Factory made with full thickness insulation.

7. Manufacturers: The following or equal:
    a. Techlite® Insulation, 379 SSL Series.

B. Jacket, Type 2:
1. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
2. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
3. Color: White.
4. Overlap: 1-inch minimum at joints and fittings.
5. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
6. Fittings: Factory made with full thickness insulation.
7. Manufacturers: One of the following or equal:
    a. Johns Manville, Zeston® 2000 PVC.
    b. Proto Corp., LoSMOKE PVC.
    c. Speedline® Corp., Smoke-Safe™ PVC.

C. Jacket, Type 3:
1. Material: Aluminum, Alloy 3003 or 3105; 0.016-inch (26-gauge) minimum thickness.
2. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
3. Bands: 0.5-inch wide, 0.0508-inch (16-gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
4. Joint seal: Apply waterproof adhesive at joints and overlaps.
5. Fittings: Custom fit of same materials.
6. Manufacturers: One of the following or equal:
    a. ECOIN Insulation.
    b. Haomei Aluminum.

2.05 VAPOR BARRIERS

A. Vapor barrier, Type 1:
1. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
2. Permeability: 0.02 perms or lower.
3. Maximum flame spread rating: 25.
4. Edge seal: Pressure-sensitive tape lap seal.
5. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.

B. Vapor barrier, Type 2:
1. Material: Mastic.
2. Manufacturers: One of the following or equal:
    a. Benjamin Foster, No. 30-76.
    b. Insul-Coustic, No. I.C.-580.
    c. Foster Products, 36-10/46-10 Weatherite.
    d. Childers Products CP10/11 VI-CRYL.

2.06 RELATED MATERIALS

A. Cover adhesive: Premium adhesive as recommended by the insulation cover supplier for heavy-duty service in corrosive, wet environments. Standard-duty adhesives are not permitted.

2.07 REMOVABLE INSULATING BLANKETS

A. In piping systems specified to be insulated, use removable insulating blankets for valves, meters, strainers, filters, catalytic converters, engine exhaust silencers, pumps, and other in-line piping appurtenances and equipment requiring periodic servicing, regardless of pipe size.

B. Size limits: Use removable insulating blankets for equipment and piping appurtenances 3 inches in nominal size and larger. For equipment and piping appurtenances less than 3 inches that do not require periodic servicing, insulate with molded sections of insulation or by field cutting insulation to conform to the shape of the component and to fit tightly around the component.

C. Manufacturers: One of the following, or equal:
   1. Thermal Energy Products, Inc., Energy Wrap.
   2. Accessible Products, Thermazip 2000 Jacket.
   3. Owens Corning, Temp-Mat.

D. Low temperature insulating blankets rated up to 800 degrees Fahrenheit:
   1. Use: For service temperatures up to 800 degrees Fahrenheit.
   2. Insulation: Fiberglass fiber, K factor 0.27 at 75 degrees Fahrenheit.
   3. Cover: 17-ounce fabric with both sides covered with silicone-impregnated glass cloth suitable for temperatures up to 800 degrees Fahrenheit.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire.
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

E. High temperature insulating blankets rated up to 1,400 degrees Fahrenheit:
   1. Rated for sustained service temperatures up to 1,400 degrees Fahrenheit.
   2. Insulation: Ceramic fiber, K factor 0.50 at 600 degrees Fahrenheit, insulation material suitable for up to 2,300 degrees Fahrenheit, thickness to match adjacent piping insulation specified thickness.
   3. Cover: 17-ounce silicone impregnated fiberglass cloth suitable for temperatures up to 1,400 degrees Fahrenheit.
   4. Cover fasteners: Use one of the following systems:
      a. Grommets in the blanket and stainless steel wire.
      b. 1-inch wide straps with stainless steel rectangular ring buckles and Velcro on strap tail.

2.08 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Handle and store insulation for use on stainless steel in accordance with ASTM C929.

3.02 PREPARATION

A. Pressure test piping and complete application of coating system before applying insulation.

B. When piping is to be heat traced, install and functionally test heat tracing before installation of insulation.

C. Before beginning installation of piping insulation, verify that the Engineer has accepted piping tests, pipe coating applications, and heat tracing tests.

3.03 INSULATION SCHEDULE

A. Table 2. Insulation Schedule does not include insulation required for plumbing systems. Plumbing systems insulation: As specified in Section 15400 - Plumbing Systems.

TABLE 2. Insulation Schedule

Service Designation[1]	Location[2]	Insulation Type[3]	Jacket Type[3]	Service Temp. °F[4]	Vapor Barrier
Hot Water Supply and Return	Interior or Exterior	2 or 3	2 or 3	100-200	Required
HVAC Refrigerant	Interior or Exterior	1	2	Below 40	Required
Heat Traced Pipes[7]	Exterior	1 or 2	2	N/A	Install on Type 2 insulation

Notes:

(1) Refer to Piping Schedule in Section 15052 - Common Work Results for General Piping for service designations.
(2) Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
(3) Contractor may select from options listed.
(4) Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by TABLE 1. Required Insulation Thicknesses.
(5) Service temperature based on engine rating. Use Type I calcium silicate for exhaust temperatures up to 1,200 degrees Fahrenheit; use Type II calcium silicate for exhaust temperatures above 1,200 degrees Fahrenheit.
(6) Install insulation on all aeration air piping located from the discharge of blowers to 10 feet above the slab. Insulation is not required for aeration air piping that is installed higher than 10 feet above the slab.
(7) Insulate all piping systems that are specified to be heat traced.

3.04 INSTALLATION

A. Install insulation and jacket materials in accordance with manufacturer's written instructions.

B. Apply insulation in smooth, clean manner with tight and finished smooth joints. Fit insulation tightly against surfaces. Insulate each continuous run of pipe with full-length sections of insulation with a single piece cut to length to complete the run of pipe. Do not use cut pieces or scraps to complete the installation.

C. Butt longitudinal and circumferential insulation joints firmly together.

D. Maintain the integrity of vapor barrier jacketing. Do not use staples to hold vapor barrier overlaps in place.

E. Apply sealant or cement when previous applications of adhesives and cement have thoroughly dried.

F. Apply insulation to permit expansion or contraction of pipelines without damage to insulation or jacketing.

G. Fittings:
   1. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
   2. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
   3. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.

H. Valves:
   1. Insulate valves 3 inches in nominal size and larger with removable insulating blankets.
   2. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.

I. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.

J. Extend insulation against insulation end protection shields or covers so that insulation voids do not exist and provide watertight end seals and covers where insulation terminates.

K. Insulate pipeline strainers to permit removal of strainer basket without disturbing insulation on strainer body.

L. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.

M. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.

N. Thermally isolate all insulation closure locations (end caps, transitions, etc.) Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.

O. Apply piping identification on jackets as specified in Section 15076 - Pipe Identification.

END OF SECTION

SECTION 15110

COMMON WORK RESULTS FOR VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Basic requirements for valves.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C111/A21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe Fittings.

B. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   3. A536 - Standard Specification for Ductile Iron Castings.

C. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

D. Society for Protective Coatings (SSPC):
   1. SP7 - Brush-Off Blast Cleaning.
   2. SP10 - Near-White Blast Cleaning.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Submit the following information for each valve:
      a. Valve type, size, pressure rating, Cv factor.
      b. Coatings.
      c. Power valve actuators:
         1) Information on valve actuator including size, manufacturer, model number, limit switches, mounting; and motor enclosure, seating and unseating torque coefficient, dynamic torque, and bearing friction for calculation of maximum operating torque.
         2) Complete wiring diagrams and control system schematics.
      d. Manual valve actuators:
         1) Information on valve actuator including size, manufacturer, model number.
      e. Certified drawings with description of component parts, dimensions, weights, and materials of construction.

f. Certifications of reference standard compliance:
    1) Submit certification that the valves and coatings are suitable in potable water applications in accordance with NSF 61.
g. Clearly mark submittal information to show specific items, materials, and accessories or options being furnished.
h. Factory test data.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.
    1. Furnish bound sets of installation, operation, and maintenance instructions for each type of manual valve 4 inches in nominal size and larger, and all non-manual valves. Include information on valve operators.

D. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

F. Provide structural calculations for bonnet extensions, where provided, showing the sizing, materials, and configuration of the bonnet extensions such that the torque from the actuator is effectively transferred to the valve via the valve stem and valve body, without imparting any force on the surrounding structure or causing significant strain on the valve.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications:
    1. Valves manufactured by manufacturers whose valves have had successful operational experience in comparable service.

1.05 DELIVERY STORAGE AND HANDLING

A. Protect valves and protective coatings from damage during handling and installation; repair coating where damaged.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pressure rating:
    1. Suitable for service under minimum working pressures of 150 pounds per square inch gauge.
    2. When a piping system is specified in the Piping Schedule to be tested at a pressure greater than 150 pounds per square inch gauge, provide valves for that piping system with design working pressure which is sufficient to withstand the test pressure.

B. Valve to piping connections:
   1. Metallic valves:
      a. Valves 3 inches nominal size and larger: Flanged ends.
      b. Valves less than 3 inches nominal size: Screwed ends.
   2. Plastic valves in plastic piping systems:
      a. Up to 4 inches: Provide solvent or heat welded unions, except for plastic butterfly valves.
         1) Plastic butterfly valves shall be flanged per Section 15112 - Butterfly Valves.
      b. 6 inches and above: Provide solvent or heat-welded flanges.

2.02 MATERIALS

A. Stainless steel: In accordance with ASTM A480, Type 316, or Type 304, UNS Alloy S31600 or S30400.

B. Valve and operator bolts and nuts (not including flange bolts and nuts, which are specified in Section 15052 - Common Work Results for General Piping):
   1. Fabricated of stainless steel for the following installation conditions:
      a. Submerged in sewage or water.
      b. In an enclosed space above sewage or water.
      c. In structures containing sewage or water, below top of walls.
      d. At openings in concrete or metal decks.
   2. Where dissimilar metals are being bolted, use stainless steel bolts with isolation bushings and washers.
   3. Underground bolts: Low-alloy steel in accordance with AWWA C111/A21.11.

C. Bronze and brass alloys: Use bronze and brass alloys with not more than 6 percent zinc and not more than 2 percent aluminum in the manufacture of valve parts; UNS Alloy C83600 or C92200 unless specified otherwise.

D. Cast iron valve bodies: In accordance with ASTM A126, Class 30 minimum.

E. Ductile iron valve bodies: In accordance with ASTM A536, Grade 65-45-12 minimum unless specified otherwise.

2.03 INTERIOR PROTECTIVE LINING

A. When specified in the particular valve specification, provide valves with type of protective lining specified in the particular valve Specification.

B. Apply protective lining to interior, non-working surfaces, except stainless steel surfaces.

C. Lining types:
   1. Fusion bonded epoxy:
      a. Manufacturers: The following or equal:
         1) 3-M Company, ScotchKote 134; certified to NSF 61 for drinking water use.
      b. Clean surfaces in accordance with SSPC SP 7 or SP 10, as recommended by epoxy manufacturer.

c. Apply in accordance with manufacturer's published instructions.
d. Lining thickness: 0.010 to 0.012-inch, except that:
    1) Lining thickness in grooves for gaskets: 0.005-inch.
    2) Do not coat seat grooves in valves with bonded seat.
e. Quality control:
    1) Lining thickness: Measured with a non-destructive magnetic type thickness gauge.
    2) Verify lining integrity with a wet sponge-testing unit operating at approximately 60 volts, or as recommended by the lining manufacturer.
    3) Consider tests successful when lining thickness meets specified requirements and when no pinholes are found.
    4) Correct defective lining disclosed by unsuccessful tests, and repeat test.
    5) Repair pinholes with liquid epoxy recommended by manufacturer of the epoxy used for lining.

2. High solids epoxy:
    a. Product equivalent to high solids epoxy as specified in Section 09960 - High-Performance Coatings.
        1) Certified in accordance with NSF 61 for drinking water use.
        2) Interior: Coat valve interior with manufacturer's equivalent high performance high solids epoxy coating system with a certifiable performance history for the service conditions and as approved by the Engineer. Manufacturer shall provide for approval, coating information sufficient to allow Engineer to assess equivalence to the specified high solids epoxy as specified in Section 09960 - High-Performance Coatings.
    b. Clean surfaces to meet SP-7 or SP-10, or as recommended by coating manufacturer.
    c. Quality control: After coating is cured, check coated surface for porosity with a holiday detector set at 1,800 volts, or as recommended by coating manufacturer.
        1) Repair holidays and other irregularities and retest coating.
        2) Repeat procedure until holidays and other irregularities are corrected.

2.04 UNDERGROUND VALVES

A. Provide underground valves with flanged, mechanical, or other type of joint required for the type of pipe to which the valve is to be connected.

B. Coating and wrapping:
    1. After installation, encase valves in polyethylene wrap as specified for ductile iron piping in Section 15211 - Ductile Iron Pipe: AWWA C151.
        a. Ascertain that polyethylene wrapping does not affect operation of valve.

2.05 VALVE BOXES

A. Provide cast-iron valve boxes at each buried valve to access valve and valve operators.

B. Do not support boxes on valve, valve operator, or pipe.

C. Boxes:
   1. 2-piece, fabricated of cast iron; provide cover, with asphalt varnish or enamel protective coating.
   2. Adjustable to grade, install centered around the upper portions of the valve and valve operator.

D. Manufacturers: One of the following or equal:
   1. Tyler Pipe Industries, Inc.
   2. Neenah Foundry Co.

2.06 VALVE OPERATORS

A. Valve operator "Open" direction: Open counterclockwise.

B. Provide valves located below operating level or deck with extensions for key operation or floor stands and handwheels, as indicated on the Drawings.

C. Provide manually operated valves located not more than 6 feet above the operating level with tee handles, wrenches, or handwheels.
   1. Make the valve operator more conveniently accessible by rolling valves, located more than 5 feet but less than 6 feet above the operating level, toward the operating side.
   2. Secure tee handles and wrenches to the valve head or stem, except where a handle or wrench so secured constitutes a hazard to personnel; in which case, stow handle or wrench immediately adjacent to the valve on or in a suitable hanger, bracket, or receptacle.

D. Fit valves located more than 6 feet above operating level with chain operated handles or valve wheels.
   1. Chains: Sufficient length to reach approximately 4 feet above the operating level.
   2. Where chains constitute a nuisance or hazard to operating personnel, provide holdbacks or other means for keeping the chains out of the way.

E. Provide an operator shaft extension from valve or valve operator to finished grade or deck level when buried valves, and other valves located below the operating deck or level, are specified or indicated on the Drawings to be key operated; provide 2 inches square AWWA operating nut, and box and cover as specified, or a cover where a box is not required.

2.07 Bonnet Extensions

A. Provide bonnet extensions (also referred to as a neck extensions) for valves where indicated on the drawings.
   1. The bonnet extension shall consist of a flanged outer tube which connects the valve body to the valve operator housing and an inner torque tube that connects the valve stem to the operator drive.
   2. The bonnet extension shall be designed such that it supports the actuator, located as shown on the drawings, and transfers the torque effectively into the

valve stem and valve body without imparting any force on the surrounding structure.

3. The length of the bonnet extension (between the valve body and valve actuator housing) shall be as shown on the drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. Preparation prior to installation:
   1. Install valves after the required submittal on installation has been accepted.
   2. Determine after flanged valves and flanged check valves are selected, the face-to-face dimensions of flanged valves and flanged check valves.

B. Fabricate piping to lengths taking into account the dimensions of flanged valves and flanged check valves.

3.02 INSTALLATION

A. Provide incidental work and materials necessary for installation of valves including flange gaskets, flange bolts and nuts, valve boxes and covers, concrete bases, blocking, and protective coating.

B. Where needed, furnish and install additional valves for proper operation and maintenance of equipment and plant facilities under the following circumstances:
   1. Where such additional valves are required for operation and maintenance of the particular equipment furnished by Contractor.
   2. Where such additional valves are required as a result of a substitution or change initiated by Contractor.

C. Valve and actuator orientation:
   1. Contractor shall coordinate with valve supplier final orientation of valve and actuator assembly based on Contractor's selection of equipment manufacturers and the valve and piping arrangement as indicated on the Drawings.
      a. Contractor shall rotate valve and/or actuator mounting orientation as specified in this Section unless otherwise indicated on the Drawings.
   2. Install valves with their stems in vertical position above the pipe, except as follows:
      a. Butterfly valves, gate valves aboveground, globe valves, ball valves, and angle valves may be installed with their stems in the horizontal position.
      b. Install buried plug valves with geared operators with their stems in a horizontal position.
   3. Install valves so that handles clear obstructions when the valves are operated from fully open to fully closed.

D. Place top of valve boxes flush with finished grade or as otherwise indicated on the Drawings.

E. Valves with threaded connections:
   1. Install valves by applying wrench on end of valve nearest the joint to prevent distortion of the valve body.
   2. Apply pipe joint compound or Teflon™ tape on external (male) threads to prevent forcing compound into valve seat area.

F. Valves with flanged connections:
   1. Align flanges and gasket carefully before tightening flange bolts.
   2. When flanges are aligned, install bolts and hand tighten.
   3. Tighten nuts opposite each other with equal tension before moving to next pair of nuts.

G. Valves with soldered connections:
   1. Do not overheat connection to prevent damage to resilient seats and metal seat rings.
   2. Position valves in full open position before starting soldering procedure.
   3. Apply heat to piping rather than to valve body.

3.03 FIELD APPLIED COATING OF VALVE EXTERIOR

A. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
   1. When shop-applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
   2. When shop-applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services from each manufacturer for all valves supplied:
   1. Provide Manufacturer's Certificate of Source Testing.
   2. Provide Manufacturer's Certificate of Installation and Functionality Compliance.

C. As specified elsewhere for specific valve types, sizes or actuators.
   1. Source testing.
   2. Manufacturers on site services for Owner Training, Installation Testing, Functional Testing, and during the Process Operational Period.

END OF SECTION

SECTION 15111

BALL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Ball valves.

B. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.

B. American Water Works Association (AWWA):
   1. C507 - Standard for Ball Valves 6 Inch Through 48 Inch.

C. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   3. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves:
   1. Metal body ball valves: 6 inches and larger only: Submit affidavit of compliance in accordance with AWWA C507.
   2. Operation and maintenance manual.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Unless otherwise indicated on the Drawings use:
   1. Plastic body ball valves on plastic pipelines.

B. Do not use metal body ball valves in sodium hypochlorite or sodium bisulfite systems.

2.02 PLASTIC BODY BALL VALVES – FULL PORT (BAV40)

A. Manufacturers: One of the following or equal:
   1. Asahi America.
   2. Chemtrol Division, NIBCO, Inc.
   3. Georg Fischer Piping Systems.
   4. Hayward Flow Control.
      a. For sodium hypochlorite service, provide model TB-Z. Model TBH-Z shall not be used.
   5. IPEX USA, LLC
   6. Plast-O-Matic Valves, Inc.

B. General:
   1. Type: Non-lubricated and capable of sealing in either flow direction.
   2. End connections:
      a. 4 inches and smaller size: Socket end true unions for solvent welded connection to adjacent piping.
      b. 6-inch size: Socket end true unions with attached flanges for flanged connection to adjacent piping.
   3. All valves shall have integral ISO 5211 mounting pad for actuator installation.
   4. All valves shall have integral plate for lock-out/tag-out.
   5. Stem: Double o-ring seal with shear point above seal.
   6. Pressure rating: Suitable for the test pressure and maximum temperature of the corresponding piping system listed in the Piping Schedule.

C. Materials:
   1. Body and ball:
      a. PVC piping systems: PVC.
      b. CPVC piping systems: CPVC.
   2. Seats: PTFE (Teflon™).
   3. O-rings: Match gasket material of corresponding piping system listed in the Piping Schedule.

D. Limit switches, when indicated on the Drawings:
   1. Mechanical cam type with watertight enclosure and suited for remote indication of valve open-close status.
   2. Mount on valve actuator.
   3. Contacts: 120-volt alternating current, 20 amperes at 75 to 100 percent power factor and 24-volt direct current, 5 amperes minimum.

E. Valve actuator:
   1. Valves shall be quarter turn operated with valve seat adjustability.
   2. Manually operated valves: Lever.
      Electric motor operated valves, when indicated on the Drawings: Provide electric motor operator as specified in Section 13447 - Electric Actuators.

F. Venting requirements:
   1. PVC and CPVC ball valves for hypochlorite or chlorine service:
      a. Provide valve with factory drilled 0.125-inch hole in the upstream side of the ball.
      b. Provide an engraved plastic tag permanently attached to the valve stem stating, "One side of ball drilled for hypochlorite service".
      c. Provide an arrow inscribed on the valve body to indicate direction of flow.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install each type of valve in accordance with manufacturers' printed instructions.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test, as specified in Section 15956 - Piping Systems Testing.

END OF SECTION

SECTION 15112

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Butterfly valves:
      a. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings, NPS 1/2 through NPS 24.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C504 - Rubber-Seated Butterfly Valves.
   3. C540 - Standard for Power-Actuating Devices for Valves and Sluice Gates.
   4. C550 - Protective Interior Coatings for Valves & Hydrants.
   5. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A216 - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for Higher-Temperature Service.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   5. A395 - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
   6. A479 - Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
   7. A515 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate - and Higher-Temperature Service.
   8. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate - and Lower-Temperature Service.
   9. A536 - Standard Specification for Ductile Iron Castings.
   10. A564 - Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
   11. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   12. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

13. A890 - Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.
14. B462 - Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
15. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
16. B691 - Standard Specification for Iron-Nickel-Chromium-Molybdenum Alloys (UNS N08366 and UNS N08367) Rod, Bar, and Wire.
17. D429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrate.

D. Compressed Gas Association (CGA):
   1. Standard G-4.1 - Cleaning Equipment for Oxygen Service.

E. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

F. United States Code of Federal Regulations (CFR):
   1. 21 - Food and Drugs.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.
   1. For general purpose AWWA butterfly valves, include description of the method of attachment of the disc edge to the valve disc.
   2. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves comply with all provisions in accordance with AWWA C550.
   3. Certification, for valves and coatings in contact with potable water, that the products used are suitable for contact with drinking water in accordance with NSF Standard 61.

C. Commissioning Submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

D. Vendor operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Valve pressure rating shall be greater than or equal to the piping system test pressure specified in the Piping Schedule at the maximum service temperature.
   2. General purpose AWWA butterfly valves:
      a. Design standard: Provide valves designed and manufactured in accordance with AWWA C504.
      b. Class:
         1) Provide butterfly valves in accordance with AWWA Class 150B, unless otherwise specified.
         2) Provide butterfly valves in accordance with AWWA Class 250B in piping systems with test pressure greater than 150 pounds per square inch gauge and less than 250 pounds per square inch gauge.
   3. Filter Inlet Valves and Filter Waste Washwater Valves have tight spacing requirements, see Filter Mechanical drawings. Contractor and Supplier shall coordinate valve selection and installation:
      a. Ensure the valve thrust bearings will not interfere with slabs below the valves. See Filter Mechanical drawings for additional details and dimensions.
      b. In Filters 7-16, there are concrete block outs that accommodate the mounting flanges of Filter Inlet Valves. See Filter Mechanical drawings for additional details and dimensions.
      c. In Filters 1-6, provide Filter Inlet Valves with a mounting flange that accommodates the tight spacing at the wall. See Filter Mechanical drawings for additional details and dimensions.

B. Usage:
   1. Provide and install butterfly valve types as outlined in the Butterfly Valve Application Schedule at the end of this Section.

C. Design requirements for butterfly valves with power actuating devices:
   1. Design valves and actuators for maximum operating torque, in accordance with and using safety factors required in AWWA C540, using the following values:
      a. Maximum water velocity: 16 feet per second with valve fully open.
      b. Maximum pressure differential across the closed valve equal to the pressure class designation.
      c. Coefficient for seating and unseating torque, dynamic torque, and bearing friction in accordance with valve manufacturer's published recommendations.
   2. Valve disc: Seat in an angular position of 90 degrees to the pipe axis and rotate an angle of 90 degrees between fully open and fully closed positions:
      a. Do not supply valves with stops or lugs cast with or mechanically secured to the body of the valve for limiting the disc travel.
   3. Unacceptable thrust bearings: Do not provide valves with thrust bearings exposed to the fluid in the line and consisting of a metal bearing surface in rubbing contact with an opposing metal bearing surface.

D. Performance requirements:
   1. Tight shutoff at the pressure rating of the valve with pressure applied in either direction.
   2. Suitable for the following service conditions:
      a. Throttling.
      b. Frequent operation.
      c. Operation after long periods of inactivity.
      d. Installation in any position and flow in either direction.

2.02 GENERAL PURPOSE AWWA BUTTERFLY VALVES (BFV00)

A. Manufacturers: One of the following or equal:
   1. DeZURIK/Sartell Model BAW.
   2. Mueller/Pratt Co.

B. Valve body:
   1. Material: Cast iron, ASTM A126, Grade B, or ductile iron, ASTM A536, Grade 65-45-12.
   2. Body design:
      a. Flanged body valves:
         1) Usage: Comply with limitations specified in the Butterfly Valve Application Schedule.
         2) Flanges: In accordance with ASME B16.1 Class 125 flanges for Class 150B valves, in accordance with ASME B16.1 Class 250 flanges for Class 250B valves.

C. Disc:
   1. Material: Cast iron or ductile iron with Type 316 stainless steel edge that matches seat in valve body.
   2. Secure valve disc to shaft by means of smooth-sided, taper or dowel pins, Type 316 stainless steel, or Monel.
   3. Extend pins through shaft and mechanically secure in place.

D. Shaft and bearings:
   1. Shaft design:
      a. Valves 20-inches and less: 1-piece, through disc design.
      b. Valves greater than 20-inch size: 2-piece, stub shaft design.
   2. Shaft seal: Vee type, chevron design.
   3. Shaft material for Class 150B valves: Type 316 stainless steel, ASTM A276.
   4. Shaft material for Class 250B valves: Type 17-4 pH stainless steel, ASTM A564.
   5. Shaft bearings: Self-lubricating sleeve type:
      a. Valves 20 inches and less: Nylatron.
      b. Valves greater than 20-inch size: Teflon™ with stainless steel or fiberglass backing.

E. Seats:
   1. Seat materials:
      a. Match gasket material that is specified in the Piping Schedule for the specific piping system.
      b. Low-pressure air applications: EPDM.

c. Other applications: NBR or natural rubber or EPDM.

2. For valves 20 inches in nominal size and smaller, bond or vulcanize seat into the valve body.
3. For valves 24 inches in nominal size and larger, retain seats mechanically or by adhesive:
   a. Mechanical retainage: Retain seat by a clamping ring with segmented clamping ring locks with adjusting locking screws.
      1) Clamping ring, ring locks, and adjusting locking screws: Type 316 stainless steel.
      2) Provide means to prevent ring locks and screws used to retain seats from loosening due to vibration or cavitation.
   b. Adhesive retainage: Inset the seat within a groove in the valve body and retain in place with epoxy injected behind the seat so that the seat expands into the body.
   c. Do not provide valves with seats retained by snap rings or spring-loaded retainer rings.
4. Resilient seat: Withstand 75 pounds per inch pull when tested in accordance with ASTM D429, Method B.

F. Valve packing:
1. Valves 4 to 48 inches nominal size: Self-adjusting V-type packing or chevron-type packing. NBR or EPDM to match seat material.
2. Valves 54 inches nominal size and larger: Adjustable V-type packing with bronze packing gland or self-adjusting V-type packing. NBR or EPDM to match seat material.

G. Bonnet Extensions:
1. Provide valve bonnet extensions on valves, where indicated on the drawings. The bonnet extension shall be as specified in Section 15110 – Common Work Results for Valves.

2.03 COATING REQUIREMENTS FOR METAL VALVES

A. Shop coat interior and exterior metal surfaces of valves, except as follows:
1. Interior machined surfaces.
2. Surfaces of gaskets and elastomeric seats and stem seals.
3. Bearing surfaces.
4. Stainless steel surfaces and components.

B. Coating material for components in contact with potable water applications:
1. Formulate interior coating material from materials in accordance with CFR 21, AWWA C550, and NSF 61.
2. Submit affidavit of compliance attesting that epoxy coatings applied to interior surfaces of butterfly valves in accordance with CFR 21, AWWA C550, and NSF 61.

C. Interior surfaces:
1. Interior surfaces, except for valves used in low-pressure air service: High solids epoxy as specified in Section 09960 - High-Performance Coatings, Attachment A - Coating Schedule.

2. Interior surfaces of valves used in low-pressure air service: High temperature coating for range of 150 to 350 degrees Fahrenheit as specified in Section 09960 - High-Performance Coatings, Attachment A - Coating Schedule.

D. Exterior surfaces:
   1. Exterior surfaces of valves, actuators, and accessories coating as specified in Section 09960 - High-Performance Coatings, Attachment A - Coating Schedule for the following conditions:
      a. Submerged valves: High solids epoxy.
      b. Buried valves: Coal tar epoxy.
      c. Other valves: High solids epoxy with polyurethane topcoat.
   2. Polished and machined surfaces: Apply rust-preventive compound,
      a. Manufacturers: One of the following or equal:
         1) Houghton, Rust Veto 344.
         2) Rust-Oleum, R-9.

E. Field applied coatings of valve exterior:
   1. Match color and be compatible with manufacturer's coating system and as specified in Section 09960 - High-Performance Coatings.
      a. When shop applied finish coating matches field applied coating on adjacent piping, touch up shop coating in damaged areas in accordance with instructions recommended by the paint manufacturer.
      b. When shop applied coating does not match field coating on adjacent piping, or when damage has occurred to the shop applied coating that requires more than touchup, blast clean valve surfaces or utilize other surface preparation recommended by the manufacturer of the coating material and apply the coating system used for coating adjacent piping.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install valves with valve shafts horizontal, unless a vertical shaft is required to suit a particular installation, and unless a vertical shaft is indicated on the Drawings.

B. Install pipe spools or valve spacers in locations where butterfly valve disc travel may be impaired by adjacent pipe lining, pipe fittings, valves, or other equipment.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning, and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.

b. Conduct pressure and leak test, as specified in Section 15110 - Common Work Results for Valves.

D. Owner Training:
1. Perform Owner Training as specified in Section 01756 - Commissioning.
2. Number of sessions:
a. Operations and Maintenance 1.

3.03 BUTTERFLY VALVE APPLICATION SCHEDULE

A. Acceptable butterfly valve types and body styles are listed in the Butterfly Valve Application Schedule provided at the end of this Section. Furnish and install butterfly valves in accordance with this Schedule.

Butterfly Valve Application Schedule	
Valve Type and Style	**Acceptable Applications**
General Purpose AWWA Butterfly Valves - Flanged Body Design	Aboveground or submerged in the following service applications only: • Acceptable in all service applications except oxygen and ozone service and high-pressure service. • May be used in buried applications when required by the specified piping system.
General Purpose AWWA Butterfly Valves - Mechanical Joint Body Design	Buried in the following service applications only: • Acceptable in all service applications except oxygen and ozone service and high-pressure service.
General Purpose AWWA Butterfly Valves - Lugged Body Design	Aboveground in the following service applications only: • Aeration Air Systems.
General Purpose AWWA Butterfly Valves - Wafer (not lugged) Body Design	Not allowed.
General Purpose AWWA Butterfly Valves - Grooved End Body Design	Aboveground, in sizes 20 inches and less, with piping system test pressure less than 100 psi, and in the following service applications only: • Acceptable in all service applications, except oxygen and ozone service, where piping for that service is specified in the Piping Schedule to have grooved end joints.
High Pressure Butterfly Valves - Flanged Body Design	Service applications with piping system test pressure greater than 250 psi. Acceptable in aboveground and buried installations.
High Pressure Butterfly Valves - Wafer or Lugged Wafer Body Design	Not allowed.
Industrial Class Butterfly Valves - Lugged Body Design	Aboveground in the following service applications only: • Aeration Air Systems.

Butterfly Valve Application Schedule	
Valve Type and Style	**Acceptable Applications**
	• Natural Gas Systems. • Digester Gas Systems. • Chilled and Hot Water Systems.
Industrial Class Butterfly Valves - Wafer (not lugged) Body Design	Not allowed.
Stainless Steel Butterfly Valves - Lugged Body Design	Aboveground in the following service applications only: • Oxygen Systems. • Ozone Systems.
Stainless Steel Butterfly Valves - Wafer (not lugged) Body Design	Not allowed.
Thermoplastic Butterfly Valves	Low-pressure plastic piping systems.

END OF SECTION

SECTION 15114

CHECK VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Center Guide (Silent) Check Valves.
   2. Swing Check Valves:
      a. General Swing Check Valves.
      b. Cushioned Swing Check Valves.
   3. Ball Check Valves:
      a. Plastic Ball Check Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C508 - Standard for Swing-Check Valves for Waterworks Service 2 Inch Through 24 Inch NPS.

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A213 - Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A313 - Standard Specification for Stainless Steel Spring Wire.
   5. A536 - Standard Specification for Ductile Iron Castings.
   6. A582 - Standard Specification for Free-Machining Stainless Steel Bars.
   7. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   8. B16 - Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.
   9. B61 - Standard Specification for Steam or Valve Bronze Casting.
   10. B62 - Standard Specification for Composition Bronze or Q=Ounce Metal Castings.
   11. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

D. National Electrical Manufacturers Association (NEMA).

E. NSF International (NSF):
   1. 61 - Drinking Water Components Health Effects.
   2. 372 - Drinking Water System Components - Lead Content.

F. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. As specified in Section 01600 - Product Requirements.

C. Commissioning Submittals:
   1. Provide Manufacturer's Certificate of Installation Compliance as specified in Section 01756 - Commissioning.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements and Section 15110 - Common Work Results for Valves.

B. Provide check valves as shown on the Check Valve Schedule and suitable for service:
   1. In either horizontal or vertical position.
   2. For working pressures up to 150 pounds per square inch.

C. Check valve materials as follows unless otherwise specified.
   1. Cast iron in accordance with ASTM A126 Grade B.
   2. Ductile iron in accordance with ASTM A536 Grade 65-45-12.
   3. T-303 stainless steel in accordance with ASTM A582 (UNS S30300).
   4. Type 316 stainless steel in accordance with ASTM A313.

D. Flanges: Drilled in accordance with ASME B16.1 Class 125/150 unless otherwise specified or indicated on the Drawings.

2.02 GENERAL SWING CHECK VALVES (CKV00)

A. Valves 1/4 inch through 3 inches:
   1. Manufacturers: One of the following or equal:
      a. Crane Valve Co., Number 36.
      b. Lunkenheimer Co., Figure 554Y.
   2. Valve design:
      a. Y-pattern body with integral seat.
      b. Female threaded ends.
      c. Renewable hinged disc.

d. Threaded cap for access to valve seat without disassembly of piping.
e. Integral seats suitable for regrinding.

3. Materials:
   a. Body: Bronze in accordance with ASTM B62-83600.
   b. Disc Bronze ASTM B62 C92200.
      1) On valves less than 1-inch: Brass in accordance with ASTM B16.
   c. Hinge: Bronze in accordance with ASTM B584 C 87600.
   d. Lock nut and hinge pin plug: Brass in accordance with ASTM B16 HO2.
   e. Hinge pin: Stainless steel in accordance with ASTM A276.
   f. Cap: Bronze in accordance with ASTM B61 C92200.
   g. If used for steam service:
      1) Body and disc:S1 steam bronze in accordance with ASTM B61.

B. Valves 4 inches through 24 inches:
1. Manufacturers: One of the following or equal:
   a. APCO Model 250.
   b. Crispin SWL Series.
   c. Kennedy, Figure 106LW or M&H, Model 159.
   d. Mueller Co., Model A-2600.
2. Valve design:
   a. In accordance with AWWA C508.
   b. Constructed to permit top entry and removal of internal components without removing the valve.
   c. Equipped with outside lever and weight.
3. Materials:
   a. Body: Cast iron, ASTM A126 Class B or ASTM A536 Grade 65-45-12 Ductile Iron.
   b. Disc:
      1) Valve disc shall be ASTM A126 cast iron, ASTM A536 ductile iron, or ASTM B584 bronze.
      2) Four-inch valves: Bronze or stainless steel rings and seats.
      3) Six inches and larger valves: Bronze-faced or stainless steel rings and seats.
      4) Rubber seat Buna-N or EPDM.
   c. Hinge pins: Stainless steel.

2.03 CUSHIONED SWING CHECK VALVES (CKV20)

A. Manufacturers: One of the following or equal:
1. APCO:
   a. Series 6100 for valve sizes from 4-inch to 10-inch.
   b. Series 6000BMB for valve sizes from 12-inch to 36-inch.
2. Crispin:
   a. Series SWC-OC for valve sizes 4-inch to 10-inch.
   b. Series SWC-BD for valve sizes 12-inch to 36-inch.

B. Valve design:
1. Counterweight:
   a. Single counterweight on sizes 4 inches to 12 inches.
      1) Mounted on the valve side indicated in the Check Valve Schedule.
   b. Dual counterweights on sizes 14 inches and larger.

2. Disc:
    a. Single top-shaft mount with machined pin.
    b. Dual device hinge pinning on linkage arm to disc pinning.
    c. Disc seat: Bolted in replaceable seat.
    d. Shaft packing seals on both ends of body casting or O-rings.
    e. Shaft pin-shaft design for full rating of the valve fully extended through valve cast on each end of body casting.
    f. Shaft minimum sizing is:

Valve Size (inch)	8	10	12	14	16	18	20	24	30	36
Shaft Size (inch)	1.75	2.125	2.5	3 10	3.5	3.75	4	3	3.75	4

3. Bottom-mounted hydraulic oil cushion system:
    a. Totally enclosed oil-dampening chambers with external adjustment for closing speed to permit free opening and positive non-slam controlled closure of the disc.
        1) Hydraulic cushion shall make contact with the disc during the last 10 percent of closure to control the disc until shutoff.
    b. Externally adjustable to suit operating conditions.
    c. Removable without need to remove the entire valve.
        1) Oil system shall be totally independent from the main line to prevent corrosion or contamination to the process water.
    d. Side-mounted oil reservoir to be oriented in the vertical position after valve installation.

C. Materials:
1. Valve body, cover, and disc: Ductile iron.
2. Disc seat: As indicated in the Check Valve Schedule.
3. Shaft: T303 high-strength stainless steel:
4. Seat pins and lock screws: Type 316 stainless steel.

2.04 CENTER GUIDE (SILENT) CHECK VALVES (CKV60)

A. Manufacturers: One of the following or equal:
1. APCO, CSC 600A.
2. Crispin, GC Series.

B. Valve design:
1. Center-guided, spring-loaded plug.
2. Replaceable seat and plug.
3. Shaft guide bushing.
4. Non-slam, silent shutoff.
5. Flanged body.

C. Materials:
1. Body: Cast iron, ASTM A126 Grade B, ductile iron, ASTM A536 GR 65-45-12 or stainless steel, ASTM A743, Grade CF8M.
2. Plug and seat: Stainless steel, ASTM A743, Type 316.
3. Spring: Stainless steel, ASTM A313 Type 316.
4. Shaft and bushing: Stainless steel, ASTM A213, Type 316.
5. Seat ring: Buna-N or Viton.

D. Certified hydrostatic shell and seat test report.
    1. Only for valves larger than 16 inches.

2.05 PLASTIC BALL CHECK VALVES (CKV65)

A. Manufacturers: One of the following or equal:
    1. Georg Fischer Piping Systems.
    2. Hayward Flow Control.
    3. Nibco, Chemtrol Series.
    4. Plast-O-Matic.

B. Valve design:
    1. Ball type design.
    2. Materials: As specified in the Check Valve Schedule.
    3. Inlet pressure rating:
        a. PVC, CPVC, or PVDF: 150 pounds per square inch at 77 degrees Fahrenheit.
        b. PP: 100 pounds per square inch at 77 degrees Fahrenheit.

2.06 HIGH-PRESSURE GAS CHECK VALVES (CKV80 & CKV85)

A. Type 1 - Valves for high-pressure air, gas, or steam except compressor discharge or for air service involving frequent flow reversals (CKV80):
    1. Manufacturers: One of the following or equal:
        a. Crane, Figure 366E.
        b. Jenkins, Figure 966.
        c. Lunkenheimer Co., Figure H3 or 418.
    2. Valve design:
        a. Regrinding check valves suitable for service pressures up to:
            1) Steam: 200 pounds per square inch gauge and not less than 400 pounds per square inch gauge.
            2) Water, oil, and gas: 400 pounds per square inch gauge.

B. Type 2 - High-pressure compressor discharge check valves or check valves in other gas or air service involving frequent flow reversals (CKV85):
    1. Manufacturers: One of the following or equal:
        a. Lunkenheimer Co., Figure 1616.
        b. Walwork, Number 97.
    2. Valve design:
        a. Guided and air cushioned vertical lift check valves:
        b. Stainless steel or hard composition discs.
        c. Suitable for service pressures up to:
            1) Steam: 150 pounds per square inch gauge.
            2) Water, oil, and gas 300 pounds per square inch gauge.

2.07 INTERIOR PROTECTIVE LININGS

A. As shown in the valve schedules and as specified in Section 15110 - Common Work Results for Valves.

PART 3 EXECUTION

3.01 INSTALLATION

A. Plastic Valves:
   1. Teflon® tape will “string” as pipe threads are joined. Loose “strings” could lay across the seating surface and prevent the check valve from completely closing. To avoid this problem, clean out old tape and do not apply tape to the first thread.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Test witnessing: Witnessed.
   2. Conduct pressure and leak test, as specified in Section 15956 - Piping Systems Testing.

D. Owner Training:
   1. Perform Owner Training as specified in Section 01756 - Commissioning.
   2. Number of sessions:
      a. Operations and Maintenance: 1.

END OF SECTION

SECTION 15115

GATE, GLOBE, AND ANGLE VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Gate, globe (non-pilot controlled), and needle valves.
   2. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 inch Standard.
   2. B16.47 - Large Diameter Steel Flanges: NPS 26 through NPS 60 inch Standard.

B. American Water Works Association (AWWA):
   1. C515 - Standard for Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Services.
   2. C550 - Protective Interior Coatings for Valves and Hydrants.

C. ASTM International (ASTM):
   1. B98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning Submittals:
   1. For valves larger than 16 inches:
      a. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Interior epoxy coatings: Affidavit of compliance attesting that epoxy coatings applied to interior surfaces of valves comply in accordance with all provisions of AWWA C550.

PART 2 PRODUCTS

2.01 GATE VALVES - GENERAL SERVICE (GV00)

A. Aboveground:
   1. Valves less than 3 inches in size for clean water and air service:
      a. Manufacturers: One of the following, or equal:
         1) Crane, Figure 431.
         2) Jenkins, Figure 47.
         3) Lunkenheimer Co., Figure 2151.
      b. Design:
         1) Size and configuration: Indicated on the Drawings.
         2) Manufacturer's standard bronze, solid wedge disc, rising stem, screwed end, Class 150 pounds.
   2. Valves 3 inches in size and larger, single disk.
      a. Manufacturers: One of the following, or equal:
         1) American Flow Control, Series 2500.
         2) M&H/Kennedy Valve Co.
         3) Mueller.
      b. Design:
         1) Size, material, configuration: Indicated on the Drawings.
         2) Resilient wedge type in accordance with AWWA C515.
         3) Flange, iron body, and bonnet rated for 200 pound working pressure.
            a) Provide O-ring seal between valve body and bonnet.
         4) Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
         5) Bronze stem with double or triple O-ring or braided packing stem seals.
         6) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
         7) Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.

B. Underground:
   1. Manufacturers: One of the following, or equal:
      a. American Flow Control.
      b. M&H/Kennedy Valve Co.
      c. Mueller Co.
   2. Design:
      a. Size, material, configuration: Indicated on the Drawings.
      b. Resilient wedge type in accordance with AWWA C515.
      c. Stem:
         1) Iron body, resilient seat, non-rising stem, double O-ring stem seal.
         2) Rising stem configuration with handwheel diameter sized to allow opening of valve with no more than a 40-pound pull.
      d. Ductile or cast iron wedge encapsulated in nitrile rubber and capable of sealing in either flow direction.
      e. Bronze stem with double or triple O-ring or braided packing stem seals.
      f. Coat interior and exterior surfaces of valve body and bonnet with fusion-bonded epoxy in accordance with AWWA C550.

g. Valve operator: Provide standard AWWA 2-inch operating nut, matching valve key, and valve box for operating stem.

2.02 GLOBE VALVES, NON-PILOT-CONTROLLED (GLV00 AND GLV20)

A. General (GLV00):
1. Valves 3 inches and smaller:
a. Manufacturers: One of the following, or equal:
1) Except in welded steel piping:
a) Crane, No. 1 Globe or No. 2 Angle.
b) Lunkenheimer Co. Figure No. 2140 Globe or No. 2141 Angle.
2) In welded steel piping:
a) Crane, No. 351.
b) Lunkenheimer Co., Figure No. 1123; or equal with flanged ends.
b. Design:
1) Size and configuration: Indicated on the Drawings.
2) Valve: Class 125 threaded ends, rated for 250 degrees Fahrenheit at pressure of 170 pounds per square inch.

B. Plug disc type for throttling or severe service (GLV20):
1. Manufacturers: One of the following, or equal:
a. Crane, No. 212P or No. 384P.
b. Lunkenheimer Co., 72-PS or 73-PS1.
2. Design:
a. Size and configuration: Indicated on the Drawings.
1) Material: Iron body stainless steel trimmed plug type seat and disc.

C. Hose valves:
1. Manufacturers:
a. Globe threaded valve: One of the following, or equal:
1) Crane, No. 7TF.
2) Stockham, Figure No. B22T.
b. Angle threaded valve: One of the following, or equal:
1) Crane, No. 17TF.
2) Stockham, Figure No. B222T.
2. Design:
a. Size and configuration: Indicated on the Drawings.
b. Valve: Globe or angle valve with threaded ends.
c. Disc: Renewable, made of Teflon™ or Buna-N.
d. Threaded ends rated for a pressure of 200 pounds per square inch.

D. Yard hydrants:
1. Freezeless yard hydrant:
a. Manufacturers: One of the following, or equal:
1) Kupferle Foundry Co.
a) #1 Total Eclipse Yard Hydrant - 3/4-inch and 1 inch.
2) Murdock Company:
a) #M-75 - 3/4-inch or #M100 - 1 inch.
3) Zurn Company:
a) #1385 - 3/4-inch or 1 inch.

b. Design:
1) Self-draining, non-freezing, compression type.
a) Inlet connection size: Indicated on the Drawings.
b) Outlet connection size: Indicated on the Drawings.
c) Materials:
(1) Exterior casing pipe material: Indicated on the Drawings.
(2) Interior operating rod material: Indicated on the Drawings.
(3) Casing guard material: Indicated on the Drawings.
(4) Principal interior operating parts material: Brass and/or bronze and removable from yard hydrant for servicing without excavation.
d) Provide 4 spoke, ball wheel handle operated.

2. Freezeless post hydrants (HYD01):
a. Manufacturers: The following or equal:
1) Kupferle Foundry Co.:
a) #2 Eclipse Post Hydrant.
2) Mueller Co.:
a) #A-411 Post Hydrant.
3) Murdock Co.:
a) #M-200 Post Hydrant.
b. Design:
1) Self-draining, non-freezing, compression type with a 2-3/16-inch valve opening.
2) Inlet connection size: Indicated on the Drawings.
3) Outlet connection size: Indicated on the Drawings.
4) Materials:
a) Exterior casing pipe material: Indicated on the Drawings.
b) Interior operating rod material: Indicated on the Drawings.
c) Top stock material: Indicated on the Drawings.
d) Principal interior operating parts material: Brass and/or bronze and removable from hydrant for servicing without excavation.
5) Provide 1-1/2-inch pentagon operating nut operated by a hydrant wrench or 10-inch handwheel:
a) Manufacturers: The following or equal:
(1) Kupferle Foundry Co.

2.03 NEEDLE VALVES (NV00)

A. Manufacturers: One of the following, or equal:
1. Crane No. 88 or No. 89.
2. Lunkenheimer Co., Figure No. 906-BS or No. 907-BS.
3. Powell, Figure No. 180.

B. Design:
1. Size and configuration: Indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mount yard hydrants on minimum 1-inch supply pipe or size indicated on the Drawings.

B. Mount post hydrants on minimum 2-inch supply pipe or size indicated on the Drawings.

C. Set yard and post hydrants in 4 cubic feet of 3/4-inch minimum crushed stone surrounding valve body to allow for proper drainage.
   1. Install in accordance with AWWA recommendations for hydrants.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services: For valves larger than 16 inches.
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15117

SPECIALTY VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Specialty valves.

B. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Civil Engineers (ASCE):
   1. 25 - Earthquake-Actuated Automatic Gas Shutoff Devices.

B. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

C. American Water Works Association (AWWA):
   1. C511 - Standard for Reduced Pressure-Principle Backflow-Prevention Assembly.
   2. C800 - Underground Service Line Valves & Fittings (Also Included: Collected Standards For Service Line Materials).

D. ASTM International (ASTM):
   1. A48 - Standard Specification for Gray Iron Castings.
   2. A126 - Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings.
   3. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   4. A536 - Standard Specification for Ductile Iron Castings.
   5. B584 - Standard Specification for Copper Alloy Sand Castings for General Application.
   6. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

E. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Backflow preventer certification.
   2. Provide Manufacturer’s Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

2.02 BACKFLOW PREVENTERS

A. Manufacturers: One of the following or equal:
   1. Febco backflow prevention:
      a. Model LF860 all sizes.
   2. Zurn/Wilkins:
      a. Model 975XL for 1/2-inch through 2-inch.
      b. Model 375AST for sizes 2 1/2 inch, 3 inch, 8 inch, and 10 inch.
      c. Model 375 and 375DA for sizes 4 inch and 6 inch.
   3. Watts regulator: Series LF909.

B. Design: Reduced pressure chamber type in accordance with AWWA C511.

C. Include shutoff valves at each end of backflow preventer with properly located test cocks.

D. Shutoff valves:
   1. Backflow preventers 2-inch and smaller: Provide with full-port, quarter turn, resilient seated ball valves.
   2. Backflow preventers larger than 2-inch: Provide with resilient seated, outside stem and yoke gate valves.

2.03 MUD VALVES

A. Manufacturers: One of the following or equal:
   1. Clow Corp., Series F-3075T.
   2. Waterman Industries, Inc., Model MV-11.

B. Design:
   1. Provide mud valves with non-rising stem.
   2. Provide standard AWWA 2-inch valve nut on stainless steel stem extension to height required.

C. Materials:
   1. Body, cover, and yoke: Stainless steel.
   2. Disc plug: Stainless steel.
   3. Seat rings: Resilient Neoprene or Buna-N seating face.
   4. Stem and stem nut: Stainless steel.
   5. Cap screws to bolt valve to cast-iron pipe flange: Type 316 stainless steel.

2.04 SOLENOID VALVES

A. 2-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Co., Series 8210.
         1) Contractor shall provide external bypass to solenoid valve. External bypass shall use pipe of same material and size as main line and include a ball valve for manual operation.
      b. Skinner Electric Valve Division, Series C.

B. 3-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Co., Series 8320.
      b. Skinner Electric Valve Division, Type A4.

C. 4-way solenoid valves:
   1. Manufacturers: One of the following or equal:
      a. Automatic Switch Co., Bulletin 8344.
      b. Skinner Electric Valve Division, Series V9.

D. Design:
   1. Valves: Suitable for service under the following conditions:
      a. Fluid water.
      b. Temperature of fluid: 4-80 degrees Fahrenheit.
      c. Piping test pressure: as indicated on the Drawings.
   2. Unless otherwise indicated on the Drawings, provide valves that meet the following requirements:
      a. Minimum NEMA Type 4 enclosure.
      b. 120 VAC operation.
      c. Suitable for use as indicated on the Drawings.
      d. Minimum Class F coil insulation.
   3. 2-way valves: Furnish with openings of size equal to or larger than the nominal size designation of the valve.
   4. Furnish with manual/bypass operators.

E. Materials:
   1. Body: Brass or bronze.
   2. Seats: Resilient material.

2.05 CIRCUIT BALANCING VALVES

A. Manufacturers: One of the following or equal:
   1. Bell and Gossett.
   2. Tour and Anderson.
   3. Flowset.
   4. Taco.
   5. Flow Design.

B. Design:
   1. Four function capability - Flow measurement, flow balancing with memory stop, positive shut off, and drain.

2. Provide provisions for connecting differential pressure meter. Each meter port connection shall have shut off valves.
3. Include tamper proof and memory features.

2.06 PLASTIC BODY DIAPHRAGM VALVES

A. Type of service: Use plastic body diaphragm valves as indicated on the Drawings in the following services:
   1. Chlorine gas.
   2. Sodium chlorite.
   3. Chlorine dioxide.
   4. Sodium hydroxide (caustic soda)

B. Manufacturers: One of the following or equal:
   1. Simtech.
   2. Chemtrol.
   3. Asahi-America (2-1/2 inch and less only for chlorine service).
   4. Georg Fischer Piping Systems.
   5. Hayward Flow Control.

C. Materials:
   1. Body: CPVC or PVC with reinforcing ribs at body and end connections.
   2. Diaphragm: Unless otherwise specified below, provide 2 diaphragm layers - Teflon™ diaphragm with EPDM backing or other material suitable for the intended use.
      a. For chlorine, chlorine dioxide, or sodium chlorite service: 3 diaphragm layers, Teflon™ (PTFE), PVDF, and ethylene propylene diene (EPDM) or Viton™ backing cushion.
   3. Bonnet: PVC or Reinforced polypropylene with cast iron or silicon bronze drive nut, double lead acme stem threads, acrylic protective cap and visual position indicator.
      a. Adjustable travel stop: Type 316 stainless steel.
      b. Compressor: PVDF or cast iron.
   4. Handwheel: Polypropylene.
   5. Sleeve: Bronze or cast iron.
   6. Stem: Type 316 stainless steel.
   7. Bolt, nut, and washer: Type 316 stainless steel.
   8. Thrust bearing: Teflon™ disc or carbon steel.
   9. End connector: PVC.
   10. End connector seal (flange gasket): Suitable for the intended use unless otherwise specified below.
      a. For chlorine solution service: Hypalon 1/8-inch thick gaskets.
   11. O-rings: Viton™.
   12. Position indicator: Carbon steel.

D. Valve design:
   1. End connections: Flanged.
   2. Operator handle: Handwheel, with position indicator and adjustable travel stop to prevent overtightening. Provide acrylic stem cap.
   3. Diaphragm valves: Weir type.
   4. Pressure: 150 pound per square inch gauge at 70 degrees Fahrenheit.

E. Electric actuator:
   1. Manufacturers: One of the following or equal:
      a. Asahi/America.
      b. Barton/ITT Fluid Technology Corporation.
      c. Gemu.
   2. General:
      a. Reversing type motor.
      b. Suitable for 115 volt, 1 phase, 60 hertz power supply.
      c. Travel stop limit switches with remote valve open and closed status indication.
      d. Brushless, capacitor-run motors with integral thermal overload protection and auto reset.
      e. Permanently lubricated gear train.
      f. Visual position indicator.
      g. Declutchable manual override.
   3. Materials:
      a. Actuator housing: Aluminum.
      b. Output shaft: Type 316 stainless steel.
      c. Electrical housing: NEMA Type 4.
      d. Enclosure: NEMA Type 4.
      e. Thermally bonded epoxy powder coating with Type 316 stainless steel trim.

2.07 PINCH VALVES

A. Manufacturers: One of the following or equal:
   1. Red Valve Company, Series 75 with Type DW sleeves.
   2. RKL Controls, Inc., Series KEFR.
   3. Onyx Valve, equivalent product.

B. Design: Open frame handwheel type.

C. Materials:
   1. Sleeve material: Suitable for operation requiring continuous opening and closing of the valve.
      a. The sleeve trim shall be connected to the pinch bar by tabs imbedded in the sleeve trim-reinforcing ply.
   2. Sleeves: Teflon™ reinforced with butyl nylon or other equivalent reinforcing material.
   3. Housing: Cast iron.
   4. Mechanism (stem, guide rods, pinch bars): Carbon steel.
   5. Bolts/Fasteners: Type 316 stainless steel.

2.08 CORPORATION STOPS

A. Type: In accordance with AWWA C800:
   1. Manufacturers: One of the following or equal:
      a. Ford.
      b. Mueller Co.

2.09 CURB STOPS

A. Manufacturers: One of the following or equal:
   1. Ford.
   2. Mueller Co.

B. Description: Round way solid tee head stops.

2.10 COCKS

A. Gauge cock:
   1. Manufacturers: The following or equal:
      a. Lunkenheimer Co., Figure 1178 or Figure 1180.

B. Air cock:
   1. Manufacturers: One of the following or equal:
      a. Swagelok, Model B-42S4.
      b. Hoke, Inc., 7122G4B.

C. Plug cock:
   1. Manufacturers: The following or equal:
      a. Lunkenheimer Co., Figure 454.
   2. Design: Plug cocks: Bronze, straightway pattern complete with lever.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves in accordance with manufacturer's published instructions.

B. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.

C. Plastic body diaphragm valves for sodium hypochlorite service:
   1. When valves are installed horizontally, install valves with valve stem position rotated as necessary such that no internal valve obstruction prevents the passage of vapors traveling along the top of adjacent piping from traveling through the valve.

D. Backflow preventers:
   1. Install with a minimum clearance of 12 inches and with maximum clearance of 30 inches between the relief port and the floor or finished grade or top of containment wall.
   2. Install with sufficient side clearance for access for testing and maintenance.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer's Certificate of Installation and Functionality Compliance.
    2. Manufacturer's Representative onsite requirements:
        a. For the following valves:
            1) Backflow preventer and plastic body diaphragm valves.
        b. Installation: 1 trip, 1 day minimum.
        c. Functional Testing: 1 trip, 1 day minimum each.
        d. Training:
            1) Maintenance and Operations: 1 session.

C. Functional testing:
    1. Backflow preventer:
        a. Test witnessing: Witnessed.
        b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.
        c. Backflow preventer certification.

    2. Plastic body diaphragm valves:
        a. Test witnessing: Witnessed.
        b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15118

PRESSURE CONTROL VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Pressure reducing and pressure relief valves for water and chemical service.

B. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300.

B. ASTM International (ASTM):
   1. A536 - Standard Specification for Ductile Iron Castings.

C. Underwriters Laboratories, Inc. (UL).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 METAL BODY PRESSURE REDUCING VALVES - WATER SERVICE (PRV00)

A. Metallic pressure reducing valves for water service, 2 1/2 inches and smaller:
   1. Manufacturers: One of the following or equal:
      a. Watts, Series LF223.
      b. Zurn Wilkins, 500 Series.
   2. Direct operated, single seat type pressure reducing valve.

3. Downstream pressure adjustment range: 30 to 300 pounds per square inch gauge (psig).
4. Materials:
    a. Body and spring cover: Bronze or brass alloy meeting the zinc and aluminum requirements of Section 15110 - Common Work Results for Valves.
    b. Valve seat: Type 304 stainless steel.
    c. Diaphragm: Match the gasket/elastomer material of the corresponding piping system, as specified in the Piping Schedule.
    d. Disk: Match the gasket/elastomer material of the corresponding piping system, as specified in the Piping Schedule.

B. Metallic pressure reducing valves for water service, 3 inches and larger:
1. Manufacturers: One of the following, or equal:
    a. Watts, Ames Fire & Waterworks ACV Series LF910GD.
    b. Cla-Val Model 90-01.
2. Design:
    a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
    b. Rated for the test pressure of the corresponding piping system, as specified in the Piping Schedule.
    c. Downstream pressure adjustment range: 30 to 300 psig.
    d. Pilot line: Equipped with a strainer.
    e. Flanges: Class 150, in accordance with ASME B16.42.
3. Materials:
    a. Body and cover: Ductile Iron ASTM A536.
    b. Valve trim: Bronze.
    c. Pilot control: Cast bronze with Type 304stainless steel trim.
    d. Diaphragm: Match the gasket/elastomer material of the corresponding piping system, as specified in the Piping Schedule.

2.02 METAL BODY PRESSURE RELIEF AND BACKPRESSURE SUSTAINING VALVES - WATER SERVICE (PRV20)

A. Metallic pressure relief valves for water service, 1 inch and smaller:
1. Manufacturers: One of the following, or equal:
    a. Cla-Val Model CRL-60.
2. Design:
    a. Direct-acting, spring loaded, diaphragm type relief valve.
    b. Pressure relief adjustment range: 20 to 200 psig.
3. Materials:
    a. Body and spring cover: Bronze or brass alloy meeting the zinc and aluminum requirements of Section 15110 - Common Work Results for Valves.
    b. Valve seat: Type 304stainless steel.
    c. Diaphragm: Match the gasket/elastomer material of the corresponding piping system, as specified in the Piping Schedule.
    d. Disk: Match the gasket/elastomer material of the corresponding piping system, as specified in the Piping Schedule.

B. Metallic pressure relief valves for water service, 1 1/4 inches and larger:
   1. Manufacturers: One of the following, or equal:
      a. Watts, Ames Fire & Waterworks ACV Series LF920GD.
      b. Cla-Val Model 50-01.
   2. Design:
      a. Pilot controlled, hydraulically operated, diaphragm actuated, globe patterned valve.
      b. Rated for 125 pounds per square inch gauge, minimum, or higher pressure rating if necessary to meet the test pressure of the corresponding piping system, as specified in the Piping Schedule.
      c. Pressure relief adjustment range: 20 to 200 psig.
      d. Pilot line: Equipped with a strainer.
      e. End connections:
         1) 2 1/2 inch and smaller: Screwed.
         2) 3 inch and larger: Class 150 flanges in accordance with ASME B16.42.
   3. Materials:
      a. Body and cover: Ductile Iron ASTM A536.
      b. Valve trim: Bronze.
      c. Pilot control: Cast bronze with Type 304stainless steel trim.
      d. Diaphragm: Match the gasket/elastomer material of the corresponding piping system, as specified in the Piping Schedule.

2.03 PLASTIC BODY PRESSURE REDUCING VALVES - CHEMICAL OR WATER SERVICE (PRV40)

A. Manufacturers: One of the following or equal:
   1. Plast-O-Matic: Series PRHM.

B. Materials:
   1. Valve body:
      a. PVC piping systems: PVC.
      b. CPVC piping systems: CPVC.
   2. U-cups:
      a. Match gasket/elastomer material of corresponding piping system, as indicated on the Piping Schedule.
   3. Non-wetted metallic components: Stainless steel.

C. Design:
   1. Diaphragm type.
   2. Pressure rating: Not less than 150 pounds per square inch.
   3. In-line or angle pattern design, size as indicated on the Drawings.
   4. End connections: Threaded.
   5. Downstream pressure set point:
      a. Externally adjustable without removing valve from piping system.
      b. Adjustable from 5 to 125 psig.

2.04 PLASTIC BODY PRESSURE RELIEF AND BACKPRESSURE SUSTAINING VALVES FOR CHEMICAL OR WATER SERVICE (PRV24)

A. Manufacturers: One of the following or equal:
   1. Plast-O-Matic, Series RVT, RVDT or TRVDT.
   2. Asahi/America.
   3. Georg Fischer Piping Systems.

B. Materials:
   1. Valve body:
      a. PVC piping systems: PVC.
      b. CPVC piping systems: CPVC.
   2. U-cup seals:
      a. Match gasket/elastomer material of corresponding piping system, as specified in the Piping Schedule.
      b. Chlorine dioxide: Viton.
   3. Adjusting bolt, locknut, control spring and fasteners: Stainless steel.

C. Design:
   1. Pressure rating: Not less than 150 pounds per square inch.
   2. In-line or angle pattern design, size as indicated on the Drawings.
   3. End connections:
      a. 1 inch and smaller: Threaded.
      b. Larger than 1 inch: Flanged.
   4. Relief set point:
      a. Externally adjustable without removing valve from piping system.
      b. Adjustment range:
         1) Valve sizes 2 inches and smaller: 5 to 125 psig.
         2) Valve sizes 3 inches and larger: 5 to 100 psig.
      c. For chemical pump discharge applications, set valve to open at 10 pounds per square inch more than pump discharge pressure at maximum operating point, or as indicated on the Drawings.

2.05 METAL BODY LPG PRESSURE REGULATING VALVES (PRV85)

A. LPG pressure regulating valves:
   1. Manufacturers: The following, or equal:
      a. Emerson, Fisher R622 series.
   2. Type: UL listed self-operated LP gas pressure high capacity regulator for low-pressure installations.
   3. Design:
      a. Size: Same size as pipe size indicated on the Drawings.
      b. Inlet pressure rating: Not greater than 10 pounds per square inch gauge.
      c. End connections: Screwed, compatible with joint type specified for the piping system.
      d. Internal pressure relief capability for minor seat leakage.
   4. Materials:
      a. Body: Cast iron.
      b. Diaphragm and disc: Fluoroelastomer suitable to 300 degrees Fahrenheit.
      c. Valve trim: Type 416 stainless steel.

5. Output pressure: 11 inches of water column:
    a. Spring range: Provide lowest spring range that will allow adjustment to the specified output pressure.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
    1. Provide certificates:
        a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional testing:
    1. Valves:
        a. Test witnessing: Witnessed.
        b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15119

AIR AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Air release valves, air and vacuum valves, and air vents.

B. As specified in Section 15110 - Common Work Results for Valves.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA).

C. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   3. A270 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Sanitary Tubing.
   4. B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15110 - Common Work Results for Valves.

C. Commissioning Submittals:
   1. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bond.

PART 2 PRODUCTS

2.01 METAL BODY AUTOMATIC AIR VENT VALVE - HOT WATER SERVICE (AAV00)

A. Manufacturers: One of the following or equal:
   1. Hoffman Specialty Manufacturing Corp., Number 78.
   2. ITT-Bell and Gossett, Number 87.

2.02 METAL BODY AIR RELEASE VALVES - WATER SERVICE (ARV00)

A. Manufacturers: One of the following or equal:
   1. Multiplex Manufacturing Co., Crispin PL Series.
   2. Valve and Primer Corp., DeZURIK/APCO Series 200.

B. Design:
   1. Pressure rating: 150 pounds per square inch gauge unless differently indicated on the Drawings.
   2. Provide low pressure seat when the operating pressure is below 10 psi.
   3. Inlet: Screwed, 2-inch.
   4. Orifice size: 1/4-inch diameter.

C. Materials:
   1. Valve body: Cast iron.
   2. Float and internal trim: Type 316 stainless steel.
   3. Seat or valve plunger: Buna-N.

2.03 PLASTIC BODY AIR RELEASE VALVES - CHEMICAL OR WATER SERVICE (ARV40)

A. Manufacturers: The following or equal:
   1. Plast-O-Matic, ARV.

B. Materials:
   1. Body:
      a. PVC piping systems: PVC.
      b. CPVC piping system: CPVC.
   2. Elastomers: Match the gasket material specified in the Piping Schedule.
   3. Minimum pressure rating at 75 degrees Fahrenheit: 150 pounds per square inch gauge.
   4. Connection: 1/4-inch NPT minimum.

2.04 METAL BODY AIR AND VACUUM VALVES - WATER SERVICE (AVV00)

A. Manufacturers: One of the following or equal:
   1. Multiplex Manufacturing Co., Crispin A Series.
   2. Valve and Primer Corp., DeZURIK/APCO Series 140.

B. Design:
   1. Pressure rating: Up to 125 pounds per square inch gauge unless differently indicated on the Drawings.
   2. Inlet: Screwed, 2-inch size and less, Flanged, 3-inch size and larger.

C. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.

2.05 METAL BODY COMBINATION AIR VALVES - WATER SERVICE (CAV00)

A. Manufacturers: One of the following or equal:
   1. Multiplex Manufacturing Co., Crispin UL Series.
   2. Valve and Primer Corp., DeZURIK/APCO, Series 140C.

B. Design:
   1. Operation: Automatic exhaust of large quantities of air from pipelines during filling and draining and release of accumulated air while pipeline is under pressure.
   2. Utilize compound lever system in conjunction with large and small orifices.
   3. Internal parts removable through top cover without removing valve from pipeline.
   4. Pressure rating: 125 pounds per square inch.
   5. Inlet: Screwed, 2-inch size and smaller, Flanged, 3-inch size and larger.

C. Materials:
   1. Body: Cast iron.
   2. Float: Type 316 stainless steel.
   3. Needle: Buna-N.
   4. Lever frame: Cast iron or Delrin.

2.06 PLASTIC BODY COMBINATION AIR VALVES - CHEMICAL OR WATER SERVICE (CAV40)

A. Manufacturers: The following or equal:
   1. Plast-O-Matic, CARD.

B. Materials:
   1. Body:
      a. PVC piping systems: PVC.
      b. CPVC piping system: CPVC.
   2. Elastomers: Match the gasket material specified in the Piping Schedule.
   3. Minimum pressure rating: 150 pounds per square inch gauge.

2.07 PLASTIC BODY DEGASSING VALVE FOR CHEMICAL SERVICE (DGV40)

A. Manufacturers: One of the following or equal:
   1. Plast-O-Matic, DGV.
   2. Primary Fluid Systems, Accu-Vent.

B. Materials:
   1. Body:
      a. PVC piping systems: PVC.
      b. CPVC piping system: CPVC.
   2. Elastomers: Match the gasket material specified in the Piping Schedule.
   3. Minimum pressure rating: 150 pounds per square inch gauge.
   4. Connection: 1/4-inch NPT minimum.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install as specified in Section 15110 - Common Work Results for Valves and the manufacturer's instructions.

B. Install air release valves and air and vacuum valves with suitable discharge lines to nearest drainage system.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services:
   1. Provide certificates:
      a. Manufacturer's Certificate of Installation and Functionality Compliance.

C. Functional Testing:
   1. Valves:
      a. Test witnessing: Witnessed.
      b. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Piping specialties including:
      a. Flexible rubber connections.
      b. Bellows type expansion joints.
      c. Slip type expansion joints.
      d. Rubber expansion joints.
      e. Transition fittings.
      f. Pipe couplings for stainless steel piping.
      g. Pipe saddles.
      h. Tapping sleeves.
      i. Sight gauges.
      j. Chemical Injector/Diffuser.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.

B. American Water Works Association (AWWA):
   1. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   2. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

C. ASTM International (ASTM):
   1. A148 - Standard Specification for Steel Castings, High-Strength, for Structural Purposes.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   4. A536 - Standard Specification for Ductile Iron Castings.

D. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects, Includes Errata.
   2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01600 - Product Requirements.

B. Product data:
   1. For each piping product in this Section as applicable:
      a. Design features.
      b. Load capacities.
      c. Material designations by UNS alloy number or ASTM Specification and Grade.
      d. Data needed to verify compliance with the Specifications.
      e. Catalog data.
      f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.

C. Installation instructions:
   1. Provide manufacturer's installation instructions.

D. Calculations:
   1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

E. Manufacturer's Certificate of Installation as specified in Section 01756 - Commissioning:
   1. Provide as specified in this Section.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

2.02 FLEXIBLE RUBBER CONNECTIONS

A. Manufacturers: One of the following or equal:
   1. Mercer Rubber Co., Type 150 Vibraflex.
   2. Red Valve Co., Inc., Part Number P-5.

B. Provide flexible rubber connections with 3/8-inch thick neoprene, EPDM, or Viton™ rubber tube with full-faced flanged ends suitable to withstand a pressure of 150 pounds per square inch gauge.

C. Provide complete flexible rubber connections, including galvanized retaining rings and control rods.

2.03 BELLOWS TYPE EXPANSION JOINTS

A. For general service:
   1. Flexible bellows type, or as otherwise specified or indicated on the Drawings.

2. Manufacturers:
    a. Expansion joints: One of the following or equal:
        1) Flex-Weld, Inc., Keflex, Series 308.
        2) Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
        3) Victaulic, Depend-o-Lok, Omniflex stainless bellows expansion joint.
    b. Pipe alignment guides: One of the following or equal:
        1) Flex-Weld, Inc.
        2) Senior Flexonics Pathway, Inc.
    c. Intermediate supports: Provide with protective saddles. One of the following or equal:
        1) Bergen-Paterson Pipe Support Corp.
        2) Unistrut Corporation, Roller-type.
3. Design:
    a. Expansion joint rating: 150 pounds per square inch gauge, at 300 degrees Fahrenheit.
    b. Bellows: Multi-ply (3 ply minimum) stainless steel, equipped with a self-draining liner guide.
    c. Axial travel of expansion joints: Not less than 1.50 inches.
    d. Ends: 150 pound ASME flanges, Victaulic, Depend-o-Lok Airmaster/Fluidmaster coupled ends, or plain suitable for welding connections, as required for piping in which installed.

B. For steam and hot water:
1. Manufacturers: One of the following or equal:
    a. Flex-Weld, Inc., Keflex, Series 308-1215.
    b. Senior Flexonics Pathway, Inc., Controlled Flexing Expansion Joint.
    c. Victaulic, Depend-o-Lok Omniflex Expansion Joint.
2. Design:
    a. Single reinforced bellows type or Victaulic mechanical couplings.
    b. Pressure and temperature ratings: 150 pounds per square inch gauge, and 500 degrees Fahrenheit service.
    c. Bellows: Multi-ply (3 ply minimum) Type 321 stainless steel, equipped with a Type 321 stainless steel liner.
    d. Axial travel of expansion joints: 3 inches minimum.
    e. Ends: 150 pound ASME flanges.

C. Copper piping expansion joints:
1. As specified before, except externally guided, and provide for 3-1/4 inch expansion per 100 feet of piping.

D. Roof drain expansion joints:
1. Neoprene bellows between roof drain fitting and drain piping.
2. Up to 12-inch static head.
3. Complete with Type 316 stainless steel clamps.
4. Manufacturers: One of the following or equal:
    a. Flexicraft Industries, DWV.
    b. Watts, Model RD-900.

2.04 SLIP TYPE EXPANSION JOINTS

A. PVC expansion joints:
   1. Flexible bellows type.
   2. Manufacturers: One of the following or equal:
      a. Chemtrol.
      b. NDS Flow Management, Quik-Fix.
   3. Materials: PVC with EPDM O-ring.
   4. Design:
      a. 150 pound per square inch pressure rating.
      b. Double O-ring seal.
      c. Axial travel: Not less than 1.5 inches.
      d. Ends: 150 pound ASME flanges, or plain end suitable for solvent welding connections.

2.05 RUBBER EXPANSION JOINTS

A. Manufacturers: One of the following or equal:
   1. Mercer Rubber Co., Style 500 or 700.
   2. Proco Products, Inc., Series 230 or 240.
   3. Red Valve Co., Inc., Type J-1.

B. Provide rubber expansion joints complete with control units and split retaining rings.

C. Design:
   1. Neoprene rubber, reinforced with embedded steel rings, and a strong synthetic fabric.
   2. Expansion rings, suitable for pressures of at least 125 pounds per square inch gauge, except as follows:
      a. Expansion joints in pump suction piping and where indicated on the Drawings suitable for minimum 100 pounds per square inch gauge pressure, and minimum 30 inches mercury vacuum.
      b. Ends of expansion joints, 150 pound ASME flanges with drilling to match that of the piping.
   3. Bolts, nuts, control rods/plates, and retaining rings shall be galvanized steel unless otherwise specified.
   4. Bolts, nuts, control rods/plates, and retaining rings for low pressure air systems provide materials matching the piping system.
   5. Bolts, nuts, control rods/plates, and retaining rings submerged in water or wastewater, buried, in wet vaults or structures, adjacent to wet walls, or above open water-containing structures shall be Type 316 stainless steel in accordance with ASTM A193, Grade B8M for bolts, and in accordance with ASTM A194, Grade 8M, for nuts.

D. For blowers: Butyl type rubber formulated for service application and for maximum temperature of 250 degrees Fahrenheit, suitable for minimum 40 pounds per square inch gauge pressure, and minimum 15 inches mercury vacuum.

2.06 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible hose:
   1. General:
      a. Type: Flexible stainless steel hose.
         1) Unbraided for pressures up to 150 pounds per square inch.
         2) Single braided for pressures up to 225 pounds per square inch.
         3) Double braided for pressures up to 360 pounds per square inch.
      b. End connections: Flanged, or as needed to comply with the specified type of joint:
         1) Sizes 2-1/2 inches and smaller may have threaded nipples.
         2) Sizes 2 inches through 12 inches may have grooved ends.
   2. Design:
      a. Open pitch spacing of corrugation.
      b. 1 fixed and 1 floating raised face flanged end connection.
      c. Able to withstand up to 1-inch offset motion from centerline.
   3. Materials:
      a. Hose: Type 304 stainless steel.
      b. Flanges: Carbon steel.

2.07 VIBRATION CONTROL JOINTS

A. Manufacturers:
   1. Braided bronze flexible vibration joints 2 inches and less in size: One of the following or equal:
      a. Flex-Weld, Inc., Keflex, Type KFCB.
      b. Senior Flexonics Canada, Inc., Type BRC bronze connectors.
   2. Flexible vibration joints larger than 2 inches: One of the following or equal:
      a. Flex-Weld, Inc., Keflex, Series 151-TR-1215.
      b. Senior Flexonics Canada, Inc., Type TCS.
   3. Corrugated stainless steel with stainless steel braid flexible vibration joints: One of the following or equal:
      a. Flex-Weld, Inc., Keflex, Type USFNSS-31.
      b. Senior Flexonics Canada, Inc., Type BSFS stainless steel connectors.

B. Design:
   1. Flexible vibration joints 2 inches and smaller: Braided bronze, suitable for pressures of not less than 250 pounds per square inch gauge.
   2. Flexible vibration joints larger than 2 inches: Flexible bellows type, suitable for pressures of not less than 150 pounds per square inch gauge, at 70 degrees Fahrenheit, except as follows:
      a. Provide vibration joints in piping subject to test pressures higher than 150 pounds per square inch gauge, suitable for such higher pressures.
      b. Bellows: Stainless steel, equipped with a stainless steel liner.
      c. Ends: ASME Class 150 flanges.
   3. Vibration joints in high-pressure air piping and in digester gas piping: Corrugated Type 316 stainless steel with stainless steel braid, suitable for pressures of not less than 150 pounds per square inch gauge.
      a. Ends: ASME Class 150 flanges.

C. Protection: Protect vibration absorbers against end loading and torsional stresses by anchoring attached piping.

2.08 TRANSITION FITTINGS

A. Manufacturers: One of the following or equal:
   1. Spears.

B. Materials:
   1. Slip socket: Schedule 80 PVC.
   2. Collar: Type 316 stainless steel.
   3. Threaded insert: Brass or Type 316 stainless steel.

2.09 PIPE SADDLES

A. For ductile iron pipe:
   1. Double strap brass type.
   2. Manufacturers: One of the following or equal:
      a. A.Y. McDonald, Style 3825.
      b. The Ford Meter Box Company, Style 202B.
      c. Mueller Company, Style BR2B.
   3. Materials:
      a. Pipe saddle body, straps, and nuts: Brass or silicon bronze.
      b. Gaskets: Rubber, EPDM, or Viton™.

B. For PVC C900 or C905 pipe:
   1. Manufacturers: One of the following or equal:
      a. Romac Industries, Inc., Style 202S.
      b. Smith-Blair, Inc., Style 317.
   2. Materials:
      a. Pipe saddles: Ductile iron with fusion bonded epoxy finish.
      b. Straps, bolts, and nuts: Type 304 stainless steel with Teflon™ coating on nuts.
      c. Gaskets : Rubber, EPDM, or Viton™.

2.10 TAPPING SLEEVES

A. Manufacturers: One of the following or equal:
   1. Romac Industries, Inc., Style FTS 420.
   2. Smith-Blair, Inc., Style 622.

B. Materials:
   1. Tapping sleeves: Steel construction.
   2. Bolts and nuts: Type 304 stainless steel.
   3. Nuts: Teflon™ coated.
   4. Gaskets: Rubber, EPDM, or Viton™.
   5. Size of tapped boss: As indicated on the Drawings.

2.11 SIGHT GAUGES, INDICATING FLOW OR LEVEL

A. Manufacturers: One of the following or equal:
   1. John C Ernst.
   2. Plast-O-Matic.

B. Provide sight gauges as indicated on the Drawings.

C. Double wall construction except for hydrofluoric acid or sodium hydroxide service.
   1. Borosilicate glass inner wall.
   2. High impact acrylic for outer wall.
      a. High light transmissibility.
      b. UV light resistant.

D. Single wall construction for hydrofluoric acid or sodium hydroxide service.
   1. High impact acrylic.

E. PTFE end connections.
   1. Suitable for 50 psi working pressure at 225 degrees Fahrenheit.

F. FKM O-ring seals.

G. FKM O-ring seals on ends of wafer connections.

H. Full 360-degree visibility.

I. Vinyl fluttering streamers for flow indication sight gauge.

2.12 SIGHT GLASSES

A. Assembly: Body casting with ASME standard adapter flanges, borosilicate glass section, cleaning assembly with scalloped neoprene wipers, operating rod and handle, packing gland with packing and suitable adapter, and cock with solvent hand pump.

B. Suitable for a minimum pressure of 30 pounds per square inch gauge.

C. Manufacturers: One of the following or equal:
   1. EIMCO Process Machinery Division of Envirotech Corp.
   2. John C Ernst.

2.13 CHEMICAL INJECTOR/DIFFUSER

A. Design:
   1. Chemical injector/diffuser:
      a. Injector configuration: Single feed point into center of water main.
      b. Diffuser configuration: Multiple feed points along water main with hole size and spacing as indicated on the Drawings.
      c. Operating pressure as indicated on the Drawings.
   2. Heavy duty brass corporation stop or stainless steel ball valve:
      a. Thread connection shall be NPT or AWWA inlet.

b. Corporation stop must include a safety device to prevent accidental withdrawal of Injection/Diffuser solution tube.

3. Injector/Diffuser solution tube sized to match pump discharge line or injection flow rate:
   a. Tube shall extend 1/3- to 1/2-diameter of water main into center of main.
   b. Able to safely withdraw or insert injector/diffuser tube into center of water main while under pressure and without having to shut down the main.
   c. Ball check valve located on injector/diffuser solution tube.
   d. Stainless steel safety chain located on injector/diffuser solution tube.

B. Materials:
   1. Injector/Diffuser: Compatible with chemical solution.

C. Manufacturers: The following or equal:
   1. Saf-T-Flo.

2.14 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01600 - Product Requirements.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements.

B. Drawings supersede conflicts with this Section.

C. Bellows type expansion joints and vibration control joints:
   1. Protect joints against damage during pressure test.

3.02 INSTALLATION

A. Expansion control joints:
   1. Install bellows type expansion control joints at piping connections to mechanical equipment to prevent damaging stresses due to normal expansion and contraction with temperature changes in piping and connected equipment.
   2. Install bellows type expansion joints so as to allow 2-1/4 inch expansion per 100 linear feet of piping.
   3. Install expansion joints adjacent to an anchor, and provide 1 concentric guide on piping within 12 pipe diameters, but not more than 5 feet, from the end of the joint opposite the anchor.
      a. Locate a similar guide approximately 30 diameters but not more than 10 feet from the first.
   4. For expansion joints not installed adjacent to an anchor provide 2 concentric guides similarly located at each end of the joint.
   5. Provide control rods and additional guides where indicated on the Drawings but at no greater intervals than recommended by the joint manufacturer in published instructions.

6. Space intermediate supports a minimum of 10 feet, and tack weld the protective saddles to the pipe.

B. Bellows type expansion joints for steam and hot water:
   1. Install not less than 1 expansion joint in a run of steam or hot water piping which exceeds 20 feet in length.
      a. Do not exceed 150-foot spacing of expansion for steam piping and 200 feet for hot water piping.
   2. Where possible, install expansion joints adjacent to an anchor; provide piping with 2 concentric guides, the first being within 2 feet of the end of the joint opposite the anchor.
   3. At expansion joints not installed adjacent to an anchor, provide 2 concentric guides on piping within 2 feet off both ends of the expansion joint.
   4. Lock expansion joint against movement until pressure test is completed.

C. Vibration control joints:
   1. Install at piping connections to or from mechanical equipment to prevent transmitting equipment vibration through the piping system.

D. Transition couplings:
   1. Application:
      a. Use with function and design similar to flexible couplings and flanged coupling adapters for connecting piping having different outside diameters.
   2. Install products specifically designed and manufactured for that application.

E. Pipe saddles:
   1. Coat threads on bolts with anti-gall coating prior to installation.

F. Tapping sleeves:
   1. Verify existing pipe material and outer diameter prior to ordering materials.
   2. Large diameter pipe:
      a. Verify the existence of lining material.
      b. Verify lining material type.
      c. Repair lining after hot tap operations are complete with similar lining or equal.
      d. Demonstrate ability to accomplish hot tap by staging a dry run simulation of the procedure prior to the initiation of the hot tap procedure.
         1) Walk through each step of the hot tap installation, and show the Engineer every component needed to install the hot tap, including, but not limited to, tools and materials, to ensure that the required components are on-site and in place prior to beginning the procedure.
   3. Coat threads on bolts with anti-gall coating prior to installation.

3.03 FIELD QUALITY CONTROL

A. Manufacturer services:
   1. Required only for:
      a. Transition couplings.
      b. Tapping sleeves for large diameter pipe.
   2. Provide Manufacturer’s Certificate of Installation.

B. Field testing:
   1. As specified in Section 15052 - Common Work Results for General Piping.
   2. Protect bellows type expansion joints and vibration control joints.

END OF SECTION

SECTION 15121

PIPE COUPLINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Pipe couplings for ductile iron piping.
   2. Pipe couplings for carbon steel piping.
   3. Pipe couplings for stainless steel piping.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.9 - Building Services Piping.

C. American Water Works Association (AWWA):
   1. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   2. C207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In.
   3. C213 - Standard for Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   4. C219 - Bolted, Sleeve-Type Couplings For Plain-End Pipe.
   5. C606 - Standard for Grooved and Shouldered Joints.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A193 - Standard Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   6. A449 - Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/9 ksi Minimum Tensile Strength, General Use.
   7. A536 - Standard Specification for Ductile Iron Castings.
   8. A563 - Standard Specification for Carbon and Alloy Steel Nuts.
   9. A576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.

10. C425 - Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
11. C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
12. C564 - Standard Specification for Rubber Gasket for Cast Iron Pipe and Fittings.
13. C1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.
14. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
16. D5926 - Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
17. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
18. F594 - Standard Specification for Stainless Steel Nuts.
19. F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.
2. 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
1. For each product in this Section as applicable:
a. Design features.
b. Load capacities.
c. Material designations by UNS alloy number or ASTM Specification and Grade.
d. Data needed to verify compliance with the Specifications.
e. Catalog data.
f. Clearly mark Submittal information to show specific items, materials, and accessories or options being furnished.

C. Calculations:
1. Provide calculations in accordance with NSF 372 for materials in contact with drinking water.

1.04 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements:
   1. Materials in contact with drinking waters: In accordance with NSF 61 and NSF 372.

B. Known acceptable manufacturers are listed by specific products.

C. Provide references as specified in this Section by specific product.

D. Manufacturer's representatives requirements as specified in Section 01756 - Commissioning and this Section by specific product.

E. Gaskets for flexible couplings and flanged coupling adapters:
   1. Provide gasket materials for piping applications as follows:
      a. Low-pressure and high-pressure air, steam, hot water: EPDM.
      b. All other piping applications: Neoprene rubber or Buna-N or EPDM

F. Exterior coatings for underground and submerged applications:
   1. Manufacturers: One of the following or equal:
      a. Kop-Coat Co., Inc., Bitumastic Number 50.
      b. Tapecoat Co., Inc., T.C. Mastic.
   2. Thickness: Minimum 0.040 inch.

2.02 PIPE COUPLINGS FOR DUCTILE IRON PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool: AWWA C207 steel pipe:
         1) ASTM A53 for sizes 3 inches to 12 inches.
         2) ASTM A36 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36 or A53.
      c. Follower ring: Ductile iron in accordance with ASTM A536.
      d. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
      e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.

4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

B. Equipment connection fittings:
   1. Manufacturers: The following or equal:
      a. Romac Ind., Inc., Style ECF400.
   2. Design:
      a. In accordance with AWWA C219.
      b. Suitable for minimum 150 pounds per square inch working pressure.
      c. Consist of 2 flanged coupling adapters, plain end section of pipe, thrust restraint rods, and associated fittings designed to transmit thrust without transmitting shear to the thrust restraint rods and without compromising provision for accommodating angular and parallel misalignment.
         1) Face to face length adjustment:
            a) For sizes 3 inches to 12 inches: 2 inches.
            b) For sizes 14 inches to 72 inches: 3 inches.
      d. Provide both lateral and angular misalignment adjustment between flanges.
         1) Shall accommodate a minimum of 1/4-inch lateral offset and 2 degrees deflection.
      e. Provide full pressure thrust restraint between flanges.
         1) Thrust rod:
            a) Selected to provide sufficient freedom of movement through all bolt holes to allow unrestricted maximum adjustment of equipment connection fittings.
            b) No transmission of any shear to the thrust rods.
            c) Allows full development of thrust restraint at thrust rod tension take-ups.
            d) Number and diameter selected as recommended by the manufacturer for the working pressure of the coupling.
   3. Materials:
      a. Flanged spool: AWWA C207 steel pipe:
         1) ASTM A53 for sizes 3 inches to 12 inches.
         2) ASTM A36 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36 or A53.
      c. Bolts and hex nuts:
         1) Aboveground: Type 316 stainless steel bolts in accordance with ASTM F593.
      d. Tie rods: Type 316 stainless steel in accordance with ASTM A193 B8M.
      e. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
      f. Harness lugs: ASTM A36 Steel.
      g. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flanged coupling adapters: 12-inch size and smaller:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 227.

b. Romac Ind., Inc., Style FCA501.
c. Smith-Blair, Inc., Series 912.

2. Materials:
   a. Flanged body: Ductile iron in accordance with ASTM A536.
   b. Follower ring: Ductile iron in accordance with ASTM A536.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

D. Flanged coupling adapters: Greater than 12-inch size:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 128-W.
   b. Romac Ind., Inc., Style FC400.
   c. Smith-Blair, Inc., Series 913.
2. Materials:
   a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

E. Flexible couplings:
1. Manufacturers: One of the following or equal:
   a. Dresser, Inc., Style 253.
   b. Romac Ind., Inc., Style 501.
   c. Smith-Blair, Inc., Series 441.
2. Materials:
   a. Center rings: Ductile iron in accordance with ASTM A536.
   b. Follower rings: Ductile iron in accordance with ASTM A536.
   c. Bolts and hex nuts:
      1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
      2) Buried and underwater: Type 316 stainless steel in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with following table:

Nominal Pipe Size	Sleeve Length
3 inch and Smaller	Manufacturer's Standard
4 inch through 8 inch	7 inches
10 inch through 14 inch	12 inches
Greater than 16 inch	Use Steel Flexible Coupling per Pipe Couplings for Steel Piping

F. Flexible couplings (gravity flow):
   1. Manufacturers: The following or equal:
      a. Fernco Flexible Coupling.
   2. Materials:
      a. In accordance with ASTM D5926, ASTM C1173, and applicable portions of ASTM C443, C425, C564, and D1869.
   3. Requirements:
      a. In underground and underwater installations, couplings shall be corrosion resistant or coated with a fusion applied epoxy coating in accordance with AWWA C213.
      b. Bolts and hardware shall be stainless steel 18-8 type 316 epoxy coated alloy hardware.

G. Restrained flange coupling adapter:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style RFCA.
      b. Star Pipe Products, 3200 StarFlange™.
   2. Materials:
      a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
      b. Follower ring: Lug type restraint system.
         1) Follower ring: Ductile iron in accordance with ASTM A536.
         2) Restraining lugs: Ductile iron in accordance with ASTM A536.
            a) Designed to contact the pipe and apply forces evenly.
         3) Restraining bolts:
            a) Ductile iron in accordance with ASTM A536.
            b) Bolt heads shall be designed to twist off when the proper torque has been applied.
      c. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
   5. Angular deflection: Restrained flange coupling adapter must allow angular deflection after assembly.

H. Grooved joint couplings:
   1. Manufacturers: The following or equal:
      a. Victaulic Co., Series 31 or equal.
   2. Materials:
      a. Housings: Ductile iron in accordance with ASTM A536.
      b. Gasket:
         1) FlushSeal® type, or equal. Elastomer in accordance with ASTM D2000.
         2) Neoprene or Buna-N or EPDM.
      c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
      d. Coating: As specified in Section 09960 - High-Performance Coatings.
   3. For use with rigid or flexible radius grooved components in accordance with AWWA C606.
   4. For connection to IPS steel pipe sizes, Victaulic Style 307.

2.03 PIPE COUPLINGS FOR CARBON STEEL PIPING

A. Dismantling joints:
   1. Manufacturers: One of the following or equal:
      a. Romac Ind., Inc., Style DJ400.
      b. Smith-Blair, Inc., Series 975.
   2. Materials:
      a. Flanged spool:
         1) C207 Schedule 40 pipe in accordance with ASTM A53 for sizes 3 inches to 12 inches.
         2) Steel for pipe in accordance with ASTM A36 or A53 for sizes 14 inches to 72 inches.
      b. End ring and body:
         1) For sizes 3 inches to 12 inches, ductile iron in accordance with ASTM A536.
         2) For sizes 14 inches to 72 inches, steel in accordance with ASTM A36.
      c. Follower ring: Ductile iron in accordance with ASTM A536 or steel in accordance with ASTM A36 or A576.
      d. Bolts and hex nuts:
         1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
         2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
      e. Tie rods: High tensile steel in accordance with ASTM A193 Grade B7.
   3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
   4. Coating and lining: Fusion bonded epoxy certified in accordance with NSF 61.

B. Flanged coupling adapters:
   1. Manufacturers: One of the following or equal:
      a. Dresser, Inc., Style 128-W.
      b. Romac Ind., Inc., Style FCA501 (10 inch and smaller) or Style FC400 (12 inch and larger).
      c. Smith-Blair, Inc., Series 913.

2. Materials:
    a. Flange and flanged body: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    b. Follower ring: Low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    c. Bolts and hex nuts:
        1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.
        2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.
4. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.

C. Flexible couplings:
1. Manufacturers: One of the following or equal:
    a. Dresser, Inc., Style 38.
    b. Romac Ind., Inc., Style 511 or Style 400.
    c. Smith-Blair, Inc., Series 411.
2. Materials:
    a. Center sleeve and follower flanges: Ductile iron or low carbon steel having a minimum yield strength of 30,000 pounds per square inch.
    b. Bolts and hex nuts:
        1) Aboveground: High strength, low alloy steel in accordance with AWWA C111.
        2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.
3. Coating and lining: Manufacturer's standard fusion bonded epoxy, NSF 61 certified.
4. Center sleeve dimensions: Provide center sleeves with lengths in accordance with the following table:

Nominal Pipe Diameter	Sleeve Length
2-1/2 inch and Smaller	Manufacturer's Standard
3 inch through 6 inch	7 inch
8 inch through 14 inch	7 inch
Greater than 14 inches	10 inch

D. Restrained flange coupling adapters:
1. Manufacturers: One of the following or equal:
    a. Romac Ind., Inc., Style RFCA.
    b. Star Pipe Products, 3200 StarFlange™.
2. Materials:
    a. Flange and flanged body: Ductile iron in accordance with ASTM A536.
    b. Follower ring: Lug type restraint system.
        1) Follower ring: Ductile iron in accordance with ASTM A536.
        2) Restraining lugs: Ductile iron in accordance with ASTM A536.
            a) Designed to contact the pipe and apply forces evenly.

3) Restraining bolts: Ductile iron in accordance with ASTM A536. Bolt heads shall be designed to twist off when the proper torque has been applied.

c. Bolts and hex nuts:

1) Aboveground: High-strength, low-alloy steel in accordance with AWWA C111.

2) Buried and underwater: Type 316 stainless steel bolts in accordance with ASTM F593.

3. Flange design: Class D steel ring flange in accordance with AWWA C207, compatible with ANSI Class 125 and 150 bolt circles.

4. Coating and lining: Manufacturer's standard fusion bonded epoxy certified in accordance with NSF 61.

E. Grooved joint couplings:

1. Model numbers from one manufacturer are shown to indicate type only. Equivalent products of other manufacturers may be submitted for approval.

2. Coating: As specified in Section 09960 - High-Performance Coatings.

3. Sizes through 12 inch:

a. Rigid type:

1) Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.

2) 2 inch through 6 inch: Installation-ready, for direct stab installation without field disassembly, with grade EHP gasket rated to 250 degrees Fahrenheit.

3) Manufacturers: One of the following or equal:

a) Victaulic Style 107.

b) Victaulic Zero-Flex Style 07.

b. Flexible type:

1) For use in locations where vibration attenuation and stress relief are required.

2) 3 flexible couplings may be used in lieu of a flexible connector.

3) Couplings shall be placed in close proximity to the source of the vibration.

4) Manufacturers: The following or equal:

a) Victaulic Style 77.

c. Flange adapter:

1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.

2) Manufacturers: The following or equal:

a) Victaulic Style 741.

4. Sizes 14-inch through 24-inch:

a. Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.

b. Rigid type:

1) Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ASME B31.1 and B31.9.

2) Manufacturers: The following or equal:

a) Victaulic Style W07.

c. Flexible type:
1) Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement.
2) Manufacturers: The following or equal:
a) Victaulic Style W77.
d. Flange adapter:
1) Flat face, ductile iron housings with elastomer pressure responsive gasket, for direct connection to ANSI Class 125 or 150 flanged components.
2) Manufacturers: The following or equal:
a) Victaulic Style W741.

5. For sizes 30 inch and larger:
a. Manufacturers: The following or equal:
1) Victaulic Style AGS multiple-segment housing may be used.

F. Double-grooved joint high pressure couplings:
1. Manufacturers: The following or equal:
a. Victaulic Co., Style 808.
2. Materials:
a. Housings: 2 ductile iron housings in accordance with ASTM A536.
b. Gasket: Elastomer in accordance with ASTM D2000.
1) Grade 'N' Nitrile.
2) Grade 'T' EndSeal type.
c. Bolts and nuts: Electroplated steel in accordance with ASTM A449.
d. Coating: Manufacturer's standard: As specified in Section 09960 - High-Performance Coatings.
3. Size range: 6 inch through 12 inch.
4. Operating pressure:

Size	Pipe Schedule	Max. Joint Working Pressure
6 inch	80	3,000 psig (20,690 kPa)
	160	4,000 psig (27,586 kPa)
8 inch	80	2,500 psig (17,241 kPa)
	160	3,500 psig (24,138 kPa)
10 inch	80	2,500 psig (17,241 kPa)
	160	3,000 psig (20,690 kPa)
12 inch	80	2,000 psig (13,793 kPa)
	160	2,500 psig (17,241 kPa)

5. For use with Victaulic double grooved fittings, manufactured of carbon steel pipe of the same schedule as the adjoining pipe.

G. Bolted, split-sleeve couplings:
1. In accordance with AWWA C227.
2. Provide where indicated on the Drawings or as an alternative to flexible couplings when approved by the Engineer for each individual case.
3. Split-sleeve type pipe coupling with double arch cross section:
a. Shall be designed to close around the pipe ends, confining the gaskets beneath the arches of the sleeve.

b. A watertight, axial seal is created by tightening the bolts to pull the coupling against the outside wall of the pipe.

4. Coatings:
   a. Couplings shall be epoxy-coated on the inner diameter and outer diameter prior to delivery.
   b. Buried couplings shall receive additional protection against corrosion that matches the pipe as specified in Section 09960 - High-Performance Coatings.
5. Couplings: Wall thickness that is adequate for the test pressure as specified in the Piping Schedule as indicated on the Drawings.
   a. Provide split-sleeve type coupling in an “expansion x expansion” configuration where indicated on the Drawings.
   b. Where restrained pipe joints are required or are indicated on the Drawings, provide split sleeve type coupling in a “fixed x fixed” configuration.
      1) Coordinate with coupling manufacturer and pipe supplier to provide restraint rings on pipe.
      2) Coupling manufacturer to supply restraint rings.
   c. Where axial pipe expansion must be accommodated or where they are indicated on the Drawings, provide split-sleeve type coupling in a “fixed x expansion” configuration.
      1) Coordinate with coupling manufacturer and pipe supplier to provide restraint ring on fixed side of coupling.
      2) Coupling manufacturer to supply restraint rings.
   d. Axial restraint and angular deflection:
      1) Where axial restraint is required to resist pipe thrust and angular deflection is required to provide flexibility in the piping or where they are indicated on the Drawings, provide split-sleeve type coupling in a “fixed x fixed modified” configuration.
      2) Install coupling with manufacturer’s recommended gap between ends of piping with the shoulders of coupling bearing on the inner restraint rings that are welded to the piping at both ends of coupling.
      3) Coupling shall be designed for an angular deflection of not less than the angular defection indicated in the following table, unless a larger angular deflection is indicated on the Drawings.

Nominal Pipe Diameter	Allowable Angular Deflection
18 inch and smaller	3 degrees
20 inch	2.5 degrees
24 inch	2 degrees
30 inch	1.75 degrees
36 inch	1.5 degrees
42 inch	1.25 degrees
48 and 54 inch	1 degree
60 inch	0.875 degrees
66 and 72 inch	0.75 degrees

6. Restraint rings:
    a. Provide where required to create a restrained joint.
    b. Coordinate with piping manufacturer.
    c. Shop fabricate pipe with restraint rings that engage the interior edge of the coupling shoulder.
        1) Weld for restraint ring: Suitable for test pressures indicated in the Piping Schedule as indicated on the Drawings.
7. Gaskets: Sealing members are comprised of 2 O-ring gaskets.
    a. Internal pressure shall not be required to affect the seal.
    b. For water service, the gasket supplied shall be Isoprene or Buna-N in accordance with ASTM D2000 for design pressure within temperature range of minus 20 to 180 degrees Fahrenheit.
        1) Elastomers shall have properties in accordance with ASTM D2000.
8. Manufacturers: One of the following or equal:
    a. Non-restrained coupling:
        1) Victaulic, Style 230 Type 2.
    b. Expansion coupling:
        1) Victaulic, Style 231 Type 2.
    c. Restrained coupling:
        1) Victaulic, Style 232 Type 2.
    d. Restrained coupling for dynamic joint deflection:
        1) Victaulic, Style 233 Type 2.
    e. Restrained single-gasket coupling:
        1) Victaulic, Style 234 Type 2.
9. Materials:
    a. Couplings: Steel in accordance with ASTM A36.
    b. Bolts and nuts: In accordance with ASTM F3125, Grade A325, and ASTM A563.
10. Pipe preparation:
    a. Pipe ends shall be smooth for expansion or contraction requirements.
    b. Where thrust restraint is required or is indicated on the Drawings, pipe ends shall include restraint rings affixed for pipe end restraint requirements.
    c. Coupling manufacturer shall provide restraint rings that shall be shop welded to the pipe in accordance with the manufacturer's requirements.
    d. Follow coupling manufacturer's recommendation for size and amount of welding required to attach restraint rings to the pipe.

H. Bolted, split-sleeve flanged adapter couplings:
1. In accordance with AWWA C227.
2. Provide where indicated on the Drawings or as an alternative to flexible coupling type flange adaptors when approved by the Engineer for each individual case.
3. Flanged adapter with split-sleeve type coupling with double arch cross section.
    a. Coupling shall be designed to confine the gaskets beneath the arches of the sleeve.
    b. A watertight, axial seal is created by tightening the bolts to pull the coupling together and seat the gaskets against the outside wall of the pipe and adapter.

4. Coatings:
    a. Couplings shall be epoxy-coated on the inner diameter and outer diameter prior to delivery.
    b. Buried couplings shall receive additional protection against corrosion that matches the pipe as specified in Section 09960 - High-Performance Coatings.
5. Couplings: Wall thickness that is adequate for the test pressure specified in the Piping Schedule as indicated on the Drawings.
    a. Provide coupling in a “flanged x expansion” configuration where indicated on the Drawings.
    b. Where axial pipe movement must be restrained, provide coupling in a “flanged x fixed” configuration.
        1) Coordinate with pipe supplier to provide restraint ring on fixed side of coupling.
    c. Where axial restraint is required to resist pipe thrust and angular deflection is required to provide flexibility in the piping, provide sleeve type coupling in a “flanged fixed x fixed modified” configuration.
        1) Install coupling with full 1-1/2-inch gap between ends of pipe with shoulder of coupling bearing on ring welded to pipe at both ends of coupling.
        2) Coupling shall be designed for an angular deflection of not less than the angular deflection indicated in the following table unless a larger angular deflection is indicated on the Drawings.

Nominal Pipe Diameter	Allowable Angular Deflection
18 inch and smaller	3 degrees
20 inch	2.75 degrees
24 inch	2.375 degrees
30 inch	2 degrees
36 inch	1.5 degrees
42 inch	1.375 degrees
48 and 54 inch	1 degree
60 and 66 inch	0.875 degrees
72 and 78 inch	0.75 degrees

6. Restraint rings:
    a. Provide where required to create a restrained joint.
    b. Coordinate with piping manufacturer.
    c. Shop fabricate pipe with restraint rings that engages the interior edge of the coupling shoulder.
        1) Weld for restraint ring: Suitable for test pressures as specified in the Pipe Schedule as indicated on the Drawings.
7. Gaskets:
    a. Sealing members are comprised of 2 O-ring gaskets. Internal pressure shall not be required to affect the seal.
    b. For water service, the gasket supplied shall be Isoprene or Buna-N in accordance with ASTM D2000 for design pressure within temperature range of minus 20 to 180 degrees Fahrenheit.

c. Elastomers shall have properties in accordance with ASTM D2000.

8. Manufacturers: One of the following or equal:
   a. Expansion coupling:
      1) Victaulic, Style 231 Type 2.
   b. Restrained coupling:
      1) Victaulic, Style 232 Type 2.
   c. Restrained coupling for dynamic joint deflection:
      1) Victaulic, Style 233 Type 2.
9. Materials:
   a. Couplings: Steel in accordance with ASTM A36.
   b. Bolts and nuts: In accordance with ASTM F3125, Grade A325, and ASTM A563.
10. Pipe preparation:
    a. Pipe ends shall be smooth for expansion or contraction requirements.
    b. Where thrust restraint is required or is indicated on the Drawings, pipe ends shall include restraint rings affixed for pipe end restraint requirements.
    c. Coupling manufacturer shall provide restraint rings that shall be shop welded to the pipe in accordance with the manufacturer's requirements.
    d. Follow coupling manufacturer's recommendation for size and amount of welding required to attach restraint rings to the pipe.

2.04 PIPE COUPLINGS FOR STAINLESS STEEL PIPING

A. Flexible couplings:
   1. Manufacturers: The following or equal:
      a. Dresser, Inc., Style 38.

B. Grooved joint couplings:
   1. Manufacturers: The following or equal:
      a. Victaulic Co.
   2. Materials:
      a. Housings:
         1) Ductile iron in accordance with ASTM A536.
         2) Stainless steel in accordance with ASTM A351.
      b. Gasket: Elastomer in accordance with ASTM D2000.
      c. Bolts and nuts:
         1) Electroplated steel in accordance with ASTM A449.
         2) Stainless steel in accordance with ASTM F593.
   3. Rigid type:
      a. Victaulic Style 89 and W89 (ductile iron housings).
      b. Victaulic Style 489 (stainless steel housings).
   4. Flexible type: Victaulic Style 77S.

C. Bolted, split-sleeve couplings:
   1. In accordance with AWWA C227.
   2. With a fully stainless steel double arch cross section.
      a. Designed to close around the pipe ends, confining the gaskets beneath the arches of the sleeve.
      b. A watertight, axial seal is created by tightening the bolts to pull the coupling against the outside wall of the pipe.

3. Manufacturers: One of the following or equal:
4. Manufacturers: One of the following or equal:
    a. Non-restrained coupling:
        1) Victaulic, Style 230S Type 2.
    b. Expansion coupling:
        1) Victaulic, Style 231S Type 2.
    c. Restrained coupling:
        1) Victaulic, Style 232S Type 2.
    d. Restrained coupling for dynamic joint deflection:
        1) Victaulic, Style 233S Type 2.
5. Materials:
    a. Couplings: Stainless steel in accordance with ASTM A240.
    b. Bolts and nuts: In accordance with ASTM F593 and F594.
6. Pipe preparation:
    a. Pipe ends shall be smooth for expansion or contraction requirements.
    b. Where thrust restraint is required or is indicated on the Drawings, pipe ends shall include restraint rings affixed for pipe end restraint requirements.
    c. Coupling manufacturer shall provide restraint rings that shall be shop welded to the pipe in accordance with the manufacturer's requirements.
    d. Follow coupling manufacturer's recommendation for size and amount of welding required to attach restraint rings to the pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. In underground and underwater installations, coat the exterior of coupling with a protective coating in accordance with the manufacturer's instructions.

B. Joints and flexible connections shall be installed centered with no angular deflection unless otherwise indicated on the Drawings.

C. Flexible couplings and flange coupling adapters: Install with gap between pipe ends in accordance with the following table unless a greater gap is indicated on the Drawings. Maximum gap tolerance shall be within 1/8 inch.
    1. Install flexible coupling with pipe gap located in middle of center sleeve.
    2. Install flanged coupling adapter with end of plain end pipe in middle of flanged coupling body.

Center Ring Length	Gap Dimension and Tolerance
4 inch through 6 inch	3/8 inch
7 inch	5/8 inch
10 inch and greater	7/8 inch

D. Provide harnesses (tie-downs) for flexible couplings unless otherwise indicated on the Drawings with a written note.
    1. Design harnesses (tie-downs) for the test pressures as specified in the Piping Schedule as indicated on the Drawings.

E. Grooved joint couplings:
   1. Grooved ends: Clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
   2. Gaskets: Elastomer grade suitable for the intended service, and molded and produced by the coupling manufacturer.

F. Bolted, split-sleeve couplings:
   1. Inspect each coupling to insure that there are no damaged portions of the coupling.
      a. Pay particular attention to the sealing pad/sealing plate area.
      b. Before installation, thoroughly clean each coupling of any foreign substance which may have collected thereon and shall be kept clean at all times.
   2. Wrenches:
      a. Conform to manufacturer instructions.
      b. Bolts and studs shall be tightened so as to secure a uniform gasket compression between the coupling and the body of the pipe with all bolts or studs tightened approximately the same amount.
      c. Final tightening shall be done by hand (no air impact wrenches) and is complete when the coupling is in uniform contact with the outside surface of the pipe all around the circumference of the pipe.
   3. No joint shall be misfit in any plane.
   4. On fixed ends of bolted, split-sleeve couplings, shoulders shall bear on restraint rings all around with no visible gap.
   5. Ends of piping where coupler are installed shall be smooth and free of defects.
      a. Remove weld splatter and grind smooth.
      b. Grind pipe seam welds flush with pipe wall and smooth.

END OF SECTION

SECTION 15122

FIRE HYDRANTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Barrel type fire hydrants.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C 502 - Standard for Dry-Barrel Fire Hydrants.

1.03 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. One of the following or equal:
   1. Mueller Super Centurion 250 Model A-423
   2. Waterous WB67-250 Clow Valve Co., Medallion Hydrant.

2.02 MATERIALS

A. Fire hydrants:
   1. Dry barrel in accordance with type AWWA C 502, as complemented and modified in this Section.
   2. Provide hydrants with ground level break-off feature and manufactured such that the valve stem will not be bent when the hydrant is damaged or broken at or near the ground level.
   3. When shut, provide valves that remain reasonably tight when the upper portion of the barrel is broken off.
   4. Diameter of the main valve opening: Not less than 4 inches.
   5. Inlet connection: 6-inch diameter mechanical joint for ductile iron pipe.
   6. Provide two 2-1/2-inch hose nozzles and one 5-1/2-inch pumper nozzle facing the street.
      a. Provide nozzles with hose caps chained to the hydrant barrel.
      b. Nozzle threads: National standard hose thread.
   7. Hydrants: Furnish with drain valve.
   8. Color of hydrant above ground: Red.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install hydrants with proper extension so that branch pipe to hydrant and supply main are at the same elevation.

B. Attach auxiliary 6-inch gate valves by mechanical joint at 18 inches from the hydrant joint, and attach piping ductile-iron to the supply.

C. Firmly set hydrants on a bed of coarse gravel.

END OF SECTION

SECTION 15125

STRAINERS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Strainers.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   2. A420 - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service.

B. Society of Automotive Engineers (SAE).

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 Y-TYPE STRAINERS

A. Y-type strainers less than 4 inches in diameter:
   1. Materials:
      a. Bodies: Cast iron or semi-steel.
      b. Ends: Flanged or threaded.
      c. Screen: Brass or Type 304 stainless steel.
   2. Suitable for maximum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: The following or equal:
      a. Armstrong, Y-Type Strainer.

B. Y-type strainers for chemical service:
   1. Materials:
      a. Bodies: PVC or CPVC as required for the chemical service.
      b. Ends: Flanged, socket, or threaded.
      c. Screen: Type 304 stainless steel.
      d. Gaskets: Viton or EPDM as required for the chemical service;
   2. Suitable for maximum pressure of 250 pounds per square inch gauge.
   3. Screens: Perforations: 1/32 inch.
   4. Manufacturers: The following or equal:
      a. Hayward.

2.02 BASKET TYPE STRAINERS

A. Provide basket type strainers single or duplex as indicated on the Drawings.

B. Materials:
   1. Bodies: Cast iron or cast steel or PVC or CPVC for chemical service.
   2. Baskets: Low-zinc bronze or stainless steel or PVC for chemical service.

C. Pressure rating: Where not otherwise indicated on the Drawings, 125 pounds per square inch gauge, minimum.

D. Connections: Threaded or flanged, as required.

E. Covers:
   1. For strainers 6 inches and smaller in size, secured by yokes or similar quick opening devices.
   2. For strainers larger than 6 inches in size, bolted or hinged and bolted with slotted washers so that bolts or nuts need not be completely removed to open the strainer.
   3. Provide lifting eyes on covers weighing more than 50 pounds.

F. Baskets:
   1. Screen: Mesh or perforated sheet.
   2. Openings: Not greater than 1/4 inch.
   3. Free area: Not less than 30 percent.
   4. Free area to pipe ratio: Not less than 3.

G. Provide duplex strainers with tapered plug transfer valve or with gate type transfer valves.
   1. Where action on two valve actuators is required to transfer operation from one chamber to the other, provide actuators mechanically linked for simultaneous operation.

H. Manufacturers: One of the following or equal:
   1. Single basket strainers:
      a. Fluid Engineering, Series 528B.
      b. Mueller Steam Specialty.
   2. Double basket strainers:
      a. Fluid engineering, Series 534 for sizes 1-1/2 inch to 8 inch, and Series 424 for sizes 10 inch and larger.

b. Mueller Steam Specialty.

3. Basket strainers for chemical service:
   a. Hayward.
   b. Dual or simplex as indicated on the Drawings; baskets and bodies PVC or CPVC; gaskets Viton or EPDM as required for the chemical service; basket mesh size to be specified by the Engineer during shop drawing review.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with the manufacturer's recommendations.

3.02 COMMISSIONING

A. As specified in Section 01756 - Commissioning and this Section.

B. Manufacturer services for mechanically cleaned strainers, only:
   1. Provide certificates:
      a. Manufacturer’s Certificate of Installation and Functionality Compliance.
   2. Manufacturer’s Representative onsite requirements:
      a. Installation: 1 trip, 1 day minimum.
      b. Functional Testing: 1 trip, 1 day minimum each.
   3. Training:
      a. Maintenance and Operations: 1 session.
   4. Process operational period:
      a. As required by Owner or Contractor.

C. Functional testing:
   1. Mechanically cleaned strainers only:
      a. Test witnessing: Witnessed.
      b. Conduct Level 1 General Equipment Performance Test.

END OF SECTION

SECTION 15211

DUCTILE IRON PIPE: AWWA C151

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Ductile iron pipe, joints, connections, fittings, and pipe linings and coatings.

B. As specified in Section 15052 - Common Work Results for General Piping.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association (AWWA):
   1. C104 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   2. C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
   3. C110 - Standard for Ductile-Iron and Gray-Iron Fittings.
   4. C111 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   5. C150 - Standard for Thickness Design of Ductile-Iron Pipe.
   6. C151 - Standard for Ductile-Iron Pipe, Centrifugally Cast.
   7. C153 - Standard for Ductile-Iron Compact Fittings for Water Service.
   8. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   9. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   10. C600 - Installation of Ductile Iron Water Mains and Their Appurtenances.
   11. C606 - Standard for Grooved and Shouldered Joints.

C. American Welding Society (AWS):
   1. D11.2 - Guide for Welding Iron Castings.

D. ASTM International (ASTM):
   1. A536 - Standard Specifications for Ductile Iron Castings.
   2. B1000 - Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-Lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry.
   3. C33 - Standard Specification for Concrete Aggregates.
   4. C150 - Standard Specification for Portland Cement.
   5. C283 - Standard Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
   6. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   7. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.

E. Ductile Iron Pipe Research Association (DIPRA):
   1. Thrust Restraint Design Manual.

F. National Association of Pipe Fabricators, Inc. (NAPF):
   1. 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

G. NSF International (NSF):
   1. 61 - Drinking Water System Components - Health Effects.

H. Society for Protective Coatings (SSPC):
   1. SP 5 - White Metal Blast Cleaning.
   2. SP 10 - Near White Wet Blast.
   3. SP 11 - Bare Metal Power Tool Cleaning.
   4. PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages.
   5. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data.

C. Manufacturer's qualifications.
   1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

D. Manufacturer's Quality Assurance Manual:
   1. Submit manufacturer's coating and lining application quality assurance manual to the Engineer prior to beginning coating application.
      a. Strict conformance to the requirements of the manual will be required.
      b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

E. Shop Drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.
   2. Thrust restraint systems.
   3. Photographs, drawings, and descriptions of fittings, gaskets, couplings, grooving of pipe and fittings.

F. Calculations:
   1. Thrust restraint system design.

G. Manufacturer's Certificate of Source Testing for ceramic epoxy, glass lined, plural component polyurethane, and zinc materials:
   1. Certify successful performance of holiday detection tests on 100 percent of lining in accordance with ASTM B1000.
   2. Identify each test piece by mark designation and show the actual test results during the final inspection by the manufacturer prior to shipment.

3. Include coating manufacturer's technical representative's reports.

1.04 QUALITY ASSURANCE

A. Ductile iron pipe shall be supplied by a single manufacturer.

B. Hydrostatically test each joint of ductile iron pipe in accordance with AWWA C151.

C. Pre-installation meeting:
   1. Arrange for coating manufacturer's technical representative to attend preconstruction conferences, and to make periodic visits to factory or shop to inspect surface preparation of pipe, fittings, and accessories; and to inspect application of linings to interior and coatings to exterior of pipe, fittings, and accessories.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Block piping and associated fittings for shipment to prevent damage to coatings and linings.

B. Carefully handle piping and associated fittings during loading, unloading, and installation:
   1. Do not drop piping material from cars or trucks.
   2. Lower piping by mechanical means.
   3. Do not drop or pound pipe to fit grade.

C. Protect gaskets and polyethylene encasement from long-term exposure to sunlight.

D. Store piping, fittings, and other accessories such that they do not accumulate and hold rainwater, dirt, and debris.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Ductile iron piping:
   1. Manufacturers: One of the following or equal:
      a. American Cast Iron Pipe Co.
      b. McWane Ductile.
      c. SIP Industries.
      d. U.S. Pipe.

2.02 THRUST RESTRAINT SYSTEM DESIGN

Restrain all buried pipe joints.

2.03 CONCRETE THRUST BLOCK RESTRAINT

A. Joint thrust restraint system designed by the Contractor.
   1. Concrete thrust blocks will only be permitted in certain locations where indicated on the Drawings.

2.04 DUCTILE IRON JOINTS AND CONNECTIONS

A. General:
   1. Pressure class or special thickness class as indicated in the Piping Schedule provided in Section 15052 - Common Work Results for General Piping.
   2. In accordance with AWWA C150 and AWWA C151.
   3. Joints:
      a. Flanged.
      b. Grooved.
      c. Mechanical.
      d. Mechanical wedge action.
      e. Integrally restrained push-on.
   4. Connections:
      a. Tapping saddle.
      b. Tapping sleeve.
      c. Welded outlet.
   5. Fittings.

B. Joints:
   1. Flanged joints:
      a. Screw-on flanges:
         1) Comply with the diameter, thickness, drilling, and other characteristics in accordance with ASME B16.1.
         2) Ductile iron.
         3) Long hub, threaded, and specially designed for ductile iron pipe.
         4) After attaching to pipe, machine flange face to make pipe end and flange even and perpendicular to the axis of the pipe.
      b. Bolt holes on flanges: 2-holed and aligned at both ends of pipe.
      c. Cap screw or stud bolt holes: Tapped.
      d. Bolts and nuts:
         1) As specified in Section 15052 - Common Work Results for General Piping.
      e. Gaskets:
         1) Standard styrene butadiene copolymer (SBR) unless specified otherwise in Section 15052 - Common Work Results for General Piping.
   2. Grooved joints:
      a. In accordance with AWWA C606, as complemented and modified below, radius-cut type.
      b. Couplings:
         1) Rigid type, cast from ductile iron in accordance with ASTM A536, Grade 65-45-12.
      c. Bolts and nuts:
         1) As specified in Section 15052 - Common Work Results for General Piping.
      d. Gaskets:
         1) As specified in Section 15052 - Common Work Results for General Piping.
      e. Fittings:
         1) In accordance with AWWA C606, rigid radius-cut groove.
         2) Center-to-center dimensions: In accordance with AWWA C110.

3) Wall thickness and other characteristics: In accordance with AWWA C606.

f. Flanged unit connections:

1) Flanged to grooved joint adapters or a long enough spool with one end flanged and the other end grooved to prevent interference with the operation of adjacent valves, pumps, or other items.

3. Mechanical joints:

a. In accordance with AWWA C111.

b. Gaskets:

1) As specified in Section 15052 - Common Work Results for General Piping.

c. Bolts and nuts, including T-bolts:

1) As specified in Section 15052 - Common Work Results for General Piping.

4. Push-on rubber gasket joints:

a. In accordance with AWWA C111.

b. Gaskets:

1) As specified in Section 15052 - Common Work Results for General Piping.

5. Mechanical wedge action joint restraints:

a. Manufacturers: One of the following or equal:

1) EBAA Iron, Inc., Megalug® Series 1100.

2) Sigma Corp., One-Lok Model SLDE.

3) Star Pipe Products, Split Stargrip Series 3000.

b. Materials:

1) Gland body:

a) Ductile iron in accordance with ASTM A536.

2) Wedges and wedge actuating components:

a) Ductile iron in accordance with ASTM A536.

b) Wedges shall be heat treated to a minimum of 370 BHN.

3) Actuating bolts and nuts:

a) Ductile iron in accordance with ASTM A536.

b) Provide torque-limiting twist off components to ensure proper installation.

4) Gaskets:

a) As specified in Section 15052 - Common Work Results for General Piping.

c. Coatings:

1) Provide manufacturer applied coating system.

2) Manufacturers: One of the following or equal:

a) EBAA Iron Inc., Mega-Bond.

b) Sigma Corp., Corrsafe™ Electro-deposition coating.

c) Star Pipe Products, Star-Bond.

d. Working pressure:

1) Shall include a minimum safety factor of 2:1.

2) Sizes 3- through 16-inch: 350 pounds per square inch.

3) Sizes 18- through 48-inch: 250 pounds per square inch.

e. Restraint shall consist of multiple gripping wedges incorporated into a follower gland meeting the requirements of AWWA C111.

f. Restraint shall allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.

g. Restraint must be in accordance with applicable requirements of AWWA C110 and AWWA C111 for mechanical joints.

6. Integrally restrained push-on joints:
   a. Application:
      1) Where designation restrained push-on as indicated on the Drawings, supply a restrained push-on joint piping system, which includes restrained push-on joints where necessary based upon thrust calculations.
      2) Standard push-on rubber gasket joints as specified above can be used where thrust calculations demonstrate restraint is not required.
   b. Design:
      1) Restrained push-on joints of the configuration which utilizes a gripping or friction force for restraint will not be acceptable.
      2) Suitable for the following working pressures:
         a) 4- through 24-inch pipe: 350 pounds per square inch gauge.
         b) 30- through 54-inch pipe: 250 pounds per square inch gauge.
   c. Gaskets:
      1) As specified in Section 15052 - Common Work Results for General Piping.
   d. Manufacturers: One of the following or equal:
      1) American Cast Iron Pipe Co., Flex Ring or Lok-Ring.
      2) McWane Ductile, TR Flex.
      3) U.S. Pipe, TR Flex.
   e. Limit buried joints to half the manufacturer's published allowable angular joint deflection for purposes of pipeline alignment and elimination of fittings.

C. Connections:
   1. Tapping saddle as specified in Owner standard specification.
      a. If Owner does not have a standard specification, provide tapping saddles as specified in Section 15120 - Piping Specialties.
   2. Tapping sleeve as specified in Owner standard specification.
      a. If Owner does not have a standard specification, provide tapping sleeves as specified in Section 15120 - Piping Specialties.
   3. Welded outlet:
      a. Not allowed without Engineer approval.

D. Fittings:
   1. Ductile iron in accordance with AWWA C110or AWWA C153.
   2. Joint type:
      a. Same as that of the associated piping as specified in Section 15052 - Common Work Results for General Piping.
   3. Plain end-to-flanged joint connectors using setscrews are not acceptable.

2.05 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C104 and as specified in this Section.

B. Cement:
   1. Cement: In accordance with ASTM C150, Type II.

C. Water:
   1. In accordance with AWWA C104 and as specified in this Section.

D. Sand and aggregate:
   1. In accordance with AWWA C104.
   2. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

E. Lining:
   1. Minimum thickness: Standard in accordance with AWWA C104.
   2. Apply cement mortar on clean bare metal surfaces.
   3. Extend to faces of flanges, ends of spigots, and shoulders of hubs.
   4. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
      a. Extend to faces of flanges and ends of spigots.
      b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
      c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
   5. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
   6. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C104 and approved by the Engineer.
      a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
         1) No. 12 gauge spaced at maximum 1-inch centers.
         2) No. 14 gauge steel wire at maximum 1/2-inch centers.

2.06 POLYETHYLENE ENCASEMENT

A. General:
   1. Polyethylene encasement shall be supplied by the pipe manufacturer.

B. Materials: Supply one of the following polyethylene encasements:
   1. 2 layers of linear low-density polyethylene (LLDPE) film, minimum thickness of 8 mils in accordance with AWWA C105; or,
   2. Single layer of high-density, cross-laminated polyethylene (HDCLPE) film, minimum thickness of 4 mils in accordance with AWWA C105.
   3. Single layer of V-Bio® enhanced polyethylene encasement (3 layers of coextruded LLDPE film with anti-microbial additive and volatile corrosion inhibitor infused on the inside surface), meeting all requirements of AWWA C105.

2.07 PLURAL COMPONENT EPOXY

A. Coat pipe with plural component, 100 percent solids, non-extended in accordance with AWWA C210 and as specified in this Section.

B. Surface preparation:
   1. In accordance with SSPC-SP 10 or SSPC-SP 11.

2. In accordance with AWWA C210 and as specified in this Section.
    a. Steel pipe: SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer's requirements, whichever is greater.

C. Primer: In accordance with coating manufacturer's requirements.

D. High build epoxy coating:
1. 2 component, high build polyamide or polyamine cured epoxy coating, suitable for direct burial or immersion, dries to touch in 2 or more hours, suitable for immersion or burial after full cure of coating.
2. Manufacturers: One of the following or equal:
    a. Carboline.
    b. ICI Devoe.
    c. Sherwin Williams.
    d. Warren Environmental.

E. Fast cure epoxy coating:
1. 2 component, 100 percent solids by volume, fast cure epoxy coating suitable for direct burial or immersion, dry to touch in less than 1 hour at 72 degrees Fahrenheit, capable of curing while immersed or buried.
2. Manufacturers: One of the following or equal:
    a. North American Denso, Protal 7125 or Protal 7200.
    b. Tapecoat Inc., TC 7010.

F. Application:
1. Apply coating using plural component spray equipment by a manufacturer certified coating applicator.
2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer.
    a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
3. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61, unless otherwise approved by the Engineer.
4. Concrete embedded pipe penetrations: Extend epoxy coating a minimum of 6 inches outside of interior and exterior surfaces of concrete walls or floors.
5. Concrete penetrations minimum dry film thickness: 12 mils.
6. Apply heat shrink sleeves to buried transitions from epoxy to tape wrap or extruded polyolefin coating systems.
    a. Backfill as soon as practical to limit exposure to direct sun or heat and potential thermal creep of sleeve.

G. Self-priming, plural component, 100 percent solids, suitable for burial or immersion, and in accordance with AWWA C210 and the following, whichever is more stringent:
1. Non-NSF certified: Ceramic fill.
2. NSF certified: Poly amine epoxy or poly amide epoxy.
3. Shop applied coating thickness:
    a. Minimum: 1 coat, 35 mils total dry film thickness.
4. Shop applied lining thickness:
    a. Minimum: 1 coat, 35 mils total dry film thickness.

H. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
      d. In accordance with ASTM D4541 using standard 20 millimeter dollies.
      e. Base adhesion testing on 3 tests.
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30-minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
      g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
   2. Attach dollies for adhesion testing to the coating surface using a 2 part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
      a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
   3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
      a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
   4. Epoxy coating and lining adhesion criteria:
      a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
      b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
   5. Pipe lot performance criteria:
      a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
      b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
         1) Reject each pipe that fails the coating adhesion criteria.
   6. Adhesion test evaluation and records:
      a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
      b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.

c. Adhesion test failure:
    1) Adhesive or substrate failure.
        a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
    2) Cohesive test failure.
        a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
d. Retest coating adhesion tests:
    1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
    2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
    3) Retest disputed adhesion tests.
        a) Owner's representative will witness dolly attachment and adhesion retesting.
e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
    1) Pipe identification.
    2) Pipe coating date.
    3) Adhesion test date.
    4) Surface tested (interior or exterior).
    5) Surface temperature at time of test.
    6) Coating thickness.
    7) Tensile force applied.
    8) Applied load rate per second.
    9) Mode of failure.
    10) Percentage of failure types, previously defined, relative to dolly surface area.
    11) Dolly size and attachment glue used.
    12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
    a. Fabricator or Contractor to complete adhesion repairs as specified this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

l. Long term adhesion test:
1. Acceptance criteria:
    a. Not more than 10 percent loss of adhesion over duration of test.
    b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
    a. 1 day.
    b. 7 days.
    c. 3 weeks.
    d. 2 months.

3. Sample preparation:
    a. SSPC-SP 5, 3.00 mil profile, minimum.
    b. Test area minimum: 18-inches by 18-inches.
    c. Curved steel plate:
        1) Minimum radius of 15 inches.
        2) Inclined between 30 and 45 degrees.
4. Test procedure:
    a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
    a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
    b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.08 PLURAL COMPONENT POLYURETHANE

A. Coat pipe with plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
    1. Chemline, Chemthane 2265.
    2. Lifelast, Equivalent product.

C. Surface preparation:
    1. In accordance with AWWA C222 and as specified in this Section.
    2. In accordance with SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer's requirements, whichever is greater.

D. Adhesion test procedures:
    1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A, except as modified in this Section.
        a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
        b. Use automatic adhesion test equipment.
        c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
        d. In accordance with ASTM D4541 using standard 20 millimeter dollies.
        e. Base adhesion testing on 3 tests.
            1) Conduct the tests by the same person, test equipment, and test procedure.
            2) Complete the tests within a 30-minute period.
        f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
        g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.

2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
    a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
    a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
4. Epoxy coating and lining adhesion criteria:
    a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
    b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
    a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
    b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
        1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
    a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
    b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
    c. Adhesion test failure:
        1) Adhesive or substrate failure.
            a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
        2) Cohesive test failure.
            a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
    d. Retest coating adhesion tests:
        1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
        2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
        3) Retest disputed adhesion tests.
            a) Owner's representative will witness dolly attachment and adhesion retesting.
    e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
    f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
        1) Pipe identification.
        2) Pipe coating date.

3) Adhesion test date.
4) Surface tested (interior or exterior).
5) Surface temperature at time of test.
6) Coating thickness.
7) Tensile force applied.
8) Applied load rate per second.
9) Mode of failure.
10) Percentage of failure types, previously defined, relative to dolly surface area.
11) Dolly size and attachment glue used.
12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
   a. Fabricator or Contractor to complete adhesion repairs as specified this Section.
   b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

E. Long term adhesion test:
1. Acceptance criteria:
   a. Not more than 10 percent loss of adhesion over duration of test.
   b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
   a. 1 day.
   b. 7 days.
   c. 3 weeks.
   d. 2 months.
3. Sample preparation:
   a. SSPC-SP 5, 3.00 mil profile, minimum.
   b. Test area minimum: 18-inches by 18-inches.
   c. Curved steel plate.
      1) Minimum radius of 15 inches.
      2) Inclined between 30 and 45 degrees.
4. Test procedure:
   a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
   a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
   b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.09 SEAL COAT

A. Asphaltic or Water-based seal coat:
1. Apply over cement mortar linings and to outside surface of pipes that will not receive another coating.
2. Apply in accordance with AWWA C151.

2.10 CORROSION MONITORING

A. Continuity bonding as indicated on the Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install ductile iron piping in accordance with AWWA C600, or as modified in Section 15052 - Common Work Results for General Piping.
   2. For underground piping, the trenching, backfill, and compaction:
      a. Inspect coating prior to backfill.
      b. As specified in Section 02318 - Trenching.

B. Joints:
   1. Install types of joints as specified in the piping schedule provided in Section 15052 - Common Work Results for General Piping.
   2. Mechanical joints are not acceptable in above ground applications.
   3. Field closure for restrained push-on pipe:
      a. Locate field closures in areas where thrust calculations demonstrate restraint is not required.
   4. Grooved joints:
      a. Install piping with grooved joints where specified in the piping schedule as specified in Section 15052 - Common Work Results for General Piping.
      b. Assemble grooved joints in accordance with manufacturer's published instructions.
      c. Support grooved-end pipe in accordance with manufacturer's published instructions.
         1) Install at least 1 support between consecutive couplings.

C. Connection:
   1. Tapping ductile iron pipe:
      a. Direct tapping of ductile iron pipe may be performed but is limited to the following conditions:
         1) Maximum allowable tap diameter by pipe diameter and pressure class:

Pipe Size (inches)	Pressure Class				
	150	200	250	300	350
	Maximum Allowable Direct Tap Size (inches)				
3	-	-	-	-	3/4
4	-	-	-	-	3/4
6	-	-	-	-	1
8	-	-	-	-	1
10	-	-	-	-	1
12	-	-	-	-	1-1/4
14	-	-	1-1/4	1-1/2	1-1/2

16	-	-	1-1/2	2	2
18	-	-	2	2	2
20	-	-	2	2	2
24	-	2	2	2	2

b. Maximum allowable tap diameter for pipelines greater than 24 inches is 2 inches.
c. 2 layers of 3-mil thread sealant are required to minimize the torque required to effect a watertight connection.

2. When direct tapping of ductile iron pipe is not possible due to limited wall thickness, a saddle tap shall be used.

3.02 DEFECTS IN COATINGS EXCEPT TAPE WRAP AND CEMENT MORTAR COATING

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
1. Pipe joints exceeding the following defect maximum will be rejected.
a. Minor defects:
1) No more than 1.5 per 100 square feet of surface area.
2) 2 or more minor repairs within an 8-inch diameter circle will be considered a single repair.
3) Repairs for adhesion testing will not be included in the total number of repairs.
4) Repair in accordance with manufacturer's requirements.
b. Major defects:
1) No more than 3 major repairs on each pipe joint.
2) No more than 30 percent repairs on the pipe surface area with defects.
2. Minor repairs:
a. Less than 8 inches in the greatest dimension.
b. Repair in accordance with manufacturer's requirements.
3. Major repairs:
a. Exceed 8 inches in the greatest dimension.
b. Repair in accordance with manufacturer's requirements.

3.03 PLURAL COMPONENT EPOXY

A. Joints:
1. Field applied coating shall be of the same density, smoothness, and thickness as shop applied coating.
2. Comply with same application requirements as shop applied coating or lining.
a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.04 PLURAL COMPONENT POLYURETHANE

A. Joints:
1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.

2. Comply with same application requirements as shop applied coating or lining.
    a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.05 POLYETHYLENE ENCASEMENT

A. Wrap buried ductile iron pipe and fittings in 2 layers of loose low-density polyethylene wrap or a single layer of high-density polyethylene wrap or a single layer of V-Bio polyethylene wrap in accordance with AWWA C105 and as specified in this Section.

B. Wrap polyethylene encasement to be continuous and terminated neatly at connections to below grade equipment or structures.

C. At wall penetrations, extend encasement to the wall and neatly terminate.

D. At slab penetrations, extend encasement to 2 inches below the top of slab and neatly terminate.

E. When rising vertically in unimproved areas, extend encasement on pipe 6 inches above existing grade and neatly terminate.

F. Repair tears and make joints with 2 layers of plastic tape.

G. Work shall be inspected prior to backfilling of pipe and associated items.

3.06 CORROSION MONITORING FACILITIES

A. Bond pipe joints and associated fittings to provide electrical continuity.

B. Install dielectric insulating fittings and corrosion monitoring facilities as indicated on the Drawings.

3.07 FIELD QUALITY CONTROL

A. Testing ductile iron piping:
    1. Test as specified in Section 15052 - Common Work Results for General Piping and Section 15956 - Piping Systems Testing.

B. Repair damaged cement mortar lining to match quality, thickness, and bonding of original lining in accordance with AWWA C104.
    1. When lining cannot be repaired or repairs are defective, replace defective piping with undamaged piping.

C. Verify that interior surfaces of ceramic epoxy and glass lined pipe and fittings have continuous coverage:
    1. Test random samples, as directed by the Engineer, in accordance with ASTM B1000.
    2. Discard lined piping and fittings found to have pinholes, crazing, or fish scales, which expose the metal substrate.

END OF SECTION

SECTION 15229

REINFORCED CONCRETE PIPE: ASTM C76

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Reinforced concrete gravity piping with plastic liner.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
   2. C150 - Standard Specification for Portland Cement.
   3. C361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
   4. D297 - Standard Test Methods for Rubber Products-Chemical Analysis.
   5. D395 - Standard Test Methods for Rubber Property-Compression Set.
   6. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
   7. D2240 - Standard Test Method for Rubber Property-Durometer Hardness.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Detailed layout drawings including listing of connector pipes with size and D-Load of pipe, stations where pipe joins mainline, and number of sections of pipe, length of sections, type of sections indicating straight, horizontal bevel, vertical bevel, or other type; pipe stubs; gasket shape and size; and liner details.
   2. Gasket specifications.
   3. Design calculations.

C. Provide Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning. Include:
   1. Cement mill certificates for each load of cement delivered showing specification, type, chemical analysis, and quantity; or for stockpiled pipe, certification that cement meets Specifications.
   2. Cement content compliance with yield to cubic yard of concrete.
   3. Lack of calcium chloride or admixtures.
   4. Admixture approval.
   5. Reinforcing steel mill certificates showing heat numbers, chemical analysis, and physical tests; or for stockpiled pipe, certification that steel meets or exceeds specifications.
   6. Gasket test results showing physical properties.

D. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 QUALITY ASSURANCE

A. Manufacturer qualifications: Manufacture of proposed products for minimum 5 years with satisfactory performance record.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Maintain struts and other protective methods to prevent the formation of cracks larger than the specified tolerances.

B. Handle pipe with exterior slings or suitable forklifts.
   1. Do not use interior hooks or slings when lifting pipe.

C. Store cement in weathertight, dry, well-ventilated structures.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Determine reinforcement required for adequate pipe wall thicknesses and to support anticipated loads.

2.02 MATERIALS

A. Portland cement, aggregate, water, and steel: ASTM C76, with following exceptions:
   1. Cement: ASTM C150, Type II, low alkali.
   2. Admixtures: Without calcium chloride.

B. Gaskets: ASTM C361; o-ring type; diameter as indicated within 1/32 inch; with synthetic rubber compound containing minimum 50 percent neoprene by volume and no deleterious substances, and having the following characteristics:
   1. Tensile strength: Minimum 1,900 pounds per square inch when tested in accordance with ASTM D412.
   2. Elongation at break: Minimum 425 percent when tested in accordance with ASTM D412.
   3. Durometer hardness: Maximum Type A Shore of 55 within 3 when tested in accordance with ASTM D2240.
   4. Compression set: Maximum 20 percent after aging by the oxygen-pressure chamber for 96 hours, at 158 within 1.8 degrees Fahrenheit, and 300 pounds per square inch within 15 pounds per square inch, and tested in accordance with ASTM D395, Method B, except with 1/2-inch long disc of gasket stock.
   5. Aged tensile strength: Maximum 80 percent of pre-aged strength after aging by the oxygen-pressure chamber for 96 hours, at 158 within 1.8 degrees Fahrenheit, and 300 pounds per square inch, and tested in accordance with ASTM D395, Method B, except with 1/2-inch long disc of gasket stock.

6. Aged durometer hardness: Maximum Type A Shore of 63 within 3, after aging in an oxygen-pressure chamber for 96 hours, at 158 within 1.8 degrees Fahrenheit, and 300 pounds per square inch within 15 pounds per square inch, and tested in accordance with ASTM D2240.
7. Specific gravity: From 1.29 to 1.31 when tested in accordance with ASTM D297.

C. Curing compound: As specified in Section 03300 - Cast-in-Place Concrete.

2.03 MIXES

A. Pipe concrete: Minimum 564 pounds cement per cubic yard of concrete, and water to produce a maximum 4-inch slump.

B. Reject lumpy concrete.

C. Allow concrete to cool to below 150 degrees Fahrenheit before use.

2.04 FABRICATION

A. Fabricate pipe in accordance with ASTM C76 as modified by the Contract Documents with Class and diameter indicated on the Drawings.

B. Fabricate pipe by vertical wet-cast centrifugally spun process, Tamped, or Packer Head method.

C. Form rectangular grooves to be filled substantially with gaskets, and to compress and confine gaskets; while not reducing concrete cover over reinforcing.

D. Wrap steel reinforcement with maximum of 5 percent less wraps than wraps indicated on shop drawings.

E. Plainly mark manufacturer's identification, D-Load, class of pipe, and date poured inside pipe sections.

F. Vibrate, spade, or compact concrete against liner carefully to protect liner and to produce a dense, homogeneous concrete that securely anchors liner anchors.

G. Cure concrete by one of the following methods:
1. Steam curing:
    a. Provide adequate steam plant, piping, enclosures, and other facilities for curing pipe.
    b. Maintain enclosures between 110 and 150 degrees Fahrenheit continuously with maximum rate of rise of 30 degrees per hour.
    c. Equip steam-curing enclosures with 7-day recording thermometers.
    d. Cure pipe when concrete has attained an initial set, but not sooner than 1 hour or later than 8 hours after placing of concrete.
2. Water cure:
    a. When water curing is not started immediately, seal concrete surfaces with curing compound.
    b. Keep pipe moist during daylight hours.

c. Cover pipe, including ends, with burlap for the first 3 days, or keep pipe constantly and completely wet with fog spray during daylight hours.

2.05 SOURCE QUALITY CONTROL

A. Require scales used to proportion materials to be calibrated and sealed by the government agency having jurisdiction over weights and measures.

B. Provide satisfactory facilities for identifying, inspection, and sampling cement at the mill, warehouse, and manufacturing site; and concrete at the manufacturing site.
   1. Engineer may inspect cement and obtain samples for testing at the mill, warehouse, and pipe-manufacturing site.
   2. Engineer may inspect concrete and obtain samples for testing at the manufacture site.

C. Pipe acceptance: Based on plant load-bearing tests, material tests, and inspection of pipe for defects in accordance with ASTM C76 as modified by the Contract Documents.

D. Concrete cylinder tests:
   1. In accordance with ASTM C76.
   2. Allow for a reasonable number of additional cylinders for testing by Owner.

E. Edge bearing tests: Perform a minimum of two, 3-edge bearing tests and determine the load needed to produce a 0.01-inch crack for each size of pipe.

F. Cracks:
   1. Reject pipe with cracks extending through pipe walls and extending for more than 1 foot; cracks measuring 0.01-inch wide, 1/16 inch or more deep, and 1 foot or more long; hairline cracks to reinforcing steel; and cracks longer than half the length of pipe.
   2. Repair pipe with single continuous hairline cracks longer than 1 foot, and not extending to reinforcing steel.

G. Porous areas:
   1. Remove porous or honeycomb concrete areas 6 inches in or less in diameter or in longest dimension, and repair areas.
   2. Reject pipe with larger porous or honeycomb concrete areas.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Lay pipe as specified in Section 15052 - Common Work Results for General Piping and this Section.
   2. Curves, bends, and closures:
      a. Make long radius curves by deflecting joints of straight pipe.
         1) Limit deflections to maximum 3/4-inch joint openings for 36-inch diameter pipe and larger.

b. Make short radius curves by using straight pipe with beveled joints.
   1) Limit bevels to 5 degrees.
c. Make shorter radius curves and closures by using fabricated specials.
d. Install pipe so pipe joints fall on radii indicated on the Drawings.

3. Avoid tension and distortion of joint strips integrally molded with liner when bending back joint strips to make pipe joints.

B. Pipe repairs:
1. Repair pipe in accordance with source quality control above.
2. Repair or replace pipe with cracks wider than 0.01 inch.
   a. Repair pipe by injecting cracks with epoxy under pressure or chipping out V-sectors to full depth of defects and filling V-sections with patching compound.
3. Fill remaining cracks with patching compound.
4. Repair pipe joints with blisters involving less than 1/4 the interior surface area by removing loose material and exposing hollow areas, applying an acceptable bonding agent, placing fresh concrete, and curing repairs with curing compound.
   a. Reject pipe with blisters affecting larger areas of joints.
5. Do not paint pipe with grout to cover defects, minor or major, until pipe has been accepted by Engineer.

END OF SECTION

SECTION 15230

PLASTIC PIPING AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Plastic pipe, tubing, and fittings for systems that are not plumbing systems.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.12 - Cast Iron Threaded Drainage Fittings.

B. ASTM International (ASTM):
   1. D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. D1869 - Standard Specification for Rubber Rings for Asbestos-Cement Pipe.
   5. D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated (SDR Series.
   6. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   7. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   8. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   9. D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.
   10. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   11. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   12. D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
   13. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   14. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   15. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   16. D3350 - Standard Specification for Polyethylene Plastic Pipes and Fittings Materials.

17. D4101 - Standard Specification for Polypropylene Injection and Extrusion Materials.
18. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
19. F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
20. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
21. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
22. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
23. F645 - Standard Guide for Selection, Design and Installation of Thermoplastic Water-Pressure Piping Systems.
24. F679 - Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
25. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. American Water Works Association (AWWA):
   1. C900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches to 12 Inches, for Water Transmission Distribution.

D. NSF International (NSF).

E. Plastics Pipe Institute (PPI):
   1. TR 31 - Underground Installation of Polyolefin Piping.

1.03 ABBREVIATIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. CPVC: Chlorinated polyvinyl chloride.

C. DR: Dimension ratio.

D. DWV: Drain, waste, and vent.

E. HDPE: High-density polyethylene.

F. ID: Inside diameter of piping or tubing.

G. NPS: Nominal pipe size followed by the size designation.

H. NS: Nominal size of piping or tubing.

I. PE: Polyethylene.

J. PP: Polypropylene.

K. PVC: Polyvinyl chloride.

L. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop Drawings:
   1. Describe materials, pipe, fittings, gaskets, and solvent cement.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Plastic pipe in potable water applications: Provide pipe and tubing bearing NSF seal.

B. Mark plastic pipe with nominal size, type, class, schedule, or pressure rating, manufacturer and all markings required in accordance with ASTM and AWWA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle PE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. Fittings: Same material as the pipe and of equal or greater pressure rating, except that fittings used in drain, waste, and vent piping systems need not be pressure rated.

C. Unions 2-1/2 inches and smaller: Socket end screwed unions. Make unions 3 inches and larger of socket flanges with 1/8-inch full-face soft neoprene or EPDM gasket.

2.02 PVC PIPING, SCHEDULE TYPE

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Materials:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 material in accordance with ASTM D1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
      c. DWV fittings: In accordance with ASTM D2665.
   3. Solvent cement: In accordance with ASTM D2564:
      a. Chemical service: For CPVC or PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp., Type P70.
         2) Cement: IPS Corp., Type 724 cement or another cement certified by the manufacturer for chemical service.

2.03 PVC PIPING, CLASS TYPE

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. PVC pipe, Class Type: In accordance with ASTM D2241:
   1. Thermoplastic pipe materials designation code: PVC 1120, 1220, or 2120.
   2. PVC compound: Class 12454 in accordance with ASTM D1784.
   3. Standard dimension ratio: SDR not greater than 21.

C. Fittings: Ductile iron with transition gasket sized to accommodate the outside pipe diameter.

2.04 CPVC PIPING

A. Materials:
   1. CPVC pipe: Schedule 40 or Schedule 80, as specified, in accordance with ASTM F441 and Appendix, CPVC 4120:
      a. Pipe: Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D1784.
      b. Manufacturers: One of the following or equal:
         1) Charlotte Pipe and Foundry Co.
         2) Eslon Thermoplastics, Inc.
         3) GF Harvel.
   2. Fittings: In accordance with ASTM F438 or ASTM F439 for pressure fittings, as appropriate to the service and pressure requirement:
      a. Fittings: Supplied by the pipe manufacturer.
      b. Manufacturers: One of the following or equal:
         1) Colonial Engineering.

2) Eslon Thermoplastics, Inc.
3) Chemtrol.
4) Spears Manufacturing Co.

3. Solvent cement: In accordance with ASTM F493:
   a. For CPVC pipe in chemical service, utilize IPS Corp., Type 724 cement or another cement certified by the manufacturer for high strength hypochlorite service.

2.05 PP PIPING

A. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Materials:
   1. Pipe: Schedule 40 dimensions, extruded from Type I-19509 material in accordance with ASTM D4101.
   2. Fittings: Molded from the same material and same laying length in accordance with ASME B 16.12:
      a. Fittings: Manufactured by pipe manufacturer.

2.06 PE TUBING AND FITTINGS

A. Materials:
   1. Small bore PE tubing: Black flexible virgin PE tubing, OD copper tubing size.
      a. Plastic tubing ID as follows:
         1) For NS 1/4 inch, ID of 0.170 inch.
         2) For NS 5/16 inch, ID of 0.187 inch.
         3) For NS 3/8 inch, ID of 0.251 inch.
         4) For NS of 1/2 inch, an ID of 0.375 inch.
   2. Fittings: Compression fittings, Dekoron E-Z; or equal.
   3. Protective sheath:
      a. Manufacturers: One of the following or equal:
         1) Dekoron, "Poly-Cor."
         2) Parker Hannifin Corp./Fluid connector Products, Parflex Division, Multitube.
   4. Plug-in fittings for connection to instruments: Brass quick-connect fittings.

2.07 PE PIPING FOR UNDERGROUND GAS DISTRIBUTION

A. Manufacturers: One of the following or equal:
   1. DuPont.
   2. Amsted Industries Inc., Plexco.

B. Manufactured in accordance with ASTM D2513 using a compound in accordance with ASTM D1248, PE 2306/2406:
   1. SDR: Maximum of 11.

C. Fittings: In accordance with ASTM D2513 for socked fusion joints, and ASTM D3261 for butt fusion joints.

2.08 PE PIPING FOR DRAIN, WASTE, AND VENT PIPING SYSTEMS

A. General:
   1. Pipe and fittings: High-density polyethylene.
   2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F714:
      a. SDR: Maximum of 11.

B. Manufacturers: One of the following or equal:
   1. DuPont, Sclairpipe.
   2. Polaris, Duratuff; or equal.

C. Pipe, fittings, and adapters: Furnished by the same manufacturer, and compatible with components in the same system and with components of other systems to which connected.

D. Materials:
   1. Polyethylene: In accordance with ASTM D1248, Type III, Class C, Category 5, Grade P34; listed by the Plastic Pipe Institute under the designation PE 3408; and have a minimum cell classification, in accordance with ASTM D3350.
   2. Pipe and fittings: Manufactured from material with the same cell classification.

2.09 PVC BRAID REINFORCED FLEXIBLE TUBING

A. Materials:
   1. Tubing: Polyvinyl Chloride in accordance with ASTM D 2240 and D 638.
      a. Manufacturers: One of the following or equal:
         1) Fingerlakes Extrusion, BraidFLEX70N.
   2. Fittings: Insert/barbed fittings of material compatible with chemicals being conveyed through tubing.

2.10 FEP TUBING

A. Materials:
   1. Tubing: Fluoropolymer tubing in compliance with ASTM D 3296
      a. Suppliers: One of the following or equal:
         1) Harrington Plastics, Part Number FEP1614.
   2. Fittings: Material shall be PVDF.
      a. Manufacturers: One of the following or equal:
         1) FlareLINK.
   3. FEP Tubing shall be 1-inch O.D. by 7/8-inch I.D. for chlorine gas service, unless otherwise indicated on the Drawings.

2.11 SOURCE QUALITY CONTROL

A. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. PVC piping, Schedule Type:
   1. Mark pipe and fittings in accordance with ASTM D1785.

C. PVC piping, Class Type:
   1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, two times the pressure class of the pipe for a minimum of 5 seconds.

D. CPVC piping:
   1. Mark pipe and fittings in accordance with ASTM F441.

E. PP piping:
   1. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Test samples and testing: Cut test samples of pipe, 6 inches long, from full length sections and test by the method outlined in accordance with ASTM D2412:
      a. Deflect pipe at least 35 percent without failure. Stiffness at 5 percent deflection equals or exceeds 55 pounds per square inch after the test samples have been immersed in a 5 percent solution by weight of sulfuric acid and n-Heptain for a period of 24 hours prior to testing.
      b. Failure is defined as rupture of the pipe wall.
      c. Stiffness factor may be computed by the method outlined in accordance with ASTM D2412 or by dividing the load in pounds per linear inch by the deflection in inches and 5 percent deflection.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from plastic to metal or IPS pipe. Do not thread plastic pipe.
   3. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
   4. Provide serrated nipples for transition from plastic pipe to rubber hose.

B. Installation of PVC piping, Schedule Type:
   1. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Solvent weld joints in accordance with ASTM D2855:
      a. For PVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
   3. Install piping in accordance with manufacturer's published instructions.

C. Installation of PVC piping, Class Type:
   1. Install piping in accordance with the Appendix of AWWA C900 complemented with manufacturer's published instructions.

D. Installation of CPVC piping:
   1. Clean dirt and moisture from pipe and fittings.
   2. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file. Remove burrs.
   3. Use solvent cement and primer formulated for CPVC:
      a. For CPVC pipe in chemical service use IPS Corp., Type 724 cement in accordance with manufacturer's instructions.
   4. Use primer on pressure and non-pressure joints.
   5. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

E. Installation of PP piping:
   1. The requirements for PP piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Install piping in accordance with manufacturer's published instructions.

F. Installation of polyethylene (PE) tubing and fittings:
   1. Install small bore PE tubing in accordance with manufacturer's printed instructions, in neat straight lines, supported at close enough intervals to avoid sagging, and in continuous runs wherever possible.
   2. Bundle tubing in groups of parallel tubes within protective sheath.
   3. Tubes within protective sheath may be color coded, but protect tubing other than black outside the sheath by wrapping with black plastic electrician's tape.
   4. Grade tubing connected to meters in one direction.

G. Installation of PE piping for underground gas distribution:
   1. Socket fuse joints for piping equal or less than NPS 2.
   2. Butt fuse joints for piping larger than NPS 2.
   3. Install piping in accordance with requirements of the gas utility company and with manufacturer's published instructions.

H. Installation of PE piping for drain, waste, and vent:
   1. Install piping as recommended in manufacturer's published instructions.

3.02 FIELD QUALITY CONTROL

A. Leakage test for PVC piping, Class Type:
   1. The requirements for PVC piping used in plumbing systems are found in Section 15400 - Plumbing Systems.
   2. Polyvinyl chloride (PVC) piping, Class Type: Subject to visible leaks test and to pressure test with maximum leakage allowance, as specified in Section 15956 - Piping Systems Testing.
   3. Pressure test with maximum leakage allowance: Perform test after backfilling:
      a. Pressure: 125 pounds per square inch, gauge.
      b. Maximum leakage allowance as follows, wherein the value for leakage is in gallons per 100 joints per hour:

NPS, Inches	1-1/2	2	2-1/2	3	4	6	8	10	12
Leakage	0.41	0.52	0.63	0.76	0.98	1.45	1.88	2.35	2.80

B. Leakage test for HDPE piping:
   1. Pressure test with maximum leakage allowance: Perform test prior to backfilling (cover pipe at intervals and/or curves if necessary to hold pipe in place during testing):
      a. Pressure: As specified in Section 15052 - Common Work Results for General Piping or 125 pounds per square inch, gauge.
      b. Test with water as test medium.
      c. Remove all free air from test section and raise pressure at steady rate to test pressure.
      d. Apply and allow initial test pressure to stand without makeup pressure for 3 hours to allow for diametric expansion or pipe stretching to stabilize.
      e. After stabilization period, return to test pressure and hold for 3 hours.
      f. Amount of makeup water allowable for expansion during pressure test in accordance with PPI Technical Report TR 31-88.
      g. No visual leaks or pressure drops allowed during final test period.

END OF SECTION

SECTION 15241

HIGH DENSITY POLYETHYLENE (HDPE) PIPE: AWWA C906

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: High Density Polyethylene Pipe (HDPE), and fittings, 4-inch through 63-inch size.

1.02 REFERENCES

A. American Water Works Association (AWWA):
   1. C906 - Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 63 in., for Water Distribution.

B. ASTM International (ASTM):
   1. D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.
   2. D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique.
   3. D1599 - Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings.
   4. D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics.
   5. D2122 - Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.
   6. D2290 - Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method.
   7. D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   8. D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Material.
   9. F645 - Standard Guide for Selection, Design, and Installation of Thermoplastic Water-Pressure Piping Systems.
   10. F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

C. International Organization of Standardization (ISO):
   1. 10863 - Non-destructive testing of welds - Ultrasonic testing - Use of time-of-flight diffraction technique (TOFD).

D. Plastic Pipe Institute (PPI):
   1. PE 4710.

1.03 ABBREVIATIONS

A. HDPE: High-density polyethylene.

B. ID: Inside diameter of piping or tubing.

C. OD: Outside diameter.

D. SDR: Standard dimension ratio.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Shop drawings:
   1. Detailed layout drawings showing alignment of pipes, location of valves, fittings, and appurtenances, types of joints, and connections to pipelines or structures.

C. Product data: As specified in Section 15052 - Common Work Results for General Piping:
   1. Describe materials and installation equipment including fusion machine.
      a. Include optimum range of fusion conditions such as fusion temperature, interface pressure, and cooling time.
   2. Pipe loads and structural calculations.
   3. Installation instructions.

D. Qualifications of installation crew for high-density polyethylene pipe including qualifications of the fusion machine technician. Furnish proof of training in the use of fusion equipment.

1.05 QUALITY ASSURANCE

A. Markings on the pipe shall be in accordance with AWWA C906.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect piping materials from sunlight, scoring, and distortion.

B. Do not allow surface temperatures on pipe and fittings to exceed 120 degrees Fahrenheit.

C. Store and handle HDPE pipe and fittings as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 GENERAL

A. In accordance with AWWA C906.

2.02 MATERIALS

A. Fittings: Same material as the pipe and of equal or greater pressure rating.

2.03 HDPE PIPING

A. General:
   1. Pipe and fittings: High-density polyethylene.
   2. Dimensions of pipe and fittings: Based on controlled outside diameter in accordance with ASTM F714:
      a. SDR: As given in Piping Schedule; or, if not given, minimum thickness shall be SDR 17.
      b. Pipe Diameter: IPS dimensions.
   3. Pipe, fittings, and adapters: Furnished by the same manufacturer, or compatible with components in the same system and with components of other systems to which connected.

B. Materials:
   1. Manufacturers: One of the following or equal:
      a. Performance Pipe (Chevron Phillips Chemical Company): DriscoPlex 4000/4100 Series.
      b. ISCO Industries.
   2. Polyethylene: As listed by the PPI under the designation PE 4710; and have a minimum cell classification, in accordance with ASTM D3350, of 445574C:
      a. Pipe and fittings: Manufactured from material with the same cell classification.
      b. Manufacturer shall certify that pipe and fittings meet the above classifications.
   3. Polyethylene fittings and custom fabrications:
      a. Molded or fabricated.
      b. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe.
      c. All fittings and custom fabrications shall be fully rated for the same internal pressure as the mating pipe.
      d. Pressure de-rated fabricated fittings are prohibited.
   4. Molded fittings:
      a. Manufactured in accordance with ASTM D3261, Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing, and shall be so marked.
      b. Each production lot of molded fittings shall be subjected to the tests required under ASTM D3261.
   5. X-ray inspection: The Manufacturer shall submit samples from each molded fittings production lot to x-ray inspection for voids, and shall certify that voids were not found.

6. Fabricated fittings:
    a. Made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings.
    b. Rated for internal pressure service at least equal to the full service pressure rating of the mating pipe.
7. Polyethylene flange adapters:
    a. Flange adapters shall be made with sufficient through-bore length to be clamped in a butt fusion joining machine without the use of a stub-end holder.
    b. The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blowout.
8. Back-up rings and flange bolts:
    a. Flange adapters shall be fitted with Type 316 stainless steel back-up rings pressure rated equal to or greater than the mating pipe.
        1) Back-up rings shall be convoluted style for 150-pound bolt hole pattern.
    b. The back-up ring bore shall be chamfered or radiused to provide clearance to the flange adapter radius.
    c. Flange bolts and nuts shall be as specified in Section 15052 - Common Work Results for General Piping.

2.04 SOURCE QUALITY CONTROL

A. HDPE piping:
1. Manufacturer's quality control: The pipe and fitting manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials.
2. Incoming polyethylene materials:
    a. Inspected for density, melt flow rate, and contamination.
    b. The cell classification properties of the material shall be certified by the supplier and verified by manufacturer's quality control.
    c. Approved by quality control before processing into finished goods.
3. Outgoing materials shall be checked for:
    a. Outside diameter, wall thickness, and eccentricity in accordance with ASTM D2122 at a frequency of at least once per hour.
    b. Out of roundness at a frequency of at least once per hour.
    c. Straightness, inside and outside surface finish, markings and end cuts shall be visually inspected in accordance with ASTM F714 on every length of pipe:
        1) Quality control shall verify production checks and test for:
            a) Density in accordance with ASTM D1505 at a frequency of at least once per extrusion lot.
            b) Melt Index in accordance with ASTM D1238 at a frequency of at least once per extrusion lot.
            c) Carbon content in accordance with ASTM D1603 at a frequency of at least once per day in accordance with extrusion line.
            d) Quick burst pressure in accordance with ASTM D1599 at a frequency of at least once per day per line.
            e) Ring Tensile Strength in accordance with ASTM D2290 at a frequency of at least once per day per line.

d. X-ray inspection shall be used to inspect molded fittings for voids, and knit line strength shall be tested. All fabricated fittings shall be inspected for joint quality and alignment.

4. Permanent records: The manufacturer shall maintain permanent QC and QA records.
5. Compliance tests:
   a. Manufacturer's inspection and testing of the materials.
      1) In case of conflict with manufacturer's certifications, the Contractor, Engineer, or Owner may request retesting by the manufacturer or have retests performed by an outside testing service.
      2) All retesting shall be at the requestor's expense and shall be performed in accordance with this Section.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Where not otherwise specified, install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
   2. Provide molded transition fittings for transitions from HDPE to metal or IPS pipe. Do not thread or solvent weld HDPE pipe.

B. Installation of HDPE piping:
   1. Joining:
      a. Heat fusion joining:
         1) Joints between plain end pipes and fittings shall be made by butt fusion, and joints between the main and saddle branch fittings shall be made utilizing saddle fusion employing only procedures that are recommended by the pipe and fitting manufacturer.
         2) The Contractor shall certify, in writing, that persons making heat fusion joints have received training in the manufacturer's recommended procedure and have had at least 3 years' current experience in the heat fusion butt welding process.
         3) The Contractor shall maintain records of trained personnel and shall certify that training was received not more than 12 months before commencing construction.
         4) External and internal beads shall not be removed.
      b. Heat fusion training services: The manufacturer shall provide training in the manufacturer's recommended butt fusion and saddle fusion procedures to the Contractor's installation personnel, and to the inspector(s) representing the Owner, prior to the start of construction.
      c. Mechanical joining:
         1) Unless otherwise indicated on the Piping Schedule, HDPE pipe and fittings may be joined together or to other materials by means of flanged connections (flange adapters and back-up rings) or, where specifically indicated on the Drawings, flexible couplings designed for joining polyethylene pipe or for joining polyethylene pipe to another material.

2) Flexible couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins.

2. Installation:
   a. General:
      1) The Manufacturer shall package products for shipment in a manner suitable for safe transport by commercial carrier.
      2) When delivered, a receiving inspection shall be performed, and any shipping damage shall be reported to the Manufacturer within 7 days.
      3) Damaged pipe shall be promptly removed from the job site.
      4) Installation shall be in accordance with Manufacturer's recommendations, and this specification.
      5) Prior to making a terminal connection of each individual run of HDPE pipe, the temperature of the pipe should be allowed to approach the service temperature at which the pipe is intended to operate.
      6) All necessary precautions shall be taken to ensure a safe working environment in accordance with applicable codes and standards.
   b. Large diameter fabricated fittings: Fabricated fittings shall be butt fused to the end of a pipe.
   c. Mechanical joint and flange installation:
      1) Mechanical joints and flange connections shall be installed in accordance with the manufacturer's recommended procedure.
      2) Flange faces shall be centered and aligned to each other before assembling and tightening bolts.
      3) Every effort shall be made to ensure that the opposing faces of the flange assemblies mate up securely at a temperature approximately the same as the service temperature.
      4) In no case shall the flange bolts be used to draw the flanges into alignment.
      5) Bolt threads shall be lubricated, and flat washers shall be fitted under the flange nuts.
      6) Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the manufacturer.
      7) At least 1 hour after initial assembly, flange connections shall be re-tightened following the tightening pattern and torque step recommendations of the manufacturer.
      8) The final tightening torque shall be 100 feet-pounds or less as recommended by the manufacturer.
   d. Pipe handling:
      1) Lift, move, or lower pipe and fittings only with wide fabric choker slings.
      2) Wire rope or chain shall not be used.
      3) Slings shall be of sufficient capacity for the load, and shall be inspected before use.
      4) Worn or defective equipment shall not be used.
   e. Excavation, backfill material and backfilling and compacting:
      1) As specified in Specification 02318 - Trenching.

3.02 FIELD QUALITY CONTROL

A. Butt fusion testing on pipe size 14 inches and larger:
   1. The first fusion of each day shall be a trial fusion.
      a. The trial fusion shall be allowed to cool completely.
      b. Fusion test straps shall be cut out.
         1) The test strap shall be 12 inches (minimum) or 30 times the wall thickness in length with the fusion in the center, and 1 inch (minimum) or 1.5 times the wall thickness in width.
      c. Bend the test strap until the ends of the strap touch.
   2. If the fusion fails at the joint, a new trial fusion shall be made, cooled completely and tested.
   3. Butt fusion of pipe to be installed shall not commence until a trial fusion has passed the bent strap test.

B. Data logging and test data:
   1. A data logger shall be installed on the fusion heated joining machine. Data on each joint shall be recorded by the data logger. Data to be recorded shall be minimum temperature of joint fusion and interface pressure of the fused joint.
   2. Recorded data from the fusion data logger and the TOFD shall be transmitted to the Owner daily.

C. Pressure testing:
   1. Conduct as per ASTM F2164 in accordance with AWWA M 55 Chapter 9.
   2. Test pressures as specified in the Piping Schedule.
   3. Temperature of test water shall be no more than 73 degrees Fahrenheit.

END OF SECTION

SECTION 15244

POLYVINYL CHLORIDE (PVC) PIPE: PRESSURE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. AWWA C900 PVC pipe and fittings.

1.02 REFERENCES

A. Abbreviations:
   1. DR: Dimension ratio = OD/t (OD is pipe outer diameter, t is pipe wall thickness).
   2. NPS: Nominal pipe size followed by the size designation.

B. Standards:
   1. American Water Works Association (AWWA):
      a. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
      b. C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.
      c. C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In.
      d. C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. through 48 In., for Water Transmission and Distribution.
      e. M23 - PVC Pipe - Design and Installation Manual.
   2. ASTM International (ASTM):
      a. A536 - Standard Specification for Ductile Iron Castings.
      b. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
      c. D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
      d. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
      e. F645 - Standard Guide for Selection, Design, and Installation of Thermoplastic Water-Pressure Piping Systems.
   3. NSF International (NSF):
      a. 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. As specified in Section 15052 - Common Work Results for General Piping.

1.04 QUALITY ASSURANCE

A. Pipe in potable water applications: Provide pipe bearing NSF 61 seal.

B. Mark plastic pipe with date of extrusion, nominal size, class, manufacturer, and markings required in accordance with ASTM and AWWA standards.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Deliver, offload, handle, and store pipe in accordance with manufacturer's or pipe supplier's recommendations and best practices provided by AWWA M23 and AWWA C605, including compliance with minimum recommended bending radius and maximum safe pulling forces for each specific pipe.

PART 2 PRODUCTS

2.01 PIPE

A. General:
   1. As specified in Section 15052 - Common Work Results for General Piping.
   2. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   3. In accordance with AWWA C900.
   4. Made from a PVC compound conforming to cell classification 12454 in accordance with ASTM D1784.
   5. Marked verifying suitability for potable water service in accordance with NSF 61.

B. Pipe:
   1. Bell and spigot:
      a. Pipe with integral bell.
      b. Pressure Class as scheduled in Section 15052 - Common Work Results for General Piping with a maximum DR of 21.
      c. Manufacturers: One of the following or equal.
         1) CertainTeed.
         2) Diamond Plastics Corp.
         3) Westlake Pipe and Fittings.

2.02 FITTINGS

A. Material:
   1. Cast or ductile iron fittings as specified in Section 15211 - Ductile Iron Pipe: AWWA C151 sized for the dimensions of the pipe being used.

B. Equal to or greater pressure rating than the pipe.

2.03 JOINTS

A. Bell and spigot joints:
   1. Push-on or mechanical joint type as identified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
   2. Gasketed joint assembly: Meet or exceed the requirements in accordance with ASTM D3139.
   3. Factory installed gaskets: SBR, Neoprene, or EPDM in accordance with ASTM F477.
   4. Joint restraint at fittings:
      a. Concrete thrust blocks:
         1) Install at changes in pipe diameter and at fittings.
         2) Design using a safety factor of at least 1.5:1 for both the test and peak operating pressures.
      b. Mechanical wedge action joint restraints:
         1) Manufacturers: One of the following or approved equal:
            a) EBAA Iron, Inc.:
               (1) For pipes 3- to 36-inch: Series 2000PV.
               (2) For pipes 42- and 48-inch: Series 2200.
            b) Sigma Corp.:
               (1) For pipes 3- to 36-inch: One-Lok Model SLCE.
               (2) For pipes 42- and 48-inch: PV-Lok Model PWM.
            c) Star Pipe Products, Series 4000.
         2) Materials:
            a) Mechanical joints bolts and nuts as specified in Section 15052 - Common Work Results for General Piping.
            b) Gland body: Ductile iron in accordance with ASTM A536.
            c) Wedge and wedge actuating components: Ductile iron in accordance with ASTM A536.
               (1) Wedges: Heat-treated to a minimum of 370 BHN.
            d) Actuating bolts and nuts: Ductile iron in accordance with ASTM A536.
               (1) Provide torque-limiting twist off components to ensure proper installation.
         3) Coatings:
            a) Provide a manufacturer applied coating system.
            b) Manufacturers: One of the following or equal:
               (1) EBAA Iron Inc., Mega-Bond.
               (2) Sigma Corp., Corrsafe™ Electro-Deposition Coating.
               (3) Star Pipe Products, Star-Bond.
         4) Consist of multiple gripping wedges incorporated into a follower gland meeting the requirements in accordance with AWWA C111.
         5) Allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the mechanical joint.
         6) Pressure rating equal to or greater than that of the pipe on which it is being used and a minimum safety factor of 2:1 for all sizes.
      c. Push-on joint restraint harnesses:
         1) Manufacturers: One of the following or approved equal:
            a) EBAA Iron, Inc.:
               (1) For pipes 4- to 12-inch: Series 1500.
               (2) For pipes 14- to 48-inch: Series 2800.

b) Sigma Corp., PV-Lok Model PWP.
c) Star Pipe Products, Series 4100P.

2) Materials:
   a) Restraint and backup rings: Ductile iron in accordance with ASTM A536.
   b) Wedge and wedge actuating components: Ductile iron in accordance with ASTM A536.
   c) Tie rods: Low alloy steel in accordance with AWWA C111.
3) Coatings:
   a) Provide manufacturer applied coating system.
   b) Manufacturers: One of the following or equal:
      (1) EBAA Iron Inc., Mega-Bond.
      (2) Sigma Corp., Corrsafe™ Electro-deposition coating.
      (3) Star Pipe Products, Star-Bond.
4) Consist of a backup ring behind the PVC bell and a restraint ring consisting of multiple gripping wedges connected with number and type of tie rods as recommended by the manufacturer.
5) Allow post assembly angular deflection that is a minimum of 50 percent of the angular deflection allowed by the push-on joint.
6) Pressure rating equal to or greater than that of the pipe on which it is being used and a minimum safety factor of 2:1 for all sizes.

2.04 SOURCE QUALITY CONTROL

A. Bell and spigot piping:
   1. Hydrostatic proof testing in accordance with AWWA C900: Test pipe and integral bell to withstand, without failure, 2 times the pressure class of the pipe for a minimum of 5 seconds.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Install PVC piping in accordance with ASTM F645, AWWA C605, and manufacturer's or pipe supplier's published installation instructions.
   2. Trenching and backfill as specified in Section 02318 - Trenching.
   3. Install pipe with tracer wire as specified in Section 15076 - Pipe Identification.

B. Tapping PVC:
   1. Direct tapping:
      a. Allowed for AWWA C900 have a pipe class of Class 235 or greater, NPS 6-inch through 12-inch only.
      b. 1-inch is the maximum allowable outlet size for performing a direct tap.
   2. Saddle tapping:
      a. Allowable on all sizes and classes of AWWA C900 pipe.
      b. 2-inch is the maximum allowable outlet size for performing a saddle tap.
      c. As specified in Section 15120 - Piping Specialties for allowable service saddles.

3. Tapping sleeves:
    a. Allowable on all sizes and classes of PVC AWWA C900.
    b. As specified in Section 15120 - Piping Specialties for allowable tapping sleeves.

3.02 FIELD QUALITY CONTROL

A. Leakage test for piping:
    1. Subject to visible leak test and pressure test with maximum leakage allowance, as specified in Section 15956 - Piping Systems Testing.
    2. Pressure test with maximum leakage allowance:
        a. Perform test after placing sufficient backfill.
        b. In areas requiring immediate backfill, test prior to placement of permanent surfacing.
        c. Test pressure: As specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
        d. Maximum leakage allowance for bell and spigot pipe is as listed in the table below:

Test Pressure (psi)	**Bell and Spigot Pipe Allowable Leakage (gallons per 50 joints per hour) Nominal Pipe Size (inches)**									
	4	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**24**
50	0.19	0.29	0.38	0.48	0.57	0.67	0.76	0.86	0.96	1.15
75	0.23	0.35	0.47	0.59	0.70	0.82	0.94	1.05	1.17	1.40
100	0.27	0.41	0.54	0.68	0.81	0.95	1.08	1.22	1.35	1.62
125	0.3	0.45	0.6	0.76	0.91	1.06	1.21	1.36	1.51	1.81
150	0.33	0.50	0.66	0.83	0.99	1.16	1.32	1.49	1.66	1.99
175	0.36	0.54	0.72	0.89	1.07	1.25	1.43	1.61	1.79	2.15
200	0.38	0.57	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.29
225	0.41	0.61	0.81	1.01	1.22	1.42	1.62	1.82	2.03	2.43
250	0.43	0.64	0.85	1.07	1.28	1.50	1.71	1.92	2.14	2.56
275	0.45	0.67	0.90	1.12	1.34	1.57	1.79	2.02	2.24	2.69
300	0.47	0.70	0.94	1.17	1.40	1.64	1.87	2.11	2.34	2.81

END OF SECTION

SECTION 15247

POLYVINYL CHLORIDE (PVC) PIPE: GRAVITY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Gravity sewer pipe and fittings in accordance with ASTM D3034 and ASTM F679 standards.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   2. D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
   3. D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   4. D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
   5. D3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
   6. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

1.03 ABBREVIATIONS

A. PVC: Polyvinyl chloride.

B. SDR: Standard dimension ratio; the outside diameter divided by the pipe wall thickness.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect from sunlight, scoring, and distortion.

B. Do not allow surface temperatures to exceed 120 degrees Fahrenheit.

C. Store and handle as recommended by manufacturer in published instructions.

PART 2 PRODUCTS

2.01 PIPE

A. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.

B. PVC compound: Cell classification 12454-C in accordance with ASTM D1784.

C. Stabilizers, antioxidants, lubricants, colorants, and other additives and fillers not to exceed 10 parts by weight per 100 of PVC resin in the compound.

D. Pipe less than or equal to 15-inch diameter:
   1. In accordance with ASTM D3034.
   2. Wall thickness SDR 26 or as specified in the Piping Schedule or the Drawings.
   3. Joints: Push-on in accordance with ASTM D3212.
      a. Integral bell.
      b. Factory installed gaskets meeting the requirements in accordance with ASTM F477.

2.02 FITTINGS

A. Same material as the pipe.

B. Minimum wall thickness: Same as the minimum wall thickness of the equivalent size pipe as specified in Table 1 of ASTM F679.

C. Supplied by the pipe manufacturer.

D. Factory molded with joints and gaskets equal to those of the pipe.

E. Gasket:
   1. In accordance with ASTM F477.
   2. Manhole adapter gasket: Stainless steel clamp with gasket or similar device to seal the penetration.

F. Flexible gaskets for precast bases with a flexible pipe connection: In accordance with ASTM C923:
   1. Manufacturer: One of the following or approved equal:
      a. Press-Seal Gasket Corp.: PSX.
      b. A-Lok Premium.

G. Waterstop grouting rings:
   1. Manufacturer: One of the following or approved equal:
      a. Trelleborg.
      b. Press-Seal Gasket Corp.

2.03 SOURCE QUALITY CONTROL

A. Mark pipe and fittings in accordance with ASTM D3034 and ASTM F679 as appropriate.

B. Mark the production control code on pipe and fittings.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Install piping in accordance with ASTM D2321 and manufacturer's published installation instructions.
2. Provide plugs or caps for stubs and branch pipes left unconnected to laterals.
3. Lubricate and assemble joints in accordance with the pipe manufacturer's published instructions.
4. Trenching and backfill as specified in Section 02318 - Trenching.
5. For open cut installations, install underground warning tape as specified in Section 15076 - Pipe Identification.
6. Install pipe with tracer wire as specified in Section 15076 - Pipe Identification.

B. Connections to manholes:
1. Make connections to manholes with a manhole gasket that prevents infiltration and exfiltration through the penetrations using 1 of the following methods:
   a. Precast bases with a flexible pipe connection:
      1) Pipe connectors shall be cast into the base.
         a) Pipe openings shall contain flexible gaskets.
      2) Follow manufacturer's recommendation for lubrication to prevent damage to the gasket during pipe insertion.
      3) When PSX gaskets are used, the take-up screws for the gasket clamps shall be positioned a minimum of 90 degrees apart.
      4) Install and grout in place per manufacturer's instructions.
   b. Cast in place or precast bases using grouting rings:
      1) Provide opening for connection large enough to allow subsequent grouting around the grouting ring.
      2) Grout around the pipe penetration manhole gasket and seal the opening.

3.02 FIELD QUALITY CONTROL

A. Test pipe as specified in Section 15956 - Piping Systems Testing.

B. Mandrel tests:
1. Perform initial mandrel test:
   a. After cleaning and completion of other tests.
   b. After placement and compaction of backfill.
   c. Before construction of pavement or surfacing.
   d. Not sooner than 30 days after pipe installation.
   e. Not later than 60 days after installation.

2. Utilize a 9 rod mandrel with minimum length equal to NPS and diameter as follows:

Nominal Pipe Size (NPS)	Mandrel Dia (in) (SDR 35/PS46)	Mandrel Dia (in) (SDR 26/PS 115)
6	5.45	5.33
8	7.28	7.11
10	9.08	8.87
12	10.79	10.55
15	13.20	12.90
18	16.13	15.76
21	19.00	18.57
24	21.36	20.87
27	24.06	23.51
30	27.68	27.04

3. Test procedure: Pull the mandrel through the line under test by 1 person, by hand, with reasonable effort, without the aid of mechanical equipment.
4. Failing test: Where the mandrel test is not successful, remove and replace the section of piping with the obstruction; test the piping again, including visible leaks test, pressure test with maximum leakage allowance, mandrel tests, and other specified tests:
   a. Correction of excessive deflection or obstructions by methods other than removal of the affected piping and replacement of the removed piping with new piping will not be accepted.

END OF SECTION

SECTION 15270

STEEL PIPE: ASTM A53

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Steel pipe: Galvanized and black, ASTM A53.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   3. B16.9 - Factory-Made Wrought Buttwelding Fittings.
   4. B16.11 - Forged Fittings, Socket-Welding and Threaded.

B. American Water Works Association (AWWA):
   1. C110 - Ductile-Iron and Gray-Iron Fittings.
   2. C203 - Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied.
   3. C205 - Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 Inches and Larger-Shop Applied.
   4. C206 - Field Welding of Steel Water Pipe.
   5. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   6. C214 - Tape Coatings for Steel Water Pipe.
   7. C216 - Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings.
   8. C217 - Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings.
   9. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   10. C606 - Standard for Grooved and Shouldered Joints.

C. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
   4. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.
   6. A536 - Standard Specification for Ductile Iron Castings.
   7. C150 - Standard Specification for Portland Cement.
   8. D2000 - Standard Classification System for Rubber Products in Automotive Applications.

9. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
10. E165 - Standard Practice for Liquid Penetrant Testing for General Industry.

D. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

E. Society for Protective Coatings (SSPC):
1. SP 1 - Solvent Cleaning.
2. SP 3 - Power Tool Cleaning.
3. SP 5 - White Metal Blast Cleaning.
4. SP 6 - Commercial Blast Cleaning.
5. SP 10 - Near White Wet Blast.
6. SP 11 - Bare Metal Power Tool Cleaning.
7. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Manufacturer's qualifications.
1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.

D. Manufacturer's Quality Assurance Manual.
1. Submit manufacturer's coating and lining application quality assurance manual to the Engineer prior to beginning coating application.
   a. Strict conformance to the requirements of the manual will be required.
   b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Steel pipe:
1. General:
   a. In accordance with ASTM A53.
      1) Type E - electric-resistance welded or Type S - seamless.
      2) Grade A or B.
   b. Schedule:
      1) As indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
      2) Minimum Schedule unless otherwise indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule:
         a) Pipe 6 inches and smaller: Schedule 40.

b) Pipe greater than 6 inch to 12 inch: Schedule 20.
c) Pipe greater than 12 inch: 0.25 inches.

B. Pipe fittings:
1. Flanged and welding fittings:
a. Butt-weld fittings in accordance with ASME B16.9.
b. Schedule of fittings: Same class or thickness as the pipe to which it connects.
2. Screwed fittings:
a. Malleable iron:
1) Class 150 or Class 300 in accordance with ASME B16.3, as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
2) Galvanized in accordance with ASTM A153 where used with galvanized pipe.
3. Grooved joint fittings:
a. Fittings for grooved joint steel piping: Rigid-grooved type.
b. Fittings for grooved joint piping:
1) Manufacturers: One of the following or equal:
a) Anvil.
b) Grinnell**.**
c) Victaulic Co. of America.
2) Ductile iron fittings:
a) Larger than 4 inches in diameter: In accordance with ASTM A536, Grade 65-45-12, long radius, in accordance with AWWA C110.
b) Less than 4 inches in diameter: Malleable iron in accordance with ASTM A47, Grade 32510.
3) Where cast fittings are not made, forged steel in accordance with ASME B16.9, ASTM A105, Grade B with 0.375-inch minimum wall thickness.
a) Bends: Long radius.
4) Furnished by the manufacturer of the grooved joint coupling.
5) For rigid-grooved type joints.
6) Connection to flanged units shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items, minimum length, 4 inches.

C. Pipe joints:
1. General:
a. Use type of pipe joints as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule.
b. In addition to the type of pipe joints indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule, use flexible couplings, unions or flanged joints to allow ready assembly and disassembly of the piping.
2. Flanged joints:
a. In accordance with ASME B16.5, steel, 150 pounds, slip-on or weld neck, galvanized in accordance with ASTM A153 where used with galvanized pipe.

b. Companion flanges:
    1) In accordance with ASME B16.5, steel.
    2) Class 150 pounds, slip-on or welding neck.
c. Weld flanges to pipe or fittings before applying lining.
d. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
e. Match pipe flanges to the valve flanges.
f. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
g. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

3. Grooved joints:
    a. Grooves: Cut grooves. Rolled grooves are not acceptable.
    b. Couplings housing: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
    c. Bolts and nuts: In accordance with ASTM A183, Grade 2.
    d. Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
        1) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
        2) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
    e. Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
        1) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
        2) Shoulder: Type B or D in accordance with AWWA C606.
    f. Couplings and grooving:
        1) Manufacturers: One of the following or equal:
            a) Anvil.
            b) Grinnell.
            c) Victaulic Co.
    g. Grooved joint piping shall not be used in the following installations:
        1) In underground and underwater installations.
        2) In piping subject to test pressures of 150 pounds per square inch gauge, or more.
        3) In steam and gas piping.
        4) In sludge and scum piping designed to be steam cleaned.
4. Welded joints: Butt welds, 2 pass, full depth with beveled ends and no backing rings.

2.02 COATING AND LINING - GENERAL

A. Coating and lining shall be as indicated on the Drawings or as specified in the Drawings.

B. Extend pipe coatings for underground piping 6 inches above finished grade or 3 inches above finished floor, and neatly terminate.

C. As specified in Section 01600 - Product Requirements.

D. Prepare, install, and repair in accordance with manufacturer's requirements.

E. Contractor is responsible for:
   1. Material selection suitable for the application conditions anticipated, such as temperature, humidity, etc.
   2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

2.03 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C205 and as specified in this Section.
   1. Cement:
      a. In accordance with ASTM C150, Type II.
   2. Water:
      a. In accordance with AWWA C205 and as specified in this Section.
   3. Sand and aggregate:
      a. In accordance with AWWA C205, except that the total percentage of deleterious material shall not exceed 3 percent.

B. Application location:
   1. Shop apply cement-mortar lining in accordance with AWWA C205.

C. Lining:
   1. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
      a. Extend to faces of flanges and ends of spigots.
      b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
      c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
   2. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
   3. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 and approved by the Engineer.
      a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
         1) No. 12 gage spaced at maximum 1-inch centers.
         2) No. 14 gage steel wire at maximum 1/2-inch centers.

2.04 COAL TAR

A. Lining:
   1. Line pipe with coal tar enamel in accordance with AWWA C203 and as specified in this Section.
   2. Line pipe with coal tar epoxy as specified in this Section and as specified for submerged metal in Section 09960 - High-Performance Coatings.

2.05 HEAT SHRINK SLEEVES

A. Coat pipe in accordance with AWWA C216 and as specified in this Section.

B. Manufacturers: One of the following or equal:
   1. Canusa.
   2. Covalence.

C. Engineer may approve use of “Weld After Backfill.”

D. Sleeve width:
   1. Consider sleeve shrinkage and joint profile in determining sleeve width required.
   2. Overlapping of 2 or more heat shrink sleeves to achieve the necessary width on pipe joints will not be permitted without Engineer approval.

E. Sleeve overlap:
   1. Minimum of 3 inches, or as indicated on the Drawings.

F. Heat shrink sleeve material:
   1. Cross-linked polyolefin wrap with a mastic sealant.
   2. Nominal thickness: 85-mil.
   3. Suitable for pipeline operating temperature.
   4. Sleeve material recovery in accordance with sleeve manufacturer’s requirements.

G. Filler mastic:
   1. Adhere filler material to the pipe and heat shrink sleeve.
   2. Size and type in accordance with sleeve manufacturer’s requirements.
   3. Provide filler material at step changes greater than 1/4-inch.

H. Apply filler material in a manner, and of sufficient thickness that, no tenting or voids remain under the heat shrink sleeve.
   1. Joints subject to weld after backfill: Filler mastic melt temperature minimum of 500 degrees Fahrenheit.

I. Heat shrink sleeve locations as indicated on the Drawings.

J. Heat shrink sleeves are restricted to pipeline joints and couplings under buried or concrete encased applications only.
   1. Application inside vaults or where exposed to the weather will not be allowed.

K. Store, handle, and apply field heat shrink sleeve coatings in accordance with AWWA C216 and as specified in this Section.
   1. Store sleeves in shipping box until use is required.
   2. Keep dry and sheltered from exposure to direct sunlight.
   3. Store off the ground or concrete floors.
   4. Maintain at a temperature between 60 and 100 degrees Fahrenheit in accordance with sleeve manufacturer's requirements.
   5. Acceptable types of heat shrink sleeves: Type I or II.

L. Shop prepare pipe joints for heat shrink sleeves with holdback primer as specified this Section.

2.06 HIGH SOLIDS EPOXY

A. Line pipe as specified for submerged metal or exposed metal in Section 09960 - High-Performance Coatings.

2.07 PLURAL COMPONENT EPOXY

A. Coat pipe with plural component, 100 percent solids, non-extended in accordance with AWWA C210 and as specified in this Section.

B. Surface preparation:
   1. In accordance with SSPC-SP 10 or SSPC-SP 11.
   2. In accordance with AWWA C210 and as specified in this Section.
      a. Steel pipe: SSPC-SP 5, 3.00 mils profile, minimum, or in accordance with manufacturer's requirements, whichever is greater.

C. Primer: In accordance with coating manufacturer's requirements.

D. High build epoxy coating:
   1. 2 component, high build polyamide or polyamine cured epoxy coating, suitable for direct burial or immersion, dries to touch in 2 or more hours, suitable for immersion or burial after full cure of coating.
   2. Manufacturers: One of the following or equal:
      a. Carboline.
      b. ICI Devoe.
      c. Sherwin Williams.
      d. Warren Environmental.

E. Fast cure epoxy coating:
   1. 2 component, 100 percent solids by volume, fast cure epoxy coating suitable for direct burial or immersion, dry to touch in less than 1 hour at 72 degrees Fahrenheit, capable of curing while immersed or buried.
   2. Manufacturers: One of the following or equal:
      a. North American Denso, Protal 7125 or Protal 7200.
      b. Tapecoat Inc., TC 7010.

F. Application:
   1. Apply coating using plural component spray equipment by a manufacturer certified coating applicator.

2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer.
    a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
3. In potable water applications, provide epoxy lining suitable for potable water contact in accordance with NSF 61, unless otherwise approved by the Engineer.
4. Concrete embedded pipe penetrations: Extend epoxy coating a minimum of 6 inches outside of interior and exterior surfaces of concrete walls or floors.
5. Concrete penetrations minimum dry film thickness: 12 mils.
6. Apply heat shrink sleeves to buried transitions from epoxy to tape wrap or extruded polyolefin coating systems.
    a. Backfill as soon as practical to limit exposure to direct sun or heat and potential thermal creep of sleeve.

G. Self-priming, plural component, 100 percent solids, suitable for burial or immersion, and in accordance with AWWA C210 and the following, whichever is more stringent:
1. Non-NSF certified: Ceramic fill.
2. NSF certified: Poly amine epoxy or poly amide epoxy.
3. Shop applied coating thickness:
    a. Minimum: 1 coat, 35 mils total dry film thickness.
4. Shop applied lining thickness:
    a. Minimum: 1 coat, 35 mils total dry film thickness.

H. Adhesion test procedures:
1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
    a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
    b. Use automatic adhesion test equipment.
    c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
    d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
    e. Base adhesion testing on 3 tests.
        1) Conduct the tests by the same person, test equipment, and test procedure.
        2) Complete the tests within a 30-minute period.
    f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
    g. Score coatings with more than 10 percent elongation or 25-mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
    a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.

3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
    a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
4. Epoxy coating and lining adhesion criteria:
    a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
    b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
    a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
    b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
        1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
    a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
    b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
    c. Adhesion test failure:
        1) Adhesive or substrate failure.
            a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
        2) Cohesive test failure.
            a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
    d. Retest coating adhesion tests:
        1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the acceptance criteria or the minimum criteria.
        2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
        3) Retest disputed adhesion tests.
            a) Owner's representative will witness dolly attachment and adhesion retesting.
    e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
    f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
        1) Pipe identification.
        2) Pipe coating date.
        3) Adhesion test date.
        4) Surface tested (interior or exterior).
        5) Surface temperature at time of test.
        6) Coating thickness.
        7) Tensile force applied.

8) Applied load rate per second.
9) Mode of failure.
10) Percentage of failure types, previously defined, relative to dolly surface area.
11) Dolly size and attachment glue used.
12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
   a. Fabricator or Contractor to complete adhesion repairs as specified in this Section.
   b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

I. Long term adhesion test:
1. Acceptance criteria:
   a. Not more than 10 percent loss of adhesion over duration of test.
   b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
   a. 1 day.
   b. 7 days.
   c. 3 weeks.
   d. 2 months.
3. Sample preparation:
   a. SSPC-SP 5, 3.00 mils profile, minimum.
   b. Test area minimum: 18 inches by 18 inches.
   c. Curved steel plate.
      1) Minimum radius of 15 inches.
      2) Inclined between 30 and 45 degrees.
4. Test procedure:
   a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
   a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
   b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.08 PLURAL COMPONENT POLYURETHANE

A. Coat pipe with plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
1. Chemline, Chemthane 2265.
2. Lifelast, Equivalent product.

C. Surface preparation:
   1. In accordance with AWWA C222 and as specified in this Section.
   2. In accordance with SSPC-SP 5, 3.00 mils profile, minimum, or in accordance with manufacturer's requirements, whichever is greater.

D. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
      d. In accordance with ASTM D4541 using standard 20-millimeter dollies.
      e. Base adhesion testing on 3 tests.
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30-minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
      g. Score coatings with more than 10 percent elongation or 25-mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
   2. Attach dollies for adhesion testing to the coating surface using a 2-part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
      a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
   3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
      a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
   4. Epoxy coating and lining adhesion criteria:
      a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
      b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
   5. Pipe lot performance criteria:
      a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
      b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
         1) Reject each pipe that fails the coating adhesion criteria.
   6. Adhesion test evaluation and records:
      a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.

b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
c. Adhesion test failure:
    1) Adhesive or substrate failure.
        a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
    2) Cohesive test failure.
        a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
d. Retest coating adhesion tests:
    1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the acceptance criteria or the minimum criteria.
    2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
    3) Retest disputed adhesion tests.
        a) Owner's representative will witness dolly attachment and adhesion retesting.
e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
    1) Pipe identification.
    2) Pipe coating date.
    3) Adhesion test date.
    4) Surface tested (interior or exterior).
    5) Surface temperature at time of test.
    6) Coating thickness.
    7) Tensile force applied.
    8) Applied load rate per second.
    9) Mode of failure.
    10) Percentage of failure types, previously defined, relative to dolly surface area.
    11) Dolly size and attachment glue used.
    12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
    a. Fabricator or Contractor to complete adhesion repairs as specified in this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

E. Long term adhesion test:
    1. Acceptance criteria:
        a. Not more than 10 percent loss of adhesion over duration of test.
        b. Differential based on the highest average adhesion result to the lowest average adhesion result.
    2. Test durations, cumulative:
        a. 1 day.
        b. 7 days.

c. 3 weeks.
d. 2 months.

3. Sample preparation:
   a. SSPC-SP 5, 3.00 mils profile, minimum.
   b. Test area minimum: 18-inches by 18-inches.
   c. Curved steel plate.
      1) Minimum radius of 15-inches.
      2) Inclined between 30 and 45 degrees.
4. Test procedure:
   a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
   a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
   b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.09 POLYURETHANE LINING

A. Polyurethane as specified for submerged metal in Section 09960 - High-Performance Coatings.

2.10 TAPE WRAP

A. Coat pipe in accordance with AWWA C214 and as specified in this Section.

B. Manufacturers: The following or equal:
   1. Liquid adhesive: Polyken 1019, 1027, 1029, or in accordance with coating manufacturer's requirements.
   2. Weld stripe tape: Polyken 931 (no backing), 4-inches wide minimum.
   3. Corrosion layer (inner wrap): Polyken 989.
   4. Mechanical layer of tape wrap: Polyken 955.
   5. Mechanical layer (outer wrap): Polyken 956.

C. Ultraviolet resistance:
   1. Able to resist above grade exposure for a minimum of 12 months or the proposed storage and construction time, whichever is greater.

D. Tape width maximum: 12 inches.
   1. Engineer can approve conditional use of wider tape will be if the coating applicator can demonstrate that proper tensioning can be maintained, and mechanical wrinkling prevented throughout the coating application.
      a. If at any time during the pipe fabrication, tape quality becomes inconsistent, the Engineer can require the remainder of the pipe to be coated using the maximum specified tape width.

E. Manufacturing requirements:
    1. Monitoring system:
        a. Provided by applicator.
        b. Approved by the tape manufacturer that constantly records pipe and tape conditions during coating application.
        c. Recorded monitoring parameters include, but are not limited to, the following: Pipe temperature; line speed, primer and tape roll body temperature, and tape tension.
    2. Pipe surface temperature: Between 45 and 120 degrees Fahrenheit and 5 degrees Fahrenheit above dew point, whichever is greater.
    3. Apply a uniform liquid adhesive layer in accordance with manufacturer's requirements.
        a. Rug type application is not acceptable.
        b. Finish with skips, runs, or sags is not acceptable.
    4. Weld seams stripping tape:
        a. In accordance with AWWA C214 and as specified in this Section.
        b. Corrosion layer adherence to pipe surface.
            1) 100 percent adhering to the metal surface.
            2) No visible damage, wrinkles, voids, contamination, or holidays.
            3) Perform tape coating adhesion test.

F. Tape-coating system thickness:
    1. Pipe 24-inch diameter and larger: 80 mil (nominal).
        a. Liquid adhesive layer.
        b. Corrosion layer:
            1) Layer 1 of 20 mil (nominal), black colored tape.
        c. Mechanical layer:
            1) Layer 1 of 30 mil (nominal), grey color tape.
            2) Layer 2 (outer layer) of 30 mil (nominal), white color tape.
    2. Pipe less than 24-inch diameter: 50 mil (nominal).
        a. Adhesive layer.
        b. Corrosion layer:
            1) Layer 1 of 20 mil (nominal), black colored tape.
        c. Mechanical layer:
            1) Layer 1 (outer layer) of 30 mil (nominal), white color tape.

G. Surface preparation by material type: SSPC-SP 6, 1 to 3 mils blast profile.

H. Adhesion testing:
    1. Apply continuous pulling tension without stopping.
        a. Monitor throughout at least 12-inches length of the pull.
    2. Sample preparation:
        a. Conduct on pipe in either of the following conditions:
            1) Prior to application of the cement mortar overcoat, where applicable.
            2) Pipe that has been mortar coated prior to adhesion testing.
                a) Remove mortar coating of sufficient dimensional area to permit the adhesion test to be conducted as directed by the Engineer.
    3. Adhesion pull evaluation:
        a. Adhesive failure, defined as separation of the adhesive from the metal substrate, will be rejected.
        b. Failure: Cohesive failure of the adhesive only.

c. Delamination failure, defined as separation of the adhesive from the backing material, requires the following additional testing:
    1) Pipe that fails the test by delamination will be retested on 2 other pipes within the same lot of coated pipe.
    2) Failure of any 2 pipes within the tape lot will result in rejection of each pipe coated with the rejected tape lot.

2.11 FABRICATION

A. Shop coat of primer:
    1. Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
    2. Primer compatible with finish coating system.

PART 3 EXECUTION

3.01 INSTALLATION

A. Joints:
    1. General:
        a. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. Type of joint for piping is as specified in Section 15052 - Common Work Results for General Piping pipe schedule or as indicated on the Drawings.
        b. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
        c. Unless otherwise indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping pipe schedule, pipe joints shall be as follows:
            1) Pipe smaller than 2 inches in nominal diameter shall have screwed joints, welded joints, unions, or flexible couplings.
            2) Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
            3) Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.
    2. Flanged joints:
        a. Flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
        b. Secure welding neck flanges with full penetration butt welds without backing rings.
        c. Secure slip-on flanges with both internal and external welds.
        d. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.
    3. Grooved joints:
        a. Assemble in accordance with manufacturer’s published instructions.

b. Support grooved joint pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.

4. Screwed joints:
   a. Perform threading with clean, sharp dies.
      1) Wavy, rough, or otherwise defective pipe threads are not acceptable.
   b. Make screwed joints tight and clean with an application of Teflon™ tape or paste compound applied to the male threads only, except as follows:
      1) Make up liquid and liquefied petroleum gas lines, with litharge and glycerin.
   c. Provide railroad type unions with bronze-to-iron seat. Galvanized where used with galvanized pipe.
      1) Flanged joints may be used instead of unions.
5. Welded joints:
   a. Field welded joints: Electric arc welded in accordance with AWWA C206.
   b. Welder's qualification: Qualified in accordance with AWWA C206.
      1) Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
   c. Do not weld galvanized pipe.

3.02 DEFECTS IN COATINGS EXCEPT CEMENT MORTAR AND TAPE WRAP

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
   1. Pipe joints exceeding the following defect maximum will be rejected.
      a. Minor defects:
         1) No more than 1.5 per 100 square feet of surface area.
         2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
         3) Repairs for adhesion testing will not be included in the total number of repairs.
         4) Repair in accordance with manufacturer's requirements.
      b. Major defects:
         1) No more than 3 major repairs on each pipe joint.
         2) No more than 30 percent repairs on the pipe surface area with defects.
   2. Minor repairs:
      a. Repairs less than 8 inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.
   3. Major repairs:
      a. Repairs that exceed 8 inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.

3.03 CEMENT MORTAR

A. Lining:
   1. Field applied interior joint lining:
      a. Field applied lining shall be of the same density, smoothness, and thickness as shop applied lining.

b. After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar.
    1) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
    2) Remove excess cement mortar.

3.04 HEAT SHRINK SLEEVES

A. Apply heat shrink sleeve joint coating system as indicated on the Drawings.
    1. No cement mortar coating is required.
    2. Do not use heat shrink sleeves on complex shapes like couplings, valves, flanges, and other similar shapes.
    3. Field prepare pipe joints in accordance with SSPC-SP 1 and SSPC-SP 3 to remove dirt, mud, oil, and grease prior to application of heat shrink sleeve.
    4. Temperature requirements:
        a. Preheat pipe uniformly in accordance with sleeve manufacturer's requirements.
            1) Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons.
            2) Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
    5. Fill cracks, crevices, gaps, and step-downs greater than 1/8 inch with filler mastic.
        a. Apply filler material in accordance with the manufacturer's requirements.
    6. Overlap on a 1-inch wide step from outer wrap to middle wrap to inner wrap.
    7. Completed joint sleeve fully adhered to the pipe and existing coating surface without voids.
        a. Provide visible mastic beading along the full circumference of the sleeve.
        b. Wrinkling or excessive burns on the sleeves are not acceptable.
        c. Reject sleeves that do not meet requirements.
        d. Make minor repairs using heat applied patch material specified for minor coating repairs.
    8. Allow the sleeve to cool before backfilling.
        a. In hot climates, provide shading from direct sunlight.
        b. Use water quenching only when permitted by the sleeve manufacturer.
    9. Bury heat shrink sleeves as soon as practical after installation. Limit exposure to direct sunlight in accordance with manufacturer's requirements.
    10. Reject heat shrink joint coatings which have become wrinkled or disbonded because of prolonged exposure to UV light or thermal cycling.
    11. Double coating of defective heat shrink coatings will be permitted if the second sleeve is wider to adhere directly to the pipe.

3.05 PLURAL COMPONENT EPOXY

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.06 PLURAL COMPONENT POLYURETHANE

A. Joints:
   1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
   2. Comply with same application requirements as shop applied coating or lining.
      a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.07 TAPE WRAP

A. Field applied coating shall be of the same density, smoothness, and thickness as shop applied coating.

B. Engineer will identify defective tape wrap coating to be field repaired in accordance with AWWA C214.
   1. Pipe joints exceeding the defect maximum will be rejected.
      a. No more than 5 repairs.
      b. No more than 2 areas of coating damage greater than 5 square feet.

C. Minor repairs:
   1. Repairs less than 8 inches in the greatest dimension.
   2. Complete minor repairs using a heat applied coating patch material.
   3. Limit material removal to only damaged layers:
      a. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting undamaged layers.
      b. Cut in a stepped fashion to expose 1 inch or more of the underlying tape layer for the circumference of the repair.
   4. Cut patch material to overlap onto the undamaged coating a minimum of 2 inches on each side with 1-inch radius on each corner of the patch.
   5. Apply patch material in accordance with manufacturer's requirements.

D. Major repairs:
   1. Repairs that exceed 8 inches in the greatest dimension.
   2. Complete major repairs:
      a. With heat shrink sleeves as specified for joints.
   3. Limit material removal to only damaged layers.
      a. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting undamaged layers.
      b. Cut in a stepped fashion to expose 1 inch or more of the underlying tape layer for the circumference of the repair.
      c. If corrosion layer is exposed:
         1) Holiday test.
            a) If a holiday is detected:
               (1) Cut outer layers back to fully expose the holiday(s).
               (2) Retest for holidays.
   4. Apply repair material in accordance with manufacturer's requirements or as specified in this Section.
      a. Clean surfaces by solvent wiping and applying primer over the inner tape layer for a minimum of 6 inches onto the outer wrap in all directions.

b. Cigarette wrap coating:
    1) Apply first layer of repair coating, over lapping 1 inch or more onto undamaged coating in all directions.
        a) On larger areas, lap the repair tape within a minimum of 1-inch overlap, offsetting the overlap from the previous layer overlap, until the area is properly covered.
        b) If corrosion layer is repaired:
            (1) Holiday test.
                (a) If a holiday is detected.
                (b) Cut outer layers back to fully expose the holiday(s).
                (c) Retest for holidays.
    2) Repeat for each tape layer damaged with each succeeding layer applied at 90 degrees to the preceding layers and overlapping onto the undamaged coating a minimum of 2 inches.
    3) Apply the last tape layer, use the cigarette wrap method for the full pipeline circumference covering any previous repair layers and overlapping a minimum of 2 inches onto undamaged coating.
        a) Point ends of the cigarette wrap downward.
c. Heat shrink sleeves:
    1) Width: Equal to width of the damaged area plus 4-inch overlap.
    2) Multiple sleeves may be used for larger repairs but must be overlapped a minimum of 2 inches.

3.08 WAX TAPE COATING

A. Apply in accordance with AWWA C217 and manufacturer's requirements.

B. Filler mastic:
    1. Irregular shapes: Apply between primer and wax tape.
    2. Apply by hand, working material on to metal to displace moisture to maximize adhesion.
    3. Build up an even surface.

3.09 FIELD COAT

A. Aboveground steel pipe as specified in Section 09960 - High-Performance Coatings.

3.10 FIELD QUALITY CONTROL

A. Field test fabricated steel manifolds with the pipe to which they connect.

B. Weld testing:
    1. Liquid penetrant testing:
        a. As soon as possible after welding of pipeline joints, fillet welds shall be tested by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method "B" and "Leak Testing".
        b. Chip out defects, rebell, and retest.
            1) Upon retest, the repaired area shall show no leaks or other defects.

END OF SECTION

SECTION 15272

STEEL PIPE: BURIED

TABLE OF CONTENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel transmission piping greater than 22 inches in nominal diameter and internal pressures up to 250 pounds per square inch, including joints and fittings.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Society of Mechanical Engineers (ASME):
   1. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Inch Standard.
   2. B31.3 - Process Piping Materials, Fabrication, Examination & Testing.
   3. Boiler and Pressure Vessel Code.
      a. BPVC-VIII - Boiler and Pressure Vessel Code Section VIII - Rules for Construction of Pressure Vessels Division 1.
      b. BPVC-IX - Boiler and Pressure Vessel Code Section IX - Welding and Brazing Qualifications.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   2. C203 - Coal-Tar Protective Coatings and Linings for Steel Water.
   1. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe: 4 inches and Larger-Shop Applied.
   2. C206 - Field Welding of Steel Water Pipe.
   3. C207 - Steel Pipe Flanges for Waterworks Service, Sizes 4 inches Through 144 inches.
   4. C208 - Dimensions for Fabricated Steel Water Pipe Fittings.
   1. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   2. C214 - Tape Coatings for Steel Water Pipe.
   3. C216 - Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings.
   4. C217 - Microcrystalline Wax and Petrolatum Tape Coatings Systems for Steel Water Pipe and Fittings.
   5. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   6. C225 - Fused Polyolefin Coatings for Steel Water Pipe
   7. Manual M11 - Steel Pipe: A Guide for Design and Installation.

D. ASTM International (ASTM):
   1. A36 - Standard Specification for Carbon Structural Steel.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
   4. A106 - Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.

5. A139 - Standard Specification for Electro-Fusion (Arc) Welded Steel Pipe (NPS 4 and Over).
6. A181 - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
7. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
8. A283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
9. A370 - Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
10. A516 - Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
11. A572 - Standard Specification for High Strength Low-Alloy Columbian-Vanadium Steels of Structural Quality.
12. A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
13. A1018 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
14. C33 - Standard Specification for Concrete Aggregates.
15. C150 - Standard Specification for Portland Cement.
16. D297 - Standard Test Methods for Rubber Products - Chemical Analysis.
17. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
18. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
19. E94 - Standard Guide for Radiographic Examination Using Industrial Radiographic Film.
20. E165 - Standard Practice for Liquid Penetrant Examination for General Industry.
21. E1032 - Standard Test Method for Radiographic Examination of Weldments.

E. American Welding Society (AWS):
   1. D1.1 - Structural Welding Code - Steel.

F. International Organization for Standardization (ISO).

G. NSF International:
   1. 61 - Drinking Water System Components - Health Effects.

H. Society for Protective Coatings (SSPC):
   1. SP 1 - Solvent Cleaning.
   2. SP 3 - Power Tool Cleaning.
   3. SP 5 - White Metal Blast Cleaning.
   4. SP 6 - Commercial Blast Cleaning.
   5. SP 10 - Near White Wet Blast.
   6. SP 11 - Bare Metal Power Tool Cleaning.
   7. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Wall thickness design calculations sealed by a Professional Engineer licensed in the state the project is located, including:
   1. Internal pressure:
      a. Maximum design pressure.
      b. Surge pressure.
   2. External pressure:
      a. Deflection.
      b. Buckling.
      c. Extreme loading conditions.
   3. Special physical loading such as supports or joint design.
   4. Thermal expansion and/or contraction.

D. Thrust restraint calculations for fittings and valves including the restraint length, single, and double weld lengths sealed by a Professional Engineer licensed in the state where the project is located.

E. Fabrication and Lay drawings showing a schematic location with profile and tabulated layout schedule that is sealed by a Professional Engineer licensed in the state where the project is located, including:
   1. Pipe class.
   2. Joint types.
   3. Fittings.
   4. Outlets.
   5. Thrust Restraint.
   6. Stationing (in accordance with the Plans).
   7. Transitions.
   8. Joint deflection.
   9. Interior lining.
   10. Exterior coating.
   11. Outlet locations for welding, ventilation, and access.
   12. Welding requirements and provisions for thermal stress control.

F. Certificate of Source Testing as specified in Section 01600 - Product Requirements.

G. Certified test reports:
   1. Factory hydrostatic tests and test of fittings.
   2. Mill certificates, including chemical and physical test results for each heat of steel, Charpy V-notch tests, and elongation tests.
   3. Certified test reports for factory welds of fittings from a third party independent Certified Welding Inspector paid for by the Pipe Manufacturer.
   4. Gasket certification in accordance to AWWA C200, as specified for bell and spigot gasket joint pipe.
   5. Copies of Manufacturers' factory quality control tests.

6. Pipe welding, welding procedures and qualification records in accordance with ASME BPVC Section IX, and include the following:
    a. Welder Qualifications Records (WQR) in accordance with AWWA C206 and AWS D1.1 for both factory and field welders.
    b. Welding Procedure Specifications (WPS) for each proposed field and shop welding procedure or process, including those procedures or processes used for shop and field welding of piping and supports.
    c. Procedure Qualification Record (PQR) for each WPS submitted.
    d. Welders' and welding operators' certification records for each proposed WPS and each welder assigned to the work in the shop and field.
        1) Welders and welding operators must be qualified for making welds in position 6G for each welding process to be used.
    e. Preheat and post-weld heat treatment processes and equipment.
    f. Post-weld cleaning and de-scaling procedures.
    g. Certified non-destructive (NDE) testing results and weld inspection reports, performed by the manufacturer in accordance with the applicable codes, submitted prior to the shipping of the piping.

H. Manufacturer's qualifications:
    1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
    2. Plural component epoxy and polyurethane field repair: SSPC-QP 1 certification required.

I. Manufacturer's Quality Assurance Manual.
    1. Submit manufacturer's coating and lining application quality assurance manual to Engineer prior to beginning coating application.
        a. Strict conformance to the requirements of the manual will be required.
        b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

1.04 QUALITY ASSURANCE

A. Manufacturers:
    1. Certified under S.P.F.A. or ISO quality certification program for steel pipe and accessory manufacturing.
    2. Pipe manufacturing operations (pipe, lining, and coatings) performed under the control of the manufacturer.
    3. Qualifications requirements: Not less than 5 years successful experience manufacturing pipe of the particular type and size indicated, or which has demonstrated an experience record that is satisfactory to Engineer and Owner.
        a. The acceptability of this experience record will be thoroughly investigated by the Engineer, and will be sole discretion of the Engineer and Owner.
    4. Pipe manufacturing operations (pipe, fittings, lining, and coating) performed at 1 location unless otherwise approved by Engineer.
    5. Manufacture pipe in accordance with the latest revisions of AWWA C200, AWWA C205, and AWWA C222.

B. Hydrostatic pressure testing:
   1. Hydrostatic mill pressure testing results meet or exceed the requirements of AWWA C200.
   2. Hydrostatically test each joint of the pipe prior to application of lining or coating.
      a. Internal test pressure: That which results in a fiber stress equal to 75 percent of the minimum yield strength of the steel used.
      b. Test each joint of pipe completely watertight under maximum test pressure.
      c. Hold test pressure for sufficient time to observe the weld seams.
      d. Maintain a recording pressure gauge, reference number of pipe testing, etc.
         1) Number the pipe in order that this information can be recorded.
   3. Fabricate fittings from hydrostatically tested pipe.
      a. Test fittings by one of the following methods:
         1) Hydrostatic test.
         2) Magnetic particle tests.
         3) Ultrasonic.
         4) Radiography.
   4. Charpy V-Notch Test:
      a. Test each heat of steel for plates or coil used 0.25 inches and thicker to verify minimum impact values of 25 feet per pound at 30 degrees Fahrenheit in accordance with ASTM A370.
      b. Minimum Charpy values for sub-size samples in accordance with ASTM A370.
   5. Elongation:
      a. Tensile test specified in ASTM A370.
         1) Elongation minimum:
            a) Test specimens, 2-inch: Not less than 22 percent for each heat of steel.
            b) Test specimens, 8-inch: Not less than 18 percent for each heat of steel.
   6. Mill certification:
      a. Maximum carbon content of steel used in the fabrication of pipe, fittings, and related appurtenances: 0.25 percent.
      b. Furnish mill test certificates on reinforcing steel or wire, steel plate, steel coil.
      c. Perform the tests described in AWWA C200, for pipe, fittings, and specials.

C. Owner testing and inspection of pipe manufacturer:
   1. Pipe may be subject to inspection by an independent testing laboratory that is selected and retained by Owner.
      a. Provide access to the work whenever it is in preparation or progress for the laboratory staff or Engineer.
      b. Provide proper facilities for access and for inspection.
      c. Notify Owner in writing, a minimum of 2 weeks prior to the pipe fabrication so that Owner may advise the Manufacturer as to Owner's decision regarding test to be performed by an independent testing laboratory.
      d. Owner may reject material, fabricated parts, and pipe, which are discovered to be defective, or which do not conform to the requirements of

this specification at any time prior to Owner's final acceptance of the product.

2. Inspection and testing by the independent testing laboratory anticipates that production of pipe uses standard production procedures.

D. Pipe manufacturer's representative during pipe installation:
   1. Factory trained, qualified, job experienced technician to advise and instruct as necessary in pipe laying and pipe jointing.
      a. Assist and advise Contractor in pipe laying operations.
      b. Instruct construction personnel in proper joint assembly and joint inspection procedure.
      c. Not required to be on-site full time.
      d. Be on-site regularly during the first 2 weeks of pipe laying and as requested by Engineer, Owner, or Contractor.

E. Warranty:
   1. Provide warranty as specified in Section 01783 - Warranties and Bonds.
   2. Special warranty:
      a. Pipe will be free from defects in materials and workmanship for a period of 5 years from the date of Substantial Completion of this Contract.
      b. Repair or replace with parts manufactured by the manufacturer of the original component.
      c. Repair or replace, at the sole option of, and at no cost to Owner, Work found to be defective.
      d. Such repair or replacement shall include removal and reinstallation, inspection, and acceptance testing.

1.05 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver, store, and handle pipe in accordance with AWWA C200, Manual M-11 and as specified.

B. Preparations for shipping:
   1. Make minor repairs to cement mortar lining or coating as specified in this Section.

C. Stulling:
   1. 30 inch and smaller diameter pipe:
      a. Install 2 inch by 4 inch (nominal) stulls both ways 2 feet from the end of each pipe.
   2. 30 inch to 48 inch diameter pipe:
      a. Install nominal 3 inch by 3 inch, 4-point wooden stulls or equivalent with nailed wooden wedges at the quarter points, following the cure of the lining.
      b. Install a similar single strut 2 feet from each end of the pipe.
   3. Greater than 48 inch and larger pipe:
      a. Install nominal 4 inch by 4 inch, 6 point wooden stulls or equivalent with nailed wooden wedges, at the quarter points, following the cure of the lining.

4. Keep the stulls in place during:
    a. Subsequent manufacturing process and curing.
    b. Transport to the job site.
    c. Placement in the trench for pipe 30 inch and larger:
        1) Horizontal stulls must be removed prior to backfilling.
        2) Vertical stulls should remain in place until after the trench is backfilled.
5. Remove stulls prior to testing.
6. Temporary removal of stulls will be allowed for repairs to the lining or welding of joints, if required.

D. Plastic covers:
1. Attach to the ends of the pipe and fittings during curing of lining storage and shipment, and on the installation site.
    a. They may be removed just prior to installation.
2. Banding: Use one of the following methods:
    a. Steel bands.
    b. Reinforced plastic straps.
3. Temporary holes may be cut into the plastic covers during curing of mortar or to add water to facilitate repairs.
    a. Promptly tape the holes closed after completing the curing or repair.

E. Loading, transporting, unloading and handling pipe and fittings:
1. Handle pipe in a manner and by methods that prevent damage to pipe, lining, and coatings.
2. Use padded slings and supports during handling as necessary to prevent damage.
3. Take necessary precautions to maintain the integrity of the coating.
4. Handle pipe with proper equipment and do not be push or drag along the ground.
5. Do not stack or otherwise externally load pipe such that the dimensional integrity of the joint configuration and/or roundness of the pipe may not be compromised.

F. Storage:
1. Store pipe and fittings on skids, sand or dirt berms, sandbags, old tires, or other suitable means to prevent damage to pipe and fittings.
2. Store and protect pipe from damage from equipment, traffic, and vandalism.

G. Inspection:
1. Inspect pipe lining and coating immediately before installation for damage.
2. Repair any damage as specified in this Section.

H. Remove rejected pipe from the project site.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Pipe design:
   1. Designed, manufactured, and tested in accordance with AWWA C200, AWWA Manual M11, and these specifications.
   2. Design fittings, specials, and connections for the same pressures as the adjacent pipe.
   3. Base pipe design on trench conditions and the design pressure in accordance with AWWA Manual M-11; using the following parameters:
      a. Steel minimum yield strength: 36- kips per square inch.
      b. Steel modulus of elasticity (E): $30x10^6$-pounds per square inch.
      c. Cement mortar modulus of elasticity: 4x106-pounds per square inch.
      d. Unit weight of fill (W): 140 pounds per cubic feet.
      e. Live load:
         1) AASHTO HS-20.
      f. Trench depth: As indicated on the Drawings.
         1) Verify depths after existing utilities are located.
         2) Make appropriate change in pipe trench depth when vertical alignment changes are required because of existing utility or other conflicts.
         3) Do not install pipe deeper than its design allows.
      g. Deflection lag factor, (Dl): 1.25.
      h. Coefficient K: 0.10.
      i. Maximum allowable calculated deflection:
         1) 2 percent for cement mortar lined and coated.
         2) 3 percent for cement mortar lined and flexible coated.
         3) 5 percent for flexible lined and coated.
      j. Design Temperature: 45 degrees Fahrenheit.
      k. Soil reaction modulus (E'): 700 pounds per square inch.
      l. Working pressure: 15 pounds per square inch.
      m. Design Pressure: 25 pounds per square inch.
      n. Test Pressure: See Pipe Schedule.
   4. Fittings and specials:
      a. Design in accordance with AWWA C208 and AWWA Manual M11.
   5. Furnish alternate methods for pipe embedment where the pipe requires additional external support to achieve the specified maximum deflection.
      a. No additional compensation will be made to the Contractor by Owner where this method is required.
   6. Field fabrication or cutting is not allowed unless otherwise approved by Owner and Engineer.

B. Provisions for thrust:
   1. Use design pressure for the purposes of thrust restraint.
   2. Restrained joints use welded joints.
   3. Resist bends, tees, or other fittings with restrained joints.
      a. Restrain thrust at bends adjacent to casing by welding joints through the casing and a sufficient distance each side of the casing.
      b. Pipe in casing does not contribute to thrust restraint unless the annular space in the casing is filed with grout.

4. Restrain joints a sufficient distance from each side of the bend, tee, plug, or other fitting to resist thrust which develops at the design pressure of the pipe.
    a. Treat inline valves as a dead-end in both directions with respect to thrust restraint calculations.
5. Pipe manufacturer is responsible for thrust restraint.
6. Validate the length of pipe with restrained joints to resist thrust forces in accordance with AWWA Manual M-11 and the following:
    a. Calculate the weight of earth as the weight of the projected soil prism above the pipe.
    b. Unit weight of fill: as indicated above.
    c. Coefficient of friction:
        1) Unsaturated soil conditions: 0.20 (maximum value to be used for steel pipe with tight bonded coating).
        2) In locations where ground water in encountered:
            a) Reduce the soil density to its buoyant weight for backfill below the water table.
            b) Reduce the coefficient of friction to 0.15 for steel pipe with tight bonded coating.
    d. Calculate the length of pipe to be restrained.
        1) Length of restraint must extend up to the full length required by the Calculation.
        2) Joints that are determined to be partially restrained must always be rounded up to the nearest full length.
        3) Use the following parameter to calculate the restrained length in accordance with AWWA M11:
        4) For Horizontal Restrained Lengths:

            Bends less than 90 degrees.

$$L = \frac{PA(1-\cos\Delta)}{f\left(W_{eH} + W_p + W_w\right)}$$

            Tee branches, dead-end conditions, 90-degree bends and Reducers.

$$L = \frac{PA}{f\left(W_{eH} + W_p + W_w\right)}$$

        5) For Vertical Restrained Lengths:

            Bends less than or equal to 90 degrees.

$$L = \frac{PA(1-\cos\Delta)}{f\left(W_{eV} + W_p + W_w\right)}$$

            L = Length of pipe to be restrained
            P = 1.5 times working pressure
            A = Cross sectional area of pipe settle cylinder I.D.
            Δ = Deflection angel
            W_{eH} = 2 times the weight of the soil over the pipe
            W_{eV} = Weight of the soil over the pipe
            W_p = Weight of pipe

W_w = Weight of water
f = Coefficient of friction

C. Minimum insider diameter, including the cement-mortar lining: Nominal diameter of the pipe specified, unless otherwise indicated on the Drawings.

D. Wall thickness:
   1. Minimum pipe wall steel thickness: As designed, but not less than values shown in the Pipe Schedule.
   2. Fiber stress shall not exceed:
      a. 50 percent of the minimum yield strength of the steel for working pressure.
      b. 75 percent of the minimum yield strength of the steel at the maximum pressure (including transient pressure), nor the following, at the specified working pressure.
   3. Pipe, fittings, and specials shall be designed such that the maximum stresses the pipe due to thrust loading will not exceed 50 percent of the steel yield strength at the thrust design pressure (1.5 times the working pressure).

2.02 MATERIALS

A. Steel pipe, fittings, and specials:
   1. General:
      a. Steel pipe in accordance with AWWA C200, and as specified.
         1) ASTM A106, Grade C seamless high-temperature carbon steel stock pipe.
         2) ASTM A53, Type S, Grade A (S-A) seamless carbon steel stock pipe.
         3) ASTM A53, Type E, Grade A (E-A) ERW carbon steel stock pipe.
         4) ASTM A139, Grade C welded steel stock pipe.
         5) Spiral or straight-seam-welded ASTM A36 steel sheet or plate stock.
         6) Spiral or straight-seam-welded ASTM A283, Grade D sheet or plate stock.
         7) Spiral or straight-seam-welded ASTM A1011, Grade 50 HSLA-F sheet or coil stock.
         8) Spiral or straight-seam-welded ASTM A1018, Grade 50 HSLA-F sheet or coil stock.
         9) Straight-seam-welded ASTM A572, Grade 50 plate stock.
         10) Straight-seam-welded ASTM A572, Grade 42 plate stock.
      b. Fittings and specials dimensions in accordance with AWWA C208.
      c. Provide identification marks in accordance with AWWA C200.
      d. Diameter designation: The pipe diameter specified or indicated on the Drawings is the clear inside diameter after application of the lining with a tolerance of minus 0 inch and plus 3/16 inch.

B. Manufacturers: The following or equal:
   1. Northwest Pipe.
   2. American Cast Iron Pipe Co.
   3. Thompson Pipe Group.

2.03 FABRICATION

A. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation.
   1. Minimize number of field welds.
   2. Do not exceed 50 feet for pipe lengths.

B. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.

C. Flanges.
   1. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
   2. Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment.

D. Identification marks: Stenciled or otherwise shown at the top of the piping items exterior, and include the following information:
   1. As specified in Section 01600 - Product Requirements.
   2. Date of manufacture of the item.
   3. Name or trademark of the manufacturer.
   4. Internal diameter in inches.
   5. Number of the item, sequential from initial to end station.
   6. NSF approval, if applicable for potable water service.

2.04 COATING AND LINING - GENERAL

A. Coating and lining shall be as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping.

B. Extend pipe coatings for underground piping 6-inches above finished grade or 3-inches above finished floor, and neatly terminate.

C. As specified in Section 01600 - Product Requirements.

D. Prepare, install, and repair in accordance with manufacturer's requirements.

E. Contractor is responsible for:
   1. Material selection suitable for the application conditions anticipated, such as temperature, humidity, etc.
   2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

2.05 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C205 and as specified in this Section).
   1. Cement:
      a. Cement: In accordance with ASTM C150, Type II.
   2. Water:
      a. In accordance with AWWA C205 and as specified in this Section.

3. Sand and aggregate:
    a. In accordance with AWWA C205.
    b. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

B. Lining:
1. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
    a. Extend to faces of flanges and ends of spigots.
    b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
    c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
2. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
3. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 and approved by the Engineer.
    a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
        1) No. 12 gage spaced at maximum 1-inch centers.
        2) No. 14 gage steel wire at maximum 1/2-inch centers.

2.06 PLURAL COMPONENT POLYURETHANE

A. Coat pipe with plural component, polyurethane coating system (referred to as a polyurethane system) applied in accordance with AWWA C222 and as specified in this Section.

B. Manufacturers: One of the following or equal:
1. Chemline, Chemthane 2265.
2. Lifelast, Equivalent product.

A. Surface preparation:
3. In accordance with AWWA C222 and as specified in this Section.
4. In accordance with SSPC-SP 5, 3.00 mil profile, minimum, or in accordance with manufacturer’s requirements, whichever is greater.

C. Adhesion test procedures:
1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
    a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
    b. Use automatic adhesion test equipment.
    c. Perform tests to coating or glue failure or maximum test load, whichever is happens first.
    d. In accordance with ASTM D4541 using standard 20 millimeter dollies.
    e. Base adhesion testing on 3 tests.
        1) Conduct the tests by the same person, test equipment, and test procedure.
        2) Complete the tests within a 30 minute period.

f. Conduct adhesion tests within an area not to exceed 6 inches by 6 inches.
g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.

2. Attach dollies for adhesion testing to the coating surface using a 2 part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
   a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
   a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
4. Epoxy coating and lining adhesion criteria:
   a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
   b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
5. Pipe lot performance criteria:
   a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
   b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
      1) Reject each pipe that fails the coating adhesion criteria.
6. Adhesion test evaluation and records:
   a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
   b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.
   c. Adhesion test failure:
      1) Adhesive or substrate failure.
         a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
      2) Cohesive test failure.
         a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
   d. Retest coating adhesion tests:
      1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
      2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
      3) Retest disputed adhesion tests.
         a) Owner's representative will witness dolly attachment and adhesion retesting.

e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
1) Pipe identification.
2) Pipe coating date.
3) Adhesion test date.
4) Surface tested (interior or exterior).
5) Surface temperature at time of test.
6) Coating thickness.
7) Tensile force applied.
8) Applied load rate per second.
9) Mode of failure.
10) Percentage of failure types, previously defined, relative to dolly surface area.
11) Dolly size and attachment glue used.
12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
a. Fabricator or contractor to complete adhesion repairs as specified this Section.
b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

D. Long term adhesion test:
1. Acceptance criteria:
a. Not more than 10 percent loss of adhesion over duration of test.
b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
a. 1 day.
b. 7 days.
c. 3 weeks.
d. 2 months.
3. Sample preparation:
a. SSPC-SP 5, 3.00 mils profile, minimum.
b. Test area minimum: 18-inches by 18-inches.
c. Curved steel plate:
1) Minimum radius of 15-inches.
2) Inclined between 30 and 45 degrees.
4. Test procedure:
a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

2.07 TAPE WRAP

A. Coat pipe in accordance with AWWA C214 and as specified in this Section.

B. Manufacturers: The following or equal:
   1. Liquid adhesive: Polyken 1019, 1027, 1029, or in accordance with coating manufacturer's requirements.
   2. Weld stripe tape: Polyken 931 (no backing), 4 inches wide minimum.
   3. Corrosion layer (Inner wrap): Polyken, 989.
   4. Mechanical layer of tape wrap: Polyken, 955.
   5. Mechanical layer **(**Outer wrap): Polyken 956.

C. Ultraviolet resistance:
   1. Able to resist above grade exposure for a minimum of 12 months or the proposed storage and construction time, whichever is greater.

D. Tape width maximum: 12 inches.
   1. Engineer can approve conditional use of wider tape will be if the coating applicator can demonstrate that proper tensioning can be maintained, and mechanical wrinkling prevented throughout the coating application.
      a. If at any time during the pipe fabrication, tape quality becomes inconsistent, the Engineer can require the remainder of the pipe to be coated using the maximum specified tape width.

E. Manufacturing requirements:
   1. Monitoring system:
      a. Provided by applicator.
      b. Approved by the tape manufacturer that constantly records pipe and tape conditions during coating application.
      c. Recorded monitoring parameters include, but not be limited to the following: Pipe temperature; line speed, primer and tape roll body temperature, and tape tension.
   2. Pipe surface temperature: Between 45 and 120 degrees Fahrenheit and 5 degrees Fahrenheit above dew point, whichever is greater.
   3. Apply a uniform liquid adhesive layer in accordance with manufacturer's requirements.
      a. Rug type application is not acceptable.
      b. Finish with skips, runs, or sags is not acceptable.
   4. Weld seams stripping tape:
      a. In accordance with AWWA C214 and as specified in this Section.
      b. Corrosion layer adherence to pipe surface.
         1) 100 percent adhering to the metal surface.
         2) No visible damage, wrinkles, voids, contamination, or holidays.
         3) Perform tape coating adhesion test.

F. Tape-coating system thickness:
   1. Pipe 24 inch diameter and larger: 80 mil (nominal).
      a. Liquid adhesive layer.
      b. Corrosion layer:
         1) Layer 1 of 20 mil (nominal), black colored tape.

c. Mechanical layer:
1) Layer 1 of 30 mil (nominal), grey color tape.
2) Layer 2 (Outer Layer) of 30 mil (nominal), white color tape.

2. Pipe less than 24 inch diameter: 50 mil (nominal).
a. Adhesive layer.
b. Corrosion layer:
1) Layer 1 of 20 mil (nominal), black colored tape.
c. Mechanical layer:
1) Layer 1 (Outer Layer) of 30 mil (nominal), white color tape.

G. Surface preparation by material type: SSPC-SP 6, 1 to 3 mils blast profile.

H. Overcoat: Cement mortar.

I. Adhesion testing:
1. Apply continuous pulling tension without stopping.
a. Monitor throughout at least 12-inches length of the pull.
2. Sample preparation:
a. Conduct on pipe in either of the following conditions:
1) Prior to application of the cement mortar overcoat, where applicable.
2) Pipe that has been mortar coated prior to adhesion testing.
a) Contractor remove mortar coating of sufficient dimensional area to permit the adhesion test to be conducted as directed by the Engineer.
3. Adhesion pull evaluation:
a. Adhesive failure, defined as separation of the adhesive from the metal substrate, will be rejected.
b. Failure: Cohesive failure of the adhesive only.
c. Delamination failure, defined as separation of the adhesive from the backing material, requires the following additional testing:
1) Pipe that fails the test by delamination will be retested on 2 other pipes within the same lot of coated pipe.
2) Failure of any 2 pipes within the tape lot will result in rejection of each pipe coated with the rejected tape lot.

2.08 STEEL PIPE JOINTS AND CONNECTIONS

A. General:
1. Joints:
a. Provide lap welded or bell and spigot type joints with rubber gaskets for pipelines 54 inches and smaller, except as otherwise specified or indicated on the Drawings.
b. Use single and/ or double lap welded joints for restraint as indicated on the Drawings.
c. Welded Carnegie joints can be used if working pressure is less than 75 pounds per square inch.
d. Use butt-strap joints only where required for closures or where indicated on the Drawings.
e. Provide deep bells where required for shrinkage expansion control joints.
f. Provide joints with the same or higher pressure rating as the abutting pipe.

B. Bell and spigot joint rings:
   1. United States Steel, Rolled Carnegie shape M 3818 with rubber gaskets.
   2. Rubber gasket requirements:
      a. Minimum tensile strength, tested in accordance with ASTM D412, between 2,000 and 2,700 pounds per square inch.
      b. Minimum elongation at rupture, tested in accordance with ASTM D412, between 350 and 400 percent.
      c. Specific gravity, tested in accordance with ASTM D297, between 0.90 and 1.50.
   3. Install joint bonding on joints, regardless of whether cathodic protection is provided or not, electrical isolation and test stations should be provided to isolate the joints between major structures and existing pipelines.
   4. Furnish joints with recesses in the coating or lining exposing the joint for attachment of electrical bonds.
      a. Install 2 exterior or interior recesses at each joint.

C. Bell and rolled spigot joints:
   1. Bell and rolled spigot joints with rubber gaskets.
   2. Manufactured joints with the clearance between the bells and spigots such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when installed.
   3. Submit details complete with dimensions and tolerances.
   4. Form bell ends by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling.
   5. Yield strength of the steel used in the spigot rolling operation: limited to 52,000 pounds per square inch.
   6. Rubber gaskets requirements:
      a. Minimum tensile strength, tested in accordance with ASTM D412, between 2,000 and 2,700 pounds per square inch.
      b. Minimum elongation, tested in accordance with ASTM D412, between 350 and 400 percent.
      c. Specific gravity, tested in accordance with ASTM D297, between 0.90 and 1.50.
   7. Install joint bonding on joints, regardless of whether cathodic protection is provided or not, electrical isolation and test stations should be provided to isolate the joints between major structures and existing pipelines.
   8. Furnish joints with recesses in the coating exposing the joint for attachment of electrical bonds.
      a. Install 2 recesses at each joint.

D. Flange requirements:
   1. Steel ring flanges:
      a. Steel ring flanges shall meet the requirements of AWWA C207 and shall have a pressure rating equal to or greater than that of connecting pipe.
      b. Steel ring flanges shall be manufactured from one of the following materials:
         1) ASTM A105 forged steel.
         2) ASTM A36 steel plate.
         3) ASTM A516, Grade 65 or 70 steel plate.

2. Forged steel flanges:
    a. Forged steel flanges shall meet the requirements of ASME B16.5 and shall have a pressure rating equal to or greater than that of connecting pipe.
    b. Steel ring flanges shall be manufactured from one of the following materials:
        1) ASTM A105 forged steel.
        2) ASTM A181 steel.
        3) ASTM A182 steel.
3. Raised face flanges shall not be used when connecting steel flanges to cast iron flanges.
4. Blind flanges in accordance with AWWA C207, Table 7.
5. Match pipe flanges to the valve flanges.

E. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.

F. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

G. Welded joints:
1. Lap welded joints:
    a. Lap joints prepared for electric field welding in accordance with AWWA C206.
    b. Joint forming:
        1) Joint geometry and joint field weld will be such that no part of any field weld will be closer than 1 inch to the nearest point of tangency to the bell radius.
        2) Form bell ends by and expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.
    c. Provide surfaces of the bell and spigot that are essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Cleaning: Thoroughly clean pipe and fittings before placement.
2. Install steel pipe, fittings, specials, and appurtenances as specified and required for the proper functioning of the complete pipeline.
3. Install pipe, fittings, and specials in accordance with the Manufacturer's recommendations and AWWA Manual M11.
    a. The requirements of the plans and specifications govern for the excavation and backfilling of trenches for laying steel pipe, fittings and specials.
4. Pipe shall be laid to the lines and grade indicated.

5. Inspect and test each joint prior to pipe being lowered into the trench as specified in this Section.
    a. Repair damaged areas and holidays before the pipe is lowered into the trench.
6. Place and consolidate embedment and backfill prior to removing pipe stulls.
7. Maximum allowable pipe deflection is limited to the following as measured by a mandrel:
    a. 2 percent for cement mortar lined and coated.
    b. 3 percent for cement mortar lined and flexible coated.
    c. 5 percent for flexible lined and coated.
8. Keep the pipe clean during the laying operation and free of sticks, dirt, animals, and trash.
9. At the close of each operating day, effectively seal the open end of the pipe against the entrance of water using a gasketed night cap.
10. Do not lay pipe in water.
11. Install bonds at pipe joints, other than welded joints or insulated joints as specified.

B. Pipe handling:
1. Handle pipe with a minimum of 2 wide non-abrasive slings, belts or other equipment designed to prevent damage to the coating or lining.
2. The equipment shall be kept in such repair that its continued use is not injurious to the coating.
3. The spacing of pipe supports required to handle the pipe shall be adequate to prevent cracking or damage to the lining or coating.

C. Line up at bends:
1. Line up pipe for joining so as to prevent damage thereto.
    a. Thoroughly clean the bell and spigot ends of each joint of pipe of foreign matter, rust and scale before placing spigot into bell.
2. Where abrupt changes in grade and direction occur, employ special shop fabricated fittings for the purpose.
    a. Field cutting the ends of the steel pipe to accomplish angular changes in grade or direction of the line shall not be permitted.

D. Pipe laying:
1. Lay pipe to the lines and grades indicated on the Drawings unless they are amended or supplemented by the manufacturer's tabulated lay schedule and accepted by Engineer.
2. Lower pipe into the trench slowly and gently with slings or properly padded calipers.
3. Make the bell end of the pipe face the direction of laying wherever practicable.
4. Keep the pipe trench free from water which might impair the bedding or joining and welding operations.

E. Joints:
1. Gasket joints:
    a. Lubricate the spigot groove, and the first 2 inches of the bell, with an approved soft vegetable soap compound.
    b. Position the gasket in the spigot groove such that the rubber is distributed uniformly around the circumference.

c. Lay the pipes in such manner that the blockouts on the interior linings are at the spring line of the pipe to facilitate electrical connection of adjacent pipes.
d. The width of the space provided at the joint may be varied to compensate for the permissible manufacturing tolerance in pipe lengths plus or minus 1/4 inch to maintain the laying length indicated on the Drawings and lay schedule.
e. Place metal or wooden spacers against the inside shoulder of the bells.
f. Joints may be pulled on one side and most joint designs can be closed on the opposite side of pipe for long radius curves and slight changes or correction of alignment and grade.
    1) Do not exceed the pipe manufacturer recommendation on the amount of joint deflection for the type and size of the joint being used.
g. Insert a thin metal feeler gauge between the bell and spigot after the joint is assembled in order to check the position of the gasket around the complete circumference of the pipe.
h. If the gasket is not in its proper position, disassemble the joint and inspect the gasket for cuts or damage.
    1) If gasket is damaged relay the pipe with a new gasket.
    2) If the gasket is not damaged, relay the pipe.
i. Install 2 interior or exterior bonding clips at each joint.

2. Flange joints:
    a. Flanges:
        1) Apply lining and coating to the steel pipe section as specified in this Section.
    b. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
3. Welded joints:
    a. Weld joints in accordance with the AWWA C206 for Field Welding of Steel Water Pipe and AWS D1.1 Structural Welding Code. Contractor shall provide adequate ventilation for welders and for Owner to observe welds.
        1) Unless otherwise specified, welds shall be full circle fillet welds.
        2) Exterior joint welding shall be completed before application of field applied joint coating for pipe 42 inches and smaller.
        3) It will be acceptable to weld the joint from the inside after the exterior joint coating and backfilling has been done for pipe 48 inches and larger, if it can be demonstrated that this procedure will not damage the exterior joint coating.
    b. A Welding Procedure Qualification (WPQ) and Procedure Qualification Record (PQR) shall be approved by Engineer before welding of joints begins. The procedure shall be in accordance with AWWA C206 and AWS D1.1.
    c. Adequate provisions for reducing temperature stresses shall be the responsibility of Contractor.
    d. If the Contractor chooses to use Weld after Backfill (WAB), special techniques shall be used to limit damage to the exterior coating system.
        1) Hand (stick) welding shall be used.
        2) The maximum heat input shall not exceed 23,000 joules.
        3) One test joint shall be provided for each welder.

4) After welding, the test joint shall be excavated to verify no unacceptable damage to the exterior coating system.
5) Should the inspection of the exterior coating reveal damage in the opinion of the Engineer, the test will be considered a failure and the coating will be removed and replaced at no additional cost to Owner.
6) The test for the failed welder may be repeated on another joint at Contractor's option with the approval of Engineer.
7) After the pipe has been joined and properly aligned and prior to the start of the welding procedure, the spigot and bell shall be made essentially concentric by tacking to obtain a 1/8 inch maximum clearance tolerance around the periphery of the joint.
8) In no case shall the clearance tolerance be permitted to accumulate.
9) Before welding, thoroughly clean pipe ends to bare metal.
10) All welding shall be hand welding to avoid damage to the coating system.
11) Cover the lining and/or coating as necessary to protect from welding splatter.

e. Furnish labor, equipment, tools and supplies to construct the work as required in the Contract Documents.
1) Protect welding rod from deterioration.
2) If any portion of a box or carton is damaged, reject the entire box or carton.

4. Restrained joints:
a. Double fillet-welded lap joints are required for areas of restrained length determined in accordance with AWWA Manual M11 and as required for pipeline bending.
1) The length of restraint must extend up to the full length required by the Calculation in accordance with AWWA Manual M11.
2) Joints that are determined to be partially restrained must always be rounded up to the nearest full length.

b. Restrain with single fillet welds on lap joints as required by AWWA Manual M11.
1) The length of restraint must extend up to the full length required by the Calculation in accordance with AWWA Manual M11.
2) Joints that are determined to be partially restrained must always be rounded up to the nearest full length.

5. Shrinkage/expansion control joints:
a. Provide a deeper bell to accommodate thermal movement for which the minimum lap shall be 4 inches.
b. Location:
1) At intervals not exceeding 1,000 feet along welded reaches of the pipeline.
2) The first regular lap-welded field joints outside of each concrete encasement or structure.
3) Where the shrinkage/expansion control joints occur in a traveled roadway or other inconvenient location, the location of the joint may be adjusted to a convenient location.

c. Installation:
1) Lay the pipe with an initial lap of not less than 1 inch greater than the typical lap.

2) Install welded shrinkage control joint when:
   a) The temperature is approximately the lowest during the workday.
   b) At least 500 feet of pipe have been laid and the joints have been welded ahead of and in back of the shrinkage control joint.
   c) After backfill has been completed to at least 1 foot above the top of the pipe ahead and in back of the joint.

6. Butt-strap joints:
   a. Dimensions shall be as indicated on the Drawings.
   b. Joint stress analysis will be required for restrained joint areas on pipelines 36 inches and larger.

F. Protection of buried metal:
   1. Coat buried ferrous metal that does not receive another coating such as bolts and flanges with heat shrink sleeves as specified in this Section.
   2. Coat buried ferrous metal that does not receive another coating such as bolts and flanges which cannot be protected with heat shrink sleeves, with 2 wraps of wax tape and encase in controlled low strength material as specified in Section 02312 - Controlled Low Strength Material (CLSM).

G. Joint lining and coating repair:
   1. As specified in this Section.

H. Joint bonding:
   1. As specified in Section 15302 - Galvanic Cathodic Protection.

3.02 FIELD QUALITY CONTROL

A. Perform field-testing as specified in Section 15052 - Common Work Results for General Piping.

B. The pipe manufacturer shall have a minimum of 5 years of experience in the fabrication and testing of outlets of similar size and configuration similar to those used on the Project.

3.03 CERTIFIED WELD INSPECTOR AND NON-DESTRUCTIVE EXAMINATION OF WELDS

A. Owner will retain the services of a certified weld inspector and non-destructive examination technician for the review of welding procedure specification, qualification, and individual welder's certifications.

B. Inspect full-penetration butt welds as follows:
   1. Visual (VT) examine 100 percent of root passes of each full penetration butt-welds.
      a. Ground root pass prior to VT examination.
   2. Visual (VT) and radiography (RT) examine 100 percent of final cover passes of each full penetration butt-welds.
   3. Acceptance criteria in accordance with ASME B31.3, Table 341.3.2 for the scheduled fluid service.

C. Inspect fillet welds as follows:
   1. Visual (VT) examine 100 percent of fillet welds, including root and cover passes.
   2. Magnetic particle (MP) examine 40 percent of fillet welds, including root and cover passes.
   3. Acceptance criteria in accordance with ASME B31.3, Table 341.3.2 for the scheduled fluid service.

D. Non-destructive radiographic examination:
   1. Qualified technician hired by Owner or Engineer to develop and interpret radiographic inspection procedure and radiographs.
   2. Make radiographs of welds in accordance with ASTM E94 and ASTM E1032.
      a. Approve in accordance with ASME BPVC Section V.
      b. Use at least 1 penetrometer with each radiographic negative.
      c. Take 1 set duplicate films and submit to Engineer.
   3. Develop radiographic film at the location where the radiography is performed.
      a. Contractor and Engineer view the radiographs and have them interpreted independently by a qualified NDE technician.
   4. Remove sharp protrusions made by film clips.
      a. Select penetrometers and place in accordance with ASTM E94.
      b. If the penetrometer cannot be placed on the source side, make a technique shot in accordance with the procedures included in ASTM E94, to demonstrate the ability to produce an acceptable technique.
      c. Submit the technique shot radiograph for approval.

E. Test double-welded buttstrap joints using the compressed air and soap method.
   1. Plug weld seal the threaded test fitting following successful completion of the test.

F. If the Contractor disagrees with the Engineer's interpretation of welding tests, additional test sections may be cut from the joint for physical testing.
   1. Contractor is responsible for the expense of repairing the joint, regardless of the results of physical testing.
   2. Engineer approval of joint repair procedure required before proceeding.

3.04 DEFECTS IN COATINGS EXCEPT CEMENT MORTAR AND TAPE WRAP

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
   1. Pipe joints exceeding the following defect maximum will be rejected.
      a. Minor defects:
         1) No more than 1.5 per 100 square feet of surface area.
         2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
         3) Repairs for adhesion testing will not be included in the total number of repairs.
         4) Repair in accordance with manufacturer's requirements.
      b. Major defects:
         1) No more than 3 major repairs on each pipe joint.
         2) No more than 30 percent repairs on the pipe surface area with defects.

2. Minor repairs:
    a. Repairs less than 8 inches in the greatest dimension.
    b. Repair in accordance with manufacturer's requirements.
3. Major repairs:
    a. Repairs that exceed 8 inches in the greatest dimension.
    b. Repair in accordance with manufacturer's requirements.

3.05 CEMENT MORTAR

A. Coating:
    1. Engineer will identify defective cement mortar coating to be field repaired in accordance with AWWA C205.
        a. Reject pipe with mortar coating defects on greater than 25 percent of the pipe surface.

B. Lining:
    1. Field applied interior joint lining:
        a. Field applied lining shall be of the same density, smoothness, and thickness as shop applied lining.
        b. After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar.
            1) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
            2) Remove excess cement mortar.

3.06 HEAT SHRINK SLEEVES

A. Apply heat shrink sleeve joint coating system as indicated on the Drawings.
    1. No cement mortar coating is required.
    2. Do not use heat shrink sleeves on complex shapes like couplings, valves, flanges, and other similar shapes.
    3. Field prepare pipe joints in accordance with SSPC-SP 1 and SSPC-SP 3 to remove dirt, mud, oil, and grease prior to application of heat shrink sleeve.
    4. Temperature requirements:
        a. Preheat pipe uniformly in accordance with sleeve manufacturer’s requirements.
            1) Monitor pipe temperature using a surface temperature gauge, infrared thermometer, or color changing crayons.
            2) Protect preheated pipe from rain, snow, frost, or moisture with tenting or shields and do not permit the joint to cool.
    5. Fill cracks, crevices, gaps, and step-downs greater than 1/8 inch with filler mastic.
        a. Apply filler material in accordance with the manufacturer's requirements.
    6. Overlap on a 1-inch wide step from outer wrap to middle wrap to inner wrap.
    7. Completed joint sleeve fully adhered to the pipe and existing coating surface without voids.
        a. Provide visible mastic beading along the full circumference of the sleeve.
        b. Wrinkling or excessive burns on the sleeves are not acceptable.
        c. Reject sleeves that do not meet requirements.
        d. Make minor repairs using heat applied patch material specified for minor coating repairs.

8. Allow the sleeve to cool before backfilling.
    a. In hot climates, provide shading from direct sunlight.
    b. Use water quenching only when permitted by the sleeve manufacturer.
9. Bury heat shrink sleeves as soon as practical after installation. Limit exposure to direct sunlight in accordance with manufacturer's requirements.
10. Reject heat shrink joint coatings which have become wrinkled or disbonded because of prolonged exposure to UV light or thermal cycling.
11. Double coating of defective heat shrink coatings will be permitted if the second sleeve is wider to adhere directly to the pipe.

3.07 PLURAL COMPONENT EPOXY

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.08 PLURAL COMPONENT POLYURETHANE

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.09 TAPE WRAP

A. Field applied coating shall be of the same density, smoothness, and thickness as shop applied coating.

B. Engineer will identify defective tape wrap coating to be field repaired in accordance with AWWA C214.
    1. Pipe joints exceeding the defect maximum will be rejected.
        a. No more than 5 repairs.
        b. No more than 2 areas of coating damage greater than 5 square feet.

C. Minor repairs:
    1. Repairs less than 8 inches in the greatest dimension.
    2. Complete minor repairs using a heat applied coating patch material.
    3. Limit material removal to only damaged layers:
        a. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting undamaged layers.
        b. Cut in a stepped fashion to expose 1-inch or more of the underlying tape layer for the circumference of the repair.
    4. Cut patch material to overlap onto the undamaged coating a minimum of 2 inches on each side with 1-inch radius on each corner of the patch.
    5. Apply patch material in accordance with manufacturer's requirements.

D. Major repairs:
    1. Repairs that exceed 8-inches in the greatest dimension.
    2. Complete major repairs:
        a. With heat shrink sleeves as specified for joints.
    3. Limit material removal to only damaged layers.
        a. Carefully remove damaged layers by cutting the coating with a sharp knife without cutting undamaged layers.
        b. Cut in a stepped fashion to expose 1-inch or more of the underlying tape layer for the circumference of the repair.
        c. If corrosion layer is exposed:
            1) Holiday test:
                a) If a holiday is detected:
                    (1) Cut outer layers back to fully expose the holiday(s).
                    (2) Retest for holidays.
    4. Apply repair material in accordance with manufacturer's requirements or as specified in this Section.
        a. Clean surfaces by solvent wiping and applying primer over the inner tape layer for a minimum of 6-inches onto the outer wrap in all directions.
        b. Cigarette wrap coating:
            1) Apply first layer of repair coating, over lapping 1-inch or more onto undamaged coating in all directions.
                a) On larger areas, lap the repair tape within a minimum of 1-inch overlap, offsetting the overlap from the previous layer overlap, until the area is properly covered.
                b) If corrosion layer is repaired:
                    (1) Holiday test:
                        (a) If a holiday is detected.
                        (b) Cut outer layers back to fully expose the holiday(s).
                        (c) Retest for holidays.
            2) Repeat for each tape layer damaged with each succeeding layer applied at 90 degrees to the preceding layers and overlapping onto the undamaged coating a minimum of 2-inches.
            3) Apply the last tape layer, use the cigarette wrap method for the full pipeline circumference covering any previous repair layers and overlapping a minimum of 2-inches onto undamaged coating.
                a) Point ends of the cigarette wrap downward.
        c. Heat shrink sleeves:
            1) Width of sleeve: Equal to width of the damaged area plus 4-inch overlap.
            2) Multiple sleeves may be used for larger repairs, but must be overlapped a minimum of 2 inches.

3.10 WAX TAPE COATING

A. Apply wax tap coating system in accordance with AWWA C217 and manufacturer's requirements.

B. Filler mastic:
    1. Irregular shapes: Apply filler mastic between primer and wax tape.
    2. Apply filler mastic by hand, working material on to metal to displace moisture to maximize adhesion.

3. Build up an even surface.

3.11 FIELD QUALITY CONTROL

A. Field test fabricated steel manifolds with the pipe to which they connect.

B. Weld testing:
   1. Liquid penetrant testing:
      a. As soon as possible after welding of pipeline joints, test fillet welds by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method “B” and “Leak Testing”.
      b. Chip out defects, rebell, and retest.
         1) Upon retest, the repaired area shall show no leaks or other defects.

3.12 CLEANING

A. Disinfection: Perform as specified in Section 01757 - Disinfection.

END OF SECTION

SECTION 15278

STEEL PIPE: EXPOSED

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Steel piping, joints, fittings, and fabricated steel piping fittings and specials.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.3 - Malleable-Iron Threaded Fittings: Classes 150 and 300.
   3. B16.5 - Pipe Flanges and Flanged Fittings.
   4. B16.9 - Factory-Made Wrought Buttwelding Fittings.
   5. B16.12 - Cast Iron Threaded Drainage Fittings.

C. American Water Works Association (AWWA):
   1. C200 - Steel Water Pipe 6 Inches and Larger.
   2. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe: 4 inches and Larger-Shop Applied.
   3. C206 - Field Welding of Steel Water Pipe.
   4. C207 - Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 inches Through 144 inches.
   5. C208 - Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
   6. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   7. C222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.
   8. C606 - Standard for Grooved and Shouldered Joints.
   9. M11 - Steel Pipe: A Guide for Design and Installation.

D. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Casting.
   2. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. A105 - Standard Specification for Carbon Steel Forgings for Piping Applications.
   4. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   5. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   6. A536 - Standard Specification for Ductile Iron Castings.
   7. C33 - Standard Specification for Concrete Aggregates.

8. C150 - Standard Specification for Portland Cement.
9. C205 - Standard Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements.
10. D297 - Standard Test Methods for Rubber Products-Chemical Analysis.
11. D395 - Standard Test Methods for Rubber Property-Compression Set.
12. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
13. D471 - Standard Test Methods for Rubber Property-Effect of Liquids.
14. D573 - Standard Test Methods for Rubber -Deterioration in an Air Oven.
15. D2000 - Standard Classification System for Rubber Products in Automotive Applications.
16. D2240 - Standard Test Method for Rubber Property-Durometer Hardness.
17. D4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
18. E165 - Standard Practice for Liquid Penetrant Testing for General Industry.

E. NSF International (NSF):
1. 61 - Drinking Water System Components - Health Effects.

F. Society for Protective Coatings (SSPC):
1. SP 5 - White Metal Blast Cleaning.
2. SP 10 - Near White Wet Blast.
3. SP 11 - Bare Metal Power Tool Cleaning.
4. QP 1 - Industrial Contractor Qualification.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Manufacturer's qualifications.
1. Manufacturer qualifications and list of projects using the specified material: 5 years minimum.
2. Plural component epoxy and polyurethane field repair: SSPC-QP 1 certification required.

D. Manufacturer's Quality Assurance Manual:
1. Submit manufacturer's coating and lining application quality assurance manual to Engineer prior to beginning coating application.
    a. Strict conformance to the requirements of the manual will be required.
    b. Deviation from the requirements of the manual will be grounds for the Engineer to reject the applied coating.

E. Shop drawings:
1. Details of fittings and specials showing thickness and dimensions of plates.
2. Details of welds and materials.
3. Listing of proposed services and locations for use of grooved joint type piping.
4. Tabulated layout schedules for cement-mortar lined and coated steel pipe.
5. Grooved joint piping fittings, gaskets, and couplings.

6. Grooving of pipe and fittings.

F. Calculations:
   1. Submit calculations prepared and stamped by a professional engineer licensed in the State of Utah. The calculations shall be based on the requirements defined in this Section.
   2. Design calculations: Wall thicknesses for external loading, special loading, internal pressure, and other necessary design cases.

G. Certificates of Compliance: Cement-mortar lined and coated steel pipe.

H. Mill certificates.

I. Test reports: Rubber gaskets.

1.04 QUALITY ASSURANCE

A. Applicable standards:
   1. Steel pipe larger than 12 inches diameter shall conform to the following standards, as complemented and modified in this Section:
      a. Steel pipe: AWWA C200.
      b. Fittings and specials: AWWA C208.
      c. Reinforcement of fittings and specials: AWWA M11.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Design requirements:
   1. Design criteria for pipe and pipe fittings: In accordance with AWWA M11 with the following modifications:
      a. Wall thickness: Thicker of the thickness specified in Section 15052 - Common Work Results for General Piping Pipe Schedule, and the following thickness:
         1) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
         2) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
         3) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
      b. Inside diameter of unlined pipe: Nominal.
      c. Inside diameter of lined pipe: As measured from face to face of liner, but not less than nominal.
      d. Deflection of underground pipe inside diameter: Maximum 2 percent under trench load of H-20 live load in accordance with AASHTO specifications.
      e. Working stress of steel: Maximum 50 percent of yield stress.
      f. Contractor shall develop and submit calculations to determine the steel pipe and fitting wall thickness and design requirements according to the requirements of this specification.

2.02 MATERIALS

A. The requirements for steel piping materials used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Steel pipe:
   1. Type, pipe 6 inches and smaller: ASTM A53, black or galvanized, seamless or straight seam electric resistance welded. Minimum Schedule 40.
   2. Type, from 6 to 12 inches: ASTM A53, black or galvanized pipe, seamless or straight seam electric resistance welded. Minimum Schedule 20.
   3. Type, larger than 12 inches: AWWA C200, without butt strap, riveted, or swaged joints; wall thickness as specified.
   4. Type, 24 inches and larger, with grooved type couplings and wall thickness less than 1/2-inch: Provided with stub ends, sized as follows, for grooves.
      a. Thickness: As recommended by coupling manufacturer, but not less than 1/2-inch.
      b. Length: Width of coupling plus 1 inch, but not less than 6 inches.
   5. Type for liquid or gaseous dry chlorine: ASTM A106, Grade A, Schedule 80, assembled with 300 pounds per square inch malleable iron fittings and ammonia type flanges.

C. Steel pipe fittings:
   1. Screwed fittings:
      a. Malleable iron: ASME B16.3, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Cast iron drainage: ASME B16.12, galvanized in accordance with ASTM A153 where used with galvanized pipe.
   2. Flanged fittings:
      a. Type for 12-inch and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; or ASME B16.5, steel, 150 pounds, galvanized in accordance with ASTM A153 where used with galvanized pipe.
      b. Type for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207 and AWWA C208, fabricated from flanges and steel pipe, respectively.
      c. Companion flanges for 4 inches and smaller pipe: ASME B16.1, cast iron or ductile iron, 125 pounds; ASME B16.5, steel, 150 pounds, slip-on or welding neck; or ammonia type for use on chlorine liquid or gas piping.
      d. Companion flanges for larger than 4 inch to and including 12-inch pipe: ASME B16.5, slip-on or welding neck type.
      e. Companion flanges for larger than 12-inch pipe: ASME B16.5, steel, 150 pounds; galvanized in accordance with ASTM A153 where used with galvanized pipe; or AWWA C207, steel plate or raised hub type.
      f. Weld flanges to pipe or fittings before applying lining.
      g. Machine flanges or provide tapered filler for changes in grade or to slope lines for drainage.
      h. Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
      i. Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

3. Welding fittings:
    a. Welding fittings for piping 8 inches and less in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, standard wall, or standard weight.
    b. Welding fittings for piping larger than 8 inches in nominal diameter: Butt-welding fittings in accordance with ASME B16.9, or, at the option of the Contractor, made up out of sections of pipe welded together, except where smooth bends are indicated for air lines.
    c. Fittings made up of sections of pipe welded together shall be made of pipe of at least the same wall thickness as the pipe with which used, and bends shall be miter bends, fabricated in accordance with AWWA C208 and as supplemented by AWWA M11. Welding of these made-up fittings shall be in accordance with AWWA C206.
        1) Design and fabricate outlets and 4 branch fittings in accordance with AWWA M11.
        2) Bends may be welded to adjacent pipe sections.
            a) Bends shall be manufactured of the following number of pieces:
                (1) Bends from 0 to 30 degrees angle, 2 pieces.
                (2) Bends from 30 to 45 degrees angle, 3 pieces.
                (3) Bends from 45 to 67-1/2 degrees angle, 4 pieces.
                (4) Bends from 67-1/2 to 90 degrees angle, 5 pieces.
4. Grooved joint fittings:
    a. Fittings for grooved joint steel piping: Rigid-grooved type, and as follows:
        1) Grooves: Cut; rolled grooves are not acceptable.
        2) Couplings: Cast in 2 or more segments of ductile iron in accordance with ASTM A536, Grade 65-45-12 or malleable iron in accordance with ASTM A47, Grade 32510.
        3) Bolts and nuts: As specified in Section 15052 - Common Work Results for General Piping.
        4) Gaskets: Composition water sealing designed so that the internal piping pressure serves to increase the seal's watertightness.
            a) Gaskets for water service and oil-free air systems at temperatures less than 230 degrees Fahrenheit shall be made of ethylene propylene diene monomers (EPDM) in accordance with ASTM D2000 Line Call Out 2CA615A25B24.
            b) Gaskets for use with cement-mortar lined steel piping shall be captured between the ends of the pipe to protect exposed metal from corrosion, and shall be made of nitrile in accordance with ASTM D2000, Line Call Out 2CA615A25B24.
        5) Perform grooving of the pipe wall only on standard or heavier schedule weight pipe.
            a) For pipe with wall thickness less than standard weight, weld a shouldered end on the pipe in accordance with AWWA C606.
            b) Fabricated pipe, pipe in accordance with AWWA C200, shall have shouldered ends welded onto the pipe.
            c) Shoulder: Type B or D in accordance with AWWA C606.
        6) Couplings and grooving:
            a) Manufacturers: One of the following or equal:
                (1) Gustin-Bacon Piping Products.
                (2) Victaulic Co.

b. Fittings for grooved joint piping: Ductile iron in accordance with ASTM A536, Grade 65-45-12, or malleable iron in accordance with ASTM A47, Grade 32510, and as follows:
    1) Where cast fittings are not made, standard fittings including large diameter elbows shall be made of forged steel in accordance with ASTM A105, Grade B with 0.375 inch wall thickness, or shall be standard segmentally welded fittings fabricated of Schedule 40 carbon steel pipe.
        a) Grooves:
            (1) Manufacturers: One of the following or equal:
                (a) Gustin-Bacon Piping Products.
                (b) Victaulic Co.
    2) Fittings for grooved joint piping shall be furnished by the manufacturer of the grooved joint material.
    3) Fittings for grooved joint piping shall be for rigid-grooved type joints.
    4) Connection to flanged units shall be by means of flange to grooved joint adapters.
        a) Where the flanged to grooved joint adapters interfere with the operation of adjacent valves, pumps, or other items, the connection shall be by means of a spool with one end flanged and the other grooved, long enough to prevent interference with adjacent valves, pumps, or other items.

D. Steel pipelining and coating:
    1. General:
        a. Except where otherwise specified in the Specifications or indicated on the Drawings, lining and coating for steel pipe shall be as specified in Section 15052 - Common Work Results for General Piping.

E. Fabricated steel piping fittings and specials:
    1. General: Specified in this Section are the design and fabrication of fabricated steel piping fittings and specials, which include elbows, branches, nozzles, manifolds, headers, heads, collars, stiffeners, reinforcements, and other steel fabrications relating to steel piping, but shall not include steel pipe.
    2. Design:
        a. Contractor shall design and detail fittings and specials.
            1) Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
            2) Nozzles: Reinforced in accordance with recommended practice in AWWA M11, Steel Pipe Manual.
            3) Design reinforcing for fittings and specials for the specified test pressure.
            4) Fittings shall conform in dimension to AWWA C208, complemented with the provisions specified in this Section.
            5) The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
        b. The thickness of pipe, large elbows, and headers, except header nozzles, shall be the thicker of:
            1) The thickness designed in accordance with the design methods specified in this Section.

2) The thickness indicated on the Drawings or specified in Section 15052 - Common Work Results for General Piping Pipe Schedule, or as required by the Contractor's calculations.
3) The following thicknesses:
a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.

c. Elbows shall be of the number of pieces as specified in this Section, and thickness of material shall conform to thickness of pipe or manifold shells specified.
d. Ends of fittings to be welded to pipe shall be beveled for welding.

3. Fabrication:
a. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation. Minimize number of field welds.
b. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
c. Fabricate fittings and specials to allow field assembly without cutting or special work.
d. Where specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping or indicated on the Drawings, the inside of fabricated steel manifolds and other fittings and specials shall receive a cement-mortar lining in accordance with AWWA C205.
1) Reinforce lining for piping 24 inches in diameter and larger with wire fabric.
e. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
1) Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment. Properly locate and align equipment.

4. Dished heads:
a. Dished heads on 84 inch diameter and smaller manifolds: 1 piece (seamless) spherically dished (torispherical) heads.
1) Larger heads may be seamed.
b. Dish radius: Same dimension as the outside diameter of the head measured at skirt.
c. Skirt face length: Not less than 3 inches.
d. Design heads in accordance with recommended practice in AWWA M11, Steel Pipe Manual.

5. Testing: No shop testing will be required for manifolds or piping connected thereto.

F. AWWA C200 steel pipe and fittings design and fabrication:
1. General:
a. Applicable standards: AWWA C200 steel pipe shall conform to the standards specified in General of this Section.

b. Identification marks: Provide identification marks in accordance with AWWA C200. These marks shall be stenciled or otherwise shown at the top of the piping items exterior, including the following information:
    1) Name or trademark of the manufacturer.
    2) Date of manufacture of the item.
    3) Internal diameter in inches.
    4) Number of the item, sequential from initial to end station.
c. Diameter designation: The pipe diameter specified in the Specifications and indicated on the Drawings shall be the clear inside diameter after application of the cement-mortar lining with a tolerance of plus 0 inch and minus 1/4 inch.

2. Design:
    a. Pipe and fittings shall be designed by Contractor.
    b. Design: In accordance with the recommended procedures in AWWA Manual M11, as complemented and modified in this Section.
    c. Thicknesses of pipe, fittings and specials shall be the thicker of:
        1) The thickness designed in accordance with the design methods specified in this Section.
        2) The thickness indicated on the Drawings or specified in Section 15052 - Common Work Results for General Piping Pipe Schedule.
        3) The following thicknesses:
            a) For pipes smaller than 26 inches in diameter: Minimum 1/4 inch.
            b) For pipes 26 inches and larger but less than 38 inches in diameter: Minimum 5/16 inch.
            c) For pipes 38 inches and larger in diameter and including 72 inches in diameter: Minimum 3/8 inch.
    d. The working stress for steel used for fabrication of pipe shall not exceed 50 percent of the yield stress.
    e. Break longitudinal and girth seams for straight seam pipe shall be no greater in number than would be required for the fabrication of pipe with 96-inch by 120-inch steel plates.
        1) Break longitudinal seams at the girth seams.
    f. Design pipe, fittings and specials for a deflection, under external loads, not to exceed 2 percent of the diameter.
        1) Stiffness computations shall not consider the effect of the cement-mortar lining and coating.
        2) Calculate deflection using the Spangler formula and the following values:
            a) Bedding constant K = 0.100.
            b) Modulus of soil reaction E' = 700 pounds per square inch.
            c) Deflection lag constant D_1 = 1.00.
    g. Where piping is designated to be flanged or welded in order to restrain thrust, the design of the cylinder and flange or welded joint shall take into account the effect of stresses caused by thrust loads.

3. Materials:
    a. Coatings and linings: As required in Section 15052 - Common Work Results for General Piping.

b. Gaskets shall be as specified in Section 15052 - Common Work Results for General Piping and meet the following requirements:
    1) Minimum tensile strength, tested in accordance with ASTM D412, between 2,000 and 2,700 pounds per square inch.
    2) Minimum elongation, tested in accordance with ASTM D412, between 350 and 400 percent.
    3) Shore A durometer hardness, tested in accordance with ASTM D2240, between 50 and 65.
    4) Specific gravity, tested in accordance with ASTM D297, between 0.90 and 1.50.
    5) Maximum compression set, tested in accordance with Method B of ASTM D395, 20 percent.
    6) Maximum tension strength loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
    7) Maximum elongation loss, tested in accordance with ASTM D573 at 96 hours, 70 degrees Centigrade, in air, 20 percent.
    8) Maximum absorption, tested in accordance with ASTM D471 at 48 hours, 70 degrees Centigrade, in air, 5 percent.

4. Joints and connections:
    a. Joints:
        1) Except as otherwise specified or indicated on the Drawings, provide lap welded or bell and spigot type joints with rubber gaskets for pipelines 54 inches and smaller.
        2) Butt-strap joints shall be used only where required for closures or where indicated on the Drawings.
        3) The joints furnished shall have the same or higher-pressure rating as the abutting pipe.
    b. Connections:
        1) Connections to existing systems shall be made using a flange isolation joint.
        2) If an existing pipeline or facility does not include a flange at or near the connection point:
            a) An isolation flange shall be placed in the first length of pipe.
            b) A butt-strap joint shall be used to connect the first length of pipe to the existing pipeline.
    c. Bell and spigot joint rings: Rolled Carnegie shape M-3516.
    d. Lap welded joints:
        1) Double fillet weld lap welded joints shall be welded on the inside and outside of the joint.
        2) Lap joints prepared for electric field welding shall be in accordance with AWWA C206.
        3) Joint forming:
            a) Joint geometry and joint field weld will be such that no part of any field weld will be closer than 1 inch to the nearest point of tangency to the bell radius.
            b) Bell ends shall be formed by and expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape.

4) Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

e. Butt-strap joints: Butt-strap joints where used or required, shall be:
   1) A minimum of 10 inches wide.
   2) The same thickness as the pipe wall.
   3) Provide for a minimum of 2-inch lap at each pipe joint.
   4) Double fillet weld each side of joint on the inside and outside of the joint.

f. Flanges: AWWA C207, Class D, steel ring, and as follows:
   1) Match pipe flanges to the valve flanges:
      a) At flanged joints connecting to valves, provide a steel pipe section without rod reinforcing and not less than 24 inches in length.
      b) Apply cement-mortar lining and coating to the steel pipe section.
   2) Flange bolts: As specified in Section 15052 - Common Work Results for General Piping.
   3) Gaskets: As specified in Section 15052 - Common Work Results for General Piping.

5. Fabrication:
   a. Shop coat of primer: Flanges and portions of pipe not covered with cement-mortar shall be given a shop coating of primer.
   b. Bend radii of fittings: Not less than 1.0 times the nominal diameter, unless otherwise noted.

2.03 COATING AND LINING - GENERAL

A. Coating and lining shall be as indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping.

B. Extend pipe coatings for underground piping 6-inches above finished grade or 3 inches above finished floor, and neatly terminate.

C. As specified in Section 01600 - Product Requirements.

D. Prepare, install, and repair in accordance with manufacturer's requirements.

E. Contractor is responsible for:
   1. That coating selected is suitable for the application conditions anticipated, such as temperature, humidity, etc.
   2. Managing the project schedule to allow adequate cure time before backfill or immersion based on surface temperatures at the time of application.

2.04 CEMENT MORTAR

A. Line pipe with cement mortar in accordance with AWWA C205 and as specified in this Section).
   1. Cement:
      a. Cement: In accordance with ASTM C150, Type II.
   2. Water:
      a. In accordance with AWWA C205 and as specified in this Section.

3. Sand and aggregate:
    a. In accordance with AWWA C205.
    b. Provide silica sand or other aggregate that is not subject to leaching in accordance with ASTM C33.

B. Lining:
1. Line special pieces or fittings by mechanical, pneumatic, or hand placement.
    a. Extend to faces of flanges and ends of spigots.
    b. Less than 12 inches in width: Coat with epoxy bonding agent prior to applying cement mortar.
    c. Larger than 12 inches in width: Reinforced with 2-inch by 4-inch No. 13 gauge welded steel wire mesh prior to applying cement mortar.
2. Provide plastic end caps of sufficient thickness and strength to resist shipping, handling, and storage stresses.
3. Repair damage to the cement mortar lining, including disbondment, or cracking caused by improper curing, shipping, handling, or installation in accordance with AWWA C205 and approved by the Engineer.
    a. Reinforce coating with 2 layers spirally-wound steel wire positioned approximately in center of mortar coating positioned approximately at the third points of mortar coating:
        1) No. 12 gage spaced at maximum 1-inch centers.
        2) No. 14 gage steel wire at maximum 1/2-inch centers.

2.05 EPOXY POLYURETHANE

A. Coat pipe with epoxy polyurethane system EPU-M-1 per Section 09960 - High Performance Coatings.

B. Surface preparation:
1. In accordance with AWWA C210 and as specified in Section 09960 - High Performance Coatings.

C. Primer: In accordance with coating manufacturer's requirements.

D. Application:
1. Apply coating using equipment by a manufacturer certified coating applicator.
2. Perform coating application in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer.
    a. It is not acceptable to apply coating in outdoor conditions without adequate environmental shelter, environmental controls, and/or dehumidification.
3. Concrete embedded pipe penetrations: Extend coating a minimum of 6 inches outside of interior and exterior surfaces of concrete walls or floors.
4. Concrete penetrations minimum dry film thickness: 12 mils.

E. Adhesion test procedures:
   1. Use self-aligning pneumatic pull off equipment and test procedures in accordance with ASTM D4541, Method E, using Delfesko Positest AT-A except as modified in this Section.
      a. Perform at an applied load rate of 100 pounds per square inch per second, plus or minus 10 pounds per square inch.
      b. Use automatic adhesion test equipment.
      c. Perform tests to coating or glue failure or maximum test load, whichever happens first.
      d. In accordance with ASTM D4541 using standard 20 millimeter dollies.
      e. Base adhesion testing on 3 tests.
         1) Conduct the tests by the same person, test equipment, and test procedure.
         2) Complete the tests within a 30 minute period.
      f. Conduct adhesion tests within an area not to exceed 6 inches by 6-inches.
      g. Score coatings with more than 10 percent elongation or 25 mils thick around dolly to metal substrate using manual methods and tools, normal to the pipe surface, and in a manner that does not stress or overheat the coating.
   2. Attach dollies for adhesion testing to the coating surface using a 2 part epoxy or cyanoacrylate glue and cured for a minimum of 12 hours before testing or until full cure, whichever is greater.
      a. Pipe fabricator and coating manufacturer determine glue type for the pipe diameter, temperatures, and environmental conditions.
   3. Perform adhesion testing at temperatures between 55 and 90 degrees Fahrenheit or at temperatures in accordance with coating manufacturer's requirements.
      a. Testing up to 115 degrees Fahrenheit or below 55 degrees Fahrenheit will be permitted if tests can demonstrate no statistically detectable effect on test results and in accordance with coating manufacturer's requirements and Engineer's approval.
   4. Epoxy coating and lining adhesion criteria:
      a. Coating is acceptable if first dolly pull test exceeds 1,750 pounds per square inch, minimum.
      b. If first dolly pull is less than 1,750 pounds per square inch, perform 2 additional tests with acceptance based on "Best of 3" evaluation method as defined in this Section.
   5. Pipe lot performance criteria:
      a. Minimum median value for coating or lining adhesion tests: 2,000 pounds per square inch.
      b. Classify failing pipe lots as rejected until 100 percent of the pipe within the pipe lot has been tested for adhesion.
         1) Reject each pipe that fails the coating adhesion criteria.
   6. Adhesion test evaluation and records:
      a. Definition: "Best of 3" evaluation method is when 2 of 3 test values meet the adhesion criteria.
      b. Consider adhesion tests as valid and suitable for acceptance or rejection of the coating, except where retesting is required.

c. Adhesion test failure:
    1) Adhesive or substrate failure.
        a) Definition: A percentage of separation of the coating from the steel substrate or between distinct coating layers.
    2) Cohesive test failure.
        a) Definition: A percentage of failure within the coating, resulting in coating remaining both on the steel substrate and test dolly.
d. Retest coating adhesion tests:
    1) When any test is glue failure at 25 percent or more of dolly surface area and the test value is less than the Acceptance Criteria or the Minimum Criteria.
    2) Within the same 6-inch by 6-inch test area as the original adhesion testing.
    3) Retest disputed adhesion tests.
        a) Owner's representative will witness dolly attachment and adhesion retesting.
e. Adhesion tests will be conducted on pipe coating and lining independently and will be accepted or rejected independently.
f. Maintain adhesion test records in an electronic spreadsheet that includes the following information:
    1) Pipe identification.
    2) Pipe coating date.
    3) Adhesion test date.
    4) Surface tested (interior or exterior).
    5) Surface temperature at time of test.
    6) Coating thickness.
    7) Tensile force applied.
    8) Applied load rate per second.
    9) Mode of failure.
    10) Percentage of failure types, previously defined, relative to dolly surface area.
    11) Dolly size and attachment glue used.
    12) If different coatings are tested, include coating manufacturer and product number.

7. Adhesion test repairs:
    a. Fabricator or contractor to complete adhesion repairs as specified this Section.
    b. Randomly select repair patches on epoxy or polyurethane coating for adhesion testing in a manner as described in this Section and at the discretion of the coating inspector.

F. Long term adhesion test:
1. Acceptance criteria:
    a. Not more than 10 percent loss of adhesion over duration of test.
    b. Differential based on the highest average adhesion result to the lowest average adhesion result.
2. Test durations, cumulative:
    a. 1 day.
    b. 7 days.
    c. 3 weeks.
    d. 2 months.

3. Sample preparation:
    a. SSPC-SP 5, 3.00 mils profile, minimum.
    b. Test area minimum: 18 inches by 18 inches.
    c. Curved steel plate:
        1) Minimum radius of 15 inches.
        2) Inclined between 30 and 45 degrees.
4. Test procedure:
    a. Expose samples to ambient, outdoor conditions, and facing in a southern direction for maximum UV exposure for the full duration of the test.
5. Adhesion test results:
    a. Based on 8 pulls per test period with the 3 lowest pulls discarded.
    b. Based an average of the 5 highest pulls and identify the values used.
6. Record adhesion pulls and their failure mode.
7. Repair sample after adhesion tests to prevent water from causing any effects on subsequent adhesion tests.

PART 3 EXECUTION

3.01 INSTALLATION

A. The requirements for installation of steel pipe used in plumbing systems are found in Section 15400 - Plumbing Systems.

B. Joints:
1. Steel pipe joints shall be screwed, welded, flanged, grooved, or made with flexible joints. The type of joint for piping is specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping.
2. In addition to the joints indicated on the Drawings, provide unions, flexible couplings, flanged joints, and other types of joints or means necessary to allow ready assembly and disassembly of the piping.
3. Unless otherwise indicated on the Drawings or specified in the Piping Schedule in Section 15052 - Common Work Results for General Piping, pipe joints shall be as follows:
    a. Pipe smaller than 2 inches in nominal diameter shall have screwed joints or flexible couplings.
    b. Pipe 2 inches to 4 inches in nominal diameter shall have screwed joints, flanged joints, welded joints, or joints made with flexible couplings.
    c. Pipe larger than 4 inches in nominal diameter shall have flanged joints, welded joints, or joints made with flexible couplings.

C. Screwed joints:
1. Perform threading with clean, sharp dies.
    a. Wavy, rough, or otherwise defective pipe threads are not acceptable.
2. Make screwed joints tight and clean with an application of Teflon™ tape or approved paste compound applied to the male threads only, except as follows:
    a. Make up liquid and dry chlorine lines, and liquefied petroleum gas lines, with litharge and glycerin.
3. Provide railroad type unions with bronze-to-iron seat, galvanized where used with galvanized pipe.
    a. Flanged joints may be used instead of unions.

D. Flanged joints:
   1. In flanged joints, flanges shall come together at the proper orientation with no air gaps between the flanges after the gaskets are in place.
   2. Attach slip-on flanges to pipe by 2 fillet welds, in accordance with AWWA C207.
   3. Secure welding neck flanges with full penetration butt welds without backing rings.
      a. After welding in place, the faces of flanges shall be perpendicular to the axis of the pipe, or, in the case of fittings, at the proper angle to each other, and bolt holes shall be in proper alignment.

E. Welded joints:
   1. Welded joints shall be electric welded in accordance with AWWA C206.
   2. Welders shall be qualified pursuant to the provisions of AWWA C206.
      a. Welders' testing shall be at the Contractor's expense, including cost of test nipples, welding rods, and equipment.
   3. Do not weld galvanized pipe.

F. Grooved joints:
   1. Piping with grooved joints shall be installed where indicated on the Drawings and may be installed in place of flanged piping and screwed piping, except that grooved joint piping shall not be used in the following installations:
      a. In underground and underwater installations.
      b. In piping subject to test pressures of 150 pounds per square inch gauge, or more.
      c. In steam and gas piping.
      d. In sludge and scum piping designed to be steam cleaned.
   2. Assemble in accordance with manufacturer's published instructions.
   3. Support grooved-end pipe in accordance with manufacturer's recommendations. In addition, provide at least 1 support between consecutive couplings.

3.02 DEFECTS IN COATINGS EXCEPT CEMENT MORTAR

A. Engineer will identify defective coating to be field repaired in accordance with the applicable AWWA standard.
   1. Pipe joints exceeding the following defect maximum will be rejected.
      a. Minor defects:
         1) No more than 1.5 per 100 square feet of surface area.
         2) 2 or more minor repairs within an 8-inches diameter circle will be considered a single repair.
         3) Repairs for adhesion testing will not be included in the total number of repairs.
         4) Repair in accordance with manufacturer's requirements.
      b. Major defects:
         1) No more than 3 major repairs on each pipe joint.
         2) No more than 30 percent repairs on the pipe surface area with defects.
   2. Minor repairs:
      a. Repairs less than 8-inches in the greatest dimension.
      b. Repair in accordance with manufacturer's requirements.

3. Major repairs:
    a. Repairs that exceed 8-inches in the greatest dimension.
    b. Repair in accordance with manufacturer's requirements.

3.03 CEMENT MORTAR

A. Lining:
    1. Field applied interior joint lining:
        a. Field applied lining shall be of the same density, smoothness, and thickness as shop applied lining.
        b. After the backfill has been completed to final grade, fill interior joint recess with tightly packed cement mortar.
            1) Trowel flush with the interior surface with no indentation or projection of the mortar exceeding 1/16-inch.
            2) Remove excess cement mortar.

3.04 EPOXY POLYURETHANE

A. Joints:
    1. Field applied coating or lining shall be of the same density, smoothness, and thickness as shop applied coating or lining.
    2. Comply with same application requirements as shop applied coating or lining.
        a. Provide heating and/or dehumidification equipment as required to meet the environmental conditions necessary for proper coating application.

3.05 FIELD QUALITY CONTROL

A. Field test fabricated steel manifolds with the pipe to which they connect.

B. Weld testing:
    1. Liquid penetrant testing:
        a. As soon as possible after welding of pipeline joints, all fillet welds shall be tested by the liquid penetrant inspection procedure in accordance with ASTM E165 under Method “B” and “Leak Testing”.
        b. Chip out defects, rebell, and retest.
            1) Upon retest, the repaired area shall show no leaks or other defects.

END OF SECTION

SECTION 15286

STAINLESS STEEL PIPE AND TUBING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Stainless steel piping and tubing.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   2. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   3. B16.11 - Forged Fittings, Socket-Welding and Threaded.
   4. B31.3 - Process Piping.
   5. B36.19 - Stainless Steel Pipe.

B. ASTM International (ASTM):
   1. A182 - Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   2. A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   3. A194 - Standard Specification for Carbon and Alloy Steel Nuts and Bolts for High Pressure or High Temperature Service, or Both.
   4. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   5. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   6. A276 - Standard Specification for Stainless Steel Bars and Shapes.
   7. A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   8. A351 - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   9. A380 - Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   10. A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
   11. A743 - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
   12. A744 - Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.

13. A774 - Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Services at Low and Moderate Temperatures.
14. A778 - Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
15. A789 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service.
16. A790 - Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.
17. A928 - Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal.
18. A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
19. B622 - Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube.
20. B912 - Standard Specification for Passivation of Stainless Steels Using Electropolishing.
21. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

C. NSF International (NSF):
   1. Standard 61 - Drinking Water System Components - Health Effects.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15052 - Common Work Results for General Piping.

C. Shop Drawings:
   1. Detailed layout drawings:
      a. Dimensions and alignment of pipes.
      b. Location of valves, fittings, and appurtenances.
      c. Location of field joints.
      d. Location of pipe hangars and supports.
      e. Connections to equipment and structures.
      f. Location and details of shop welds.
   2. Thickness and dimensions of fittings and gaskets.
   3. Photographs, drawings, and descriptions of pipe, fittings, welding procedures, and pickling and passivating procedures.
   4. Material specifications for pipe, gaskets, fittings, and couplings.
   5. Data on joint types and components used in the system including stub ends, backing flanges, flanged joints, grooved joint couplings and screwed joints.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. Piping layout: Lay out and fabricate piping systems with piping sections as long as possible, while still allowing shipment, so that joints are minimized.
   1. Piping design indicated on the Drawings illustrates piping layout and configuration and does not indicate the location of every joint and flexible coupling that may be needed to connect piping sections fabricated in the shop.
   2. Where joints and couplings are specifically indicated on the Drawings, design and shop-fabricate piping sections utilizing the joint or coupling illustrated at the locations shown.
   3. Add joints and flexible couplings in a manner that achieves intent of maximizing size of individual piping sections.

B. Shop fabrication: Fabricate piping sections in the shop and pickle and passivate at point of manufacture.

C. Field assembly:
   1. Field welding is prohibited.

2.02 STAINLESS STEEL PIPE

A. General:
   1. Pipe sizes specified in the Specifications and indicated on the Drawings are nominal.

B. Wall thickness:
   1. Piping 3 inches in nominal diameter and greater:
      a. For general service applications with pressures less than 250 pounds per square inch gauge, pipe diameter 24-inches or less, minimum wall thickness corresponding to Schedule 10S.
   2. Piping less than 3 inches in nominal diameter:
      a. Piping with threaded or grooved joints:
         1) Minimum wall thickness corresponding to Schedule 40S.
      b. Piping with Vic-Press joints:
         1) Minimum wall thickness corresponding to Schedule 10S.

C. Piping material and manufacturing:
   1. Comply with the requirements outlined in the following table:

Service	Stainless Steel Grade	Pipe Manufacturing Process
For low chloride water service with chloride concentrates below 200 parts per million and/or free chlorine less than 2 parts per million at ambient temperatures.		
Piping 3 inches in nominal diameter and larger	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A778
Piping less than 3 inches in nominal diameter	Type 304L stainless steel in accordance with ASTM A240	In accordance with ASTM A312

D. Fittings for piping 3 inches in nominal diameter and greater:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A774.
   3. Wall thickness of fitting: In accordance with ASME B36.19 for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Dimensional standards:
      a. Fittings with weld ends: In accordance with ASME B16.11.
      b. Fittings with flanged ends: In accordance with ASME B16.5, Class 150.

E. Fittings for piping less than 3 inches in diameter:
   1. Material: In accordance with ASTM A240 stainless steel, grade to match the pipe.
   2. Manufacturing standard: In accordance with ASTM A403, Class WP.
   3. Wall thickness and dimensions of fitting: In accordance with ASME B16.11 and as required for the schedule of pipe specified.
   4. End configuration: As needed to comply with specified type of joint.
   5. Forgings in accordance with ASTM A182, or barstock in accordance with ASTM A276. Match forging or barstock material to the piping materials.

F. Piping joints:
   1. Joint types, piping greater than 2 inches in diameter, general:
      a. Where type of joint is specifically indicated on the Drawings or specified, design and shop-fabricate piping sections utilizing type of joint illustrated or scheduled.
      b. Where type of joint is not specifically indicated on the Drawings or as specified in Section 15052 - Common Work Results for General Piping, Piping Schedule, design and shop-fabricate piping sections utilizing any of the following joint types:
         1) Piping stub ends with backing flanges.
         2) Welded joints.
         3) Flanged joints.
         4) Grooved joints.
      c. Joints at valves and pipe appurtenances:
         1) Provide flanged valves and flanged pipe appurtenances in stainless steel piping systems with flanged ends.
         2) Design and fabricate piping sections to make connections with flanged valves and pipe appurtenances using piping stub ends with backing flanges, flanged coupling adapters or flanged joints.
            a) Flexible couplings and flanged coupling adapters: Provide stainless steel construction with materials matching the piping system and in accordance with requirements as specified in Section 15121 - Pipe Couplings.
   2. Joints in piping 2 inches in diameter and smaller: Flanged, grooved, welded, press fit, or screwed with Teflon™ tape thread lubricant.
   3. Welded joints:
      a. Piping 12 inches and larger in diameter: Automatically weld joints using gas tungsten-arc procedures.
      b. Piping 4 inches through 12 inches in diameter: Double butt welded joints.
      c. Piping less than 4 inches in diameter: Single butt-welded joints.

d. Mark each weld with a symbol that identifies the welder.

4. Flanged joints: Conforming to the requirements in accordance with ASME B16.5, Class 150
5. Piping stub ends and backing flanges for pipe 3 inches and larger:
   a. Piping stub ends: Cast stainless steel to match the pipe material with machined gasket and wetted surfaces of stub ends free of crevices, pits, cracks and protrusions.
      1) Manufacturers: The following or equal:
         a) Alaskan Copper Works, Figure SK-38.
   b. Backing flanges: Forged or plate stainless steel (type to match pipe material) with drilled bolt patterns in accordance with ASME B16.1, Class 125 or ASME B16.5, Class 150.
      1) Manufacturers: The following or equal:
         a) Alaskan Copper Works, Figure SK-39 (tube) or SK-39P (pipe).
   c. Stub ends and backing flanges are not allowed for use with wafer style or lugged style valves.
6. Flanges for Schedule 40S and Schedule 80S pipe:
   a. Provide forged stainless steel (type matching piping system) welding neck flanges or slip-on flanges in accordance with ASME B16.5 Class 150.
   b. Material: In accordance with ASTM A182.
7. Grooved joints:
   a. Pressure less than 500 pounds per square inch:
      1) Cut grooves from Schedule 40 or higher.
   b. Heavier schedule pipe sections used for cut groove ends:
      1) Tapered inside diameter to transition from the inside diameter of the lighter schedule pipe.
   c. Butt welds connecting pipes of different schedules that leave an abrupt change in inside diameter are not allowed.
   d. Couplings:
      1) Rigid type, cast from ductile iron, Victaulic Style 07 or equal. High-performance coating as specified in Section 09960 - High-Performance Coatings.
      2) Type 316 (Grade CF-8M) Superduplex stainless steel in accordance with ASTM A351, ASTM A743, and ASTM A744.
         a) Bolts: Stainless steel in accordance with ASTM F593, Group 2, Condition CW.
         b) Nuts: Stainless steel, Silicon bronze or High manganese stainless steel, Type B8S in accordance with ASTM A194.
         c) Manufacturers: One of the following, or equal:
            (1) Piedmont Pacific Corp.
            (2) Victaulic Style 489 Rigid Coupling.
8. Press fit joints:
   a. Pressures less than 500 pounds per square inch:
      1) Fittings:
         a) Victaulic Vic-Press™ 316, ASTM A312 stainless steel housings with ASTM A276 and ASTM A312 outlets and stainless steel plain or grooved ends, Type 316 stainless steel.
         b) Flange adaptors:
            (1) ANSI Class 150, Van Stone type with stainless steel backup flange and Vic-Press™ ends.

(2) Rated for service up to 275 pounds per square inch gauge. Victaulic Style P566.

c) Threaded unions shall be Victaulic Style P585, Type 316 stainless steel, with Vic-Press™ ends.

2) Gaskets:

a) Gaskets shall be Grade E EPDM rated for services up to 250 degrees Fahrenheit.

3) Valves:

a) Provide Victaulic Series P569 stainless steel ball valves with PTFE seats and Vic-Press™ and/or grooved ends.

b) Rated for services to 400 pounds per square inch (2,750 kilopascals).

c) Swing-out design to facilitate in-line maintenance: 3-piece.

G. Gaskets:

1. Aeration air service: As specified in Section 15052 - Common Work Results for General Piping.
2. All other service applications: EPDM, nitrile, or other materials compatible with the process fluid.
   a. Drinking water applications: NSF Standard 61 compliant materials only.

H. Bolts for flanges and stub end/backing flanges:

1. Bolts and nuts: Type 316 stainless steel in accordance with ASTM A193 heavy hex head.
   a. Bolt length such that after installation, end of bolt projects 1/8-inch to 3/8-inch beyond outer face of nut.
   b. Nuts: In accordance with ASTM A194 heavy hex pattern.

I. Fabrication of pipe sections:

1. Welding: Weld in accordance with ASME B31.3.
2. Weld seams:
   a. Full penetration welds, free of oxidation, crevices, pits and cracks, and without undercuts.
   b. Provide weld crowns of 1/16 inch with tolerance of plus 1/16 inch and minus 1/32 inch.
   c. Where internal weld seams are not accessible, use gas tungsten-arc procedures with internal gas purge.
   d. Where internal weld seams are accessible, weld seams inside and outside using manual shielded metal-arc procedures.

J. Cleaning (pickling) and passivation:

1. Following shop fabrication of pipe sections, straight spools, fittings, and other piping components, clean (pickle) and passivate fabricated pieces.
2. Clean (pickle) and passivate in accordance with ASTM A380 or ASTM A967.
   a. If degreasing is required before cleaning to remove scale or iron oxide, cleaning (pickling) treatments with citric acid are permissible.
      1) However, these treatments must be followed by inorganic cleaners such as nitric acid/hydrofluoric acid.
   b. Passivation treatments with citric acid are not allowed.
3. Finish requirements: Remove free iron, heat tint oxides, weld scale, and other impurities, and obtain a passive finished surface.

4. For piping less than 2 inches in diameter:
    a. Following shop fabrication of piping sections, descale, clean and seal piping section in accordance with CGA Standard G-4.1.

2.03 STAINLESS STEEL TUBING

A. Stainless steel tubing:
    1. Seamless tubing made of Type 316L stainless steel and in accordance with ASTM A269, wall thickness not less than 0.035 inch.

B. Fittings: Swage ferrule design:
    1. Components made of:
        a. Type 316 stainless steel.
    2. Double acting ferrule design, providing both a primary seal and a secondary bearing force.
    3. Flare type fittings are not acceptable.
    4. Manufacturers: One of the following, or equal:
        a. Crawford Fitting Co., Swagelok.
        b. Hoke, Gyrolok.
        c. Parker, CPI.

C. Valves for use with stainless steel tubing:
    1. Ball type valves with swage ends to match tubing diameter.
    2. Constructed from:
        a. Type 316 stainless steel with TFE seats.
    3. Manufacturers: The following or equal:
        a. Crawford Fitting Co., Swagelok.

2.04 SOURCE QUALITY CONTROL

A. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

B. Provide written certification that the pipe as supplied are in accordance with ASTM A778. Supplemental testing is not required.

C. Provide written certification that the fittings as supplied are in accordance with ASTM A774.
    1. Supplementary testing is not required.

D. Examine 3 percent of the welds by radiography. For each weld that fails, inspect 3 additional welds using the same methods:
    1. Radiographic methods: In accordance with standards of AWS Standard D1.6 (Chapter 6). and
    2. For each weld found to be defective by radiographic methods, examine 3 additional welds using the same method.
    3. Provide interpretation of radiographic pictures by an independent testing laboratory acceptable to the Engineer and submit written report of the findings issued by the laboratory.
    4. Repair or replace defective joints**.**

E. Thoroughly clean any equipment before use in cleaning or fabrication of stainless steel.

F. Storage: Segregate location of stainless steel piping from fabrication of any other piping materials.

G. Shipment to site:
   1. Protect flanges and pipe ends by encapsulating in dense foam.
   2. Securely strap all elements to pallets with nylon straps. Use of metallic straps is prohibited.
   3. Cap ends of tube, piping, pipe spools, fittings, and valves with non-metallic plugs.
   4. Load pallets so no tube, piping, pipe spools, fittings, or valves bear the weight of pallets above.
   5. Notify Engineer when deliveries arrive so Engineer may inspect the shipping conditions.
   6. Engineer may reject material due to improper shipping methods or damage during shipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install piping in such a manner as not to impart strain to connected equipment.

B. Install Victaulic Vic-Press™ joint systems in accordance with the manufacturer's latest recommendations. Follow the instructions listed in the latest Victaulic I-P500 assembly manual.
   1. Pipe shall be square cut, plus or minus 0.030 inches, properly deburred and cleaned.
   2. Pipe ends shall be marked at the required location, using a manufacturer-supplied gauge, to ensure full insertion into the coupling or fitting during assembly.
      a. Use a Victaulic PFT-510 series tool with the proper sized jaw for pressing joints.
      b. Tool shall be fitted with the proper size Victaulic jaw for pressing.

C. Slope horizontal lines so that they can be drained completely.

D. Provide valve drains at low points in piping systems.

E. Install eccentric reducers where necessary to facilitate draining of piping system.

F. Provide access for inspection and flushing of piping systems to remove sediment, deposits, and debris.

3.02 FIELD ASSEMBLY OF SHOP-FABRICATED PIPING SECTIONS

A. Join shop-fabricated piping sections together using backing flanges, flexible couplings, flanged coupling adapters, grooved couplings, or flanges.

3.03 FIELD QUALITY CONTROL

A. Test piping to pressure and by method as specified in Section 15052 - Common Work Results for General Piping.
   1. If pressure testing is accomplished with water:
      a. Use only potable quality water.
      b. Piping: Thoroughly drained and dried or place immediately into service.

B. Visually inspect pipe for welding defects such as crevices, pits, cracks, protrusions, and oxidation deposits.

3.04 PROTECTION

A. Preserve appearance and finish of stainless steel piping by providing suitable protection during handling and installation and until final acceptance of the Work.
   1. Use handling methods and equipment to prevent damage to the coating, include the use of wide canvas slings and wide padded skids.
   2. Do not use bare cables, chains, hooks, metal bars, or narrow skids.
   3. Store stainless steel piping and fittings away from any other piping or metals. Storage in contact with ground or outside without projection from bad weather is prohibited.
   4. Protect stainless steel piping and fittings from carbon steel projections (when grinding carbon steel assemblies in proximity) and carbon steel contamination (do not contact stainless steel with carbon steel wire brush or other carbon steel tool).

END OF SECTION

SECTION 15302

GALVANIC CATHODIC PROTECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Section includes: the work necessary to furnish and install galvanic cathodic protection and joint bonding for electrical continuity on all buried metallic piping and appurtenances associated with the construction of metallic (steel/ductile iron) piping.

B. Section includes: the work necessary to furnish and install galvanic cathodic protection and joint bonding for electrical continuity on all buried and non-metallic (HDPE/PVC) piping appurtenances as indicated on the Drawings and specified herein, complete.

C. The quantity and location of the specified galvanic anodes are provided on the Drawings.

D. Galvanic anode installations associated with the 36-inch BWS steel waterline include anodes connected to the pipe through Type “A” test stations.

E. Galvanic anodes for metallic fittings associated with non-metallic pipe shall be directly connected to pipe or appurtenance as shown on drawings.

F. All buried metallic pipe and appurtenances shall be coated with a bonded dielectric coating, as indicated on the Drawings and specified herein, complete.

1.02 DEFINITIONS

A. Ferrous Metal Pipe: Pipe made of steel or iron, or pipe containing steel or iron as a principal structural material, except reinforced concrete pipe.

B. Foreign-Owned: Buried pipe or cable not specifically owned or operated by the Owner.

C. Lead, Lead Wire, Joint Bonds, Pipe Connecting Wires, Cable: Insulated copper conductor; the same as wire.

D. Electrically Continuous Pipeline: A pipeline which has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this section.

1.03 REFERENCES

A. The Association for Materials Protection and Performance (AMPP).

B. National Association of Corrosion Engineers (NACE) International.

1.04 STANDARDS

A. The following standards are included by reference:
   1. AMPP/NACE International
      a. NACE SP-0169.
      b. NACE SP-0177.

1.05 SUBMITTALS

A. Shop Drawings: Catalog cuts, laboratory report, and other information for products proposed for use.

B. Quality Assurance Submittals:
   1. Manufacturers' Certificates of Compliance.
   2. Field Test Reports.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials provided hereunder shall be the product of one manufacturer to achieve standardization for appearance, maintenance, and replacement.

B. The use of a manufacturer's name and model or catalog number is for establishing the standard of quality and general configuration desired only. Products of other manufacturers will be considered in accordance with the General Conditions.

C. Materials and workmanship as specified in this section shall be installed concurrently with pipe installation. Coordinate all work specified herein with related sections.

2.02 SUPPLIERS

A. Alternate suppliers will be considered, subject to approval of the Engineer. Location provided is that of the general office; contact these offices for information regarding the location of their representative nearest the project site.
   1. Corrpro, Houston, TX.
   2. Farwest Corrosion Control, Downey, CA.
   3. Mesa Products, Tulsa, OK.

2.03 GALVANIC ANODES

A. High-Potential Magnesium Alloy (Prepackaged-Backfill Supplied):
   1. Composition:
      a. Aluminum: 0.01 percent maximum.
      b. Manganese: 0.5 to 1.3 percent.
      c. Zinc: 0.
      d. Silicon: 0.
      e. Copper: 0.02 percent maximum.
      f. Nickel: 0.001 percent maximum.

g. Iron: 0.03 percent maximum.
h. Total Others: 0.05 percent each or 0.3 percent maximum, total.
i. Magnesium: Remainder.

2. Dimensions:
   a. Bare Weight: 32 pounds or as indicated on the Drawings.
3. Manufacturers and Products:
   a. Dow; Galvomag.
   b. Amax; Maxmag.
   c. Approved equal.

B. Backfill:
1. Composition:
   a. Ground Hydrated Gypsum: 75 percent.
   b. Powdered Wyoming Bentonite: 20 percent.
   c. Anhydrous Sodium Sulfate: 5 percent.
2. Grain Size: 100 percent passing through a 20-mesh screen and 50 percent retained by a 100-mesh screen.
3. Mixture: Thoroughly mixed and firmly packaged around the galvanic anode within the cloth bag or cardboard tube by means of adequate vibration.
4. The quantity of backfill shall be sufficient to cover surfaces of the anode to a depth of 1 inch.

2.04 CATHODIC PROTECTION TEST STATIONS

A. Flush Mounted:
1. Test Box: Concrete body cast with a cast iron ring, with a minimum weight of 55 pounds and minimum dimensions of 8 inch inside diameter and 12 inches long. Furnish extensions as required to penetrate concrete surfaces by 4 inches minimum. Furnish with a 12-pound cast iron lid with the letters "TS" or words "Test Station" cast into the lid.
2. Manufacturer and Products: Brooks; Models 1RT or equal.
3. Flush Mount Test Station Terminal Board:
   a. Test boards for terminating pipeline test leads and other test leads inside test boxes: Plastic or glass reinforced 6-inch- by 10-inch- by 1/4-inch-thick laminate.
   b. Furnish terminal block with 5 stainless steel studs, washers, and lock washers.
   c. Shop fabricated as shown on the Drawings with engraved labels on terminal board.

B. Post Mounted (hot-dipped Galvanized Steel Post):
1. Test Station Head: Type A, T, I, and F: Testox series 700 or 1000 series test head.
2. Terminal Block: Plastic with minimum 7 terminals. Terminal heads shall have special heads to keep them from turning or shall be easily accessible from both sides of the terminal block without requiring its removal. Terminal studs, washers, and nuts shall be stainless steel.
3. Mounting Post: 3-inch diameter by 6 foot long hot-dipped galvanized steel post.

4. Mounting Hardware: Conduit, straps, nipple, reducer, and hardware for mounting test station to the post as specified under CONDUIT, LOCKNUTS, AND STRAPS.
5. Manufacturers and Products: Testox 700 and 1000 series test station as manufactured by Gerome Manufacturing, Uniontown, PA.

C. Test Station Wires:
1. General: Conform to applicable requirements of NEMA WC 3-80, WC 5-73, and WC 7-88.
2. Single-conductor, No. 10 AWG stranded copper with 600-volt TW, THWN, or THHN insulation.
3. Galvanic Anode Header Wire: Single-conductor, No. 8 AWG, stranded copper with 600-volt HMWPE insulation.
4. Insulation Color/Identification: Wire insulation color shall indicate the function of each wire and shall be as follows:
   a. Anodes/Header Cable: Black.
   b. Pipelines: White.
   c. Stationary Reference Cell: Yellow.
   d. Foreign Pipeline: Red (gas), Blue (water).
   e. Insulated Joints: Green (insulated side), White (protected side).

D. Stationary Reference Electrodes:
1. Prepackaged Copper-Copper Sulfate Reference Electrodes:
2. Material: High impact ABS, ceramic with Moisture Retention Membrane.
3. Dimensions: 1.5 inches by 10.5 inches or 1 inch by 8 inches.
4. Wire: Minimum 14 AWG stranded copper wire with yellow, 600-volt TW, THWN, or THHN insulation. The wire shall be attached to the electrode and insulated with the manufacturer's standard connection. Connection shall be stronger than the wire.
5. Packaging: Furnish electrode packaged in a plastic or heavy paper bag of sufficient thickness to protect the electrode, backfill, and cloth bag during normal shipping and handling.
6. Manufacturers:
   a. Borin Manufacturing, Stelth 2 Series.
   b. MC Miller, IonX Permanent Reference Electrode.

2.05 JOINT BONDS

A. General:
1. All joint bonds provided by pipe manufacturer or Contractor shall meet the following minimum requirements:
   a. All connections shall be welded or soldered.
   b. Mechanical or compression type connections will not be permitted.
   c. Bonds and welds shall exhibit sufficient strength and flexibility to allow thermal movement of the pipe after pipe backfill without cracking or breakage.
   d. Bond connections to pipe shall be with an Engineer approved welding method.
2. All installed bonds shall be insulated or coated copper with all exposed copper field coated to prevent galvanic corrosion of pipe.

B. Steel, Ductile or Cast Iron Pipe, External Joint Bonds:
   1. Joint bonds required for all non-welded pipe joints.
   2. Single-conductor, stranded copper wire with 600-volt HMWPE or THHN insulation. Supply joint bonds complete with a formed copper sleeve on each end of the wire.
   3. No. 2 AWG wires, 18 inches long min. 24 inches long max.
   4. Quantity of joint bonds per pipe joint by pipe diameter shall be as defined below:

Bond Type	One Bond	Two Bonds	Three Bonds
No. 2 AWG Wire	Less than 8" Diameter	8" to 36" Diameter	Greater than 36" Diameter

   5. Connection of wire joint bonds to pipe shall be with the thermite weld method using molds and cartridges as recommended by the welder manufacturer for bond type used.
   6. Strap Bond:
      a. Manufacturers:
         1) Erico Products Inc. (Cadweld), Cleveland, OH.
         2) Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.
         3) Approved Equal.

A. Flexible Coupling, Flanged Coupling Adapter, and Other Non-standard Joints:
   1. Ductile Iron Pipe:
      a. No. 2 AWG wires, 24 inches long, HMWPE or THHN insulation, with two 12-inch long THHN insulated No. 12 AWG wire pigtails or as specified on the drawings.
         (1) Manufacturer:
            (a) Erico Products Inc. (Cadweld), Cleveland, OH.
            (b) Hoff Company, Denver, CO.
            (c) "Or-Equal".
   2. Steel Pipe:
      a. Solid copper strap, 1-1/4-inch wide by 1/16-inch thick, equivalent to 1/0 AWG wire, with 5 punched holes for thermite welding to the coupling follower rings, middle, ring, and pipe. Strap bond shall be fabricated for the length of the coupling with sufficient additional length for 1 inch of joint movement. Strap holes shall be sized for the thermite weld mold and shall provide for physical centering of the mold over the hole.
         (1) Weld bonds to pipe with the thermite weld mold recommended by the bond manufacturer.
         (2) Strap bond manufacturer:
            (a) Erico Products Inc. (Cadweld), Cleveland, OH.
            (b) Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.
            (c) "Or-equal."
      b. At Contractor's option, single-conductor 2 AWG stranded copper wire with 600-volt HMWPE insulation, 24 inches long, with two 12-inch-long HMWPE insulated 12 AWG pigtails.
         (1) Manufacturer:
            (a) Erico Products Inc. (Cadweld), Cleveland, OH.

B. Insulated Flexible Coupling Joints:
   1. Only install joint bonds across insulated joint where specifically denoted on the plan drawings, if applicable.

2. Ductile Iron Pipe:
    a. No. 8 AWG THHN or HMWPE wire, 18-inch long, with one 12-inch long THHN insulated No. 12 AWG wire pigtail.
3. Steel Pipe:
    a. Solid copper strap, 1-1/4-inch wide by 1/16-inch thick, equivalent to 1/0 AWG wire, with four punched holes for thermite welding to the coupling and pipe. Strap bond shall be fabricated for the length of the coupling with sufficient additional length for 1 inch of joint movement.
        (1) Weld bonds to pipe with the thermite weld mold recommended by the bond manufacturer.
        (2) Strap bond manufacturer:
            (a) Erico Products Inc. (Cadweld), Cleveland, OH.
            (b) Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.
            (c) “Or-equal.”

C. Insulated Sleeve Coupling Joints:
1. Ductile Iron Pipe:
    a. No. 8 AWG wire, 18-inch long, with one 12-inch long THHN insulated No. 12 AWG wire pigtail
        (1) Manufacturer:
            (a) Erico Products Inc. (Cadweld), Cleveland, OH.
            (b) Hoff Company, Denver, CO.
            (c) “Or-equal.”
2. Steel Pipe:
    a. Solid copper strap, 1-1/4-inch wide by 1/16-inch thick, equivalent to 1/0 AWG wire, with four punched holes for thermite welding to the coupling and pipe. Strap bond shall be fabricated for the length of the coupling with sufficient additional length for 1 inch of joint movement. Strap holes shall be sized for the thermite weld mold and shall provide for physical centering of the mold over the hole.
    b. Strap bond manufacturer:
        (1) Erico Products Inc. (Cadweld), Cleveland, OH.
        (2) Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.
        (3) “Or-equal.”

2.06 THERMITE WELD MATERIALS

A. General:
1. Thermite weld materials consist of wire sleeves, welders, and weld cartridges according to the weld manufacturer's recommendations for each wire size and pipe or fitting size and material.
2. Welding materials and equipment shall be the product of a single manufacturer. Interchanging materials of different manufacturers is not acceptable.

B. Molds: Graphite.

C. Adapter Sleeves:
1. For No. 12 AWG and No. 2 AWG wires.
2. Prefabricated factory sleeve joint bonds or bond wires with formed sleeves made in the field are acceptable. Attach field-formed joint bonds sleeves with

the appropriate size and type of hammer die furnished by the thermite weld manufacturer.

3. Extend wire conductor 1/8 inch beyond the end of the adapter sleeve.

D. Cartridges:
   1. Steel: 32 grams, maximum.
   2. Cast and Ductile Iron: 32 grams, maximum, XF-19 Alloy, specifically for use on cast iron and ductile iron.

E. Welders and Cartridges: For attaching copper wire to pipe material:

Pipe Material	Weld Type	Cartridge Size, Max.
No. 4 AWG Wire and Smaller		
Steel	HA, VS, HC	25 gm
Ductile or Cast Iron	HB, VH, HE	32 gm
No. 2 AWG Wire Joint Bonds		
Steel	FS	32 gm
Ductile or Cast Iron	FC	45 gm

F. Welding Materials Manufacturers:
   1. nVent/Erico Products Inc. (Cadweld), Cleveland, OH.
   2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

2.07 COATING REPAIR MATERIAL FOR PIPE AND FITTINGS

A. General:
   1. Complete coating repairs in accordance with recommendations of the pipe or fitting manufacturer.
   2. Coat steel pipe with epoxy coating repair as specified.
   3. Coat thermite weld connections to ductile or cast iron pipe with fast cure epoxy OR petrolatum wax tape, as specified under Wax Tape Coating System.

B. Epoxy Coating:
   1. 100 percent solids, fast curing epoxy suitable for submerged or buried conditions.
   2. Acceptable products and manufacturers or equal:
      c. Protal 7125, 7200, or 7300 Denso North American, Houston, TX.
      d. TC 7010, Tapecoat, Evanston, IL.
      e. 3M; ScotchKote 323.
      f. Aquata-poxy, American Chemical Corp., East Lake, OH.
      g. “Or-equal.”

C. Wax Tape Coating:
   1. Buried thermite welds shall be coated in accordance with AWWA C217.
   2. Do not use wax tape coating systems on vault piping, atmospherically exposed piping and appurtenances, or where subject to UV exposures.

3. All components of the wax tape coating system shall be from a single manufacturer as manufactured by Denso North American, Trenton, or equal.

2.08 COATING MATERIAL FOR METALLIC PIPE AND FITTINGS

A. General:
   1. All metallic fittings, valves, and metallic hardware (nuts, bolts, etc.) associated with non-metallic pipe construction shall be dielectrically coated with a bonded coating.
   2. Prepare surface of items to be coated in accordance with coating manufacturer's requirements and as specified herein.

B. Dielectric Coating Systems for Metallic Pipe, Fittings, and Appurtenances:
   1. Wax Tape Coating System:
      a. Metallic piping, fittings, and appurtenances shall be coated in accordance with AWWA C217.
      b. Apply coating system to all buried metallic pipe appurtenances, including joints, fittings, bolts, and irregularly shaped surfaces.
      c. Do not use wax tape coating systems on vault piping, atmospherically exposed piping and appurtenances, or where subject to UV exposures.
      d. Provide wax tape coating system filler material to fill and smooth all irregular surfaces, such that no tenting or voids remain under the applied wax tape.
      e. Use sand backfill to protect wax coating from damage.
      f. Coating System:
         1) Surface Preparation: As required by coating manufacturer. Remove all dirt and debris from pipe surface. Pipe surface shall be completely dry before application of wax tape components.
         2) Primer: petroleum or petrolatum wax.
         3) Filler Material: petroleum or petrolatum wax sealer/filler with closed cell plastic filler.
         4) Inner Tape: Petroleum or petrolatum wax impregnated fabric, 6-inch width maximum, 40 mils thick.
         5) Protective Outerwrap (for burial in native soil, not required for sand backfill).
            a) Provide fiber mesh fabric outerwrap over wax tape resin coated, woven fiber-mesh fabric that is .005 inches. Protect coating from damage and use sand backfill to protect wax coating from damage.
      g. All components of the wax tape coating system shall be from a single manufacturer as manufactured by Denso North American, Trenton, or equal.
   2. Epoxy Coating System:
      a. Fusion Bonded Epoxy:
         1) Prepare surface and apply coating in accordance with C213 and coating manufacturer's guidelines.
         2) Apply minimum dry film thickness of 12 mils.
      b. Polyamide Epoxy:
         1) Prepare surface as required by coating manufacturer and apply coating in accordance with C210 and coating manufacturer's guidelines.

2) Apply minimum of 2 coats at a total minimum dry film thickness of 12 mils.

2.09 INSULATING JOINTS

A. General: Insulating joints shall be dielectric unions, flanges, or couplings. The complete assembly shall have an ANSI rating equal to or higher than that of the joint and pipeline. All materials shall be resistant for the intended exposure, operating temperatures, and products in the pipeline.

B. Insulating Flanges:
   1. Complete assembly shall have an ANSI rating of 150 pounds, minimum, or equal to or higher than that of the joint and pipeline.
   2. Gasket materials shall be resistant to intended chemical exposure, operating temperatures, and pressures in the pipeline.
   3. Gaskets: Full-face Type E with O-ring seal.
   4. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA G 10 grade).
   5. Insulating Washers: Fiberglass reinforced epoxy (NEMA G 10 grade).
   6. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
      a. Provide 2 washers per bolt for flange diameters equal to or less than 36-inch diameter.
      b. Provide four washers bolt for flange diameters larger than 36-inch diameter.
   7. Manufacturers:
      a. GPT, Denver, CO.
      b. Central Plastics Co., Shawnee, OK.
      c. Advance Products and Systems, Scott, LA.
      d. Approved equal.

   8. Insulating Unions: O-ring sealed with molded and bonded insulating bushing to union body.
      a. Manufacturer:
         1) Central Plastics Co., Shawnee, OK.
         2) Or approved equal.

2.10 ANCILLARY MATERIALS

A. Wire Connectors: 1-piece, tin-plated crimp-on ring tongue connector as manufactured by Burndy Co. or Thomas and Betts.

B. Compression Connectors:
   1. For in-line, tap, and multi-splice, furnish "C" taps made of conductive wrought copper, sized to fit the wires being spliced.
   2. Provide crimp tool and dies as recommended by the manufacturer for the wire and connector size.
   3. Manufacturer and Product: Burndy; Type YC, or equal.

C. Electrical Tape:
   1. Linerless rubber high-voltage splicing tape and vinyl electrical tape suitable for moist and wet environments.

2. Use Scotch 130 C and Scotch 88 as manufactured by 3M Products.

PART 3 EXECUTION

3.01 GENERAL

A. Install galvanic cathodic protection and joint bonding for electrical continuity on all buried metallic piping and appurtenances associated with the construction of metallic (steel/ductile iron) piping.

B. Install galvanic cathodic protection and joint bonding for electrical continuity on all buried and non-metallic (HDPE/PVC) piping appurtenances as indicated on the Drawings and specified herein.

C. Installation of anodes to be performed in conjunction with pipeline trenching and as specified in other sections.

D. All materials and equipment associated with joint bonding, cathodic protection, and coatings, as shown and specified herein, shall be furnished and installed by the Contractor. Any changes in design or method of installation of an item as specified shall be reviewed by the Engineer.

E. The Contractor shall coordinate the installation of the specified items with the General Contractor or other subcontractors on the project such that installation of the items herein specified can be completed concurrently with pipeline installation. Items not installed before backfilling of the pipe shall be installed at the Contractor's sole expense.

F. Whenever the requirements of the Specifications or Drawings exceed those of the codes or manufacturer's instructions, the requirements of the Specifications or Drawings shall prevail. Where a larger size or better grade of material or a higher standard of workmanship is required, the most stringent requirement shall apply.

3.02 STORAGE AND HANDLING

A. Store all packaged anodes, anode backfill, and associated materials off the ground and keep them dry at all times.

B. Protect materials against weather, condensation, and mechanical damage. Immediately remove from site all damaged anodes.

C. Anode backfill material that has become wet will not be acceptable.

3.03 GALVANIC ANODE INSTALLATION

A. General: Install galvanic anodes as shown on the Drawings.

B. Remove anode packaging materials prior to installing anode.

C. Provide a minimum anode spacing of 2 feet from the protected structure, other unprotected pipelines, thrust blocks, or adjacent structures. Anode depth shall be at or below the pipe depth, and not less than 4 feet below the finished grade.

D. Connect anode lead wire directly to the pipe/fitting or route to test station as specified on the Drawings.

E. After installation, flood each anode with a minimum of 5 gallons of water.

F. Thoroughly compact backfill around each anode to a point 1 foot above the anode.

3.04 PIPE JOINT BONDING

A. To form an electrically continuous pipeline and associated appurtenances, the joints of all buried steel and iron pipe, vault and manhole piping, fittings, and restrained joints shall be provided with joint bonds as specified herein, except joints specified to be threaded, welded, or insulated.

B. Mechanical pipe connections are not considered to provide electrical continuity and require joint bonds, except where specified or approved by Engineer. All metallic components associated with appurtenances and fittings, including follower rings and retainer glands shall be electrically bonded to the piping system.

C. Contractor shall consider options for thermite welding to follower rings and retainer glands to aid in welding to surfaces with limited space and to avoid potential damage from discharged thermite weld metal. Options could include completing thermite welds on the follower rings and retainer glands prior to installation on pipe or utilizing alternate welding method.

D. Quantity of joint bonds for fittings and appurtenances shall be as shown on the Drawings.

E. Electrical connection of all wires to pipe and fittings shall be by the thermite weld process.

F. Each bonded joint shall be tested as specified under ELECTRICAL CONTINUITY TESTING, this section.

3.05 TEST STATION INSTALLATION

A. Location, type, and style of test stations shall be as shown on the Schedules on Drawings. Final field location shall be determined based on actual site conditions and as approved by the Engineer.

B. Locate test stations where shown on the Schedules on Drawings.
   1. Install test stations as appropriate at 1,000-foot intervals or less.
   2. Install Type I test stations at insulating flange locations specified on the Drawings.
   3. Install Type F test stations where any ferrous metal pipe crosses a foreign owned pipeline under cathodic protection.

C. Wires to foreign-owned pipelines will be attached by pipeline owner, unless permission is granted to Contractor in writing by owner of foreign pipeline. Coordinate this Work with owner of foreign pipeline before pipe is excavated.

D. Attach all test wires to the pipe by the thermite weld method unless approved otherwise.

E. The wires from the test stations shall be buried a minimum of 36 inches below finished grade. Provide 12-inch loop in wires at pipe and beneath test station to prevent them from being stressed or broken during backfilling operations.

F. Test wires within paved roadways and with less than 36 inches of ground cover shall be installed in rigid PVC-coated steel conduit, except when located under concrete floor slabs.

G. Make wire connections to test station terminals with crimp-on ring tongue terminals, except where solid wire is specified.

H. Wire Labels:
   1. Install labels on conductors in test stations.
   2. Position markers in boxes so they do not interfere with operation and maintenance.

3.06 WIRE CONNECTIONS

A. Thermite Weld:
   1. Use thermite weld method for electrical connection of copper wire to steel, ductile, and cast iron surfaces.
      a. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation recommended by the welder manufacturer.
      b. Assure that the pipe or fitting wall thickness is of sufficient thickness that the thermite weld process will not damage the integrity of the pipe or fitting wall or protective lining.
   2. After the weld connection has cooled, remove slag, visually inspect, and physically test wire connection by tapping with a hammer; remove and replace any defective connections.
   3. On pipe and fittings with dielectric linings, make the weld connection on the shop tab provided or on a thick metal section to minimize damage to the lining and coating. After the weld is made, coat the weld with coating repair material.
   4. Coat each completed wire connection as specified, this section.
   5. If the lining is damaged by welding, repair damage in accordance with the lining applicator's recommendations.

3.07 REFERENCE ELECTRODE INSTALLATION

A. Remove plastic or paper wrapper and place reference electrode within the pipeline trench excavation 6 inches below the centerline of the pipe in a vertical position or as required by manufacturer.

B. Install reference cell as required by manufacturer at the locations indicated on the Drawings.
   1. Do not use lead wire in lowering reference cell.
   2. Backfill hole with select native material in 6-inch layers and hand tamp each layer around anode.
   3. Use only native soil for backfill; do not use sand.
   4. Exercise care not to strike reference cell or lead wire with tamper.

C. Terminate reference electrode wire in test station on separate terminal.

3.08 WIRE INSULATION REPAIR

A. Splicing of wire will not be permitted except where specifically shown on the drawings and approved by the Engineer.

B. Splices or damage to the wire insulation shall be required by spirally wrapping with 2 coats of high-voltage rubber splicing tap and two layers of vinyl electrical tape.

C. Make wire splices with suitable sized compression connectors or mechanically secure and solder with rosin cored 50/50 solder.

3.09 INSULATED JOINTS

A. Install insulated joints to electrically isolate the pipeline from existing piping, vault piping, electrically grounded facilities, and where shown on the Drawings.

B. Align and install insulating joints according to the manufacturer's recommendations to avoid damaging insulating materials.

C. After assembly of insulated flanges, prepare cement-mortar surface in accordance with paint manufacturer's instructions and apply a 20-mil minimum thickness of EPA potable water approved, 100 percent solids water or air curing epoxy coating to the interior of the pipeline.
   1. Apply coating for a minimum of 2 pipe diameter lengths from the insulating flange in both directions.
   2. Apply and cure coating in accordance with the manufacturer's recommendations.
   3. Do not apply coating where it will interfere with operation of pipeline valves or other pipeline assemblies.

D. The Contractor shall test each insulated joint for electrical insulation as specified this section. Defective insulating joints shall be repaired by the Contractor at his sole expense. All damaged or defective insulation parts shall be replaced.

3.10 TESTS AND INSPECTION

A. Electrical Continuity Testing:
   1. General:
      a. Furnish all necessary equipment and materials and make all electrical connections to the pipe as required to test continuity of bonded joints.

b. Conduct a continuity test on all buried joints that are required to be bonded. Test the electrical continuity of joint bonds after the bonds are installed but before backfilling of the pipe.
c. The Contractor shall test completed joint bonds for electrical continuity using digital low resistance ohmmeter or by the Calculated Resistance Test Method at the Contractor's option. The equipment and test procedures for the two methods are described herein.

2. Digital Low Resistance Ohmmeter Method:
   a. Equipment and Materials:
      1) One Biddle Model 247001 digital low resistance ohmmeter or equal.
      2) One set of duplex helical current and potential handspikes, Biddle Model No. 241001, cable length as required.
   b. Test Procedure:
      1) Measure the resistance of joint bonds with the low resistance ohmmeter in accordance with the manufacturer's written instructions.
      2) Use the helical handspikes to contact the pipe on each side of the joint, without touching the thermite weld or the bond.
      3) The contact area shall be cleaned to bright metal by filing or grinding and without any surface rusting or oxidation.
      4) Record the measured joint bond resistance on the test form described herein.
      5) Repair any damaged pipe coating in accordance with WIRE CONNECTIONS, this section.
3. Joint Bond Acceptance:
   a. Joint bond resistance shall be less than or equal to the maximum allowable bond resistance values shown in Table 1.

Table 1

Joint Type	Max. Allowable Resistance (Ohms)		
	One Bond/Joint	Two Bonds/Joint	Three Bonds/Joint
No. 2 AWG wire Bonds	0.000325	0.000162	0.000081
Flexible Coupling	0.000425	0.000212	0.000115

   b. The Contractor shall replace any joint bond that exceeds the allowable resistance. Replacement joint bonds shall be retested for compliance with the specified bond resistance.
   c. Any defective joint bond discovered during energizing and testing shall be located, excavated, repaired, and backfilled by the Contractor.
4. Test Records: Records shall be made of each bonded pipeline during the test and submitted to the Engineer. These records shall include:
   a. Description and location of the pipeline tested.
   b. Starting location and direction of test.
   c. Date of test.
   d. Joint type.
   e. Test current and voltage drop across each joint and calculated bond resistance (Calculated Resistance Method only).

f. Measured joint bond resistance (Digital Low Resistance Ohmmeter method only).

B. Electrical Isolation Testing:
   1. Pipe penetrations shall be tested for electrical isolation from rebar and wire ties before, during, and after pouring concrete.
      a. Electrical shorts shall be mitigated prior to pouring concrete. Testing shall be performed again after concrete is poured.
      b. Electrical isolation shall be verified and if electrical isolation cannot be achieved, Contractor shall propose alternatives to resolve the problem, including installation of impressed current system at the Contractor's cost.
   2. Acceptable electrical isolation test methods include 1 or more of the following tests that provided conclusive information confirming electrical isolation:
      a. 4-Point Electrical Resistance Testing.
      b. Pipe-To-Rebar Potential Difference Measurements.
      c. Current Applied Testing.
   3. Contractor shall conduct additional electrical isolation tests as required to assure the pipe is not electrically shorted by contact with concrete reinforcement or other equipment.

C. Insulated Joint Testing:
   1. Test each insulating joint after assembly with a GAS Electronics Model 601 insulator tester or equivalent instrument in accordance with the manufacturer's written instructions. Conduct test before burial and coating of buried insulating flanges.
   2. Contractor to replace damaged or defective insulation parts identified during testing.
   3. Electrical Isolation is defined as a condition of being electrically isolated from other metallic structures (including, but not limited to, other piping, concrete reinforcement, casings, and other structures not intended to be cathodically protected) and the environment as defined in NACE Standard Practice SP0169.
   4. Contractor shall conduct additional insulating joint tests as required to assure that insulating flanges are not electrically shorted by other equipment or incidental contact with concrete reinforcement or other equipment during energizing and testing.

D. Cathodic Protection System Energizing and Testing:
   1. Initial Survey: Contractor shall conduct an initial potential survey at all test stations and measure the baseline (native) pipe-to-soil potential before connecting the anodes. Record GPS coordinates for each test station.
   2. Functional Testing:
      a. Perform functional testing in presence of Engineer.
      b. When construction of each cathodic protection station(s) is completed, notify Engineer that anodes are ready to be connected.
      c. System deficiencies shall be repaired by Contractor.

3. Energizing and Testing:
    a. Performed by Engineer.
    b. General:
        1) Upon successful completion of functional testing, Engineer shall connect the galvanic anodes to the pipe through the shunt inside the test stations.
            a) Complete additional testing and adjustment to provide cathodic protection at all test points in accordance with NACE SP0169.
        2) Record baseline potentials at all test stations.
        3) Record ON and OFF potentials at all test stations by temporarily disconnecting the galvanic anodes from the pipe at the test station being evaluated.
        4) Measure and record galvanic anode current at each test station.
4. Final Testing, Adjustment, and Report:
    a. Performed by Engineer.
    b. All test data shall be submitted in electronic file compatible with Microsoft Excel for Office, most recent version.
        1) The data shall be organized in tabular form with location descriptions and GPS coordinates.

END OF SECTION

SECTION 15400

PLUMBING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for materials and installation of plumbing systems.

1.02 REFERENCES

A. Abbreviations:
   1. gpf - gallons per flush.
   2. gph - gallons per hour.
   3. gpm - gallons per minute.
   4. psig - pounds per square inch, gauge.

B. Definitions:
   1. Buried: Piping that is installed below buildings, foundations, or finish grade, either in soil or encased in concrete in soil.
   2. Exterior: Piping that is installed outside a building or within a pipe trench or tunnel.
   3. Flame Spread and Smoke Density: Burning characteristics determined in accordance with ASTM E84.
   4. Interior: Piping that is installed inside a building.
   5. K Factor: Thermal conductivity determined in accordance with ASTM C177 or C518.
   6. Mineral Fiber: Fibers manufactured of glass, rock, or slag processed from a molten state, with or without a binder.
   7. Water Vapor Permeance: Water vapor transmission determined in accordance with ASTM E96 and expressed in units of perm-inch.

C. Standards:
   1. American Concrete Institute (ACI).
   2. American Gas Association (AGA).
   3. American Society of Mechanical Engineers (ASME).
      a. B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
      b. B16.12 - Cast Iron Threaded Drainage Fittings.
   4. American Society of Sanitary Engineering (ASSE):
      a. 1070 - Performance Requirements for Water Temperature Limiting Devices.
   5. American Water Works Association (AWWA):
      a. C511 - Reduced-Pressure Principle Backflow Prevention.
      b. C700 - Standard for Cold-Water Meters -- Displacement Type, Bronze Main Case.
      c. C702 - Standard for Cold-Water Meters -- Compound Type.
   6. Americans with Disabilities Act (ADA).

7. ASTM International (ASTM):
    a. A48 - Standard Specification for Gray Iron Castings.
    b. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
    c. A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
    d. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
    e. A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
    f. A888 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
    g. B32 - Standard Specification for Solder Metal.
    h. B88 - Standard Specification for Seamless Copper Water Tube.
    i. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
    j. B828 - Standard Specification for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
    k. C117 - Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
    l. C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
    m. C547 - Standard Specification for Mineral Fiber Pipe Insulation.
    n. C552 - Standard Specification for Cellular Glass Thermal Insulation.
    o. C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
    p. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
    q. D256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
    r. D297 - Standard Test Methods for Rubber Products—Chemical Analysis.
    s. D395 - Standard Test Methods for Rubber Property—Compression Set.
    t. D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
    u. D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
    v. D638 - Standard Test Method for Tensile Properties of Plastics
    w. D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
    x. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
    y. D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride (CPVC) Compounds.
    z. D1785 - Standard Specification for Poly(Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
    aa. D2240 - Standard Test Method for Rubber Property—Durometer Hardness.
    bb. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
    cc. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

dd. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
ee. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
ff. D4101 - Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials.
gg. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
hh. E96 - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.
ii. F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
jj. F439 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
kk. F441 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
ll. F493 - Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
mm. F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
nn. F594 - Standard Specification for Stainless Steel Nuts.
oo. F645 - Standard Guide for Selection, Design, and Installation of Thermoplastic Water- Pressure Piping Systems.

8. International Association of Plumbing and Mechanical Officials (IAPMO):
   a. IS 03 - Copper plumbing Tube Pipe and Fittings.
9. National Electrical Manufacturers Association (NEMA):
   a. 250 - Enclosures for Electrical Equipment (1000 V Maximum).
10. Plumbing and Drainage Institute (PDI):
    a. WH 201 - Water Hammer Arresters Standard.
11. Underwriters Laboratories, Inc. (UL):
    a. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
12. United States Environment Protection Agency (EPA): Water Sense.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination:
   1. Provide plumbing equipment roof penetrations information required in the preparation of roofing drawings including, but not limited to:
      a. Location.
      b. Diameter.
      c. Configuration of penetration and the surround.
   2. Provide roof mounted plumbing equipment information required in the preparation of roofing drawings including, but not limited to:
      a. Location.
      b. Size.
      c. Weight.
      d. Anchoring and support details.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Manufacturer's instructions.

C. Shop drawings: and as applicable:
   1. System layout, mechanical, electrical power, and control diagrams.
   2. Nameplate information.
   3. Materials.
   4. Coatings and linings.
   5. Rough-in drawings.
   6. Supports, vibration isolators, and details.
   7. Primary and ancillary equipment.
   8. Proposed cutting and patching.
   9. Maximum recommended equipment vibration levels and field-testing method.
   10. Copy of factory test results.

D. Certificates: As specified in Section 01600 - Product Requirements:
   1. American Backflow Prevention Association for backflow prevention assembly.
   2. National Science Foundation for products when specified.

E. Field testing documentation.

F. Warranties.

1.05 WARRANTY

A. Provide warranty as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 PLUMBING FIXTURES

A. General:
   1. Stops:
      a. Fixtures, except showers, shall have stops at the fixtures' service.
      b. Stops for laboratory equipment, and for other equipment or fixtures for which stops have not been otherwise specified in this Section, shall be chrome-plated straight pattern compression stops or chrome-plated angle pattern compression stops.

2.02 PLUMBING AND DRAINAGE PRODUCTS

A. Water hammer arrestors:
   1. Manufacturers:
      a. One of the following or equal:
         1) Jay R. Smith.
         2) Josam.
         3) Zurn.

b. Determine manufacturer model:
1) Based on Table 1 in accordance with PDI-WH201.
2) Working pressure: 125 psig.
3) Static pressure: 250 psig.
2. Temperature: 300 degrees Fahrenheit.
3. Provide water hammer arrestors on each fixture supply line branch.
4. Casing and Bellows.
a. Material: Type 316 stainless steel.
b. Welded bellows.
5. Hermetically sealed air cushion.

B. Type HB-1, Hose bib stations:
1. Manufacturers: The follow or equal:
a. Flexon Pro Series.
b. Gilmore Group.
2. Hose bib: Size and mounting requirements as indicated on the Drawings.
3. Hose rack: Type and installation as indicated on the Drawings.
4. Hose:
a. Length: 50 feet.
b. Size: 3/4-inch.
c. Commercial/industrial grade rubber hose.
5. Hose nozzle:
a. Spray: 7-pattern select-a-spray with vinyl grip.
b. Hold-open clip for continuous spraying.
c. Material: Rust resistant stainless steel spring.
d. Lifetime leak proof seal.

C. Fixed air gaps:
1. Manufacturers: One of the following or equal:
a. Zurn, Z1025.
b. Josam.
2. Provide and size as indicated on the Drawings.
3. Coated cast iron.
4. Slip joint inlet and no-hub outlet.
5. Threaded outlets.

D. Cleanouts:
1. Floor Cleanouts:
a. Cast-iron ferrule, countersunk plug, gastight and watertight seal.
b. Adjustable cleanout head extension.
c. Nickel-bronze top and securing screw.
d. Type FCO1: Floor cleanouts, finished floors:
1) Manufacturers: One of the following or equal:
a) Josam Co.
b) Zurn Ind., Inc., ZN1400.
2) For finished floors.
3) Traffic: Heavy wheel/vehicular traffic.
e. Type FCO2: Floor cleanouts, unfinished floors:
1) Manufacturers: One of the following or equal:
a) Josam Co., Model 55000.
b) Zurn Ind., Inc.

2) For unfinished floors.
f. Type FCO3, Floor cleanout, exterior, in asphalt or ground areas:
1) Manufacturers: One of the following or equal:
a) Josam Co., Model 55000.
b) Zurn Ind., Inc.
2) Rated for outdoor use.

E. Drains:
1. Drains shall be the type, shape, and size as indicated on the Drawings with connections suitable for the piping system.
a. Provide all drains of one type from the same manufacturer.
2. Type FD1: Floor drain, finished floors, pedestrian traffic:
a. Manufacturers: One of the following or equal:
1) Josam, 30000-A.
2) Zurn.
b. Round, adjustable strainer head, floor level grate.
c. Body material: Coated cast iron.
d. Strainer:
1) Material: Nickel bronze.
2) Size:
a) 6-inch diameter for 3-inch drain.
b) 8-inch diameter for 4-inch drain.
3. Type FD2: Floor drain, finished floors, heavy wheel traffic:
a. Manufacturers: One of the following or equal:
1) Zurn Z521.
2) Josam.
b. Adjustable extension frame with heavy-duty tractor grate.
1) Size: 12-inch diameter.
c. Material: Resin-coated cast iron top.
d. No-hub outlet.
e. Seepage pan with membrane flashing clamp.
4. Type RD1: Roof drain, main:
a. Manufacturers: One of the following or equal:
1) Zurn, Z100.
2) Josam.
b. Main roof drain.
c. Combined flashing collar and gravel stop.
d. Material:
1) Body: Coated cast-iron.
2) Low silhouette dome: Polypropylene.
e. Size: 15-inches.
5. Type RD2: Roof drain, overflow:
a. Manufacturers: One of the following or equal:
1) Zurn, Z108.
2) Josam.
b. Overflow roof drain.
c. Combined flashing collar and gravel stop.
d. External water dam: 2-inches high.
e. Material:
1) Body: Coated cast-iron.
2) Low silhouette dome: Polypropylene.

f. Size: 15-inches.

6. Type RD 4: Roof drain, downspout nozzle:
   a. Manufacturers: One of the following or equal:
      1) Zurn, Z199.
      2) Josam.
   b. Downspout nozzle.
   c. Material: Nickel-bronze body and wall flange.

2.03 PLUMBING PIPING SYSTEMS

A. As indicated on the Drawings in the Plumbing Pipe Schedule on drawing 00GP01.

B. PVC piping system:
   1. Pipe: Designation PVC 1120 in accordance with ASTM D1785:
   2. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 B material in accordance with ASTM D1784.
   3. PVC Pipe: Schedule 40 unless otherwise specified.
   4. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
      c. DWV fittings: In accordance with ASTM D2665.
   5. Type FD3: Floor drain, located in trench drains:
      a. Manufacturers: One of the following or equal:
         1) Josam 30304.
         2) Zurn.
      b. Round, adjustable strainer, floor level grate.
      c. Body Material: Coated cast iron.
      d. 4-inch no-hub outlet.
   6. Solvent cement: In accordance with ASTM D2564:
      a. Chemical service: For PVC pipe in chemical service, provide the following primer and cement, or equal:
         1) Primer: IPS Corp Type P-70™.
         2) Cement: IPS Corp Type 724™ cement or cement certified by the manufacturer for chemical service.

C. Chlorinated polyvinyl chloride (CPVC) piping system:
   1. Extruding and molding material: Virgin material containing no scrap, regrind, or rework material except where permitted in the referenced standards.
   2. Pipe:
      a. Manufacturers: One of the following or equal:
         1) Charlotte Pipe and Foundry Co.
         2) Eslon Thermoplastics, Inc.
         3) GF Harvel.
         4) Spears Manufacturing Co.
         5) Chemtrol.
      b. In accordance with ASTM F441 and Appendix, CPVC 4120.
      c. Extruded from Type IV, Grade 1, Class 23447 material in accordance with ASTM D1784.
      d. Schedule 80, unless otherwise specified.

3. Fittings:
    a. As appropriate to the service and pressure requirement.
        1) In accordance with:
            a) ASTM F438 for Schedule 40.
            b) ASTM F439 for Schedule 80.
    b. Same material as the pipe and of equal or greater pressure rating.
    c. Supplied by pipe manufacturer.
4. Solvent cement:
    a. In accordance with ASTM F493.
    b. Manufacturers: The following or equal:
        1) IPS Corp.
    c. Certified by the manufacturer for the service of the pipe.
    d. Primer: As recommended by the solvent cement manufacturer.
5. Unions 4 inches and smaller:
    a. Socket end screwed unions.
6. Unions 6 inches and larger:
    a. Socket flanges with 1/8-inch full-face soft Viton™ gasket.

D. Black steel pipe (BSP) piping system:
1. Pipe:
    a. In accordance with ASTM A53.
    b. Type E - electric-resistance welded or Type S - seamless.
    c. Grade A or B.
    d. Schedule 40, unless otherwise specified.
2. Fittings:
    a. Screwed fittings:
        1) Malleable iron:
            a) In accordance with ASME B16.3, Class 150 or Class 300 as specified.
            b) Galvanized in accordance with ASTM A153 when used with galvanized pipe.
3. Provide BSP for natural gas lines in the Chlorine Building and PEC, PEA, and PC Areas.

2.04 BACKFLOW PREVENTERS

A. Manufacturers: One of the following or equal:
1. Febco backflow prevention:
    a. Model LF860 all sizes.
2. Zurn/Wilkins:
    a. Model 975XL for 1/2-inch through 2-inch.
    b. Model 375AST for sizes 2 1/2 inch, 3 inch, 8 inch, and 10 inch.
    c. Model 375 and 375DA for sizes 4 inch and 6 inch.
3. Watts regulator: Series LF909.

B. Design: Reduced pressure chamber type in accordance with AWWA C511.

C. Shutoff valves:
1. Backflow preventers 2 inches and smaller: Provide with full-port, quarter turn, resilient seated ball valves.

2. Backflow preventers larger than 2 inches: Provide with resilient seated, outside stem and yoke gate valves.

2.05 WATER SOFTENERS

A. Manufacturers: One of the following or equal:
   1. Culligan, Model Hi-Flo or CTM.
   2. Fleck, Model 9500.

B. Design requirements:
   1. Valves and other parts which come into contact with water made of copper, with plastic, neoprene, EPDM or Monel internal parts.
   2. Alternating twin tank design to continuously supply softened water.
   3. Regenerate with softened water.
   4. Source water characteristics:
      a. Pressure: Minimum 20 psig; maximum 125 psig.
      b. Temperature: 35 to 110 degrees Fahrenheit.
      c. Hardness: 15 grains per gallon.
      d. Total Iron: 0.02 milligrams per liter.
      e. Chlorine: 1.0 milligrams per liter.
   5. Continuously soften up to 30 gpm to 0.3 grains per gallon:
      a. Pressure loss: 25 psi.
   6. Peak flow rate: 100 gpm.

C. Resin:
   1. 10 percent cross-linked polystyrene suitable for the source water.
   2. Volume: 15 cubic feet.
   3. 215,000 grains minimum.

D. Resin tanks: Fiberglass with molded liner.

E. Brine tank: Polyethylene.

F. Valve:
   1. Single valve for both resin tanks.
   2. Digital control and electronic meter.
   3. Adjustable, 5-cycle control for:
      a. Upflow backwash.
      b. Downflow brining and slow rinse.
      c. Rapid rinse.
      d. Timed brine refill.
      e. Downflow service.

G. Electrical controls: 120 volt, 60 hertz electrical service.

H. Warranty:
   1. Special warranty: Duration:
      a. 10-years for tanks.
      b. 5-years for valves and electronics.
      c. 2-years for all other parts and resin.

2.06 PIPE INSULATION

A. General:

1. Insulation thicknesses: Provide insulation thickness in inches in accordance with Table 1 per 2021 International Energy Conservation Code (IECC). Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

2. Insulation conductivity and nominal pipe size as specified in Table 1.

Table 1 - Insulation Thickness Requirements							
FLUID OPERATING TEMPERATURE RANGE AND USAGE (F)	INSULTATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	CONDUCTIVITY Btu x in./(h x ft^2 x ˚F)[b]	MEAN RATING TEMPERATURE Degree Fahrenheit	<1	1 to <1 ½	1 ½ to < 4	4 to < 8	>8
>350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.5	1.5	1.5	1.5
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.0

3. Service designation and location requirements as specified in Table 2 including the following requirements.
   a. Insulation type.
   b. Jacket type.
   c. Vapor barrier requirements.

Table 2. Insulation Schedule					
Service Designation(1)	**Location(2)**	**Insulation Type(3)**	**Jacket Type(3)**	**Service Temp. °F(4)**	**Vapor Barrier**
Tepid Water	Interior or Exterior	1 or 2	Type 1 on Exterior installations; none required on Interior installations	60-100	Install on Type 2 insulation
Heat Traced Pipes(5)	Exterior	1 or 2	2	N/A	Install on Type 2 insulation
Notes: (1) Refer to Plumbing Pipe Schedule as indicated on the Drawings for service designations.					

Table 2. Insulation Schedule					
Service Designation[1]	**Location[2]**	**Insulation Type[3]**	**Jacket Type[3]**	**Service Temp. °F[4]**	**Vapor Barrier**
(2) Insulation jackets are not required for concealed interior installations in accordance with appliable plumbing code. (3) Contractor may select from options listed. (4) Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table 1. (5) Insulate piping systems that are heat traced as indicated on the Drawings.					

B. Type 1: Pipe insulation, closed cell elastomeric insulation:
   1. Manufacturers: One of the following or equal:
      a. Aeroflex USA Inc., Aerocel® AC.
      b. Armacell®, AP Armaflex.
   2. Insulation material: Closed cell elastomeric insulation.
   3. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
   4. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
   5. Fire ratings:
      a. Flame spread: 25 or less.
      b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.
   6. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.

C. Type 2: Pipe insulation, preformed mineral fiberglass:
   1. Manufacturers: One of the following or equal:
      a. Johns Manville, Micro-Lok® HP.
      b. Knauf Insulation.
      c. Owens-Corning.
   2. Insulation material: Preformed mineral fiberglass insulation made from glass fibers bonded with a thermosetting resin.
      a. In accordance with ASTM C547, Class 1.
      b. Provide with factory installed vapor barrier.
         1) Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type I.
         2) Longitudinal lap seals: Pressure-sensitive, self-sealing longitudinal lap strip with factory applied adhesive.
         3) Circumferential butt seals: 4-inch wide tape or similar properties or 4 inch wide overlap with adhesive seal.
         4) Vapor barrier permeability: 0.02 perms or lower.
         5) Vapor barrier flame spread rating: 25 or less.
   3. Minimum temperature range: Minus 0 degrees Fahrenheit to plus 850 degrees Fahrenheit.
   4. K factor at 75 degrees Fahrenheit: Not more than 0.23 BTU-inch/hour-square feet degrees Fahrenheit.
   5. Maximum moisture absorption, volume percent: 5.

D. Insulation jackets:
   1. Type 1: Pipe insulation jacket, ultraviolet-resistant polyvinyl chloride:
      a. Manufacturers: One of the following or equal:
         1) Johns Manville, Zeston® 2000 PVC.
         2) Proto Corp., LoSMOKE PVC.
         3) Speedline® Corp., Smoke-Safe™ PVC.
      b. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
      c. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
      d. Color: White.
      e. Overlap: 1-inch minimum at joints and fittings.
      f. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
      g. Fittings: Factory made with full thickness insulation.
   2. Type 2: Pipe insulation jacket, aluminum:
      a. Manufacturers: One of the following or equal:
         1) Childers Products.
         2) Premetco International.
      b. Material: Aluminum, Alloy 5005; 0.016-inch (26-gauge) minimum thickness.
      c. Overlap: Overlap circumferential joints 4 inches minimum; overlap longitudinal joints 1-inch minimum; longitudinal joints oriented to minimize water entry.
      d. Bands: 0.5-inch wide, 0.0508-inch (16-gauge) thick aluminum, same alloy as jacket or 0.0179-inch thick Type 304 stainless steel; install on 18-inch centers, uniformly spaced and at all fitting joints.
      e. Joint seal: Apply waterproof adhesive at joints and overlaps.
      f. Fittings: Custom fit of same materials.

E. Vapor barriers:
   1. Type 1: Pipe insulation vapor barrier, white Kraft paper bound to aluminum foil:
      a. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
      b. Permeability: 0.02 perms or lower.
      c. Maximum flame spread rating: 25.
      d. Edge seal: Pressure-sensitive tape lap seal.
      e. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
   2. Type 2: Pipe insulation vapor barrier, mastic:
      a. Manufacturers: One of the following or equal:
         1) Benjamin Foster, No. 30-76.
         2) Childers Products.
         3) Foster Products.
         4) Insul-Coustic.
      b. Material: Mastic.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install vents required in drainage piping as part of the plumbing system, in accordance with Laws and Regulations.

B. Use anti-seize lubricant for stainless steel treads on fittings and fasteners.

3.02 INSTALLATION

A. Fixtures:
   1. Rough-in fixtures and accessories in accordance with the dimensions supplied by the manufacturers of the fixtures.
   2. Mount fixtures and accessories without cutting of finish surface.

B. Plumbing and drainage products:
   1. Traps:
      a. Install traps as near the fixtures as possible.
   2. Sizes of equipment drains and of floor drains shall be as indicated on the Drawings.

C. Plumbing piping systems:
   1. PVC, polypropylene piping systems:
      a. Where not specified otherwise, install horizontal piping with a grade of 1/4 inch per foot.
      b. Provide vents, roof drains, and pipes flashed and made watertight at the roof with lead sheet flashings.
         1) Minimum 4-pound lead sheet.
      c. Extend flashing not less than 6 inches up the pipes, and counter flash with standard cast iron or malleable iron recessed roof couplings.
      d. Extend flashing for vents up to the top of the vent and turn down into the pipe.
      e. Extend flashing shields not less than 8 inches from vent and pipe in all directions.
   2. Black steel piping system:
      a. Install per applicable codes and regulations.
   3. CPVC piping system:
      a. Install piping in accordance with ASTM F645, or manufacturer's published instructions for installation of piping, as applicable to the particular type of piping.
      b. Provide molded transition fittings for transitions from plastic to metal or IPS pipe.
         1) Do not thread pipe.
         2) Do not use flanged transition fittings unless specifically indicated on the Drawings.
      c. Locate unions where indicated on the Drawings, and elsewhere where required for adequate access and assembly of the piping system.
      d. Provide serrated nipples for transition from plastic pipe to rubber hose.
      e. Clean dirt and moisture from pipe and fittings.

f. Bevel pipe ends in accordance with manufacturer's instructions with chamfering tool or file.
    1) Remove burrs.
g. Use solvent cement and primer formulated for CPVC.
h. Use primer on pressure and non-pressure joints.
i. Do not solvent weld joints when ambient temperatures are below 40 degrees Fahrenheit or above 90 degrees Fahrenheit unless solvent cements specially formulated for these conditions are utilized.

D. Wall and floor seals:
1. Provide seals at rated walls.
2. Provide seals between floors.
3. Use specified barrier seals for concrete/masonry wall and floor penetrations.

E. Anti-seize lubricant:
1. Use with assembly of stainless steel nuts and bolts.

F. Pipe insulation:
1. Install insulation and jacket materials in accordance with manufacturer's written instructions.
2. Fittings:
    a. Insulate fittings by covering with mitered sections of insulation or utilize factory-made prefabricated fitting shapes.
    b. Terminate preformed pipe jackets or covering at sufficient distance from flanges to permit removal of bolts.
    c. Overlap flange and flanged fitting insulation on adjacent pipe covering by at least 2 inches.
3. Valves:
    a. Insulate valves 3 inches in nominal size and larger with removable insulating blankets.
    b. Size blanket to extend up to packing gland only so that replacement of packing does not require removal of insulating blanket.
4. Provide continuous insulation through and over pipe supports and provide protection saddles at supports.
5. Provide continuous pipe insulation and covering through sleeves or openings in walls and floors.
    a. When buried pipe enters a building through a below grade wall or slab penetration, begin insulation system on interior side of penetration.
6. Apply pre-molded pipe insulation with extended legs when used on pipe traced with either tubing or electric cable type.
7. Thermally isolate insulation closure locations (end caps, transitions, etc.).
    a. Type 1 or 2 jacket installation on piping with potential reach temperatures greater than 150 degrees Fahrenheit.
8. Apply piping identification on jackets as specified in Section 15076 - Pipe Identification.

G. Backflow preventers:
1. Include shutoff valves at each end of backflow preventer with properly located test cocks.

3.03 FIELD QUALITY CONTROL

A. Test water piping in accordance with the plumbing code as specified in Section 01410 - Regulatory Requirements.

B. Test drain, waste, and vent lines as specified and in accordance with the plumbing code as specified in Section 01410 - Regulatory Requirements.

C. Backflow preventer:
   1. Test witnessing: Witnessed.
   2. Conduct pressure and leak test as specified in Section 15110 - Common Work Results for Valves.
   3. Certificate of backflow prevention from a tester listed by the American Backflow Prevention Association.

3.04 CLEANING

A. Upon completion of installation, clean piping interior of foreign matter and debris.

B. Flush and disinfect potable water piping as specified in Section 01757 - Disinfection.

3.05 SCHEDULES

A. As indicated on the Drawings in the Plumbing Pipe Schedule on drawing 00GP01.

END OF SECTION

SECTION 15430

EMERGENCY EYE/FACE WASH AND SHOWER EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Emergency shower and eyewash.
   2. Water heaters.

1.02 REFERENCES

A. American Gas Association (AGA) Standards.

B. American National Standards Institute (ANSI):
   1. Z358.1 - Emergency Eyewash and Shower Equipment.

C. American Society of Mechanical Engineers (ASME).

D. American Society of Sanitary Engineering's (ASSE):
   1. 1070 - Standard for devices that limit water temperature to a fixture or fixtures such as sinks, lavatories, or bathtubs to reduce the risk of scalding.
   2. 1071 - Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment.

E. Americans with Disabilities Act (ADA) Standards.

F. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

G. National Fire Protection Association (NFPA).

H. Occupational Safety and Health Administration (OSHA).

I. Underwriters Laboratories, Inc. (UL).

1.03 ABBREVIATIONS

A. IPS - Industrial Piping Systems.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures and Section 01600 - Product Requirements.

1.05 QUALITY ASSURANCE

A. Regulatory requirements:
   1. As applicable, equipment of this Section shall comply with requirements of public agencies of the state of Utah including ASME, NFPA, OSHA and UL.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Deliver to the job site in manufacturer's original containers.

B. Delivery: After wet operations in building are completed.

C. Storage and protection:
   1. Store materials in original, unopened containers in compliance with manufacturer's printed instructions.
   2. Keep materials dry until ready for use.
   3. Keep packages of material off the ground, under cover, and away from sweating walls and other damp surfaces.
   4. Protect finished surfaces from soiling and damage during handling and installation. Keep covered with a protective covering.

PART 2 PRODUCTS

2.01 EMERGENCY SHOWERS AND EYE/FACE WASHES (ESEW)

A. General design requirements:
   1. Combination unit emergency shower with eye/face wash:
      a. Floor mounted fixture consisting of pipe standard, showerhead assembly, and eyewash assembly.
      b. Provide stanchion and floor flange, with interconnecting piping.
   2. Showerhead flow: 20.0 gallons per minute flow, minimum.
   3. Eye/face wash flow: 3.0 gallons per minute flow, minimum.
   4. Meet or exceed all requirements of ANSI Z358.1.
   5. Provide ANSI compliant identification sign and markings.
   6. Provide alarm and flow switch options.

B. Shower/eyewash unit with integral controls to alarm the system is in use.
   1. Flow switch:
      a. Construction:
         1) NEMA Type 4.
         2) Brass or Type 316 Stainless Steel.
      b. Type: Magnetic proximity switch.
      c. Alarm Contacts: Double pole, double throw contacts rated at 2.0 amps at 120 VAC configurable for either Normally Open or Normally Closed.

C. Indoor ESEW - PVC combination unit emergency shower and eye/face wash:
   1. Manufacturers: One of the following or equal:
      a. Bradley, Model No. S19-310PVC.
      b. Guardian Equipment, Model No. G1990.
      c. HAWS, Model No. 8336.
   2. Pipe standard: 2 inch Schedule 80 PVC pipe and fittings, with stainless steel rod providing additional support overhead; 2-1/2 inch diameter floor flange.
   3. Showerhead:
      a. Material and size: ABS plastic, 10-inch diameter with 20 gallons per minute flow control.
      b. Valve and actuator: Type 316 stainless steel stay open steel ball valve actuated by rigid stainless steel pull rod.
   4. Eye/face wash:
      a. Valve and actuator: Stay open Type 316 stainless steel ball valve with stainless steel ball operated by stainless steel push handle.
      b. Head(s): ABS plastic or polypropylene soft-flow eye/face wash type heads, with integral flip top protective dust covers releasing with water pressure.
      c. Receptor bowl: ABS plastic.

D. Outdoor ESEW - Freeze resistant combination unit emergency shower and eye/face wash:
   1. Manufacturers: One of the following or equal:
      a. HAWS, Model No. 8317CTFP.
      b. Bradley, Model No. S19-304GAB.
      c. Guardian Equipment, Model No. GFR3100.
   2. Pipe standard:
      a. 1-1/4-inch stainless steel pipe and galvanized fittings, wrapped with self-regulating heat cable.
      b. 120 VAC thermostatically controlled heat trace cable. Encase piping and fittings in UV resistant ABS plastic jacket with internal foam insulation for temperature control; 5 inch diameter floor flange.
   3. Shower head:
      a. Material and size: ABS plastic stainless steel, 10-inch diameter with 20 gallons per minute flow control.
      b. Valve and actuator: Chrome plated brass stay open steel ball valve actuated by rigid stainless steel pull rod.
   4. Eye/face wash:
      a. Valve and actuator: Stay open chrome plated brass ball valve with stainless steel ball and stem operated by a stainless steel or epoxy coated aluminum push handle.
      b. Heads: Twin ABS plastic or polypropylene soft-flow eye/face wash type heads, with integral flip top protective dust covers releasing with water pressure.
      c. Receptor bowl: Stainless steel.

E. Safety shower and eye/face wash tepid water mixing valves:
   1. Manufacturers: One of the following or equal:
      a. Bradley, Model No. S19-2250.
      b. Guardian Equipment, Model No. G3800 Series.
      c. Haws, Model No. 9201 Series.

2. General requirements:
    a. Provide 1 mixing valve for each safety unit or group of safety units mounted within 100 feet of each other.
3. Tepid water system to provide a minimum of 20 gallons per minute for shower and 3 gallons per minute for eye/face wash of water for a period of at least 15 minutes at a delivery temperature of 80 to 85 degrees Fahrenheit.

F. Safety shower tester:
1. Manufacturers: One of the following or equal:
    a. Bradley, Model No. S19-330ST.
    b. Guardian Equipment, Model No. AP250-005.
    c. Haws, Model No. 9010 with No. 9009.
2. Kit includes:
    a. Minimum 5-gallon plastic bucket.
    b. 7 foot long watertight 12-gallon translucent vinyl plastic bag for attaching over drench showerhead.
        1) Bag shall have drawstring at top and be hemmed at bottom.
    c. Testing record card.

2.02 WATER HEATERS

A. Size and requirements as indicated on the Drawings.

B. Provide with temperature limiting device meeting ASSE 1070.

C. Tankless natural gas water heater:
1. Natural gas internal condensing water heater.
2. Wall mounted.
3. AHRI Certified UEF up to 0.93.
4. Thermal efficiency up to 97%.
5. Ultra Low NOx.
6. Certifications: Energy Star, ANSI Z21.10.3, CSA 4.3 and AHRI.
7. High altitude approved up to 10,200 ft. Manufacturer shall provide unit at performance for the altitude where the heater will be installed.
8. Water flow control with Sensor, Electric Water Control and Bypass Control.
9. Flexible venting options.
10. Warranty:
    a. Heat exchanger: 8 years/12,000 operation hours, whichever occurs first.
    b. Other parts and components: 5 years.
    c. Labor: 1 year.
11. Safety devices:
    a. Flame failure.
    b. Boiling protection.
    c. Combustion Fan RPM Check.
    d. Over current.
    e. Remaining flame protection.
    f. Automatic frost protection.
12. Flow actuated at 0.25 gpm.
13. Inlet flow:
    a. Up to 11 gpm and 150 psig.

14. Outlet flow:
    a. Minimum temperature: 98 degrees Fahrenheit.
    b. Maximum temperature: 140 degrees Fahrenheit.
    c. Set temperature to lowest factory setting.
15. Provide water heater piping components necessary for installation:
    a. Provide tepid water mixing valve.
    b. Drain piping, material as indicated on Piping Schedule.
    c. Supply valve.
    d. Y strainer.
    e. Pressure regulating valve and gauge.
    f. Water hammer arrestor.
16. Manufacturers: One of the following or equal:
    a. Rinnai, Model CU199i.
    b. Rheem, similar models.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturers' recommendations.

B. Install products in accordance with code requirements and ANSI Z358.1.

C. Plumbing and mechanical work as specified in Section 15400 - Plumbing Systems and Section 15050 - Common Work Results for Mechanical Equipment.

3.02 FIELD QUALITY CONTROL

A. Functional testing:
    1. Shower/eyewash unit with integral controls:
        a. Test witnessing: Witnessed.
        b. Electrical Instrumentation and Controls:
            1) Test witnessing: Witnessed.
            2) Conduct testing as specified in Section 17950 - Commissioning for Instrumentation and Controls.

3.03 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15500

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. General prescriptive, design, and performance requirements for products and mechanical equipment used to heat, ventilate, cool, or otherwise condition or distribute indoor air.
   2. Specific requirements for ductwork accessories:
      a. Dampers and damper operators.
      b. Diffusers, grills, and registers.
   3. Specific requirements for refrigerant piping.

1.02 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
   2. 270 - Sound Rating of Outdoor Unitary Equipment.
   3. 340/360 - Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment.
   4. 430 - Performance Rating of Central Station Air-handling Unit Supply Fans.

B. Air Movement and Control Association International, Inc. (AMCA):
   1. 11 - Certified Ratings Program Operating Manual.
   2. 210 - Laboratory Methods for Testing Fans for Certified Aerodynamic Performance Rating.
   3. 211 - Certified Rating Program- Product Rating Manual for Fan Air Performance.
   4. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
   5. 311 - Certified Ratings Program — Product Rating Manual for Fan Sound Performance.
   6. 500 - Laboratory Methods of Testing Dampers for Rating.
   7. 511 - Certified Ratings Program Product Rating Manual for Air Control Devices.

C. American Bearing Manufacturer's Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.
   2. 11 - Load Ratings and Fatigue Life for Roller Bearings.

D. American National Standards Institute (ANSI):
   1. Z21.47 - Gas Fired Central Furnaces (except Direct Vent Central Furnaces).

E. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   1. Standard 15 - Safety Standard for Refrigeration System.
   2. Standard 52.2 - Methods of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

F. American Society of Mechanical Engineers (ASME):
   1. RTP-1 - Reinforced Thermoset Plastic Corrosion-Resistant Equipment.

G. ASTM International (ASTM):
   1. B32 - Standard Specification for Solder Metal.
   2. B75 - Standard Specification for Seamless Copper Tube.
   3. B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
   4. B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
   5. B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fitting.
   6. C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   7. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
   8. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   9. D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   10. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   11. D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

H. National Bureau of Standards: NBS PS15-69 - Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.

I. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

J. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).
   2. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

K. National Roofing Contractors Association (NRCA).

L. International Association of Plumbing and Mechanical Officials (IAPMO):
   1. IS 3 - Installation Standard for Copper Plumbing Tube, Pipe, and Fittings.

M. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

N. Underwriters Laboratories, Inc. (UL):
   1. 555 - Standard for Fire Dampers.
   2. 555S - Standard for Smoke Dampers.

3. 900 - Standard for Air Filter Units.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination.
   1. Provide roof mounted HVAC equipment information required in the preparation of roofing drawings including, but not limited to:
      a. Location.
      b. Size.
      c. Weight.
      d. Anchoring and support details.

1.04 SUBMITTALS

A. Where items in this Section are components of equipment or systems specified in other sections, include data for this Section's components with the equipment or system submittal.

B. When products are specified in this Section but are not referenced in other Technical Sections, submit:
   1. As specified in Section 01330 - Submittal Procedures.
   2. Product data:
      a. Sufficient to substantiate specified requirements.
   3. Description of coating system and instructions for field touch up and re-coating.

PART 2 PRODUCTS

2.01 GENERAL

A. Technical Sections product requirements supersede conflicting requirements in this Section.

B. As specified in Section 01600 - Product Requirements.

C. Electrical:
   1. Components and assemblies.
   2. Carry UL Listing Marking.
   3. In accordance with NEC requirements.

D. Fans:
   1. Rated and labeled in accordance with AMCA 210 and AMCA 211.
   2. Belt drive systems:
      a. Adjustable for minimum within 5 percent speed change.
      b. Rated for 150 percent of maximum motor horsepower.

E. Unitary air conditioners and heat pumps:
   1. Rated in accordance with AHRI Standards 210/240 or 340/360, AHRI 270, and AHRI 430.
   2. In accordance with ASHRAE Standard 15.

3. Heating: Certified in accordance with ANSI Z21-47.
4. Refrigerant: HFC R-410A.

F. Filters:
1. Media: UL 900 listed.

G. Insulation and adhesives: In accordance with NFPA 90A requirements for flame spread and smoke generation.

H. Roof curbs: Supplied by manufacturer of product requiring the curb.

I. Factory coating: For equipment with factory coatings, manufacturer to supply 2 containers (each about a pint) of the paint for Contractor/Owner touch up.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. General:
1. Environmental conditions as specified in Section 01850 - Design Criteria.
2. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

B. Fans:
1. Sharply rising pressure characteristics throughout the operating range and beyond the efficiency peak.
2. Peak operating points to be as close as possible to the maximum efficiency and whose operating range is within the normal fan selection range.
3. Bearings rated per ABMA 9 or 11 for a L10 life rating of not less than 50,000 hours.
4. Total sound power levels in the 8 octave band range in accordance with AMCA 301, not to exceed the lesser of the following or the sones level indicated on the Drawings.

Sound Power Level, decibels levels referenced to 10-12 watts								
Frequency, Hz	63	125	250	500	1,000	2,000	4,000	8,000
General	100	98	94	88	84	84	78	75

5. Shall comply with AMCA Publication 11 and bear the AMCA Certified Ratings Program seal for air performance and sound performance according to AMCA Publication 211 and AMCA Publication 311.

C. Unitary air conditioners and heat pumps:
1. Outdoor noise levels: Outdoor noise levels in the 8 octave band ranges, as measured in accordance with AHRI 270 shall not exceed the following:

OCTAVE BANDS								
Unit Nominal Capacity (Tons)	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
0 to 5	64	70	71	74	74	71	67	67

OCTAVE BANDS								
Unit Nominal Capacity (Tons)	**63**	**125**	**250**	**500**	**1,000**	**2,000**	**4,000**	**8,000**
6	79	85	78	74	71	73	66	59
7-1/2 to 10	64	70	73	79	82	78	74	67
12 and larger	84	88	84	83	84	78	72	68

2. Capable of starting and cooling from 45 to 125 degrees Fahrenheit ambient outdoor air temperature and exceeding the maximum load criteria of AHRI Standard 210/240 or 340/360.
3. Heat pumps capable of starting and heating at or above 0 degrees Fahrenheit outdoor ambient air temperature.
4. Minimum cooling, Energy Efficiency Ratio (EER) and Integrated Energy Efficiency Ratio (IEER), as rated in accordance with AHRI 210/240 or 340/360 for split systems and packaged units is as follows:

Equipment Type	**Net Cooling Cap (British Thermal Units per hour)**	**EER(1)**	**IEER(2)**
Space Constrained, Air Cooled	<30,000	11.7 12	N/A
Small Duct, High Velocity, Air Cooled	<65,000	12.1 12	N/A
Air Cooled	<65,000	13.4 14	N/A
Air Cooled	>65,000 and <135,000	11.2	14.8 12.9
Air Cooled	>135,000 and <240,000	11.0	14.2 12.4
Air Cooled	>240,000 and <760,000	10.0	13.2 11.6
Air Cooled	>760,000	9.7	12.5 11.2

(1) Deduct 0.2° from the required EER for units with a heating section other than electric resistance heat.

(2) IEER is only applicable to equipment with capacity control in accordance with AHRI 340/360

5. Units with heating capabilities: Meet or exceed the following:
   a. Annual fuel utilization efficiency: 80 percent.
   b. Steady state efficiency: 80 percent.

D. Filters:
1. Efficiency: 45 to 50 percent dust spot efficiency when rated in accordance with ASHRAE Test Standard 52.2.

E. Smoke detector requirements:
    1. Provide all supply, exhaust, and odor control fans greater than or equal to 2,000 cubic feet per minute with smoke detectors:
        a. Duct or fan mounted smoke detector as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

2.03 DAMPERS

A. General:
    1. Damper type, style, and size as indicated on the Drawings.
    2. Components: Include with each damper:
        a. Type, Frame, actuators, clips, connectors, and other accessories necessary for mounting.
            1) Manual actuators: Factory supplied locking quadrant on factory mounted stand-off bracket.
                a) Bracket finish to match frame.
            2) Electric actuators when indicated on the Drawings.
    3. Leakage Class, when specified, to be in accordance with AMCA Standard 511 and product to bear AMCA Rating Seal for Air Leakage.
        a. Blade seals to be mechanically attached.
    4. All fire dampers and combination smoke/fire dampers to have duct access door near damper as specified in technical sections.

B. Volume control and balancing type dampers (BD):
    1. BD-1; Style 3; rectangular, heavy duty, volume control damper:
        a. Class 1A leakage.
        b. Frame: Aluminum hat channel with concealed linkage.
            1) 6063T5 extruded.
            2) Hat mounting flanges on both sides.
            3) Reinforced corners.
            4) Finish: Industrial Epoxy.
        c. Blades: Aluminum, horizontal, single piece, opposed airfoil shape.
            1) 6063T5 extruded.
            2) Finish: Match frame finish.
        d. Blade axles: Steel, 1/2 inch hexagonal, positive lock:
            1) Electroless nickel plated.
            2) Molded synthetic bearings.
        e. Seals:
            1) Blade: Extruded vinyl.
            2) Jamb: Flexible metal compressible.
        f. Manufacturers: One of the following or equal:
            1) Greenheck: Model VCD-42.
            2) Ruskin: Model CD50.
    2. BD-7; Style 7; round, heavy duty, volume control damper:
        a. Manufacturers: One of the following or equal:
            1) Ruskin: Model 912.
            2) Greenheck.
        b. Class 1A leakage.
        c. Frame: Molded vinyl ester resin fiberglass channel.
            1) In accordance with ASME RTP-1.
                a) 30 mil resin rich interior corrosion layer.

2) Flanges integral to the web layup.

d. Blade: Vinyl ester resin fiberglass, horizontal, butterfly:
   1) In accordance with ASME RTP-1.
      a) 30 mil resin rich interior corrosion layer.
   2) Angle stops.

e. Blade axle: Pultruded vinyl ester resin fiberglass rod:
   1) PTFE bearings and axle shaft seal.
   2) Hand quadrant: Type 316 stainless steel.

f. Blade seal:
   1) Viton™.

3. BD-14, Style 14; round fiberglass damper:
   a. Manufacturers: One of the following or equal:
      1) Daniel Mechanical.
      2) Engineered Composite Systems.
   b. Zero-leakage air isolation damper.
   c. Materials of construction:
      1) Body: Vinyl ester FRP.
      2) Blade: Vinyl ester FRP.
      3) Blade seal: PTFE encapsulated O-ring, EPDM O-ring.
      4) Blade stop: FRP integral to the damper body.
      5) Shaft: Type 316 stainless steel or vinyl ester FRP.
      6) Shaft seal: Viton™ O-ring.
      7) Bearings and bushings: Graphite impregnated PTFE.
      8) Hardware: Type 316 stainless steel.
      9) Maximum operating temperature: 175 degrees Fahrenheit.
      10) Minimum pressure: 30-inches water column.
      11) Resin system: Fire retardant vinyl ester with MEKP cure system.
      12) Internal corrosion barrier: Minimum 100-mil thickness.
      13) Connections: Flanged in accordance with NBS PS15-69 Table 2.
      14) External coating: Gel coat with ultraviolet inhibitors.
      15) Gaskets: EPDM.
   d. Maximum leakage: 4.4 cfm per square feet at 30-inches water column.
   e. Actuators:
      1) Dampers 24 inches and smaller:
         a) Hand quadrant actuator fabricated from Type 316 stainless steel with a fully adjustable slot with extra hole drilled in handle to permit locking pin once system has been balanced.
         b) Provide drilled hole in the actuator handle support plate to permit locking in the full open and full closed positions.
      2) Dampers located in areas not normally accessible (all sizes):
         a) Operator: Geared 1/4 turn, Dynatorque stainless steel series DT7 (no chain wheel) or DT21 (with chain wheel) or equal.
         b) Material:
            (1) Shaft: Type 316 stainless steel shaft, enclosure, and hardware.
            (2) Gears: Type 316 stainless steel or 6061 aluminum.
         c) Extension:
            (1) Type 316 stainless steel with 2-inch operating nut, minimum 1-inch diameter or equal to the shaft diameter, whichever is larger.

(2) Provide an indicator at the top of the extension stem to indicate full open and full closed positions.

3) Dampers located 6 feet or more above finished floor or grade elevation shall use geared operators as specified above with chain wheel operator and chain extending to within 3 feet of finished floor or grade elevation.
   a) Manufacturers: One of the following or equal:
      (1) Babbitt.
      (2) Rotohammer.
   b) Aluminum chain wheels equipped with Type 316 stainless steel chain.
   c) For installations where operator and chain weight exceed 40 pounds the damper shall be reinforced to accommodate the added weight.

C. Backdraft dampers (BDD):
   1. BDD-1; Style 1; counterbalanced backdraft damper:
      a. Manufacturers: One of the following or equal:
         1) Ruskin: Model CBD6.
         2) Greenheck.
      b. Frame:
         1) Minimum depth: 2.25 inches.
         2) Minimum thickness: 0.125-inch.
         3) Material: 6063T5 aluminum.
         4) With insect screen and water stop.
      c. Blades:
         1) Minimum thickness: 0.070-inch.
         2) Material: 6063T5 aluminum.
         3) High strength nylon bearings.
         4) Elastomer edge seals.
         5) Aluminum tie-bar.
         6) Blades require no more than 4.25 inches clearance beyond frame when fully open.
      d. Counterbalance:
         1) Zinc plated bar on blades.
         2) Adjustable down to 0.01-inch wg opening.
      e. Finish:
         1) Industrial Epoxy.

D. Fire dampers (FD):
   1. FD-1, Style 1; UL 555 classified, curtain type, dynamic fire damper:
      a. Manufacturers: One of the following or equal:
         1) Greenheck.
         2) Ruskin DIBD23 - galvanized construction, Styles C, CR, or CO.
      b. Duct access door next to fire damper.
      c. Frame: 7-inch sleeve length plus 1.5-inch collars on both sides in gauges required by UL listing R-5531.
      d. Single assembly with an integral factory sleeve.
      e. Blade: Curtain type.
      f. Closure spring: Type 301 stainless steel.

g. Fusible link: 165 degrees Fahrenheit unless otherwise indicated on the Drawings.
h. Finish: Mill.

2.04 DAMPER OPERATORS

A. General: Provide manual or electric damper operator for each damper furnished as indicated on the Drawings.

B. Manual operators by damper manufacturer:
1. Operate damper manually with a force not exceeding 20 pounds.
2. Provide with locking quadrant.
3. Provide 3/8 inch, or larger, square double-ended drive shaft adequate for required damper torque, with machined keyways allowing for mounting in 2 positions, 90 degrees apart.
4. Provide sufficient number of operators for torque required to operate damper.

C. Electric damper operators:
1. Manufacturers: One of the following or equal:
a. Honeywell.
b. Johnson Controls.
2. 2-position spring return.
3. 1 internal single pole double throw auxiliary switch rated 5 A, 120 V.
4. Housed in die-cast aluminum case with mounting flange.
5. Motor and gear train components immersed in oil.
6. When required, provide auxiliary transformers factory wired to damper operator and installed in NEMA Type 4X enclosure fastened to motor housing.

2.05 DIFFUSERS, GRILLES, AND REGISTERS

A. Provide diffusers, grilles, and registers manufactured by the same manufacturer.

B. Provide style and size as indicated on the Drawings.

C. Components: Include specified style with frame, clips, connectors, and other accessories necessary for mounting.

D. Supply diffuser, grille, and register styles:
1. SR-8, Supply Register Style 8:
a. Manufacturers: One of the following or equal:
1) Titus Manufacturing Corp, DL -SV grille with AG-15-HD damper.
2) Tuttle and Bailey.
3) Kees, Inc.
4) Metal Industries, Inc., (MetalAire).
5) Krueger.
b. Service: Supply air in corrosive environments.
c. Type: High capacity, high throw drum louver.
d. Installation: when duct mounted is indicated on the Drawings, provide 4 inch drop frame.
e. Face: Flanged with sponge rubber gasket.

f. Blades: Split vane design to produce diverging airstreams.
g. Core: Adjustable drum with felt side seals; 25- to 30-degree drum rotation from the centerline.
h. Damper: Provide opposed blade volume control damper on inlet ducting; damper to be adjustable from the face of the grille.
i. Materials: aluminum frame, drum, and damper; provide baked acrylic finish.
    1) Aluminum extruded and coated border, blades, and damper; provide Titus 700 series finish or equal.
    2) Coating shall be rated to withstand a 1,500-hour corrosive environment salt spray test.
    3) Color selected by Owner.

2. SR-9, Supply Register Style 9:
    a. Manufacturers: One of the following or equal:
        1) Titus Manufacturing Corp, 300RL-SS.
        2) Tuttle and Bailey.
        3) Kees, Inc.
        4) Metal Industries, Inc., (MetalAire).
        5) Krueger.
    b. Service: Supply air in corrosive environments.
    c. Type: Stainless steel, double deflection.
    d. Installation: when duct mounted is indicated on the Drawings, provide 4 inch drop frame.
    e. Faceplate: Removable grille with double deflection blades spaced at 3/4 inch; front blades parallel to long dimension; provide gasket at frame.
    f. Core: Adjustable vanes with rectangular or round neck to match ducting.
    g. Damper: Provide opposed blade volume control damper suitable for use with ducting type; damper to be adjustable through the face.
    h. Materials: Type 316 stainless steel frame, core, damper, and faceplate.

E. Exhaust diffuser, grille, and register styles:
1. ER-3, Return/Exhaust Register Style 3:
    a. Manufacturers: One of the following or equal:
        1) Kees, Inc.
        2) Krueger.
        3) Metal Industries, Inc., (MetalAire).
        4) Titus Manufacturing Corp, 350FL.
        5) Tuttle and Bailey.
    b. Size: Rectangular grille with size as indicated on the Drawings.
    c. Installation: When duct mounted is indicated on the Drawings, provide 4-inch drop frame.
    d. Faceplate: Removable grille with fixed blades spaced at 3/4 inch; front blades parallel to long dimension with 35-degree deflection; provide gasket at frame for sealing.
    e. Core: When connected to ducting, provide suitable rectangular or round neck to match ducting.
    f. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type.
        1) Adjustable through the face of the unit.
    g. Materials: Aluminum frame, core, damper, and faceplate.

2. ER-6, Return/Exhaust Register Style 6:
    a. Manufacturers: One of the following or equal:
        1) Titus Manufacturing Corp, 350RL-SS.
        2) Tuttle and Bailey.
        3) Kees, Inc.
        4) Metal Industries, Inc., (MetalAire).
        5) Krueger.
    b. Size: Rectangular grille with size as indicated on the Drawings.
    c. Faceplate: Removable grille with fixed blades spaced at 3/4 inch; front blades parallel to long dimension with 45 degree deflection; provide gasket at frame for sealing.
    d. Core: When connected to ducting, provide suitable rectangular or round neck to match ducting.
    e. Damper: When connected to ducting, provide opposed blade volume control damper suitable for use with ducting type; damper to be adjustable through the face of the unit.
    f. Materials: Type 316 stainless steel frame, core, damper, and faceplate.

2.06 SCREENS

A. Required on all fans and louvers unless otherwise indicated on the Drawings.

B. Characteristics and features:
    1. Bird screen: 1/2-inch mesh by 14 gauges.
        a. For exhaust applications.
    2. Insect screens: 18 by 14 mesh.
        a. For intake applications.
    3. Screens and frames, same material as ductwork, hood, louver, fan, or equipment connected to screen.
    4. Screens secured in frames.

2.07 FLEXIBLE CONNECTORS

A. Provide flexible duct connectors at connections to fans and other air movement equipment as indicated on the Drawings.

B. FL-2, Duct to Duct Flexible Connection, Corrosive Environment:
    1. Manufacturers: The following or equal:
        a. Ventfabrics, “Ventel”.
    2. Fabric for flexible connections exposed to chemicals shall be glass fabric coated with Teflon™ and suitable for a temperature range of -10 to 500 degrees Fahrenheit and shall have a weight of at least 14 ounces per square yard and a thickness of 0.014 inch.

2.08 REFRIGERANT PIPING

A. Seamless copper tube:
    1. Type:
        a. Straight lengths: ASTM B75, USN Alloy C12200, H55 Temper.
        b. Coiled lengths: ASTM B280, USN Alloy C12200, O60.

c. Outside diameter sized, minimum wall thickness in accordance with ASTM B280 and B75.

2. Non-VRF System Refrigerant Piping:
   a. Solder: ASTM B32, Alloy Grade Sb5.
   b. Flux: ASTM B813.

2.09 CONDENSATE DRAIN PIPING

A. PVC:
   1. PVC Pipe: Designation PVC 1120 in accordance with ASTM D1785 and appendices:
      a. Pipe and fittings: Extruded from Type I, Grade 1, Class 12454 B material in accordance with ASTM D1784.
      b. PVC Pipe: Schedule 80 unless otherwise indicated on the Drawings.
   2. Fittings:
      a. Supplied by pipe manufacturer.
      b. Pressure fittings: In accordance with ASTM D2466 or ASTM D2467.
      c. DWV fittings: In accordance with ASTM D2665.
   3. Solvent cement: In accordance with ASTM D2564:
      a. Manufacturers: The following or equal:
         1) Primer: IPS Corp Type P-70™.
         2) Cement: IPS Corp Type 724™ cement or cement certified by the manufacturer for chemical service.

2.10 PIPE INSULATION

A. General:
   1. As specified in Section 01600 - Product Requirements.
   2. Insulation thicknesses: Provide insulation thickness in inches in accordance with the following table. Insulation thickness shown is nominal. Manufacturing tolerance of 15 percent variation is permissible.

Table 1 - Required Insulation Thicknesses (inches)

Service Temperature Range as Designated in Insulation Schedule at End of this Section	Nominal Pipe Diameters	
	1 inch and Less	1.25 to 2 inches
100 to 200 degrees Fahrenheit	1.5	1.5
40 to 100 degrees Fahrenheit	0.5	1.0

B. Insulation, Type 1:
   1. Manufacturers: One of the following or equal:
      a. Aeroflex USA Inc., Aerocel® AC.
      b. Armacell®, AP Armaflex.
   2. Insulation material: Closed cell elastomeric insulation.
   3. Minimum temperature range: Minus 40 degrees Fahrenheit to plus 220 degrees Fahrenheit.
   4. K factor at 75 degrees Fahrenheit: Not more than 0.27 BTU-inch/hour-square feet-degrees Fahrenheit.
   5. Fire ratings:
      a. Flame spread: 25 or less.

b. Smoke density: 50 or less for insulation thicknesses up to 1.5 inches.

6. Joints: Seal with manufacturer's recommended contact adhesive to form continuous water barrier.

C. Insulation jackets:

1. Type 1:
   a. Manufacturers: One of the following or equal:
      1) Johns Manville, Zeston® 2000 PVC.
      2) Proto Corp., LoSMOKE PVC.
      3) Speedline® Corp., Smoke-Safe™ PVC.
   b. Material: Ultraviolet-resistant polyvinyl chloride jacketing, 20 mil minimum thickness.
   c. Fire rating: 25 maximum flame spread, smoke developed 50 or less.
   d. Color: White.
   e. Overlap: 1-inch minimum at joints and fittings.
   f. Joint seal: PVC solvent welded or adhesive as recommended by the manufacturer.
   g. Fittings: Factory made with full thickness insulation.

D. Vapor barriers:

1. Vapor barrier, Type 1:
   a. Material: White Kraft paper bound to aluminum foil in accordance with ASTM C1136, Type 1.
   b. Permeability: 0.02 perms or lower.
   c. Maximum flame spread rating: 25.
   d. Edge seal: Pressure-sensitive tape lap seal.
   e. Circumferential joints: 4-inch wide tape or 4-inch overlap with adhesive seal.
2. Vapor barrier, Type 2:
   a. Manufacturers: One of the following or equal:
      1) Benjamin Foster, No. 30-76.
      2) Childers Products CP10/11 Vi-Acryl.
      3) Foster Products, 36-10/46-10 Weatherite.
      4) Insul-Coustic, No. I.C.-580.
   b. Material: Mastic.

E. Insulation schedule:

Table 2 - Insulation Schedule

Service Designation[(1)]	Location[(2)]	Insulation Type	Jacket Type	Service Temp. °F[(3)]	Vapor Barrier
HVAC Refrigerant	Interior or Exterior	1	1	40 - 200	Required
HVAC Condensate	Interior or Exterior	1	1	Below 60	Required

Table 2 - Insulation Schedule					
Service Designation[1]	**Location[2]**	**Insulation Type**	**Jacket Type**	**Service Temp. °F[3]**	**Vapor Barrier**

Notes:
1. Refer to Piping Schedule in Section 15052 - Common Work Results for General Piping for service designations.
2. Insulation jackets are not required for interior installations that are concealed. See definitions for description of concealed locations.
3. Unless noted otherwise, use service temperature range provided in this table to establish insulation thickness as required by Table 1.

2.11 EQUIPMENT NAMEPLATES

A. Provide a nameplate with the following markings that is plainly visible after installation:
   1. Manufacturer's name, trademark, or other descriptive marking to identify specific equipment.
   2. Where equipment is electrically powered:
      a. Supply voltage, phase, frequency, and full-load current.
      b. Power source or circuit ID.
      c. Short-circuit current rating based on one of the following:
         1) Short-circuit current rating of a listed and labeled assembly.
         2) Short-circuit current rating established utilizing an approved method.

2.12 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements.

B. Inspect fasteners for proper tightness.

C. Ship units in 1 piece (or modular, if required), factory assembled, piped, internally wired, and factory tested.

D. Provide:
   1. Filters: 2 extra (3 total) sets per each unit with filters.
   2. Sheaves and belts: 1 set for change-out for final balance per unit installed.
   3. Belts: 1 extra set for each unit installed as determined by final balance.

E. Provide a 2-year supply of maintenance products as indicated in manufacturer's maintenance literature.

PART 3 EXECUTION

3.01 GENERAL

A. Technical Sections execution requirements supersede conflicting requirements in this Section.

B. As specified in Section 01600 - Product Requirements.

C. Inspect fasteners for proper tightness.

D. Provide temporary closures for openings designed for airflow.

3.02 INSTALLATION

A. Examine and verify details and sections as indicated on the Drawings, ascertain adequacy, and determine conflicts in dimensions and clearances.
   1. Take measurements and verify dimensions to ascertain fit of installation.
   2. Ascertain structural sufficiency to support installation.
   3. Ascertain that supports and openings are correctly located; otherwise cut new openings where required.
   4. Confirm specified thermostat or other controls are compatible with specified equipment.

B. Install in accordance with manufacturer instructions.
   1. Electrical products installation in accordance with NFPA 70 NEC.
   2. If there are conflicts, NEC supersedes manufacturer's instruction.
      a. Notify Engineer of conflicts.

C. Equipment and ducts:
   1. Remove dust and debris before installation.
   2. Protect from dust and debris by covering openings with tape or plastic during installation and until equipment is operated.
   3. Adjust alignment of ducts to resolve conflicts with the work of other trades.
   4. Install and wire unitary air conditioners, controls, and thermostats in accordance with manufacturer's recommendations.
   5. Provide flexible duct and flexible piping connections at connections to unitary air conditioners.
      a. FL-2, Flexible Connections:
         1) Install at building expansion joints and as indicated on the Drawings.
         2) Install with collar and metal band to form airtight joints.
         3) Install with minimum 4 inches of slack in fabric.
         4) Install with minimum 3 inches of specified material on each side of fabric.
         5) Exterior locations: Install sheet metal weather cover over fabric.
         6) Duct alignment shall be a maximum of 1/2-inch offset.
         7) The minimum/maximum gap shall be 2-inches and 6-inches.
         8) Lap longitudinal joints and glue per manufacturer’s recommendations.
   6. Lubrication lines and fittings:
      a. Support and protect lines from source to point of use.
      b. Fittings:
         1) Bring to outside of equipment in manner such that fittings are readily accessible from outside without necessity of removing covers, plates, housings, or guards.
         2) Mount together wherever possible using factory-mounted multiple fitting assemblies securely mounted, parallel with equipment lines, and protected from damage.
   7. Concrete surfaces designated to receive non-shrink grout under equipment:
      a. Heavy sandblast concrete surface in contact with non-shrink grout.

b. Clean concrete surfaces of sandblasting sand, grease, oil, dirt, and other foreign material that may reduce bond to non-shrink grout.
c. Saturate concrete with water. Concrete shall be saturated surface damp at time non-shrink grout is placed.

8. Remove dust and debris from ductwork and equipment at completion of installation.
9. Set grilles, dampers, and diffusers to achieve flows and flow patterns indicated on the Drawings.

D. Refrigerant piping:
1. Support copper tubing as specified in Sections 15061 - Pipe Supports and 15062 - Preformed Channel Pipe Support System.
2. Clean copper lines with high-pressure air after first disconnecting piping at instruments, filters, pressure reducers, valve operators, and other special devices.
3. Installation of copper tubing:
a. Install copper tubing in accordance with ASTM B828 and IAPMO IS 3.
b. Install copper tubing in straight runs, supported at intervals close enough to avoid sagging.
c. Make cuts square with a tubing cutter or with a 32-tooth hacksaw.
1) Provide a sizing tool to correct distortions.
4. Ream the inside of the tubing and remove burrs from the outside, holding the end of the tubing downward and preventing chips and fillings from entering the tubing.
5. Perform flaring with a flare block and yoke type screw feed flaring tool:
a. After removing the tubing from the flare block, inspect both surfaces of the flare for splits, cracks, or other imperfections.
b. Where there are imperfections, cut off the imperfect flare and prepare a new flare.
6. Insulate piping as specified in Sections 15400 - Plumbing systems.

E. Gas, water piping, drains, and venting in accordance with the authority having jurisdiction and applicable codes.

F. Roof curbs: Install in accordance with NRCA Manual.

G. Completed equipment installations must have confirmation that:
1. The equipment is properly assembled.
2. The equipment moves or rotates in the proper direction.
3. Shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
4. No unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
5. The installation meets the requirements for intended use as well as the specified vibration and noise tolerances.

END OF SECTION

SECTION 15735

POSITIVE PRESSURIZATION EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Positive pressurization units with filters to remove particulate and organic contaminants.

1.02 REFERENCES

A. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
   1. 430 - Performance Rating of Central Station Air-handling Unit Supply Fans.

B. Air Movement and Control Association International, Inc. (AMCA).

C. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   1. Standard 52.2 - Methods of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

D. National Electrical Manufacturers Association (NEMA).

E. Underwriters Laboratories, Inc. (UL):
   1. 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Sufficient to substantiate specified requirements.

C. Electric: Wiring diagrams.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.

E. Manufacturer's recommendation for testing and/or maintenance of the product.

F. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

1.06 MAINTENANCE

A. Extra materials:
   1. Provide 2 extra (3 total) sets of filters per unit installed.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements and Section 15500 - Common Work Results for HVAC.

B. Unit fabrication: In accordance with AHRI 430.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 15500 - Common Work Results for HVAC.

B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

C. For equipment installed in structures designated as seismic design category C, D, E, or F.
   1. Provide guided vibration isolator for fans, so that no more than 10 percent of the vibration amplitude of the fan and motor is transmitted to the supporting structure.

D. Environmental conditions: As specified in Section 01850 - Design Criteria.

2.03 POSITIVE PRESSURIZATION UNIT (PPU)

A. Manufacturers: One of the following or equal:
   1. American Air Filter. Model, SAAF™.
   2. Circul-Aire Inc. Model, APS.
   3. MAS Innovations. Model, AFU.

B. General:
   1. Factory assembled units with cabinet, fan, filters, dampers, access sections with hinged access doors, motor, motor base, drive, and drive guard.
   2. Transition sections and filler pieces required between sections are to be provided as part of the unit.
   3. Provide nameplate for each PPU as indicated on the Drawings:
      a. Include the following:
         1) Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
         2) Supply voltage, phase, frequency, and full-load current.
         3) Power source or circuit ID.
         4) Short-circuit current rating of the panel based on one of the following:
            a) Rating of a listed and labeled assembly.
            b) Rating established utilizing an approved method.
         5) Nameplates shall be plainly visible after installation.
   4. Internal wiring to be enclosed inside weatherproof flexible UL listed conduit.

C. Housing:
   1. Constructed of a minimum 1-inch deep double-walled, foam-injected panels filled with 2 pounds per cubic unit feet dense insulation. Interior seams shall be sealed to prevent leakage.
   2. Minimum 18-gauge, double-wall panel construction.
      a. Interior panel shall be coated steel.
      b. Exterior panel shall be coated steel.
   3. Access doors shall have steel reinforcements inside the panel where hinges and handles are affixed.
      a. Positive locking latches to secure and compress the PVC closed cell gasket to prevent leakage.
   4. Fan section, intake and discharge plenums shall be lined with flexible polyester urethane foam acoustic insulation that is non-allergenic and inert, in accordance with flammability classification UL 94.
   5. Units not mounted on vibration isolators shall have rotating components internally isolated from the main unit with vibration isolators.
   6. Metal surfaces shall be coated with a lift resistant alkyd primer, followed by a 2-component polyurethane coating with a low-sheen finish.
   7. Openings shall be sized for face velocity of 500 feet per minute maximum at indicated airflow rates on as indicated on the Drawings.
   8. Grilles shall be provided for openings.
      a. Double-deflection, adjustable type or aluminum bar grilles.
   9. Provide the inlet (return) opening with an integral manual balance damper with an external position-indicating handle with locking quadrant. Dampers shall be opposed blade type.
   10. Provide a duct collar for field installation of the outside air duct when necessary or as indicated on the Drawings.

11. Provide OA inlet for OA opening as indicated on the Drawings.

D. Fan section:
   1. Fans shall be backward inclined, airfoil impeller molded from glass reinforced polyamide or backward curved made from aluminum or glass reinforced polyamide.
   2. Drives shall be adjustable v-belt type, with motor mounted on an adjustable slide base.
      a. Adjustable for minimum within 5 percent speed change, rated for 1.5 times maximum horsepower motor available for the scheduled fan size or model.
   3. Backwardly curved wheels shall be air foil type.
   4. Fans shall be statically balanced before shipment.
   5. Fans shall be AMCA rated for sound and air performance.

E. Filters:
   1. Type, thickness, and efficiency as specified or as indicated on the Drawings.
   2. Filter frame supports:
      a. 18-gauge aluminum with aluminum casing.
   3. Slide out frame with hinged access door.
   4. Constructed with a contaminant control system consisting of multiple stages of filtration. Refer to the schedule for filter types by unit and stage.
   5. Pre-filter requirements:
      a. Non-woven, pleated, reinforced cotton and synthetic fabric disposable type, framed filters, thickness as scheduled.
      b. Media shall be supported and retained with an aluminum track securely attached to housing.
      c. Pressure drop for clean filters at 300 feet per minute face velocity shall be 0.15-inch w.g. for 2-inch thick filters.
      d. Minimum MERV 8 rating in accordance with ASHRAE Standard 52.2.
      e. Manufacturers: The following or equal:
         1) Farr 30/30 Disposable Filters.
   6. First and second media stage:
      a. Intermediate stage shall be chemical filter media, consisting of activated carbon and activated alumina impregnated with potassium permanganate.
      b. Refer to the schedules for specific chemical filter requirements, including required range of contaminant removal.
      c. Filter media shall be supported and retained with an aluminum track securely attached to the housing.
      d. Capable of handling airstreams at the expected temperature, humidity, and air contaminant ranges indicated in the schedules.
      e. Media shall be disposable in standard dumpsters. Media shall be replaced either by discarding media housing or recycling by emptying spent media and refilling with new media.
   7. After-filter requirements:
      a. Final filter, where specified, is to remove airborne media from the exit air stream.
      b. Rigid filters shall have a permanent aluminum holding frame and replaceable type rigid filter cartridge with minimum efficiency of 90 to 95 percent in accordance with ASHRAE Standard 52.2.
      c. Pressure drop for clean filters at 500 feet per minute face velocity not to exceed 0.65-inch w.g.

d. UL listed.
e. Manufacturers: One of the following or equal:
    1) American Filter Co.:
        a) Riga-Flo 200.
        b) Varicel Farr Co.
    2) Cambridge:
        a) Aeropac.

2.04 ACCESSORIES

A. Flexible duct connectors:
    1. As specified in Section 15500 - Common Work Results for HVAC.

B. Dampers and grilles:
    1. As specified in Section 15500 - Common Work Results for HVAC.

2.05 CONTROLS AND EQUIPMENT SAFETY FEATURES

A. General:
    1. Provide system controls for a complete functioning system that operates as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

B. Motor control:
    1. Provide variable speed motor control by one of the 2 following methods:
        a. Variable frequency drive.
        b. Electronically commutated motor.
    2. Provide external speed adjustment of the fan.
    3. PPU shall accept a single 480 VAC, 3-phase power feed.
    4. Provide main power disconnect switch.
    5. If controls are not integrated into the unit, mount the motor controller and main power disconnect switch in NEMA Type 4 box.

C. Motor characteristics as scheduled in PPU schedule.

D. Remote monitoring and control:
    1. Provide dry contacts for the following status and alarms:
        a. Failed.
        b. Running.
        c. Dirty Filter.
    2. Provide input connections for:
        a. Smoke alarm shutdown.
        b. HVAC supervisory control/enable.

E. Differential pressure gauges:
    1. As specified in Section 15936 - Instrumentation and Control Devices for HVAC.
    2. Provide a differential pressure gauge across the pre-filter, after filters, final filters, and fans.
        a. Where more than 1 filter is used in series, each filter shall be provided with a separate gauge.

b. Pressure range of gauges shall be 3 times the clean pressure loss of the filters provided.

F. Differential pressure switches:
1. As specified in Section 15936 - Instrumentation and Control Devices for HVAC.
2. Provide a differential pressure switch for the pre-filter, after filters, final filters, and fans.
a. Where more than 1 filter is used in series, each filter shall be provided with a separate switch.
3. Wire the differential pressure switches to provide a signal dirty filter alarm.

2.06 SOURCE QUALITY CONTROL

A. Completely factory test each unit in operating modes of filtration prior to shipping the unit. Tests shall comply with relevant codes and standards applicable to unit design.

2.07 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

B. Ship units in one piece, factory assembled, piped, internally wired, and tested.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 PREPARATION

A. Anchoring and bracing to structures:
1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.
3. Install anchors with embedment indicated on approved anchoring designs.

B. Media sampling:
1. Manufacturer shall include sampling services of chemical media in the cost of purchased media without additional cost to the Owner. Manufacturer shall support media sampling services through a licensed and trained factory representative.
2. Upon testing of media at the manufacturer’s facility, furnish an analysis report to the Owner indicating spent level of media and estimated remaining life.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. Adjust alignment of ducts where necessary to resolve conflicts with architectural features or to resolve conflicts with the work of other trades.

C. Wire the positive pressurization unit and controls in accordance with the manufacturer's recommendations.

D. Provide flexible duct and flexible piping connections at connections to positive pressurization unit.

3.04 TESTING

A. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

3.05 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15740

HEAT PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mini-split systems.

1.02 REFERENCES

A. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   1. Standard 15 - Safety Standard for Refrigeration Systems.
   2. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality.

B. Federal Specification (FS):
   1. Standard 141 - Paint, Varnish, Lacquer, and Related Materials: Methods of Inspection, Sampling and Testing.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

D. Underwriters' Laboratories, Inc. (UL):
   a. 60335-2-40 - Safety Standard for Household and Similar Electrical Appliances.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Roof Coordination:
   1. As specified in Section 15500 - Common Work Results for HVAC.

1.04 DELEGATED DESIGN SUBMITTALS

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Catalog cuts, bulletins, and brochures:
   1. Design features.
   2. Load capacities.
   3. Efficiency ratings.
   4. Dimensions.
   5. Weight: Shipping and operating.

C. Drawings:
   1. Component layout and identification.
   2. Views:
      a. Front, side, rear elevations, and top and bottom views, with dimensions.
      b. Connection locations including electrical, mechanical, and other.
   3. Cut away drawings.
      a. Parts list.
      b. Material specification lists.
   4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
   5. Details for supports, isolators, and bracing.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. For equipment installed outdoors.

E. Engineering data:
   1. Manufacturer's published data for compressor, evaporator coil, condenser, evaporator fan, refrigerant, and filter.
   2. Maximum equipment vibration levels and field-testing method.
   3. Sound power level in each of 8 octave bands and overall Sones.
   4. Fan performance curves showing specified operating condition.
   5. Bearing life.

F. Manufacturer's recommendations for handling, storage, and installation.

G. Nameplate data.

H. Seismic certification.

I. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Special warranties:
   1. Refrigerant compressors and closed or sealed refrigerant systems warranty duration: Provide 5-year warranty.
   2. Electric heaters warranty duration: Provide 5-year warranty.
   3. Evaporator and condensing coils warranty duration: Provide 5-year warranty.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

B. Supplied components of the unit shall be furnished and fully integrated by the unit system supplier:
   1. Furnish and install piping, valves, dampers, sensors, and wiring within the unit package.
   2. Provide a prewired, unit mounted control panel to dampers and sensors within the unit.

C. Motors:
   1. Totally enclosed.
   2. Voltage and number of phases as scheduled.
   3. Compressor motors:
      a. Cooled by refrigerant gas passing through windings.
      b. Provided with line break thermal and current overload protection.
   4. Fan and blower motors:
      a. Permanently lubricated ball bearings.
      b. Integral automatic reset thermal overload protection.

D. Electrical:
   1. Provide a single conduit connection in the unit for both power and control wiring.

E. Refrigerant:
   1. Fully charged with R-454B.
   2. Compliant with ASHRAE 15.
   3. HFO refrigerant with global warming potential 700 GWP or less.
   4. Must have a refrigerant monitoring system and be rated according to UL 60335-2-40.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 15500 - Common Work Results for HVAC.

B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

2.03 MINI-SPLIT SYSTEM HEAT PUMPS

A. Manufacturers: One of the following or equal:
   1. Mitsubishi, Series TRUZ; when indoor air handling unit scheduled, Series TPKA (wall mounted), Series TPLA (ceiling cassette).
   2. Samsung, similar series.
   3. Daikin, similar series.
   4. Trane, similar series.

B. Compressors:
   1. Fully hermetically sealed, high-efficiency, reciprocating or rotary or scroll-type, with rubber grommet vibration isolation.

C. Fans:
   1. Indoor air fan:
      a. Direct driven with capacitor start motor; double inlet, forward curve sirocco fan, steel with corrosion resistant finish, statically and dynamically balanced.
      b. Bearings: Permanently sealed ball bearing type and permanently lubricated.
   2. Outdoor condenser fan:
      a. Propeller type, direct drive, aluminum blades, dynamically balanced.
      b. Bearings: Permanently sealed ball bearing type and permanently lubricated.

D. Coils:
   1. Evaporator and condenser coils: Seamless copper tubes with mechanically bonded aluminum plate fins.
   2. Provide corrosion resistant finish, suitable for marine environment.

E. Refrigerant components: Refrigerant circuit including:
   1. Accumulator and filter/drier.
   2. Expansion device.
   3. Reversing valve.
   4. Flow control valves.
   5. Service and gauge connections on compressor suction and discharge, and liquid lines to charge, evacuate, and contain refrigerant.

F. Controls and equipment safety features:
   1. Provide system controls for a complete functioning system:
      a. High and low evaporator fan speed control for cooling and heating modes.
      b. Fan only operation.
      c. Space temperature condition setting.
      d. Vapor bellows thermostat to cycle unit to maintain space condition.
   2. Equipment safety features:
      a. Thermostatic base pan drain to prevent freeze up of the fan in collected condensate.
   3. Provide with a low ambient cooling option.

G. Unit casing:
   1. Slide-out design unit casing manufactured of high strength molded plastic with smooth finish and outdoor casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, polyester powder coating for corrosion protection.
   2. Weatherproof design, reinforced and braced for maximum rigidity.
   3. Provided with:
      a. Filter rack for filters accessible through the front of the unit.
      b. Non-corrosive drain pan in accordance with ASHRAE Standard 62.1.
      c. Horizontal drain connection.

d. Provide mini condensate pump suitable to be powered from indoor/outdoor unit.
e. Knockouts for power connections.

2.04 ACCESSORIES

A. Sensors: As specified in Section 15936 - Instrumentation and Control Devices for HVAC.

B. Provide 24-inch minimum roof rail curb.

C. Provide hail guard to protect against damage from hail and other flying debris.

D. Provide coil guard grill to protect condenser coil from penetration by large objects.

E. Flexible duct connectors: As specified in Section 15500 - Common Work Results for HVAC.

2.05 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 15500 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 PREPARATION

A. Anchoring and bracing to structures:
1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
2. Install anchors of type and material indicated on approved anchoring designs.
3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

B. Insulate refrigerant and condensate piping as specified in Section 15500 - Common Work Results for HVAC.

C. HVAC system supplier shall provide wiring and conduit for HVAC thermostat/controller.

3.04 TESTING

A. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.
   1. Test for outdoor sound power at levels.

3.05 FIELD QUALITY CONTROL

A. Verify equipment installation operation and vibration is within the manufacturer's submitted maximum.

3.06 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15745

MAKEUP AIR UNIT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for pre-piped, pre-wired, makeup air units with integrated controls and instruments.

B. Including units with:
   1. Heating:
      a. Indirect gas fired.

1.02 REFERENCES

A. American Bearing Manufacturers' Association (ABMA):
   1. 9 - Load Ratings and Fatigue Life for Ball Bearings.

B. ASTM International (ASTM):
   1. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

C. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

D. Underwriters’ Laboratories, Inc. (UL):
   1. 900 - Standard for Air Filter Units.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination as specified in Section 15500 - Common Work Results for HVAC.

1.04 DELEGATED DESIGN SUBMITTALS

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Catalog cuts, bulletins, and brochures:
   1. Design features.
   2. Load capacities.
   3. Efficiency ratings.
   4. Dimensions.
   5. Weight: Shipping and operating.

C. Drawings:
   1. Component layout and identification.
   2. Views:
      a. Front, side, rear elevations, and top and bottom views, with dimensions.
      b. Connection locations including electrical, mechanical, and other.
   3. Cut away drawings.
      a. Parts list.
      b. Material specification lists.
   4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.

D. Delegated Design submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.

E. Calculations:
   1. Sound Power Level in each of 8 octave bands and overall sones.
   2. Bearing life.

F. Source testing:
   1. Factory tests performed - description and results.

G. Site testing:
   1. Recommended vibration levels and field testing protocol.

H. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Special warranties: Extend warranty period to:
   1. Three years: Cabinet and direct cooling heat exchanger.
   2. Five years: Indirect gas heat furnace.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 15500 - Common Work Results for HVAC.

B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

C. Unit structural integrity of 10 inches water gauge static.

D. Guided vibration isolators, if included: Limit the vibration amplitude of the fan and motor to be transmitted to the supporting structure to not more than 10 percent.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Engineered Air.
   2. Absolut-Aire.

2.04 MAKEUP AIR UNIT

A. General:
   1. As specified in Section 15500 - Common Work Results for HVAC.
   2. Complete factory assembled modules as indicated on the Drawings with components furnished and integrated by manufacturer. Each module to have as applicable:
      a. Required transition sections and filler pieces.
      b. Nameplate as specified in Section 15500 - Common Work Results for HVAC.
         1) Manufacturer's name, trademark, or other descriptive marking.
         2) Supply voltage, phase, frequency, and full-load current.
         3) Power source or circuit ID.
         4) Short-circuit current rating of the panel based on one of the following:
            a) Short-circuit current rating of a listed and labeled assembly.
            b) Short-circuit current rating established utilizing an approved method.
      c. Full-size service door:
         1) Wire reinforced glass inspection window.
         2) Continuous stainless steel hinge.
         3) Neoprene sealing gasket.
      d. Photoelectric exterior LED light over each service door.
      e. Interior LED service light with vapor proof switch.

B. Construction:
   1. Structural tube framing system.
   2. Type 316 stainless steel standing seam siding.
   3. Floor:
      a. Type 316 stainless steel to match casing at a minimum.
      b. Continuous welded.
      c. Steel mating frames:
         1) Match drilled.

4. Roofs:
    a. Slope away from service doors.
5. Doors and access panels:
    a. Silicon caulked joints and seams to be watertight.
    b. Minimum 18 gauge, Type 316 stainless steel panels, with 22 gauge Type 316 stainless steel solid liner in all insulated sections.
    c. Minimum 0.04 inch, aluminum panels, with 0.02 inch aluminum solid liner in all insulated sections.
6. Insulation:
    a. 2-inch thick 1-1/2-pound density neoprene coated acoustical fiberglass:
        1) On sides, roof, and access doors.
    b. Secured with mechanical fasteners, 12 inches on center.

C. Casing:
1. Material: As specified in MAU schedule.
    a. Minimum 18 gauge, Type 316 stainless steel panels, with 22 gauge Type 316 stainless steel solid liner in all insulated sections.
    b. Minimum 0.04 inch, aluminum panels, with 0.02 inch aluminum solid liner in all insulated sections.
    c. All fasteners to match panel material.
    d. Minimum 16 gauge, Type 304 stainless steel water sump.
    e. Reinforced with aluminum or Type 304 stainless steel structural members.
2. Silicon caulked and watertight joints and seams.
3. Utilize continuous stainless steel hinges and neoprene sealing gasket for tight compression closure at access doors.
4. Doors and access panels shall be fabricated of minimum 18 gauge Aluminum or Type 304 stainless steel with 2 inch rolled edges for rigidity and to completely cover insulation.
5. Pressure class rating shall be for the total fan static pressure. All sections of the unit shall be of the same pressure class.
6. For units that are indicated to be outside, provide pitched roof and rain gutters and/or full weather hoods at openings and access doors. Top of unit shall be constructed to prevent buckling and ponding of water.
7. Silicon caulked and watertight joints and seams.
8. Ductwork connections to units that require corrosion-resistant coatings shall be made with flanges.
    a. Flanges shall be factory drilled before coating.
    b. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange.
    c. The use of self-tapping screws or other fastening methods that will damage the coating are not acceptable.

D. Dampers:
1. Driven by motorized actuators.
2. Opposed blade type with blades mounted on 1/2-in minimum steel rods.
3. Low friction bushings and edge gaskets.
4. Blades shall be sectionalized to limit unsupported blade length and warping at full system fan static pressures. Maximum damper blade width Material: As specified in MAU schedule.
5. Material: As specified in MAU schedule.

6. Minimum 18 gauge, Type 316 stainless steel panels, with 22 gauge Type 304 stainless steel solid liner in all insulated sections.
7. Minimum 0.04 inch, aluminum panels, with 0.02 inch aluminum solid liner in all insulated sections.
8. Face and by-pass sections:
    a. Shall be of the type specified on the MAU schedule.
    b. Deflection plates shall be provided if required to maintain even air flow over coils and prevention of stratification.
9. Air Filter frost protection:
    a. Bypass plenum construction shall match the unit casing construction. Dampers shall be provided at the discharge plenum and the air intake section upstream of the filter. Dampers shall be driven by motorized actuators and shall actuate open to provide heated bypass air across the filter when the unit is in heating mode.
    b. Quantity of bypass air shall be adequate to maintain a mixed air temp across the filter to prevent frost build up.

E. Units without vibration isolators on fans to have unit vibration isolators.

F. Automatic freeze/frost protection when design criteria indicate a minimum temperature of 37 degrees Fahrenheit or less.
1. Filters:
    a. Type, thickness, and efficiency as specified in MAU schedule.
    b. Filter frame supports:
        1) 18 gauge Type 304 stainless steel with stainless steel casing.
    c. Slide out frame with hinged access door.
    d. Manufacturers: The following or equal:
        1) American Air Filter.
        2) Circul-Aire, division of P.M. Wright Limited.
        3) Purafil.

G. Electrical:
1. As indicated on the Drawings.
2. NEMA panel rating as scheduled.
3. Internal wiring enclosed with weatherproof flexible UL listed conduit.
4. Manufacturer's standard unless specified otherwise.
5. Components:
    a. Main circuit breaker:
        1) Flange-mounted operator:
            a) Pad-lockable in the off position.
        2) Disconnects all power to the panel.
        3) Interlock with the panel door:
            a) Defeat mechanism.
    b. Motor starter:
        1) Motor circuit protector circuit breaker.
        2) Full voltage non-reversing magnetic starter.
        3) Thermal or electronic overloads.
    c. Provide VFD with the following features as a minimum:
        1) UL listed.
        2) 40-character multi-lingual alphanumeric display.
            a) Keypad for programming and diagnostics of VFD.

3) Inputs and outputs:
    a) 2 analog Inputs.
    b) 6 Programmable digital Inputs.
    c) 2 Programmable Analog Outputs.
    d) 3 Programmable Form C Relay Outputs.
    e) All inputs isolated from ground and power.
4) Protection circuits:
    a) Over current.
    b) Ground fault.
    c) Over voltage.
    d) Under voltage.
    e) Over temperature.
    f) Motor overload.
5) Input line fuses.

d. Heating element contactors and fuses.
e. Control power transformer:
    1) Primary voltage: 460 VAC, 1 phase, 60 hertz.
    2) Secondary voltages:
        a) 24 volt.
        b) Additional voltages as required by the application.
    3) Sized for all panel components plus 10 percent spare capacity.
    4) Primary and secondary fuses.
f. Terminal strips for power and control wiring.
g. UL labeled.

H. Instrumentation and control:
1. A complete functioning system using PLCs as specified in Section 15936 - Instrumentation and Control Devices for HVAC.
2. Sensors: As specified in Section 15936 - Instrumentation and Control Devices for HVAC.
3. Remote monitoring and control:
    a. Dry relay contact outputs for the following:
        1) Dirty filter.
        2) Low temperature.
        3) General alarm.
        4) Smoke detector shut down.
        5) Run status.
    b. Connections for the following remote inputs:
        1) Fire alarm system shutdown.
        2) Remote start/stop.
        3) Duct smoke detector connections:
            a) Duct smoke detector power.
            b) Duct smoke detector alarm contact.
4. Interlock controls:
    a. Smoke alarm shutdown.
    b. HVAC supervisory control/enable.

I. Switches:
   1. As specified in Section 15936 - Instrumentation and Control Devices for HVAC.
   2. Differential pressure for filters:
      a. Each filter shall be provided with a separate switch.
      b. Output signal for dirty filter alarm.
   3. Current switch for each fan motor:
      a. Rated for current range of the fan motor.
      b. Output signal for loss of air flow alarm.

J. Supply air blower:
   1. Blower shall be SWSI or DWDI Class I or Class II all aluminum construction and shall have backward inclined flat or airfoil blades.
   2. V-belt drive as specified in Section 15050 – Common Work Results for Mechanical Equipment.
   3. Mounted on adjustable, spring isolated, welded structural steel base. Provide seismically restrained isolators with 1 inch deflection.
   4. Dynamically balanced.
   5. Pillow block grease lubricated, self-aligning bearings with ABMA 9, L10 life of 200,000 hours minimum.
      a. High pressure lube lines shall be internally located at a common point on the drive side.
   6. Motor shall be inverter duty rated as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

2.05 INTAKE MODULE

A. As indicated on the Drawings.

B. Deflection plates to maintain even air flow over pre-filter.

C. Damper:
   1. To open for heated bypass air to cross the filter when the unit is in heating mode.
   2. Quantity of bypass air adequate to maintain a mixed air temp across the filter to prevent frost build up.

D. Pre-filter:
   1. Minimum of 30 percent.

2.06 HEATING MODULE

A. As indicated on the Drawings.

B. Indirect gas fired:
   1. Heat exchanger construction of 20-gauge Type 409 stainless steel tubes headers.
   2. Venting flue system: Type 409 stainless steel.
   3. Burners: Die formed with stamped porting and stainless steel port protectors.
      a. Burner construction shall consist of Type 409 stainless steel.

b. Pilot accessible through an access plate without removing the burner assembly.

4. Modulating heat output.
   a. Automatic valve in series with the modulating valve shall be provided to cycle the unit.
   b. Ignition shall be at full fire (100 percent rated input) and modulate the gas input from 100 to 40 percent rated input.
   c. The modulating gas valve shall operate in response to a discharge air temperature sensor within the unit.
5. Provide a solid state ignition control system which ignites the pilot by spark during each cycle of operation.
   a. When pilot flame is proven, main burner valve shall open to allow flow to burners.
   b. Pilot and burners must be extinguished during the off cycle.
   c. Ignition system shall be 100 percent lockout type.

2.07 FAN MODULE

A. Fan:
   1. As specified in Section 15500 - Common Work Results for HVAC.
   2. SWSI or DWDI Class I or Class II all aluminum construction and shall have backward inclined flat or airfoil blades.
   3. V-belt drive as specified in Section 15500 - Common Work Results for HVAC.
   4. Mounted on adjustable, spring isolated, welded structural steel base.
   5. Seismically restrained isolators with 1 inch deflection.
   6. Dynamically balanced.
   7. Pillow block grease lubricated, self-aligning bearings with ABMA 9, L10 life of 200,000 hours minimum.
      a. Lube lines internally located at a common point on the drive side.
   8. Motor shall be inverter duty rated as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

B. Damper:
   1. Open when fan is running, closed when fan is off.

2.08 ACCESSORIES

A. Flexible duct connectors: As specified in 15500 - Common Work Results for HVAC and 15814 - Fiberglass Reinforced Plastic Ducts.

B. Curb assemblies:
   1. As indicated on the Drawings.
   2. Type 316Stainless Steel construction.
   3. Unless otherwise specified, curbs shall include provisions for supply and return air duct and piping connections to the area below.
   4. Constructed to match any roof pitch to create a level surface at the top.

2.09 COATINGS

A. Provide a thermosetting resinous coating to protect the coils against exposure to corrosive atmospheres.
   1. The process shall be accomplished by a multiple coat application of degreasing and etching, dipping and baking (4 times), resulting in complete coating coverage of the fins, tubes, headers and casing.
   2. Salt spray tested to ASTM B117 standards.

2.10 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. Silicon caulk:
   1. Identical to that used in the factory.
   2. Provide sufficient quantity to seal field connections twice.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

A. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

A. Verify equipment installation, operation and vibration is within the manufacturer’s submitted maximum.

3.06 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15762

HEATING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for gas fired unit heaters, steam/hot water unit heaters, and thermostats for heaters.

1.02 REFERENCES

A. American Gas Association (AGA).

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

C. Underwriters' Laboratories, Inc. (UL).

1.03 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination as specified in Section 15500 - Common Work Results for HVAC.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Catalog cuts, bulletins, and brochures:
   1. Design features.
   2. Load capacities.
   3. Efficiency ratings.
   4. Dimensions.
   5. Weight: Shipping and operating.

C. Drawings:
   1. Component layout and identification.
   2. Views:
      a. Front, side, rear elevations, and top and bottom views, with dimensions.
      b. Connection locations including electrical, mechanical, and other.
   3. Cut away drawings:
      a. Parts list.
      b. Material specification lists.

4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
5. Details for supports, isolators, and bracing.

D. Delegated Design Submittals:
1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
   a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
   b. For wall mounted equipment weighing 125 pounds or more.

E. Engineering data:
1. Manufacturer's published data for fan, burner, and filter.
2. Maximum equipment vibration levels and field-testing method.
3. Sound power level in each of 8 octave bands and overall Sones.
4. Fan performance curves showing specified operating condition.
5. Bearing life.

F. Manufacturer's recommendations for handling, storage, and installation.

G. Nameplate data.

H. Seismic certification.

I. Operation and maintenance manuals:
1. As specified in Section 01782 - Operation and Maintenance Manuals.
2. Include a list of configurable parameters and the final values for each.
3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. As specified in Section 15500 - Common Work Results for HVAC.

B. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

2.03 NATURAL GAS UNIT HEATERS (GUH)

A. Manufacturers: One of the following or equal:
   1. Reznor, Type UDXC.
   2. Trane Co., similar models.
   3. Sterling, similar models.

B. Fan type: Aluminum non-surging propeller:
   1. Including fan guards.
   2. Dynamically balanced.
   3. Permanently lubricated ball bearings.
   4. Automatic reset thermal overload protection.

C. Heat exchanger characteristics:
   1. Seam welded minimum 20-gauge aluminized steel tubes with minimum 18-gauge aluminized steel headers; provide non prorated 10-year exchanger warranty.
      a. Provide stainless steel heat exchangers when indicated in the Heating Unit Schedules.

D. Features:
   1. Provide unit including casing, integral draft diverter, heat exchanger, horizontal adjustable louvers with stops to prevent full closure, motor and propeller fan assembly, burners, flue vent fan, controls, and suspension mounting.
   2. Burners, universal type manufactured of die-formed, aluminized steel with stainless burner port protectors.
      a. Provide stainless steel burner when indicated in the Heating Unit Schedules.
   3. Burner orifices suitable for elevation as specified in Section 15762 - Heating Units.
   4. Intermittent solid-state ignition control system with pilot burner, made of stainless steel.
   5. Flue pipes, 16-gauge, or heavier, galvanized steel, double walled, certified for zero clearance installation.
   6. Gas piping, black steel with unions to simplify assembly and disassembly.
   7. Bronze shutoff cocks.
   8. Cabinet manufactured of minimum 20-gauge galvanized steel.
   9. Provide concentric adapter kit for combustion with unit as indicated on the Drawings.
      a. Provide protective grating enclosure around vent piping.
   10. Provide Caution signage near heaters in the Chlorine Building Truck Bay Area.
      a. Signage as specified in Section 10400 – Signage.
   11. Controls:
      a. Pressure regulators.
      b. Diaphragm gas valve; on units over 100 MBH input, provide 2-stage gas valve (50 percent and 100 percent fire) and 2-stage thermostat.
      c. Safety pilot switch with 100 percent gas shutoff.
      d. High temperature limit switch.
      e. Fan time delay.
      f. Hand shutoff valves for main burner and for pilot burner.
      g. Provide thermostat as specified in this Section.

h. Provide control transformer suitable for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.

E. Finishes:
1. Casing finish backed enamel in manufacturer's standard color.

F. Source quality control: Flame test burners:
1. Provide proof of test upon delivery.

2.04 HOT WATER OR STEAM PROPELLER UNIT HEATERS (SUH)

A. Manufacturers: One of the following or engineer approved equal:
1. Trane Co.,
2. Modine,
3. McQuay,

B. Fan type: Aluminum non-surging propeller:
1. Including fan guards.
2. Motor removable from bottom..
3. Dynamically balanced.
4. Permanently lubricated ball bearings.
5. Automatic reset thermal overload protection.

C. Coil characteristics:
1. Entering hot water temperature: 180 degrees Fahrenheit.

2. Rated capacity at entering air temperature. as scheduled.
3. Rectangular draw through..
4. Seamless copper tubing suitable for a minimum of 150 pounds per square inch gauge hot water or 75 pounds per square inch gauge steam service.
5. Aluminum fins mechanically bonded to tubing.

D. Features:
1. Adjustable horizontal and vertical louvers.
2. Casing fabricated of minimum 20-gauge, rigid steel.
3. Controls:
a. Provide thermostat as specified in this Section.
b. Provide control transformer suitable for 24-volt or 120-volt control as indicated in the Heating Unit Schedules.
4. Required mounting brackets.

E. Finishes:
1. Casing finish: Backed enamel in manufacturer's standard color.

2.05 THERMOSTATS FOR UNIT HEATERS

A. Type: Wall mounted, heat only with fan AUTO-ON selector switch when fan part of unit and separate system ON-OFF selector switch.

B. Dial or lever temperature setpoint adjustment with 45 to 90 degrees Fahrenheit setpoint range.

C. Setpoint and temperature indication.

D. Control voltage as indicated in the Heating Unit Schedules.

E. The use of mercury within the thermostat is not acceptable.

F. Bi-metallic contacts suitable for 1- or 2-stage unit heater control as specified for the heater size or as scheduled.

2.06 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

A. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

A. Verify equipment operation is within manufacturer's standards and that noise levels do not exceed levels specified.

3.06 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15772

PROCESS PIPING AND EQUIPMENT HEAT TRACING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Heat tracing cable for outdoor water and chemical piping including the following:
   1. Heating cables.
   2. Control panels.
   3. Temperature sensors.
   4. Temperature controllers.
   5. Contactors.
   6. Enclosures.
   7. All other auxiliary equipment and controls required to complete a heat tracing system.

1.02 REFERENCES

A. National Electrical Manufacturers' Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1000 V Maximum).

B. Underwriters' Laboratories, Inc. (UL):
   1. 746B - Polymeric Materials - Long Term Property Evaluations.

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog number, wattage output, voltage rating, and product data.
   2. Wiring diagrams.
   3. Installation Instructions.
   4. Warranty.

C. Shop drawings: Include isometric drawings for each heat traced pipe showing installation details, and size and type of heat tracing cable.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

1.04 QUALITY ASSURANCE

A. Regulatory requirements and reference standards:
   1. The electric heat tracing system shall be as specified in this Section and shall be designed, manufactured, and tested in accordance with the minimum applicable requirements of the latest edition of the following codes and standards.
   2. Additional specific requirements shall be further defined in the testing requirements for each Section.

1.05 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Special Warranty:
   1. Cables: All cables shall be warranted for a period of 10 years for manufacturing defects.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General: Heat tracing applications up to a maintain temperature of 250 degrees Fahrenheit and intermittent exposure to 420 degrees Fahrenheit shall use self-regulating heating cables and pads.

B. Self-regulating heating cable shall vary its heat output relative to the temperature of the surface of the pipe or the tank allowing cable to be crossed over itself without overheating and to be cut to length in the field.

C. Design for a useful life of 20 years or more with "power on" continuously.
   1. The criteria for life shall be to retain at least 75 percent of its original power when tested according to UL 746B.

D. Pipe shall be heat traced and insulated in accordance with Section 15082 - Piping Insulation to maintain an operating temperature of 75 degrees Fahrenheit for a minimum ambient temperature of 32 degrees Fahrenheit.

E. Heat trace system controller:
   1. Provided with a single power source, as described below.
   2. Provide all necessary components for heat tracing all of the piping as specified in Section 15052 - Common Work Results for General Piping and/or as indicated on the Drawings.
   3. A limited number of electrical conduits are as indicated on the Drawings as a guide for the Contractor.
   4. Contractor shall determine the quantities for all components including electrical conduit, conductors, and the sizes of the breakers for this particular application as required and recommended by manufacturer, subject to Engineer acceptance, for a complete operable system at no additional cost to the Owner.

5. Provide: Power connecting kits with junction boxes.
6. End seal kits.
7. Fittings kits.
8. Electric traced labels.
9. Aluminum tapes.
10. Line sensing thermostats:
    a. Contactor.

2.02 HEAT TRACING CABLE

A. Manufacturers: One of the following or equal:
   1. Raychem, BTV.
   2. Chromalox, Type SRL Rapid Trace.
   3. Eaton Corp., equivalent product.
   4. Dekoron, equivalent product.

B. Type: Self-regulating and self-limiting, 5 watts per foot, 120 volts, 60 hertz, flexible twin 16 American Wire Gauge copper bus wires, with tinned copper braid overshield.
   1. Provide wattage of cable suitable for maintaining specified temperature at the minimum site ambient temperature for the pipe size and insulation as indicated on the Drawings.

2.03 CONTROLLER

A. Manufacturers: The following or equal:
   1. Raychem, Elexant 4010i.

B. Operating characteristics:
   1. Controller shall provide continuous monitoring of heat tracing circuit analyzing temperature through a hard-wired RTD.
   2. Controller shall energize system automatically if the temperature drops below a preset point.
      a. Controller shall be equipped with local alarm to alert maintenance personnel if heat trace circuit is interrupted.
   3. Controller shall have the capability of performing a self-diagnostic check on the system and advising maintenance personnel of the exact nature of any circuit problems.

C. Controller shall be fully compatible with heat trace and provided by same manufacturer as heat trace.
   1. One single 120-volt 1-phase power source will be provided to the heat tracing control system panel as indicated on the Drawings:
      a. Provide any required transformers for any secondary voltages.
      b. Provide a configurable dry contact for heat trace fault.
   2. Controller shall have double pole solid-state switching, temperature control from -40 degrees Fahrenheit to 125 degrees Fahrenheit, and a 30-amp rating from -40 degrees Fahrenheit to 125 degrees Fahrenheit ambient temperature.
   3. Power supply: Provide controller power supply with adjustable ground fault detection.

4. Controller shall have battery backup system to retain programmed parameters in the event of a power failure.
5. Enclosure: Unit shall be enclosed in a NEMA Type 4X stainless steel panel.
6. Network capabilities: Controller shall have network capabilities enabling monitoring and programming from a central location.

2.04 CONNECTION KITS, END SEALS, SPLICE AND TEE KITS

A. Heat trace connection, end, splice, and tee kits shall be designed to meet or exceed the life of the heat trace and shall be given equal consideration and evaluation.

B. Provide wiring, conduits, junction boxes, and any other electrical components as required.

2.05 ACCESSORIES

A. Power connection kits.

B. Termination kits.

C. Splice kits.

D. End seal kits.

E. Straps.

F. Thermostat.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install heat tracing cable on water pipes:
   1. Heat tracing cable for outdoor aboveground water and chemical piping**.**
   2. Install heat tracing cable on water and chemical piping subject to freezing. Examples include the following areas:
      a. Emergency eyewash and shower.
      b. Caustic soda piping.(where indicated on Drawings)

B. Wrap heat-tracing tape with aluminum tape prior to installing insulation.

C. Install pipe insulation as specified in Section 15082 - Piping Insulation.

D. Install heat tape and controls in accordance with manufacturer's published installation instructions.

E. The location of the thermostat shall be as indicated on the Drawings.
   1. Thermostats will be powered from the control panel/box by the Contractor.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's field service:
   1. Inspect installed systems for proper installation.
   2. Instruct Owner's personnel on operations and maintenance of the systems.

END OF SECTION

SECTION 15812

METAL DUCTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Aluminum ductwork.
   2. Galvanized steel ductwork

1.02 REFERENCES

A. ASTM International (ASTM):
   1. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   2. A480 - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat- Resisting Steel Plate, Sheet, and Strip.
   3. A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   4. B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. HVAC Systems-Duct Design.
   2. HVAC Duct Construction Standards, Metal and Flexible.
   3. Seismic Restraint Manual: Guidelines for Mechanical Systems.

C. Underwriters Laboratories, Inc. (UL):
   1. 181A - Closure Systems for Use with Rigid Air Ducts.

1.03 ABBREVIATIONS

A. AWG - American Wire Gauge.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Duct and component material and details of construction.
   2. System layout including floor and wall penetrations.
   3. Supports and anchoring details.
   4. Components used in the duct system including turning vanes, dampers, flexible connections, and access doors.

C. Design data: Seismic design calculations:
   1. Design calculations for duct construction as specified in Section 01850 - Design Criteria and in accordance with SMACNA.

1.05 WARRANTY

A. Provide as specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials
   1. As specified in Section 01600 - Product Requirements.
   2. Ducts:
      a. Aluminum Ducts: Aluminum alloy 3003 H14 in accordance with ASTM B209.
      b. Galvanized steel ducts: G90 galvanized steel sheets with 0.9 ounces per square foot coating on each side, and in accordance with ASTM A653.
      c. Stainless steel ducts: Type 316L fabricated in accordance with ASTM A167 and A480.
   3. Reinforcing: Formed or extruded angles matching ductwork material.

B. Changes in duct size:
   1. Use uniformly tapering sections.
   2. Taper not more than 1 inch in 5 inches of run unless otherwise indicated on the Drawings.

C. Bends: With the exception of miter bends, inside radii of bends to be equal to or greater than the largest duct dimension

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Design and fabricate the aluminum ductwork
   1. Pressure allowance:
      a. Within 2 inches water gauge minimum for supply, return, general exhaust and other applications unless otherwise indicated on the Drawings or specified.
      b. Within 6 inches water gauge minimum for lab exhaust applications.
   2. In accordance with SMACNA Seismic Restraint Manual
      a. As specified in Section 01850 - Design Criteria
      b. Hanger reinforcement:
         1) Ducts 18 inches and smaller in largest dimension: None.
         2) Ducts over 18 inches and under 30 inches in largest dimension:
            a) 1-1/2 inches by 1-1/2 inches, 1-1/2 by 1/8-inch angles, 8 feet on center
         3) Ducts 30 inches and larger in largest dimension:
            a) 1-1/2 inches by 1-1/2 inches by 1/8-inch angles, 4 feet on center.

3. In accordance with SMACNA HVAC Systems-Duct Design manual
    a. Sheet metal thicknesses: The greater of the SMACNA design or:

Diameter or Largest Dimension of Rectangular Duct (Inches)	Minimum Sheet Thickness, Inches (B&S Gage)	
	Galvanized Steel	Aluminum (Conversion of galvanized steel to aluminum)
Up to 12	0.01875 (26)	0.032
13, 14	0.025 (24)	0.04
15 to 18	0.03125 (22)	0.05
19, 20	0.0375 (20)	0.063
21 to 26	0.05 (18)	0.071
Larger than 27	0.0625 (16)	0.09

    b. Spacing of hangers and supports:
        1) In accordance with SMACNA but no greater than that indicated on the Drawings.
        2) 8 feet on center for ducts 18 inches and smaller in the largest dimension
        3) 4 feet on center to ducts over 18 inches in the largest dimension
    c. Support connections:
        1) In accordance with SMACNA unless indicated on the Drawings.
        2) As a minimum, all support connections to metal or wood roofs at roof framing members only.
        3) No penetrations through roof deck, roof membrane, or connections to roof membrane.
4. Ducts specified with insulation on interior to be sized as indicated on the Drawings.

2.03 COMPONENTS

A. Duct sleeves:
    1. Install where ducts pass through concrete or masonry walls and slabs.
    2. Size: 2 inches larger than the duct or duct with external insulation.
    3. Flanges: 4 inches wide.

B. Access openings:
    1. Install in locations for access to dampers, fusible links, controllers, and similar devices.
    2. Size: 2 inches less than duct size.
    3. Doors:
        a. Gauge not less than duct sheet.
        b. Provide continuous hinge and latch on outside.
    4. Gasket: Along door periphery.
    5. Visual panel: 1/8-inch thick, clear Plexiglas.

C. Turning vanes:
    1. Install at 90 degree bends.
        a. Square-turn elbows, smooth radius elbows, and splitters.

2. Material: Same as ductwork.
3. Type:
    a. Single-blade vanes for duct widths less than 36 inches.
    b. Airfoil type vanes for duct widths of 36 inches and greater:
        1) No trailing edge.
4. Mounted in side rails.
5. Size: 2-inch blades for ducts up to 18 inches, 4-1/2 inch blades for larger ducts.

D. Flexible connectors:
1. Install at connections to air handling equipment and at other locations indicated on the Drawings.
2. As specified in Section 15500 - Common Work Results for HVAC

E. Splitter dampers: Provide at branch take-offs where necessary for balancing system.

2.04 FABRICATION

A. Fabricate ductwork to the configuration and dimensions indicated on the Drawings.

B. Do not utilize S clips, duct tape, or externally applied mastic on medium pressure duct systems.

C. Do not use snap lock seams.

2.05 SHIPPING

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 INSTALLATION

A. Hangers:
1. Install hangers as indicated on the Drawings.
2. When hangers are not detailed, conform to SMACNA HVAC Systems-Duct Design and Seismic Restraint Manual standards and the following requirements:
    a. Rectangular ducts concealed in ceiling spaces:
        1) Use metal strap hangers.
        2) Fasten to sides of duct with 2 screws.
        3) Fasten to bottom of duct with 1 screw.

b. Rectangular ducts in exposed areas:
    1) Install shelf angle trapeze hangers or Unistrut type hangers.
    2) Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.
c. Round ducts in exposed areas:
    1) Install 2 half-round bands with rods bolted to panels.
    2) Install sway bracing as required by seismic calculations, minimum 1 brace at right angle to each duct run.

B. Provide closed-cell neoprene gaskets at flanged joints.

C. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A and shall be marked.

3.03 FIELD QUALITY CONTROL

A. Inspect ductwork under operating conditions.
    1. Correct audible leaks and leaks that can be felt with the hand.

END OF SECTION

SECTION 15814

FIBERGLASS REINFORCED PLASTIC DUCTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for a Fiberglass reinforced plastic (FRP) ductwork system.
   1. Ducts and fittings.
   2. Flexible connections.
   3. Expansion joints.
   4. Supports.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):
   1. RTP-1 - Reinforced Thermoset Plastic Corrosion-Resistant Equipment.

B. American Water Works Association (AWWA):
   1. M45 - Fiberglass Pipe Design.

C. ASTM International (ASTM):
   1. C582 - Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
   2. D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   3. D2105 - Standard Test Method for Longitudinal Tensile Properties of Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube.
   4. D2344 - Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates.
   5. D2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
   6. D2992 - Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings.
   7. D2996 - Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
   8. D3982 - Standard Specification for Contact Molded “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Ducts.
   9. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

D. National Fire Protection Association (NFPA):
   1. 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids.

E. National Institute of Standards and Technology (NIST):
   1. PS 15 - Custom Contact-Molded Reinforced-Polyester Chemical Resistant Process Equipment.

F. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

1.03 SUBMITTALS

A. As specified in Sections 01330 - Submittal Procedures and Section 15500 - Common Work Results for HVAC.

B. Shop drawings:
   1. Scaled ductwork layout.
      a. Size, joint types, horizontal dimensions, and elevations.
      b. Support locations.
      c. External stiffeners and expansion joints locations.
   2. Fabrication details.
   3. Support, flexible connections, and external stiffeners.
      a. Materials and configuration.

C. Calculations:
   1. Wall thickness calculations based upon design criteria.
   2. Stresses and reaction loads at supports.

D. Manufacturer's installation instructions.
   1. Detailed instructions for field butt joints including lay-up sequence, width of each reinforcement layer, and total number of layers.

E. Submit test results as specified in Section 06608 - Fiberglass Reinforced Plastic verifying that ductwork meets standards specified.
   1. Also, in accordance with Section 06608 - Fiberglass Reinforced Plastic as to the requirements of FRP manufacturing and standard testing.
   2. If there is a conflict between this Section and Section 06608 - Fiberglass Reinforced Plastic, the more stringent requirements shall govern.
      a. Test methods by the manufacturer shall be in accordance with ASTM 2996 and ASTM 2992 (buried pipe).

1.04 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

2.02 MANUFACTURERS

A. Fiberglass reinforced plastic ductwork:
   1. One of the following or equal:
      a. Daniel Mechanical.
      b. Engineered Composite Systems.
      c. Perry Fiberglass Products, Inc.
      d. NOV Fiber Glass Systems.

2.03 DESIGN AND PERFORMANCE CRITERIA

A. Ducting for HVAC, Chlorine Scrubber systems and Ventilation systems:
   1. Minimum internal pressure: 20.0 inches water gauge.
   2. Minimum internal vacuum: 20.0 inches water gauge.

B. Support spacing: As needed to comply with wall thicknesses calculations but not greater than the following:
   1. Contact-molded ductwork: Not greater than 5 foot centers.
   2. Filament-wound ducts: In accordance with SMACNA standards below:

Duct Inside Diameter (Inches)	Maximum Span (Feet)
3 to 19	10
20 to 29	15
30 to 35	20

C. Minimum flooding: Design ductwork for water accumulation as follows:
   1. Rectangular ductwork: 1-inch deep across bottom of duct.
   2. Round ductwork: 2 inches deep across bottom of duct.

D. Physical and mechanical properties: Duct shall meet the following standards for physical and mechanical properties:

Pipe Property	Standard	Design Properties	
		Hoop (PSI)	Axial (PSI)
Ultimate Flexural Stress	ASTM D2412	50,000	18,000
Flexural Modulus		3.05×10^6	1.0×10^6
Ultimate Tensile Stress	ASTM D2105	52,000	7,485
Tensile Modulus		1.5×10^6	1.56×10^6

Pipe Property	Standard	Design Properties	
		Hoop (PSI)	Axial (PSI)
Ultimate Shear Strength		Approximate Typical Values (PSI)	
Interlaminar Cross	ASTM D2344	2130-2730 15,000	
Density	ASTM D792	0.065-0.072 lb./In^3	

E. Design tensile stress:
   1. Calculations for design of wall thickness assume a laminate ultimate tensile stress of 9,000 pounds per square inch maximum.
   2. Decrease ultimate tensile stress as appropriate to the laminate design.
      a. Round ducting: The maximum allowable design tensile stress shall be the ultimate tensile stress divided by 5.
      b. Rectangular ducting: The maximum allowable design tensile stress shall be the ultimate tensile stress divided by 10.

F. Manufacturer shall provide design calculations for FRP ductwork design and construction. Calculations shall be signed and sealed by licensed engineer registered in the state of the project location

2.04 DUCTWORK MATERIALS

A. As specified in applicable portions of Section 06608 - Fiberglass Reinforced Plastic.

B. Minimum corrosion liner:
   1. Interior surfacing "C" or Nexus veil as specified for the service environment.
   2. Exterior surfacing: “C” or “A” veil.
   3. Remainder 1-1/2 ounce per square foot mat to total minimum thickness of 0.096 inches on surface exposed to the service environment.
   4. Duct shall be resistant to the following in accordance with ASTM C582:

Sulfuric Acid	75 percent	At 100 degrees Fahrenheit
Nitric Acid	20 percent	At 100 degrees Fahrenheit
Sodium Hydroxide	50 percent	At 100 degrees Fahrenheit
Hydrofluoric Acid	20 percent	At 100 degrees Fahrenheit

C. Ultraviolet stabilizer:
   1. All exposed external surfaces of all FRP ductwork installed outdoors shall be provided with protection against ultraviolet degradation and weather erosion.
   2. The duct shall carry the flame spread rating of 25 or less in accordance with ASTM E84 and a smoke contribution rating in excess of 1,000 in accordance with NPFA 91.

3. External duct protection shall be provided by an ultraviolet stabilizer added to the final coat or resin that also incorporates paraffin wax curing elements and color pigment.
4. An alternative system to polyurethane paint with color pigments may be used if approved by the Owners Designated Representative.

D. Resin:
1. The external surface and structural layers of all FRP ductwork shall carry a flame spread rating of 25 or less in accordance with ASTM E84 and a smoke contribution of 50 or less in accordance with NFPA 91.
2. Premium vinyl ester as follows unless otherwise recommended by the resin manufacturer for the service environment:
   a. Resin for structural layers: Resin with sufficient antimony trioxide or pentoxide for Class I fire rating.
   b. Manufacturers: One of the following or equal:
      1) Ashland, Hetron 992FR.
      2) Reichhold Dion, VER 9300FR.

E. Color: Add pigment to the exterior surface resin coat such that the color of the duct will be similar to paint used for equipment, except that ducting for air conditioning systems which are concealed above suspended ceilings need not be pigmented. Color selected by Owner.

F. Provide fasteners, field joints, expansion joints, and supports required for complete installation of a duct system.

G. Flanges:
1. All flanges shall be hand laid up to the thickness specified in accordance with ASTM D3982.
2. FRP flanges shall be made of the same materials as the FRP ductwork.
3. Flange bolt hold pattern as well as flange dimensions, shall be in accordance with NIST PS 15 Tables 2 and 5 for duct and pipe, respectively, except for thickness. Thickness of flange shall be a minimum of 1/2 inch.
4. Flanges shall be manufactured using the hand lay-up technique and shall be integral to the duct in accordance with ASME RTP-1. Filament-wound and/or random chopped methods of constructing flanges will not be acceptable.

Pipe Diameter, Inches	**Minimum Flange Thickness, Inches**
Less Than 12	1/2
12-24	1/2
25-41	5/8
42-60	3/4

2.05 DUCTWORK FABRICATION

A. Hand lay-up or filament wound construction as specified in Section 06608 - Fiberglass Reinforced Plastic.
   1. Provide wall thickness necessary to comply with design criteria but not less than the following minimum thicknesses.
   2. Structural wall thicknesses shall not include the thickness of the interior corrosion barrier, inner surface, and interior layer:

Duct Size	Round Ducting (wall thickness, inches)	Rectangular Ducting (wall thickness, inches)	Buried Ducting (wall thickness, inches)
For 18 inch & smaller ducts	0.1875	0.25	0.34
20 to 36 inch ducts	0.25	0.375	0.42
42 to 54 inch ducts	0.375	0.500	0.60
60 to 72 inch ducts	0.438	0.625	0.625

B. Fittings:
   1. Type: Hand lay-up contact molded.
   2. Resin: Identical to and with same strength as resin used for FRP ductwork.
   3. Wall thickness: At least equal to the thickness of the thickest adjacent ducting.
   4. Internal diameter: Equal to the adjacent duct.
   5. Tolerance:
      a. Angles for all fittings shall be within 1 degree for up to 30-inch diameter duct.
      b. Angles for all fittings shall be within 1/2 degree for over 30-inch diameter and above duct.
   6. Round standard elbows:
      a. Standard elbow centerline radius shall be equal to 1-1/2 times the diameter unless otherwise indicated on the Drawings.
      b. Standard elbows up to 24-inch diameter shall be smooth radius elbows. Standard elbows of 26-inch diameter and greater may be mitered sections as follows:
         1) 0 to 44 degree elbows shall contain 1 mitered joint and 2 sections.
         2) 45 to 80 degree elbows shall contain a minimum of 2 mitered joints and 3 sections.
         3) Elbows greater than 80 degrees shall contain a minimum of 4 mitered joints and 5 sections.
      c. Provide turning vanes in all round mitered elbows. Round elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.
   7. Rectangular elbows:
      a. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required to meet the specified deflection requirements and to provide a system free from pulsing, warpage, sagging, and undue vibration.

b. Provide turning vanes in all rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.

C. Joints:
1. Flanged:
a. Flanged in accordance with ASTM D3982 and bolt hold patterns in accordance with NIST PS 15, Table 2.
b. Flanged joints shall be provided at the following locations:
1) At each damper and each item of equipment to facilitate disassembly.
2) At each change in material.
3) Where indicated on the Drawings.
c. Gaskets for flanged joints: 1/8-inch neoprene over full flange face.
d. Bolt nuts and washers: Type 316 stainless steel.
2. Butt and strap welded:
a. Field butt and strap welded joints shall be provided at the following locations:
1) 12 inches from any increasing or decreasing cross-section of pipe.
2) Where the pipe to be joined has the same diameter.
b. Thickness of butt and strap joint overlays: At least equal to the thickness of the thickest adjacent duct.
c. Field weld kits:
1) All necessary fiberglass and reinforcing material shall be supplied pre-cut and individually packaged for each joint.
2) Bulk Glass rolls will not be acceptable.

2.06 FLEXIBLE CONNECTIONS

A. Flexible connection shall be provided as indicated on the Drawings. When flexible connections are not shown, they shall be provided at all duct to rotating equipment connections.

B. FL-3, Duct to Equipment Heavy Duty Flexible Connection:
1. Materials: EPDM rubber vulcanized with minimum of 1 ply of reinforcing fabric; 3/16 inch thick.
2. Unit shall have minimum movement of:
a. Axial compression: 2.25 inches.
b. Axial extension: 1.25 inches.
c. Lateral offset: 1.25 inches.
3. Provide 3/8-inch thick by 2-inch wide pre-drilled retaining rings/back-up bars to clamp the expansion joints into the ducting system.
4. The expansion joint shall be of fully molded construction. Splices will not be allowed in the body of the expansion joint.
5. Manufacturers: One of the following or equal:
a. Proco Series 500, Style 530 Fabric Fan Connector.
b. Holz Rubber Style 952 Arch Design Expansion Joint.

2.07 EXPANSION JOINTS

A. Expansion joints shall be provided as indicated on the Drawings. When expansion joints are not shown, they shall be provided in above grade duct at maximum spacing of 40 foot centers.

B. Construction:
   1. Body: EPDM.
   2. Reinforcing: Multiple layers (2 minimum) of impregnated polyester or Kevlar tire cord fabric.
   3. Flange rings: Type 316 stainless steel or minimum 3/4 inch thick FRP.
   4. Hardware/Fasteners: Type 316 stainless steel.
   5. Minimum pressure rating: 1 pound per square inch.
   6. Minimum vacuum rating: 1 pound per square inch.
   7. Minimum operating temperature: 175 degree Fahrenheit.
   8. Connections: Flanged in accordance with NIST PS 15, Table 2.
   9. Seamless construction built as on continuous piece. Wrapped, seamed, or spliced type expansion joints are not acceptable.
   10. Provide Type 316 stainless steel control rods.

C. Minimum movement:
   1. Axial compression: 2.25 inches.
   2. Axial extension: 1.25 inches.
   3. Lateral offset: 1 inch.

D. Manufacturers: One of the following or equal:
   1. Daniel Co., DanFLEX Model 101.
   2. Mercer Rubber Co., Model ME for Rectangular, Model MI-9 for Round.

2.08 DUCT SUPPORTS

A. Provide duct supports as indicated on the Drawings.

B. Protect the duct from clamping force of strap hangers with a 1/8-inch thick layer of neoprene pad.

C. When anchors are required, they shall be externally bonded to the duct. Drive screws or other penetrations of the duct liner are not permitted.

D. When duct supports are not indicated on the Drawings provide supports and seismic bracing in accordance with the SMACNA Design Manual.

2.09 SHOP INSPECTION

A. Each load of FRP duct or pipe shall be shop inspected during fabrication and prior to shipment.
   1. Inspection shall be conducted by qualified third-party inspectors that have extensive experience in the design, manufacture, testing, and installation of all FRP duct and pipe.
   2. The cost for third-party inspection shall be borne by the manufacturer.

3. The name, resume, and qualifications of the third-party inspector shall be submitted to the Engineer for approval. Acceptable inspection engineers shall be one of the following or equal:
    a. Fiberglass Structural Engineers, Inc.
    b. FEMech Engineering.

2.10 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 INSTALLATION

A. All ductwork shall be fabricated and erected where indicated on the Drawings or as specified in this Section. Ductwork shall be rigidly supported and secured in an approved manner.

A. Install ductwork parallel to walls and/or roof and vertically plumb.

B. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise.
    1. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs.
    2. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment.
    3. Building siding and metal decking shall not be used to hang ductwork.

C. Contractor shall not install any equipment or materials until the Owners Designated Representative has approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

D. Wherever ducts are divided, the cross-sectional area shall be maintained. All such changes must be approved and installed as directed by the Owners Designated Representative or as approved on shop or erection drawings.

E. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions.
    1. Notify the Owners Designated Representative prior to starting any field modifications involving ductwork structural reinforcing members.
    2. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.

F. No ductwork or components shall be shipped prior to complete resin cure.

G. Cover ductwork openings with tape, plastic, or sheet metal to reduce the amount of dust or debris which may collect in the system at each of the following times:
   1. At the time of rough installation.
   2. During storage on the construction site.
   3. Until final start-up of the heating and cooling equipment.

H. Before installation remove dust and debris from ducts.

I. Install products in accordance with shop drawings and manufacturer's instructions. Drawings indicate general routing only and shall be modified as necessary.

END OF SECTION

SECTION 15830

FANS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fans, motors, and accessories.

1.02 REFERENCES

A. Abbreviations:
   1. As used in this Section and on the Drawings, abbreviations and Fan Schedule headings have the following meaning:
      a. EF or EXF: Exhaust Fan.
      b. Hp: Fan motor horsepower.
      c. SF or SPF: Supply Fan.
      d. Size: Nominal fan blade or wheel diameter in inches.
      e. SP or ESP: Fan External Static Pressure in inches water column.
      f. Type: Fan type as specified in this Section.
      g. V/Ph: Fan motor voltage and power phases.

B. Standards:
   1. Air Movement and Control Association International, Inc. (AMCA).
   2. American Bearing Manufacturers Association (ABMA):
      a. 9 - Load Ratings and Fatigue Life for Ball Bearings.
      b. 11 - Load Ratings and Fatigue Life for Roller Bearings.
   3. ASTM International (ASTM):
      a. A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
      b. D4167 - Standard Specification for Fiber Reinforced Plastic Fans and Blowers.
      c. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
   4. National Fire Protection Association (NFPA):
      a. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
   5. National Roofing Contractors Association (NRCA).
   6. Occupational Safety and Health Administration (OSHA).

1.03 ADMINISTRATIVE REQUIREMENTS

A. Roof coordination as specified in Section 15500 - Common Work Results for HVAC.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Materials.
   2. Primary and ancillary equipment.
   3. Sound Power Level in each of 8 octave bands and overall Sones.
   4. Fan system layout, mechanical, electrical power, and control diagrams.
   5. Supports, vibration isolators, and seismic bracing calculations and details.
   6. Calculated fan vibration levels and field-testing method.
   7. Bearing life.
   8. Fan performance curves showing specified operating condition.

C. Drawings:
   1. Component layout and identification.
   2. Views:
      a. Front, side, rear elevations, and top and bottom views, with dimensions.
      b. Connection locations including electrical, mechanical, and other.
   3. Cut away drawings.
      a. Parts list.
      b. Material specification lists.
   4. Wiring, control schematics, control logic diagrams and ladder logic or similar for computer-based controls.
   5. Details for supports, isolators, and bracing.

D. Delegated Design Submittals:
   1. Anchoring and bracing: Provide project-specific calculations based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria.
      a. To structures for equipment installed in structures designated as seismic design category C, D, E, or F.
      b. For equipment installed outdoors.
      c. For wall mounted equipment weighing 125 pounds or more.

E. Manufacturer's recommendations for handling, storage, and installation.

F. Nameplate data.

G. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

H. Provide manufacturers reports on factory testing.

1.06 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. As specified in Section 15500 - Common Work Results for HVAC.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide instrumentation and controls to meet the equipment operating requirements as specified in Section 15936 - Instrumentation and Control Devices for HVAC.

B. Roof curb:
   1. Factory fabricated to match fan material.
   2. Capable of supporting entire unit weight.
   3. Suitable for installing and connecting ductwork to curb.
   4. In accordance with NRCA Standards.
   5. Extend a minimum of 8 inches above top of built up roofing.
   6. Curb shall be a minimum height of 12 inches.
   7. Flashing: In accordance with NRCA Standards and roof manufacturer.

2.03 TYPE 2, UP-BLAST CENTRIFUGAL ROOF EXHAUSTERS

A. Manufacturers: One of the following or equal:
   1. Greenheck, Model CUBE.
   2. Loren Cook, similar series.
   3. Penn Ventilator, similar series.

B. Characteristics:
   1. Roof-mounted, upblast circular exhaust fan unit.
   2. Backward inclined centrifugal fan wheel with Venturi inlet; performance as scheduled.
   3. Materials: Aluminum fan, housing, roof curb, and accessories.
   4. Fan bearings: Permanently lubricated ball bearing type.
   5. Belt drive rated for 150 percent of motor horsepower.
   6. Motor characteristics: As scheduled.
   7. Finishes: Provide 2 coat finish with a 2.0 to 3.0 mils thick epoxy primer base coat and 2.0 to 3.0 mils thick polyester powder coated topcoat or approved equal finish on fan and accessories.

C. Accessories:
   1. Mounting brackets: Necessary for installation.
   2. Roof curb.
   3. Provide other accessories as scheduled.

2.04 TYPE 3, PROPELLER FILTERED ROOF SUPPLY FANS

A. Manufacturers: One of the following or equal:
   1. Greenheck, Model RBCF.
   2. Loren Cook, similar series.
   3. ACME, similar series.

B. Characteristics:
   1. Roof-mounted, propeller filtered supply fan with hood panels.
   2. Forward-curved centrifugal fan wheel.
   3. Materials: Cast aluminum.
   4. Fan bearings: Permanently lubricated ball bearing type.
   5. Belt drive rated for 150 percent of motor horsepower.
   6. Finishes: Provide 2 coat finish with a 2.0 to 3.0 mils thick epoxy primer base coat and 2.0 to 3.0 mils thick polyester powder coated topcoat.

C. Accessories:
   1. Mounting brackets: Necessary for installation.
   2. Roof curb.
   3. Filter section:
      a. Low velocity 2-inch thick pleated, washable filters of commercially available sizes.
      b. Filter face velocity: Not to exceed 350 feet per minute nominal flow.
      c. Provide filters of identical size for any 1 unit.
      d. Filters: American Air Filter or equal.
   4. Insulated cover to prevent condensation.
   5. Provide other accessories as scheduled.

2.05 TYPE 7, SQUARE IN-LINE CENTRIFUGAL FANS

A. Manufacturers: One of the following or equal:
   1. Greenheck, Model BSQ.
   2. Loren Cook, similar series.
   3. Penn, similar series.

B. Characteristics:
   1. Type: Square, in-line centrifugal type.
   2. Fan: Backward-inclined, non-overloading, aluminum wheel; statically and dynamically balanced.
   3. Housing: Square type with duct transitions to match fan supplied; galvanized steel or aluminum as scheduled, minimum 20-gauge panels with 10-gauge stiffeners and frame as required.
   4. Motor: Mounted on exterior of housing for belt drive units.
   5. Finishes: Provide 2 coat finish with a 2.0 to 3.0 mils thick epoxy primer base coat and 2.0 to 3.0 mils thick polyester powder coated topcoat or approved equal finish on fan and accessories.

C. Accessories:
   1. Mounting base: Galvanized steel or aluminum; match scheduled casing material.
   2. Mounting brackets: Necessary for installation.

3. Provide other accessories as scheduled.

2.06 SOURCE QUALITY CONTROL

A. Factory test fans listed on the Fan Schedule for proper operation, performance, and electrical controls.

2.07 SHIPPING, SPARE PARTS, MAINTENANCE PRODUCTS, AND SPECIAL TOOLS

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

B. Deliver units in 1 piece, factory assembled, internally wired, and lubricated.

PART 3 EXECUTION

3.01 GENERAL

A. As specified in Section 01600 - Product Requirements with additional requirements in Section 15500 - Common Work Results for HVAC.

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Install the equipment in accordance with the accepted installation instructions and anchorage details.

3.04 TESTING

A. Test equipment performance and balance equipment as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

3.05 FIELD QUALITY CONTROL

A. Verify equipment operation and unit vibration is within manufacturer's submitted maximum.

3.06 SCHEDULES

A. As indicated on the Drawings.

END OF SECTION

SECTION 15936

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Controls for Heating, Ventilating, and Air Conditioning (HVAC) Systems.

1.02 REFERENCES

A. CSA International (CSA).

B. National Electrical Code (NEC).

C. Restriction of Certain Hazardous Substances (RoHS).

D. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

E. National Fire Protection Association (NFPA):
   1. 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

F. Underwriters' Laboratories, Inc. (UL):
   1. 13 - Standard for Safety Power-Limited Circuit Cables.
   2. 268A - Standard for Smoke Detectors for Duct Application.
   3. 508 - Standard for Industrial Control Equipment.
   4. 1479 - Fire Tests of Through-Penetration Firestops.
   5. 1685 - Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

1.03 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Product data: As specified in Section 15500 - Common Work Results for HVAC.

C. Shop drawings:
   1. Manufacturer's information including:
      a. Catalog information clearly marked to show specific products, models, and sizes being furnished.
      b. Component cut sheets.
   2. Control diagrams showing the interconnection of control components including wiring terminal strip diagrams.
   3. Detail drawings showing control panel layout and dimensions including control panel terminal strips for wiring to outside control devices and panels.

D. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Include a list of configurable parameters and the final values for each.
   3. Include a troubleshooting chart covering the complete valve and controls/electrical power systems, showing description of trouble, probable cause, and suggested remedy.

E. Provide Manufacturer's Certificate of Installation and Functionality Compliance as specified in Section 01756 - Commissioning.

1.04 QUALITY ASSURANCE

A. The control system shall be designed in accordance with UL and CSA standards.

1.05 DELIVERY, STORAGE, AND HANDLING

A. The system control products shall be stored and handled per manufacturer's recommendations.

1.06 SITE CONDITIONS

A. Elevation and ambient conditions as specified in Section 01850 - Design Criteria.

1.07 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Special warranties: Warranty period begins at date of Project Acceptance or first date of Beneficial Use by the Owner:
   1. One year: Parts and on-site labor for components, systems, and programming.

PART 2 PRODUCTS

2.01 DESIGN AND PERFORMANCE CRITERIA

A. General requirements:
   1. All electrical components shall be UL-listed and meet the design and installation requirements of the NEC.
   2. Complete, functional system: Provide all necessary electrical power and control systems, components, and wiring to make a complete functioning system.
   3. Comply with electrical Sections for electrical power and control systems.
   4. System control functions to perform as described in Products.
   5. Materials: New, free from defects, and of the quality specified.
   6. Common manufacturer: Provide components, component accessories, and devices, as much as possible, by the same manufacturer throughout the work.
   7. Mounting: Mount control components and devices in accessible locations for maintenance and as recommended by the manufacturer; provide necessary manufacturer-approved mounting and configuration hardware for mounting and operation of control components and devices.

2.02 THERMOSTATS

A. General:
   1. Thermostat types: Thermostat types are called out on the drawings by the letter T followed by a number; this designation refers to the specified thermostat types specified in this Section; where no type is called out, provide 1 of the specified types that will match the controlled equipment requirements and provide a functioning system.
   2. Manufacturers: One of the following or equal:
      a. Johnson Controls, model as specified with each type.
      b. Honeywell, Tradeline, equivalent models.
   3. Thermostat cable:
      a. Conductor: Number of conductors required to be determined by HVAC system, solid bare copper, 18/20 American Wire Gauge (up to 250 feet); provide sufficient length to accommodate the thermostat locations as indicated on the Drawings.
      b. Insulation: Heat and moisture resistant colored Polyvinylchloride (PVC) or Polypropylene insulation.

Thermostat Terminal	Wire Color (Typical)	Function Description
R	Red	24V AC/Heat Single Transformer
Rc	Red	24V for Dual Transformer - AC
Rh	Red	24V for Dual Transformer - Heat
C	Black/Blue	Common 24VAC Power Source
Y	Yellow	Primary Cooling
Y2	Light Blue/Yellow	Secondary Cooling
W	White	Primary Heating
W2	Brown	Secondary Heating
G	Green	Fan Relay
O	Orange	Reversing Valve

      c. Jacket: White or Brown Polyvinylchloride.
      d. In accordance with:
         1) UL 13 in accordance with NEC Article 725.
         2) UL Listed Type CL2, Sunlight Resistant.
         3) UL 1685 Vertical Tray. RoHS compliant.
      e. Temperature Rating: 140 degrees Fahrenheit.
      f. Voltage Rating: Up to 150V.

B. T-2, Type 2 Thermostat, Cooling Only, Line Voltage:
   1. Manufacturers: The following or equal: Johnson Controls Model:
      a. Dry locations (no hose bibs or open water processes in room): Model A19BBC-2C in NEMA 1 enclosure.
      b. Wet locations (hose bibs or open water processes in room): Model A19QSC-1C in NEMA 4X enclosure.
   2. Switch action: Single-pole double-throw, close on rising temperature.
   3. Sensing element: Coiled bulb and capillary.
   4. Setpoint: 30 to 110 degrees Fahrenheit with knob adjuster and visible scale.
   5. Electrical ratings: 16 amps alternating current at 120 volts, 9.2 amps alternating current at 208 volts.
   6. Differential range: For dry locations, 3 to 12 degrees Fahrenheit adjustable; for wet locations, 5 degrees Fahrenheit fixed.

2.03 DIFFERENTIAL PRESSURE GAUGES

A. Gauges for local indication of indoor units shall be accurate to within 2 percent of full scale.
   1. Gauges shall have 0 adjustment screw and an adjustable set point indicator.
   2. Casing shall be cast aluminum.
   3. Unit shall be able to withstand an overpressure of 15 pounds per square inch gauge.
   4. Each gauge shall be provided with shut-off vent valves each side of the gauge to permit zeroing of the gauge without disconnecting the gauge.
   5. Manufacturers: The following or equal:
      a. Dwyer Magnehelic Series 2000.

2.04 DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches suitable for monitoring pressure drop in non-hazardous spaces:
   1. Manufacturers: One of the following or equal:
      a. Dwyer, Model EDPS series.
      b. Omega.
   2. Characteristics and features:
      a. Service:
         1) Air and other non-combustible, non-aggressive gases.
      b. Materials:
         1) Diaphragm: Silicone
         2) Housing: Acetal plastic.
         3) Switch body: PA 6.6.
         4) Cover: Polystyrene.
      c. Temperature limits: -4 degrees Fahrenheit to 185 degrees Fahrenheit.
      d. Pressure limits: Maximum 40 inches w.c.
      e. Switch type: Single-pole double-throw.
      f. Electrical rating: 1.5 A, 120 V.
      g. Enclosure: NEMA 3.
      h. Approvals: ETL approved to UL 508.

2.05 CURRENT SWITCHES

A. Current switch:
   1. Veris Industries H series or equal.
   2. Rated for current range of the equipment.
   3. Used to determine low current inferring loss of air flow.

2.06 DUCT MOUNTED SMOKE DETECTORS

A. General:
   1. Provide duct mounted smoke detectors in air ducting with flows greater than 2,000 cubic feet per minute as indicated on the Drawings.
   2. Capable of mounting to rectangular or round ducts.
   3. Integral filter to reduce dust.
   4. Comply in accordance with UL 268A for air handling systems.
   5. Airflow velocity: 100 to 4,000 feet per minute.
   6. Connect the smoke detector to:
      a. System as indicated in Control Sequences. Fan control circuit to shut down respective fan upon detection of smoke.
      b. Damper control circuits to close respective air dampers to prevent spread of smoke.

B. Corrosion Proof, Non-Explosion Proof, Non-Classified Areas (SD-4):
   1. Manufacturers: The following or equal:
      a. Air Products and Controls, RT-3000-P.
   2. Characteristics:
      a. Photoelectric type.
      b. UL 268A listed.
      c. Enclosure: NEMA Type 4X.
      d. Operating temperature range of -4 to 140 degrees Fahrenheit.
      e. Power supply voltage: 115 VAC.
      f. Contacts:
         1) Alarm contact:
            a) Form “C” rated at 10 Amps at 125VAC (2 sets).
            b) Form “A” rated at 1 Amp (FACP) at 30VDC (1 set).
         2) Fault contacts:
            a) Form “C” rated at 10 Amps at 125VAC (1 set).
            b) Form “B” rated at 7 Amps (FACP) at 30VDC (1 set).

C. Accessories:
   1. Provide metal sampling tube and end cap to match duct width. Sampling tube shall be able to be installed without use of tools.
   2. Provide mounting base and hardware.
   3. Provide duct access door as specified in Section 15812 - Metal Ducts. Provide similar for non-metallic ducting.
   4. Provide remote annunciator with alarm and power LEDs and all required wiring and conduit per installation instructions for complete working operation.
   5. Provide remote test station and all required wiring and conduit per installation instructions for complete working operation.

2.07 RESISTANCE TEMPERATURE DETECTOR (RTD) TYPE TEMPERATURE TRANSMITTER

A. Manufacturers: The following or equal:
   1. Omega Engineering, Model EWSA-PT100-TX.
   2. Greyston Energy Systems Inc., Model TDHRBF12XA002.

B. Characteristics and features:
   1. Sensor: Platinum RTD 100 ohm or 1000 ohm.
   2. Power supply: 10 to 30 Vdc, loop powered.
   3. Probe sensing range: 32 to 158 degrees Fahrenheit.
   4. Output signal: 4-20 mA.
   5. Transmitter accuracy: Within 0.1 percent of span.
   6. Enclosure:
      a. NEMA 4X (IP65) for non-hazardous areas.
      b. NEMA 7 for hazardous areas.
   7. Wiring connection: Screw terminal block, 2-wire.

2.08 HVAC CONTROL DESCRIPTIONS

A. General: Provide control systems that will maintain room or area comfort under changing ambient conditions and varying use; descriptions in this Section are general in nature and do not cover every mode of operation.

B. Chlorine Storage Building (Area 63):
   1. Chlorine Gas Leak Detection Scrubber System (CGLDSS) Control Sequences:
      a. Chlorine Scrubbers BLR-6391 and BLR-6391 shall provide emergency air scrubbing service to the Chlorine Storage Room and the Chlorinator Room.
         1) One scrubber will be in Duty at any time.
         2) One scrubber will be offline when the other scrubber is on duty.
         3) The Duty and Offline scrubber will be rotated monthly.
      b. The Chlorine Gas Leak Detection Scrubber System (CGLDSS) shall activate when the chlorine gas leak detection system activates a Hi-Hi level alarm.
         1) Upon a Hi-Hi alarm:
            a) Chlorine Storage Room
               (1) The following equipment will shut down: MAU-6354, EF-6355 and EF-6356.
               (2) Louvers LVR-6355 and LVR-6356 shall open.
            b) Chlorinator Room
               (1) Fan EF-6357 will shut down.
               (2) Louver LVR-6357 shall open.
         2) Once the Hi-Hi alarm is cleared, HVAC equipment shall return to normal operations.
   2. Electrical Room Control Sequences:
      a. Air handling unit/Heat pump mini-split systems, AHU/HP-6351 and AHU/HP-6352 shall provide primary and secondary heating and cooling to the Electrical Building. Each system will be controlled by manufacturer-provided wired thermostats with adjustable setpoints.

b. AHU/HP-6351 will serve as the Lead System and AHU/HP-6352 shall serve as the Lag System.
c. The Lead/Lag designation shall be rotated on a schedule to ensure the HVAC equipment will experience even wear and tear.
d. Lead System and Lag System setpoints:
    1) The Lead System shall have the following setpoints:
        a) The cooling setpoint will be 85 degrees Fahrenheit.
        b) When the temperature rises 5 degrees above the setpoint, the unit will energize.
        c) When the temperature falls 5 degrees below the setpoint, the unit will de-energize.
        d) The heating setpoint will be 55 degrees Fahrenheit.
        e) When the temperature drops 5 degrees below the setpoint, the unit will energize. When the temperature rises 5 degrees above the setpoint, the unit will de-energize.
    2) The Lag System shall have the following setpoints:
        a) The cooling setpoint will be 90 degrees Fahrenheit.
        b) When the temperature rises 5 degrees above the setpoint, the unit will energize.
        c) When the temperature falls 5 degrees below the setpoint, the unit will de-energize.
        d) The heating setpoint will be 50 degrees Fahrenheit.
            (1) When the temperature drops 5 degrees below the setpoint, the unit will energize. When the temperature rises 5 degrees above the setpoint, the unit will de-energize.
e. The Electrical Room shall be provided 1 RTD type room temperature transmitter as specified in this section:
    1) The RTD shall send a signal to SCADA to provide temperature status and monitoring.
f. Positive Pressure Unit PPU-6353 shall provide continuous outside air to positively pressurize the space.
    1) The PPU shall be provided with a differential pressure switch.
        a) Detection of high pressure shall send a “Dirty Filter Alarm” to SCADA.

3. Chlorinator Room:
    a. The Chlorinator shall receive continuous supply air from MAU-6354.
    b. Exhaust fan EF-6357 shall exhaust air from the room.
    c. LV-6357 shall remain closed and only used when the Chlorine Gas Scrubbing system is activated.
4. Mechanical Room :
    a. Supply Fan SF-6368 shall provide outside air to the space.
        1) The fan shall be controlled by a thermostat (Type T-2).
            a) The fan shall operate when the room is 85 degrees Fahrenheit.
5. Chlorine Storage and Chlorinator Room Control Sequences:
    a. Makeup Air Unit MAU-6354 will operate continuously to provide a minimum of 6 air changes per hour (ACH) of 100 percent outside air to the chlorine storage and chlorinator rooms.
        1) The MAU heating element will be controlled by a manufacturer provided thermostat with an adjustable set point. The thermostat will modulate the heating to ensure that the air being supplied to the chlorine building is 75 degrees Fahrenheit.

2) The MAU will have a duct mounted smoke detector (SD-4). When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system. Upon smoke detection SCADA will shut down the HVAC units within the space.
3) The MAU will send a “Dirty Filter” alarm to the SCADA system upon high pressure indication from the differential pressure switch.
4) The MAU will have a current sensor to monitor running status. When the airflow drops more than 20 percent below the scheduled CFM, a “low flow” alarm will be sent to the SCADA system.
5) The MAU will be interlocked with exhaust fan EF-6355 and EF-6357. When the MAU is operating, EF-6355 and EF-6357will operate. When the MAU is shut down, EF-6355 and EF-6357 will shut down.
6) MAU-6354 will be interlocked with the chlorine gas leak detection system. When the chlorine gas leak detection system activates a Hi-Hi level alarm MAU-6354 will shut down.

b. Exhaust Fan EF-6355 will be interlocked with MAU-6354.
1) The Exhaust Fan will be equipped with networked “Smart Starters” to monitor the running status of the fan.
a) When a drop in amperage occurs, a “Low Flow” alarm will be sent to the SCADA system.
2) The Exhaust Fan will have a duct mounted smoke detector (SD-4).
a) When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system. Upon smoke detection SCADA will shut down the HVAC units within the space.

c. Exhaust Fan EF-6357 and will be interlocked with MAU-6354 and exhaust air from the Chlorinator room.
1) The Exhaust Fan will be equipped with networked “Smart Starters” to monitor the running status of the fan.
a) When a drop in amperage occurs, a “Low Flow” alarm will be sent to the SCADA system.

d. Exhaust Fan EF-6356 will be controlled by an RTD.
1) The cooling setpoint will be 85 degrees Fahrenheit. When the temperature rises 5 degrees below the setpoint, the fan will energize. When the temperature drops 5 degrees below the set point, the fan will de-energize.
2) The Exhaust Fan will be equipped with networked “Smart Starters” to monitor the running status of the fan. When a drop in amperage occurs, a “Low Flow” alarm will be sent to the SCADA system.
3) The Exhaust Fan will have a duct mounted smoke detector (SD-4). When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system. Upon smoke detection SCADA will shut down the HVAC units within the space.
4) EF-6356 will be interlocked with the chlorine gas leak detection system. When the chlorine gas leak detection system activates a Hi-Hi level alarm EF-6356 will shut down.

e. Combination Motorized Louvers/Dampers LV-6355 and LV-6356 will provide 100 percent outside air into the chlorine storage room.
    1) The Motorized Louvers/Dampers will be interlocked with EF-6356 and the chlorine gas leak detection system.
        a) When the chlorine gas leak detection system activates a Hi-Hi level alarm, and activates the scrubber, LV-6355 and LV-6356 will open.
        b) When EF-6356 is in operation, LV-6355 and LV-6356 will be open. When the fan shuts down, LV-6355 and LV-6356 will close.

f. Standby heating will be provided by Gas Unit Heaters GUH-6358 though - GUH-6364.
    1) Each heater shall be controlled by a manufacturer provided thermostat.
        a) The heating setpoint will be 60 degrees Fahrenheit. When the temperature drops 5 degrees below the setpoint, the heaters will energize. When the temperature rises 5 degrees below the set point, the fan will de-energize.

a. The Chlorine Storage Room shall be provided with 2 RTD type room temperature transmitter as specified in this section:
    1) The RTD shall send a signal to SCADA to provide temperature status and monitoring.

b. Chlorine Storage Building ventilation system emergency shutoff:
    1) An emergency stop button shall be located outside of the chemical area door entries as shown on the plans. Upon use, all ventilation equipment shall shutdown via interlocks and an alarm shall be sent to the SCADA system.
    2) The Emergency Shutoff will NOT shut down the Chlorine Scrubber systems.

C. Caustic Storage Building (Area 65):
    1. Electrical Room Control Sequences:
        a. Air handling unit/Heat pump mini-split systems, AHU/HP-6551 and AHU/HP-6552 shall provide primary and secondary heating and cooling to the Electrical Building. Each system will be controlled by manufacturer-provided wired thermostats with adjustable setpoints.
        b. AHU/HP-6551 will serve as the Lead System and AHU/HP-6552 shall serve as the Lag System.
        c. The Lead/Lag designation shall be rotated on a schedule to ensure the HVAC equipment will experience even wear and tear.
        d. Lead System and Lag System setpoints:
            1) The Lead System shall have the following setpoints:
                a) The cooling setpoint will be 85 degrees Fahrenheit.
                b) When the temperature rises 5 degrees above the setpoint, the unit will energize.
                c) When the temperature falls 5 degrees below the setpoint, the unit will de-energize.
                d) The heating setpoint will be 55 degrees Fahrenheit.
                e) When the temperature drops 5 degrees below the setpoint, the unit will energize. When the temperature rises 5 degrees above the setpoint, the unit will de-energize.

2) The Lag System shall have the following setpoints:
a) The cooling setpoint will be 90 degrees Fahrenheit.
b) When the temperature rises 5 degrees above the setpoint, the unit will energize.
c) When the temperature falls 5 degrees below the setpoint, the unit will de-energize.
d) The heating setpoint will be 50 degrees Fahrenheit.
(1) When the temperature drops 5 degrees below the setpoint, the unit will energize. When the temperature rises 5 degrees above the setpoint, the unit will de-energize.

e. The Electrical Room shall be provided with 1 RTD-type room temperature transmitter as specified in this section:
1) The RTD shall send a signal to SCADA to provide temperature status and monitoring.

f. Positive Pressure Unit PPU-6553 shall provide continuous outside air to positively pressurize the space.
1) The PPU shall be provided with a differential pressure switch.
a) Detection of high pressure shall send a “Dirty Filter Alarm” to SCADA.

2. Caustic Storage Control Strategies
a. Makeup Air Unit MAU-6560 will operate continuously to provide a minimum of 6 air changes per hour (ACH) of 100 percent outside air to the chlorine storage and chlorinator rooms.
b. The MAU heating element will be controlled by a manufacturer provided thermostat with an adjustable set point. The thermostat will modulate the heating to ensure that the air being supplied to the chlorine building is 75 degrees Fahrenheit.
1) The MAU will have a duct mounted smoke detector (SD-4). When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system. Upon smoke detection SCADA will shut down the HVAC units within the space.
2) The MAU will send a “Dirty Filter” alarm to the SCADA system upon high pressure indication from the differential pressure switch.
3) The MAU will have a current sensor to monitor the running status. When the airflow drops more than 20 percent below the scheduled CFM, a “low flow” alarm will be sent to the SCADA system.
4) The MAU will be interlocked with exhaust fan EF-6554. When the MAU is operating, the EF will operate. When the MAU is shutdown, the EF will shut down.

c. Exhaust Fan EF-6554 will be interlocked with MAU-6560.
1) The Exhaust Fan will be equipped with networked “Smart Starters” to monitor the running status of the fan.
a) When a drop in amperage occurs, a “Low Flow” alarm will be sent to the SCADA system.
2) The Exhaust Fan will have a duct mounted smoke detector (SD-4).
a) When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system. Upon smoke detection SCADA will shut down the HVAC units within the space.

d. Supply Fan SF-6556 will provide secondary ventilation and be controlled by an RTD.
    1) The cooling setpoint will be 85 degrees Fahrenheit. When the temperature rises 5 degrees below the setpoint, the fan will energize. When the temperature drops 5 degrees below the set point, the fan will de-energize.
    2) The Supply Fan will be equipped with networked “Smart Starters” to monitor the running status of the fan. When a drop in amperage occurs, a “Low Flow” alarm will be sent to the SCADA system.
    3) The Supply Fan will have a duct mounted smoke detector (SD-4). When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system.
        a) Upon smoke detection SCADA will shut down the HVAC units within the space.
e. Exhaust Fan EF-6555 will be interlocked with Supply Fan EF-6556. will provide secondary ventilation and be controlled by an RTD.
    1) When the SF is operating, the EF will operate. When the SF is shutdown, the EF will shut down.
    2) The Exhaust Fan will have a duct mounted smoke detector (SD-4). When the detector senses smoke, the unit will send a “smoke” alarm to the SCADA system.
        a) Upon smoke detection SCADA will shut down the HVAC units within the space.
f. Standby heating will be provided by Gas Unit Heaters GUH-6561 though - GUH-6564.
    1) Each heater shall be controlled by a manufacturer provided thermostat.
        a) The heating setpoint will be 60 degrees Fahrenheit. When the temperature drops 5 degrees below the setpoint, the heaters will energize. When the temperature rises 5 degrees below the set point, the fan will de-energize.
g. The Caustic Storage Room shall be provided with 2 RTD-type room temperature transmitters as specified in this section:
    1) The RTD shall send a signal to SCADA to provide temperature status and monitoring.
    2) When the room temperature is 65 degrees Fahrenheit or below, SCADA shall display a “Low Temperature Alarm.”
h. Caustic Building ventilation system emergency shutoff:
    1) An emergency stop button shall be located outside of the chemical area door entries as shown on the plans. Upon use, all ventilation equipment shall shut down via interlocks and an alarm shall be sent to the SCADA system.

D. PEA, PC, and PEC Area (Area 69)
    1. PEA, PC, and PEC Area Control Sequences:
        a. Rooftop Exhaust Fan (EF-6961 & MD-6961):
            1) When the PEA Aging Room thermostat calls for cooling, motorized damper MD-6961 shall open and rooftop exhaust fan EF-6961 shall be energized to run to satisfy the local space temperature. The unit operates until the room temperature is satisfied and then powers off

and MD-6961 closes. The thermostat set point shall be 85°F (adjustable).

2) Motorized damper MD-6961 shall open and rooftop exhaust fan EF-6961 shall run whenever the PEA Aging Room is occupied or when the system is enabled by an adjustable timer (Tork timer style 8601).

b. Rooftop Exhaust Fan (EF-6962 & MD-6962):
   1) When the PEC Bulk Storage Room thermostat calls for cooling, motorized damper MD-6962 shall open and rooftop exhaust fan EF-6962 shall be energized to run to satisfy the local space temperature. The unit operates until the room temperature is satisfied and then powers off and MD-6962 closes. The thermostat set point shall be 85°F (adjustable).
   2) Motorized damper MD-6962 shall open and rooftop exhaust fan EF-6962 shall run whenever the PEC Bulk Storage Room is occupied or when the system is enabled by an adjustable timer (Tork timer style 8601).

c. Unit Heater (SUH-6961 & 6962):
   1) Each hydronic unit heater operates through its own factory controller.
   2) When the factory-furnished remote-mounted thermostat calls for heat, each fan cycles on to satisfy the local space temperature. Each unit operates until the room is satisfied and then powers off. The thermostat set point shall be50°F, adjustable). An aquastat prevents each fan from running if the heating water is not available.
   3) Note: The PEA Aging Room is heated with the existing-to-remain hydronic unit heaters. Verify that all unit heaters are operational. Notify the owner and design team if they are not.

PART 3 EXECUTION

3.01 PREPARATION

A. Before installation remove dust and debris from equipment and accessories.

B. During installation and until equipment is operated, protect equipment and accessories from dust and debris.

3.02 INSTALLATION

A. Install as indicated on the Drawings, in accordance with NFPA 90A, and per the manufacturer's written instructions.

B. Coordinate installation of HVAC control systems with other trades.
   1. Prior to installation, coordinate wiring and conduit requirements with electrical subcontractor.

C. Mount remote annunciator and test station on wall near smoke detector.
   1. Devices shall be easily accessible from floor level.
   2. Label annunciator and test station.

D. Provide all electrical work to support smoke detector.
   1. Coordinate with electrical subcontractor.

E. Thermostat cable conduit installation:
   1. As specified in Sections 16050 - Common Work Results for Electrical, 16123 - 600-Volt or Less Wires and Cables, and 16130 - Conduits.

F. Sensor and control station mounting:
   1. Where not otherwise indicated, mount 5 feet above floor or walking level.
   2. Provide insulating back plates when mounting is on an exterior wall or a wall adjoining an unconditioned space.
   3. Shield outside thermostats or sensors from the sun; provide thermostats with remote bulb and compensated capillary.
   4. Install locking covers where indicated on the Drawings.

3.03 TESTING

A. Test witnessing: Witnessed.

B. Test each control component and system as part of HVAC system testing, adjusting, and balancing as specified in Section 15954 - Testing, Adjusting, and Balancing for HVAC.

END OF SECTION

SECTION 15954

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Requirements for testing air systems installed as part of this contract and existing air systems affected by the installation of new equipment.

1.02 REFERENCES

A. Associated Air Balance Council (AABC):
   1. National Standards Total System Balance.

B. National Environmental Balancing Bureau (NEBB):
   1. Procedural Standards for Testing, Adjusting, and Balancing Environmental Systems.

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   1. HVAC Systems - Testing, Adjusting, & Balancing.

D. Testing, Adjusting, and Balancing Bureau (TABB):
   1. TAB Procedural Guide.

1.03 SUBMITTALS

A. Resumes of proposed supervisor and personnel showing training and qualifications.
   1. Include courses, exams, or tests relating to HVAC testing - taken and passed.

B. Testing plan:
   1. At least 30 days prior to starting field work:
   2. Set of report forms completed with design flow values and installed equipment pressure drops, and required cubic feet per minute for air terminals.
   3. Heating, ventilating, and air conditioning system schematic similar to Figure 6-1 in SMACNA HVAC Testing, Adjusting, & Balancing.
   4. Complete list of instruments proposed to be used, organized in appropriate categories, with data sheets for each showing:
      a. Manufacturer and model number.
      b. Description and use when needed to further identify instrument.
      c. Size or capacity range.
      d. Latest calibration date.
   5. Proposed schedule for testing and balancing.

C. Report:
   1. Not more than 45 days prior to Contractor's request for final inspection, submit draft report on applicable reporting forms.

2. At least 15 days prior to Contractor's request for final inspection, submit 3 copies of final reports incorporating Engineer's comments on draft report.
3. List of instruments used and last date of calibration of each.
4. Procedures followed for testing, adjusting, and balancing.
5. Identification and succinct description of systems included in report.
6. Initial balance test results made with all dampers and air control devices in full open positions.
7. Description of final locations and sizes, including opening area and dimensioned configuration of orifices and other restrictions used to achieve final balanced flows.
8. Description of final location and opening positions of dampers, registers, louvers, and valves.
9. Schematics of systems included in report; use schematics as part of testing, adjusting, and balancing report to summarize design and final balanced flows.
10. Testing, adjusting, and balancing report forms.
11. Final field results established for system balancing including airflow, fan speeds, and fan static pressures at the fan inlet and outlet.
12. Appendices.
    a. Raw field data taken during testing.
    b. Sample calculation sheet for each type of calculation made to convert raw field data to final results.
    c. Initial air balance results with dampers and registers in full open position; include airflow at all inlets and outlet, initial fan speed and fan suction and discharge pressures.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Work of testing, adjusting, and balancing of heating, ventilation, and air conditioning systems to be by an independent testing agency and a certified member in good standing with AABC, NEBB, or TABB.

B. Field testing to be performed or directly supervised by personal who have passed a Test and Balance course or exam and is an AABC, NEBB, or TABB certified supervisor.

3.02 PREPARATION

A. Prior to start of testing, adjusting, and balancing, verify that:
    1. System installation is complete in accordance with the requirements for completed equipment installations in Section 15500 - Common Work Results for HVAC and capable of full operation.
    2. Outside conditions are within reasonable range relative to design conditions.
    3. Lighting fixtures are energized.
    4. Special equipment such as computers, laboratory equipment, and electronic equipment are in full operation.

5. Requirements for preparation for testing and balancing have been met for elements of each system which require testing.

3.03 FIELD QUALITY CONTROL

A. Test, adjust, and balance each separate complete heating, ventilating, and air conditioning systems.
   1. Include existing heating, ventilating, and air conditioning components when effected by the Work.

B. Perform testing, adjusting, and balancing cycles until airflows meet acceptance criteria.
   1. Ascertain airflow balance between overall requirements and flow in individual supply and exhaust grilles.

C. Initial testing, adjusting, and balancing:
   1. Test each system with dampers, grilles, orifices, and other variable airflow devices in their full open position; measure and report initial airflows, fan speed, and fan static pressures at fan inlet and outlet.
   2. Adjust total system flow downward or upward by adjusting fan speed until one inlet or outlet is at indicated flow and all other flows exceed indicated flows.
   3. Adjust fan speed by changing fan drives or sheaves as necessary.

D. Subsequent testing, adjusting, and balancing:
   1. Perform adjustments by adjusting dampers, louvers, or size of orifices or plates.
   2. Measure and record air volume discharged at each inlet and outlet and adjust air inlets and outlets to design air volumes within 0 to 5 percent over design rates.
   3. Adjust fan speeds and motor drives within drive limitations, for required air volume.
   4. Measure air flow and static pressures and adjust air supply and exhaust fan units to deliver at least 100 to 105 percent of the design air volume.
   5. Measure and record static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
   6. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
   7. Evaluate space and zone temperature of conditions to determine adequate performance of the systems to maintain temperatures without draft.
   8. Permanently mark final balance positions of balancing dampers.

E. Develop heating, ventilating, and air conditioning system schematics similar to Figure 6-1 in SMACNA Testing, Adjusting, and Balancing.

F. Accurately record the required data on AABC, NEBB, or TABB test and balance report forms.

G. Measure amperage draw of fan and pump motors at final balance.

H. Test primary source equipment in accordance with AABC, NEBB, or TABB procedures.
   1. Primary source equipment includes items listed in this Section not previously tested as part of this testing, adjusting, and balancing work.
   2. Complete appropriate AABC, NEBB, or TABB equipment test forms for each piece of equipment.
   3. Calculate cooling and heating capacities to show conformance with specified capacities.
   4. Adjust equipment as needed to deliver specified cooling and heating loads.
   5. Record final equipment performing characteristics and adjustment settings in the final design report.

I. Testing, adjusting, and balancing acceptance criteria:
   1. Procedures successful and complete when heating, ventilating, and air conditioning systems and components are functioning properly and system air flows are within specified tolerances of design flows.

END OF SECTION

SECTION 15956

PIPING SYSTEMS TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Test requirements for piping systems.

1.02 REFERENCES

A. National Fuel Gas Code (NFGC).

B. American Society of Mechanical Engineers (ASME):
   1. B31.1 - Power Piping.
   2. B31.3 - Process Piping.
   3. B31.8 - Gas Transmission and Distribution Piping Systems.

C. Underwriters Laboratories Inc. (UL).

1.03 TESTING REQUIREMENTS

A. General requirements:
   1. Testing requirements are stipulated in Laws and Regulations; are included in the Piping Schedule in Section 15052 - Common Work Results for General Piping; are specified in the specifications covering the various types of piping; and are specified in this Section.
   2. Requirements in Laws and Regulations supersede other requirements of Contract Documents, except where requirements of Contract Documents are more stringent, including higher test pressures, longer test times, and lower leakage allowances.
   3. Test plumbing piping in accordance with Laws and Regulations, the plumbing code, as specified in Section 01410 - Regulatory Requirements, and UL requirements.
   4. Test natural gas or digester gas piping:
      a. For less than 125 pounds per square inch gauge working pressure, test in accordance with mechanical code, as specified in Section 01410 - Regulatory Requirements, or the National Fuel Gas Code, whichever is more stringent.
      b. For 125 pounds per square inch gauge or greater working pressure, test per ASME B31.3 or ASME B31.8, whichever is more stringent.
   5. When testing with water, the specified test pressure is considered to be the pressure at the lowest point of the piping section under test.
      a. Lower test pressure as necessary (based on elevation) if testing is performed at higher point of the pipe section.

B. Furnish necessary personnel, materials, and equipment, including bulkheads, restraints, anchors, temporary connections, pumps, water, pressure gauges, and other means and facilities required to perform tests.

C. Water for testing, cleaning, and disinfecting:
   1. Water for testing, cleaning, and disinfecting will be provided as specified in Section 01500 - Temporary Facilities and Controls.

D. Pipes to be tested: Test only those portions of pipes that have been installed as part of this Contract. Test new pipe sections prior to making final connections to existing piping. Furnish and install test plugs, bulkheads, and restraints required to isolate new pipe sections. Do not use existing valves as test plug or bulkhead.

E. Unsuccessful tests:
   1. Where tests are not successful, correct defects or remove defective piping and appurtenances and install piping and appurtenances that comply with the specified requirements.
   2. Repeat testing until tests are successful.

F. Test completion: Drain and leave piping clean after successful testing.

G. Test water disposal: Dispose of testing water at the sludge lagoons in accordance with requirements of federal, state, county, and city regulations governing disposal of wastes in the location of the Project and disposal site. All requirements and costs associated with notifications and obtaining any discharge permit or approvals shall be responsibility of Contractor.

1.04 SUBMITTALS

A. Submit as specified in Section 01330 - Submittal Procedures.

B. Schedule and notification of tests:
   1. Submit a list of scheduled piping tests by noon of the working day preceding the date of the scheduled tests.
   2. Notification of readiness to test: Immediately before testing, notify Engineer in writing of readiness, not just intention, to test piping.
   3. Have personnel, materials, and equipment specified in place before submitting notification of readiness.

1.05 SEQUENCE

A. Clean piping before pressure or leak tests.

B. Test gravity piping underground, including sanitary sewers, for visible leaks before backfilling and compacting.

C. Underground pressure piping may be tested before or after backfilling when not indicated or specified otherwise.

D. Backfill and compact trench, or provide blocking that prevents pipe movement before testing underground piping with a maximum leakage allowance.

E. Test underground piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:
   1. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
   2. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:
   1. Pull a mandrel through the clean piping section under test.
   2. Perform the test not sooner than 30 days after installation and not later than 60 days after installation.
   3. Use a 9-rod mandrel with a contact length of not less than the nominal diameter of the pipe within 1 percent plus or minus.
   4. Consider test complete when the mandrel can be pulled through the piping with reasonable effort by 1 person, without the aid of mechanical equipment.

3.02 AIR TESTING METHOD FOR PRESSURE PIPING

A. Air test piping, indicated with "AM" in the Piping Schedule, with air or another nonflammable or inert gas.

B. Test gas, air, liquefied petroleum gas, liquid chlorine, and chlorine gas piping by the air test method:
   1. Test chlorine piping with dry air or nitrogen having a dew point of minus 40 degrees Fahrenheit or less. Supply temporary air dryers as necessary.

C. Test at pressure as specified in Piping Schedule in Section 15052 - Common Work Results for General Piping:
   1. Provide temporary pressure relief valve for piping under test:
      a. Set at the lesser of 110 percent of the test pressure or 50 pounds per square inch gauge over the test pressure.
   2. Air method test pressures shall not exceed 110 percent of the piping maximum allowable working pressure calculated in accordance with the most stringent of ASME B31.1, ASME B31.3, ASME B31.8, or the pipe manufacturer's stated maximum working pressure.
   3. Gradually increase test pressure to an initial test pressure equal to the lesser of 1/2 the test pressure or 25 pounds per square inch gauge.
   4. Perform initial check of joints and fittings for leakage.
   5. Gradually increase test pressure in steps no larger than the initial pressure. Check for leakage; at each step increase until test pressure reached.

6. At each step in the pressure, examine and test piping being air tested for leaks with soap solution.
7. Consider examination complete when piping section under test holds the test pressure for 15 minutes without losses.

3.03 TESTING GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with "GR" in the Piping Schedule, as follows:
   1. Unless specified otherwise, subject gravity flow piping to the following tests:
      a. Alignment and grade.
      b. For plastic piping test for deflection.
      c. Visible leaks and pressure with maximum leakage allowance, except for storm drains and culverts.
   2. Inspect piping for visible leaks before backfilling.
   3. Provide temporary restraints when needed to prevent movement of piping.
   4. Pressure test piping with maximum leakage allowance after backfilling.
   5. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under a slight head for the water at least 24 hours:
      a. Examine piping for visible leaks. Consider examination complete when no visible leaks are observed.
      b. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
      c. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:
         1) Consider the test complete when leakage is equal to or less than the following maximum leakage allowances:
            a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test:
               (1) Advise manufacturer of concrete piping with rubber gasket joints of more stringent than normal maximum leakage allowance.
            b) For vitrified clay piping: 500 gallons per day per inch of diameter per mile of piping under test.
            c) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

3.04 TESTING HIGH-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure in the Piping Schedule is 20 pounds per square inch gauge or greater, by the high head pressure test method, indicated "HH" in the Piping Schedule.

B. General:
   1. Test connections, hydrants, valves, blowoffs, and closure pieces with the piping.

2. Do not use installed valves for shutoff when the specified test pressure exceeds the valve's maximum allowable seat differential pressure. Provide blinds or other means to isolate test sections.
3. Do not include valves, equipment, or piping specialties in test sections if test pressure exceeds the valve, equipment, or piping specialty safe test pressure allowed by the item's manufacturer.
4. During the performance of the tests, test pressure shall not vary more than plus or minus 5 pounds per square inch gauge with respect to the specified test pressure.
5. Select the limits of testing to sections of piping. Select sections that have the same piping material and test pressure.
6. When test results indicate failure of selected sections, limit tests to piping:
    a. Between valves.
    b. Between a valve and the end of the piping.
    c. Less than 500 feet long.
7. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Testing procedures:
1. Fill piping section under test slowly with water while venting air:
    a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
2. Before pressurizing for the tests, retain water in piping under slight pressure for a water absorption period of minimum 24 hours.
3. Raise pressure to the specified test pressure and inspect piping visually for leaks:
    a. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
1. Leakage allowance is zero for piping systems using flanged, National Pipe Thread threaded and welded joints.
2. Pressure test piping after completion of visible leaks test.
3. For piping systems using joint designs other than flanged, threaded, or welded joints, accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
    a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage and no damage to piping and appurtenances has occurred.
    b. Successful completion of the pressure test with maximum leakage allowance shall be achieved when the observed leakage during the test period is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.
    c. When leakage is allowed, calculate the allowable leakage by the following formula:

        $L = S \times D \times P^{1/2} \times 148{,}000^{-1}$

        wherein the terms shall mean:

        L = Allowable leakage in gallons per hour.

S = Length of the test section in feet.

D = Nominal diameter of the piping in inches.

P = Average observed test pressure in pounds per square inches gauge, at the lowest point of the test section, corrected for elevation of the pressure gauge.

x = The multiplication symbol.

3.05 TESTING LOW-HEAD PRESSURE PIPING

A. Test piping for which the specified test pressure is less than 20 pounds per square inch gauge, by the low head pressure test method, indicated "LH" in the Piping Schedule.

B. General:
   1. Test pressures shall be as scheduled in Section 15052 - Common Work Results for General Piping.
   2. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
   3. Test connections, blowoffs, vents, closure pieces, and joints into structures, including existing bell rings and other appurtenances, with the piping.
   4. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible leaks test:
   1. Subject piping under test to specified pressure measured at the lowest end.
   2. Fill piping section under test slowly with water while venting air:
      a. Use potable water for all potable waterlines and where noted on the Piping Schedule.
   3. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
   4. Raise pressure to the specified test pressure and inspect piping visually for leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:
   1. Pressure test piping after completion of visible leaks test.
   2. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
      a. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test after 24 hours, and no damage to piping and appurtenances has occurred.
      b. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtenances has occurred.

E. Optional joint test:
   1. When joint testing is allowed by note in the Piping Schedule, the procedure shall be as follows:
      a. Joint testing will be allowed only for low head pressure piping.
      b. Joint testing does not replace and is not in lieu of any testing of the piping system or trust restraints.
   2. Joint testing may be performed with water or air.
   3. Joint test piping after completion of backfill and compaction to the top of the trench.
   4. Joint testing with water:
      a. Measure test pressure at the invert of the pipe. Apply pressure of 4 feet plus the inside diameter of the pipe in water column within 0.20 feet in water column.
      b. Maintain test pressure for 1 minute.
      c. Base the allowable leakage per joint on 80 gallons per inch nominal diameter, per mile of piping, per 24 hours equally distributed to the actual number of joints per mile for the type of piping.
      d. Consider the pressure test to be complete when makeup water added is less than the allowable leakage.
      e. Successful completion of the joint test with water shall have been achieved when the observed leakage is equal or less than the allowable leakage.
   5. Joint testing with air:
      a. Apply test pressure of 3 pounds per square inch gauge with a maximum variation of plus 0.20 and minus 0.00 pounds per square inch.
      b. Maintain test pressure for 2 minutes.
      c. Consider the pressure test to be complete when the test pressure does not drop below 2.7 pounds per square inch for the duration of the test.

END OF SECTION

SECTION 15958

MECHANICAL EQUIPMENT TESTING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Testing of mechanical equipment and systems.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. S1.4 Specification for Sound Level Meters.

B. Hydraulic Institute (HI).

C. National Institute of Standards and Technology (NIST).

1.03 SUBMITTALS

A. Provide Source Test Plans as specified in Section 01756 - Commissioning.

B. Provide Installation and Functional Testing Plans as specified in Section 01756 - Commissioning.

C. Provide vendor operation and maintenance manual as specified in Section 01782 - Operation and Maintenance Manuals.
   1. Include motor rotor bar pass frequencies for motors larger than 500 horsepower.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Commissioning of equipment as specified in:
   1. This Section.
   2. Section 01756 - Commissioning.
   3. Equipment sections:
      a. If testing requirements are not specified, provide Level 1 Tests.

B. Test and prepare piping as specified in Section 15956 - Piping Systems Testing.

C. Operation of related existing equipment:
   1. Owner will operate related existing equipment or facilities necessary to accomplish the testing.

2. Schedule and coordinate testing as required by Section 01756 - Commissioning.

D. Provide necessary test instrumentation that has been calibrated within 1 year from date of test to recognized test standards traceable to the NIST or approved source.
   1. Properly calibrated field instrumentation permanently installed as a part of the Work may be utilized for tests.
   2. Prior to testing, provide signed and dated certificates of calibration for test instrumentation and equipment.

E. Test measurement and result accuracy:
   1. Use test instruments with accuracies as recommended in the appropriate referenced standards. When no accuracy is recommended in the referenced standard, use 1 percent or better accuracy test instruments.
      a. Improved (lower error tolerance) accuracies specified elsewhere prevail over this general requirement.
   2. Do not adjust results of tests for instrumentation accuracy.
      a. Measured values and values directly calculated from measured values shall be the basis for comparing actual equipment performance to specified requirements.

3.02 VARIABLE SPEED EQUIPMENT TESTS

A. Establish performance over the entire speed range and at the average operating condition.

B. Establish performance curves for the following speeds:
   1. The speed corresponding to the rated maximum capacity.
   2. The speed corresponding to the minimum capacity.
   3. The speed corresponding to the average operating conditions.

3.03 PUMP TESTS, ALL LEVELS OF TESTING

A. Test in accordance with the following:
   1. Applicable HI Standards.
   2. This Section.
   3. Equipment sections.

B. Test tolerances: In accordance with appropriate HI Standards, except the following modified tolerances apply:
   1. From 0 to plus 5 percent of head at the rated design point flow.
   2. From 0 to plus 5 percent of flow at the rated design point head.
   3. No tolerance for head and flow when ranges are specified.
   4. No negative tolerance for the efficiency at the rated design point, and other specified conditions.
   5. Use of specified test tolerances shall not result in motor overload while operating at any point on the supplied pump operating head-flow curve, including runout.
   6. No positive tolerance for vibration limits. Vibration limits and test methods in HI Standards do not apply, use limits and methods specified in this or other Sections of the Specifications.

3.04 DRIVERS TESTS

A. Test motors as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.

B. Test other drivers as specified in the equipment section.

3.05 NOISE REQUIREMENTS AND CONTROL

A. Perform noise tests in conjunction with vibration test analysis.

B. Make measurements in relation to reference pressure of 0.0002 microbar.

C. Make measurements of emitted noise levels on sound level meter meeting or exceeding ANSI S1.4, Type II.

D. Set sound level meter to slow response.

E. Unless otherwise specified, maximum free field noise level not to exceed 85 dBA measured as sound pressure level at 3 feet from the equipment.

3.06 PRESSURE TESTING

A. Hydrostatically pressure test pressure containing parts at the appropriate standard or code required level above the equipment component specified design pressure or operating pressure, whichever is higher.

3.07 INSPECTION AND BALANCING

A. Statically and dynamically balance each of the individual rotating parts as required to achieve the required field vibration limits.

B. Statically and dynamically balance the completed equipment rotating assembly and drive shaft components.

C. Furnish copies of material and component inspection reports including balancing reports for equipment system components and for the completed rotating assembly.

D. Critical speed of rotating equipment:
   1. Satisfy the following:
      a. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered rigid such as horizontal pumps, all non-clog pumps, blowers, air compressors, and engines shall be at least 25 percent above the equipment's maximum operating speed.
      b. The first lateral and torsional critical speed of all constant, variable, and 2-speed driven equipment that is considered flexible or flexibly mounted such as vertical pumps (vertical in-line and vertical non-clog pumps excluded) and fans shall at least 25 percent below the equipment's lowest operating speed.

c. The second lateral and torsional critical speed of all constant, variable, and 2-speed equipment that is considered flexible or flexibly mounted shall be at least 25 percent above the maximum operating speed.

E. Vibration tests:
   1. Definitions:
      a. Root mean square: for pumps operating at speeds greater than 600 rpm, the vibration measurement shall be measured as the overall velocity in inches per second root mean square (RMS).
      b. Peak-to-peak displacement: The root means squared average of the peak-to-peak displacement multiplied by the square root of 2.
      c. Peak velocity: The root mean squared average of the peak velocity multiplied by the square root of 2.
      d. Peak acceleration: The root mean squared average of the peak acceleration multiplied by the square root of 2.
      e. High frequency enveloping: A process to extract very low amplitude time domain signals associated with impact or impulse events such as bearing or gear tooth defects and display them in a frequency spectrum of acceleration versus frequency.
         1) Manufacturers: One of the following or equal:
            a) Rockwell Automation, Entek Group, "Spike Energy" analysis.
            b) CSI, "PeakVue."
      f. Rotor bar pass frequency (RBF), for detecting loose rotor bars.
      g. Low speed equipment: Equipment or components of equipment rotating at less than 600 revolutions per minute.
      h. High speed equipment: Equipment and equipment components operating at or above 600 revolutions per minute.
      i. Preferred operating range: Manufacturer’s defined preferred operating range (POR) for the equipment.
      j. Allowable operating range: Manufacturer’s defined allowable operating range (AOR) for the equipment.
   2. Vibration instrumentation requirements:
      a. Analyzers: Use digital type analyzers or data collectors with anti-aliasing filter, 12-bit A/D converter, fast fourier transform circuitry, phase measurement capability, time wave form data storage, high-frequency enveloping capabilities, 35 frequency ranges from 21 to 1,500,000 cycles per minute, adjustable fast fourier transform resolution from 400 to 6,400 lines, storage for up to one hundred 3,200 line frequency spectra, data output port, circuitry for integration of acceleration data to velocity or double integration to displacement.
         1) Manufacturers: One of the following or equal:
            a) Computational Systems Inc., (CSI) Division of Emerson Process Management, Model 2120A, Data Collector/analyzer with applicable analysis software.
            b) Pruftechnik, VIBXPERT II.
      b. Analyzer settings:
         1) Units: English, inches/second, mils, and gravitational forces.
         2) Fast fourier transform lines: Most equipment 1,600 minimum; for motors, enough lines as required to distinguish motor current frequencies from rotational frequencies, use 3,200 lines for motors with a nominal speed of 3,600 revolutions per minute; 3,200 lines

minimum for High Frequency Enveloping; 1,600 lines minimum for low speed equipment.
3) Sample averages: 4 minimum.
4) Maximum frequency (Fmax): 40 times rotational frequency for rolling element bearings, 10 times rotational frequency for sleeve bearings.
5) Amplitude range: Auto select but full scale not more than twice the acceptance criteria or the highest peak, whichever is lower.
6) Fast fourier transform windowing: Hanning Window.
7) High pass filter: Minus 3 dB at 120 cycles per minute for high speed equipment. Minus 3 dB at 21 cycles per minute for low speed equipment.

c. Accelerometers:
1) For low speed equipment: Low frequency, shear mode accelerometer, 500 millivolts per gravitational force sensitivity, 10 gravitational force range, plus/minus 5 percent frequency response from 0.5 hertz to 850 hertz, magnetic mount.
a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 797L.
(2) PCB, Model 393C.
2) For high speed equipment: General purpose accelerometer, 100 millivolts per gravitational force sensitivity, 50 gravitational force range, plus/minus 3dB frequency response range from 2 hertz to 12,000 hertz when stud mounted, with magnetic mount holder.
a) Manufacturers: One of the following or equal:
(1) Wilcoxon Research, Model 793.
(2) Entek-IRD Model 943.

3. Accelerometer mounting:
a. Use magnetic mounting or stud mounting.
b. Mount on bearing housing in location with best available direct path to bearing and shaft vibration.
c. Remove paint and mount transducer on flat metal surface or epoxy mount for High Frequency Enveloping measurements.

4. Vibration acceptance criteria:
a. Testing of rotating mechanical equipment: Tests are to be performed by an experienced, factory trained, and independent authorized vibration analysis expert.
b. Vibration displacement limits: Unless otherwise specified, equipment operating at speeds 600 revolutions per minute or less is not to exhibit unfiltered readings in excess of following:

Operating Conditions and Application Data	Overall Peak-to-Peak Displacement	
	Field, mils	Factory, mils
Operation within the POR	3.0	4.0
Operation within the AOR	4.0	5.0
Additive value when measurement location is greater than 5 feet above foundation.	2.0	2.0
Additive value for solids-handling pumps	2.0	N/A
Additive value for slurry pumps	2.0	N/A

c. Vibration velocity limits: Unless otherwise specified, equipment operating at speeds greater than 600 revolutions per minute is not to exceed the following peak velocity limits:

HI Pump Type	Horsepower	Field Test	Factory Test
		Overall RMS	Overall RMS
Horizontal Solids Handling Centrifugal Pumps	Below 33 hp	0.25	0.28
Horizontal and Vertical In-Line Centrifugal Pumps (other than Non-Clog type)	Between 33 and 100 hp	0.28	0.31
	100 hp and above	0.31	0.34
Vertical Solids Handling Centrifugal Pumps	Below 33 hp	0.30	0.33
Vertical Turbine, Mixed Flow, and Propeller Pumps (solids-handling type pumps)	Between 33 and 100 hp	0.32	0.35
	100 hp and above	0.34	0.35
Non-Solids Handling Centrifugal Pumps HI Types BB1, BB2, BB3, BB4, BB5, OH1, OH2, OH3, OH4, OH5, and OH7	Below 268 hp	0.15	0.19
	268 hp and above	0.19	0.22
Vertical Turbine, Mixed Flow, and Propeller Pumps HI Types VS1, VS2, VS3, VS4, VS5, VS6, VS7, and VS8	Below 268 hp	0.13	
	268 hp and above	0.17	
Slurry Pumps		0.25	0.30
Motors		See Applicable Motor Specification	See Applicable Motor Specification
Gear Reducers, Radial		Not to exceed AGMA 6000-B96 limits	Not to exceed AGMA 6000-B96 limits
Other Reducers, Axial		0.1	N/A

d. Equipment operation: Measurements are to be obtained with equipment installed and operating within capacity ranges specified and without duplicate equipment running.

e. Additional criteria:

1) No narrow band spectral vibration amplitude components, whether sub-rotational, higher harmonic, or synchronous multiple of running speed, are to exceed 40 percent of synchronous vibration amplitude component without manufacturer's detailed verification of origin and ultimate effect of such excitation.

2) The presence of discernable vibration amplitude peaks in Test Level 2 or 3 vibration spectra at bearing inner or outer race frequencies shall be cause for rejection of the equipment.
3) For motors, the following shall be cause for rejection:
    a) Stator eccentricity evidenced by a spectral peak at 2 times electrical line frequency that is more than 40 percent of the peak at rotational frequency.
    b) Rotor eccentricity evidenced by a spectral peak at 2 times electrical line frequency with spectra side bands at the pole pass frequency around the 2 times line frequency peak.
    c) Other rotor problems evidenced by pole pass frequency side bands around operating speed harmonic peaks or 2 times line frequency side bands around rotor bar pass frequency or around 2 times the rotor bar pass frequency.
    d) Phasing problems evidenced by 1/3 line frequency side band spectral peaks around the 2 times electrical line frequency peak.
4) The presence of peaks in a High Frequency Enveloping spectra plot corresponding to bearing, gear or motor rotor bar frequencies or harmonics of these frequencies shall be cause for rejection of the equipment; since inadequate lubrication of some equipment may be a cause of these peaks, lubrication shall be checked, corrected as necessary and the high frequency envelope analysis repeated.

5. Vibration testing results presentation:
    a. Provide equipment drawing with location and orientation of measurement points indicated.
    b. For each vibration measurement take and include appropriate data on equipment operating conditions at the time vibration data is taken; for pumps, compressors, and blowers record suction pressure, discharge pressure, and flow.
    c. When Vibration Spectra Data required:
        1) Plot peak vibration velocity versus frequency in cycles per minute.
        2) Label plots showing actual shaft or part rotation frequency, bearing inner and outer race ball pass frequencies, gear mesh frequencies and relevant equipment excitation frequencies on the plot; label probable cause of vibration peaks whether in excess of specification limits or not.
        3) Label plots with equipment identification and operating conditions such as tag number, capacity, pressure, driver horsepower, and point of vibration measurement.
        4) Plot motor spectra on a log amplitude scale versus frequency.
    d. For low speed equipment, plot peak vibration displacement versus frequency as well as velocity versus frequency.
    e. Provide name of manufacturer and model number of the vibration instrumentation used, including analyzer and accelerometer used together with mounting type.

3.08 TESTING LEVELS

A. Level 1 Tests:
   1. Level 1 Performance Test:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for 15 minutes minimum after components reach normal operating temperatures.
         2) Operate at rated design load conditions.
         3) Confirm that equipment is properly assembled.
         4) Confirm the equipment moves or rotates in the proper direction.
         5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
         6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
      b. Pumps:
         1) Comply with general performance test requirements as specified in this Section.
         2) Measure flow and head while operating at or near the rated condition; for factory testing, testing may be at reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
            a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower or the applicable equipment section.
            b) Use actual driver for field tests.
         3) Record measured flow, suction pressure, discharge pressure, and make observations on bearing temperatures and noise levels.
   2. Level 1 Vibration Test:
      a. Test requirement:
         1) Measure filtered vibration spectra versus frequency in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component.
         2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.
      b. Equipment operating condition: Test at specified maximum speed.
   3. Level 1 Noise Test:
      a. Measure unfiltered overall A-weighted sound pressure level in dBA at 3 feet horizontally from the surface of the equipment and at a mid-point of the equipment height.

B. Level 2 Tests:
   1. Level 2 Performance Test:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for at least 2 hours after components reach normal operating temperatures.
         2) Operate at rated design load conditions.

3) Confirm that equipment is properly assembled.
4) Confirm the equipment moves or rotates in the proper direction.
5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.

b. Pumps:
1) Comply with general performance test requirements as specified in this Section.
2) Test 2 hours minimum for flow and head at the rated condition; for factory testing, testing may be at a reduced speeds with flow and head corresponding to the rated condition when adjusted for speed using the appropriate affinity laws.
a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
b) Use actual driver for field tests.
3) Test for flow and head at 2 additional conditions; 1 at 25 percent below the rated flow and 1 at 10 percent above the rated flow.
4) Record measured flow, suction pressure, discharge pressure, and observations on bearing temperatures and noise levels at each condition.

2. Level 2 Vibration Test:
a. Test requirement:
1) Measure filtered vibration spectra versus frequency and measure vibration phase in 3 perpendicular planes at each normally accessible bearing housing on the driven equipment, any gears and on the driver; 1 plane of measurement to be parallel to the axis of rotation of the component; measure actual rotational speeds for each vibration spectra measured using photometric or other tachometer input connected directly to the vibration data collector.
2) Vibration spectra versus frequency shall be in accordance with Vibration Acceptance Criteria.

b. Equipment operating condition: Repeat test requirements at design specified maximum speed and at minimum speed for variable speed equipment.

c. Natural frequency test of field installed equipment:
1) Excite the installed equipment and support system in 3 perpendicular planes, use same planes as operating vibration measurement planes, and determine the as-installed natural resonant frequency of the driven equipment, the driver, gears, and supports.
2) Perform test at each bearing housing, at each support pedestal, and for pumps on the suction and discharge piping.
3) Perform with equipment and attached piping full of intended service or process fluid.

3. Level 2 Noise Test:
a. Measure filtered A-weighted overall sound pressure level in dBA for each of 8 octave band mid-points beginning at 63 hertz measured at 3 feet

horizontally from the surface of the equipment at mid-point height of the noise source.

C. Level 3 Tests:
   1. Level 3 Performance Tests:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for at least 4 hours after components reach normal operating temperatures.
         2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
         3) Confirm that equipment is properly assembled.
         4) Confirm the equipment moves or rotates in the proper direction.
         5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
         6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
         7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure, and temperature readings using appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.
         8) Bearing temperatures: During maximum speed or capacity performance testing, measure and record the exterior surface temperature of each bearing versus time.
      b. Pumps:
         1) Comply with general performance test requirements as specified in this Section.
         2) Test 4 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test at full speed.
            a) Use of a test driver is permitted for factory tests when actual driver is given a separate test at its point of manufacture as specified in Section 16222 - Low Voltage Motors up to 500 Horsepower.
            b) Use actual driver for field tests.
         3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 15 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.
         4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices are not required by the equipment section) and record observations on noise levels.
         5) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment

section in accordance with the appropriate HI standard and as follows:

a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.
b) Perform efficiency testing with test fluids at maximum rated speed.
c) Perform priming time testing with test fluids at maximum rated speed.

2. Level 3 Vibration Test:
   a. Requirements: Same as Level 2 vibration test except data taken at each operating condition tested and with additional requirements below.
   b. Perform High Frequency Enveloping Analysis for gears and bearings.
      1) Measure bearing element vibration directly on each bearing cap in a location close as possible to the bearing load zone that provides a smooth surface and direct path to the bearing to detect bearing defects.
      2) Report results in units of acceleration versus frequency in cycles per minute.
   c. Perform Time Wave Form analysis for gears, low speed equipment and reciprocating equipment; plot true peak amplitude velocity and displacement versus time and label the period between peaks with the likely cause of the periodic peaks (relate the period to a cause).
   d. Plot vibration spectra on 3 different plots; peak displacement versus frequency, peak acceleration versus frequency and peak velocity versus frequency.
3. Level 3 Noise Test: Measure filtered, un-weighted overall sound pressure level in dB at 3 feet horizontally from the surface of the equipment at mid-point height and at 4 locations approximately 90 degrees apart in plain view; report results for each of 8 octave band mid-points beginning at 63 hertz.

D. Level 4 Tests:
   1. Level 4 Performance Test:
      a. General:
         1) For equipment, operate, rotate, or otherwise functionally test for at least 8 hours after components reach normal operating temperatures.
         2) Operate at rated design load conditions for 1/2 the specified time; operate at each of any other specified conditions for a proportionate share of the remaining test time.
         3) Confirm that equipment is properly assembled.
         4) Confirm the equipment moves or rotates in the proper direction.
         5) Confirm shafting, drive elements, and bearings are installed and lubricated in accordance with proper tolerances.
         6) Confirm that no unusual power consumption, lubrication temperatures, bearing temperatures, or other conditions are observed.
         7) Take appropriate capacity, power or fuel consumption, torque, revolutions per minute, pressure and temperature readings, using

appropriate test instrumentation to confirm equipment meets specified performance requirements at the design rated condition.

8) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

b. Pumps:

1) Comply with general performance test requirements as specified in this Section.

2) Test 8 hours minimum for flow and head; begin tests at or near the rated condition; for factory and field-testing, test with furnished motor at full speed.

3) Test each specified flow and head condition at the rated speed and test at minimum as well as maximum specified speeds; operate at each test condition for a minimum of 20 minutes or longer as necessary to measure required performance, vibration, and noise data at each test condition.

4) Record measured shaft revolutions per minute, flow, suction pressure, discharge pressure; record measured bearing temperatures (bearing housing exterior surface temperatures may be recorded when bearing temperature devices not required by the equipment section) and record observations on noise levels.

5) Bearing temperatures: During maximum speed or capacity testing, measure and record the exterior surface temperature of each bearing versus time.

6) Perform efficiency and/or Net Positive Suction Head Required (NPSHr) and/or priming time tests when specified in the equipment section in accordance with the appropriate HI standard and as follows:

a) Perform NPSHr testing at maximum rated design speed, head and flow with test fluids at ambient conditions; at maximum rated speed, test at 15 percent above rated design flow, and 25 percent below rated design flow.

b) Perform efficiency testing with test fluids at maximum rated speed.

c) Perform priming time testing with test fluids at maximum rated speed.

2. Level 4 Vibration Test: Same as Level 3 vibration test.

3. Level 4 Noise Test: Same as Level 3 Noise Test except with data taken at each operating condition tested.

END OF SECTION

SECTION 16050

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Contract Drawings:
   1. Schematic diagrams:
      a. Controls are shown as de-energized.
      b. Add relays, where required, provide necessary contacts for the control system or where needed to function as interposing relays for control voltage coordination, equipment coordination, or control system voltage drop considerations.
      c. Mount devices shown on motor controller schematic diagrams in the controller compartment enclosure, unless otherwise noted.
   2. Plan drawings:
      a. Electrical drawings show desired locations, arrangements, and components of the electrical Work in a diagrammatic manner.
      b. Locations and sizes of equipment are approximate only.
   3. Installation details:
      a. Contract Drawings include typical installation details the Contractor is to use to complete the electrical Work. For cases where a typical detail does not apply, develop installation details that may be necessary for completing the Work, and submit these details for review by the Engineer.
      b. Not all typical installation details are referenced within the drawing set. Apply and use typical details where appropriate.

B. Section includes:
   1. Requirements for electrical:
      a. Basic design and performance criteria.
      b. Prescriptive requirements for common components.
      c. Installation.

1.02 REFERENCES

A. Abbreviations:
   1. FAT: Factory acceptance test that is also referred to as source test.
   2. ICSC: Instrumentation and controls subcontractor.
   3. PCIS: Process control and instrumentation system.

B. Standards:
   1. American National Standards Institute (ANSI).
   2. National Electrical Manufacturers Association (NEMA):
      a. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).
   3. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. LCP: Local control panel: Operator interface panel that may contain pilot type control devices, operator interface devices, control relays, etc., and does not contain a PLC or RIO.
   2. PCM: Process control module: An enclosure containing any of the following devices: PLC, RTU, or RIO.
   3. Space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device but is capable of accepting a device with no modifications to the equipment.
      a. Furnish hardware to accommodate the installation of future circuit breakers, instruments, relays, and controls.
      b. Wire relay and circuit breaker control power and network connections to the compartment and provide terminations.
      c. Space for future devices shall include:
         1) All necessary bus.
         2) Device supports and mounting equipment.
         3) Device connections to bus work.
         4) Wire troughs or raceway space.
   4. Spare: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that physically contains a device with no load connections to be made.
   5. Unequipped space: Portion of a switchgear, motor control center, panelboard, switchboard, or control panel that does not physically contain a device, standoff, bus, hardware, or other equipment.
   6. Vendor control panel (VCP): Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.

1.04 DELEGATED DESIGN

A. Requirements for Delegated Design are specified in the Technical Sections.

1.05 SUBMITTALS (NOT USED)

1.06 QUALITY ASSURANCE

A. General:
   1. Furnish equipment listed by and bearing the label of UL or of an independent testing laboratory acceptable to the Engineer and the Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Shipping precautions:
   1. After completion of shop assembly and successful factory testing, pack equipment in protective crates, and enclose in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture.

2. Place dehumidifiers, when required, inside the polyethylene coverings.
3. Skid-mount the equipment for final transport.
4. Provide lifting rings for moving without removing protective covering.
5. Display boxed weight on shipping tags together with instructions for unloading, transporting, storing, and handling at the job site.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Loop drawings:
      a. Provide electrical information required in the preparation of loop drawings, including, but not limited to:
         1) Conduit numbers and associated signal(s) contained within each conduit.
         2) Wire numbers.
         3) Equipment terminal numbers.
         4) Junction boxes and signal(s) contained within each junction box.
         5) Equipment power sources, and associated circuit numbers.
         6) As-built drawings detailing wiring.
   2. Roof penetrations:
      a. Show roof penetrations for electrical equipment and conduit on the roof drawing Submittal and include equipment information:
         1) Type.
         2) Size.
         3) Location.
         4) Configuration of individual penetrations or large penetrations for multiple conduits.
         5) Weight.
         6) Anchoring and support details.

B. Meetings:
   1. As specified in Section 01312 - Project Meetings.

C. Sequencing and scheduling:
   1. Equipment anchoring: Project construction schedule must include an event for obtaining the anchor layout drawings from equipment manufacturers in adequate time for templates to be constructed and anchors to be cast-in-place.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide field wiring and terminations.

B. Equipment mounting and anchoring:
   1. Design equipment anchorage, supports, and connections for dead load, running loads, loads during start-up, seismic load specified in Section 01850 - Design Criteria, and other loads as required for proper operation of equipment.
      a. For equipment with an operating weight of 400 pounds or greater and equipment that is supported higher than 4 feet above the floor, provide calculations for:
         1) Operating weight and location of the centroid of mass for the equipment.
         2) Forces and overturning moments.
         3) Shear and tension forces in equipment anchorages, supports, and connections.
         4) Design of equipment anchorage, supports, and connections based on calculated shear and tension forces.
   2. Anchorage of equipment to concrete or masonry:
      a. Perform calculations and determine number, size, type, strength, and location of anchor bolts or other connections.
      b. Unless otherwise indicated on the Drawings, select and provide anchors from the types specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
      c. Provide bolt sleeves around cast-in anchor bolts for 400 pounds or greater equipment.
         1) Adjust bolts to final location and secure the sleeve.
   3. Anchorage of equipment to metal supports:
      a. Perform calculations and determine number, size, type, strength, and location of bolts used to connect equipment to metal supports.

2.03 MANUFACTURERS (NOT USED)

2.04 MATERIALS

A. Enclosures:
   1. Provide enclosures for electrical, instrumentation, and control equipment, regardless of Supplier or Subcontractor furnishing the equipment, that meet the requirements of NEMA Standard 250.
      a. Provide metallic enclosures unless specifically indicated otherwise.

B. Stainless steel:
   1. Where stainless steel is indicated or used for any portion of the electrical Work, provide a non-magnetic, corrosion-resistant alloy, ANSI Type 316, satin finish.
   2. Provide exposed screws of the same alloys.
   3. Use stainless steel hardware, when chemically compatible, in all chemical areas or areas requiring NEMA Type 4X construction.

4. Do not use stainless steel in any area containing chlorine, gas or solution, chlorine products or ferric chloride.

C. Plant area electrical Work requirements:
   1. Provide electrical materials in accordance with the following table, unless otherwise specifically indicated on the Drawings:
      a. Conduit installation requirements: As specified in Section 16130 - Conduits.

Table 1. Electrical Material Requirements

Plant Area	Environment: W = Wet D = Damp C = Clean/dry X = Corrosive H = Hazardous	NEMA Enclosure Type	Exposed Conduit Type (as specified in Section 16130 - Conduits)	Support Materials
Caustic Soda Building (Area 65)	W, X	4X SST	PCS	SST
Chlorine Building (Area 63)	D, X	4X Non-metallic	PCS	Fiberglass
Electrical Rooms	C	1, 12	GRC	GALV STL
PEA, PC, PEC Room (Areas 62, 69, 71)	W	4 SST	GRC	GALV STL
PAC Control Building (Area 68)	C	1, 12	GRC	GALV STL
PAC Silo Equipment Room (Area 68)	W H: Class II, Div. 1 (As defined by PAC system supplier)	4X SST, 9	PCS	SST
Filters (Area 30)	W	4 SST	GRC	GALV STL
Outdoors	W	4 SST	GRC	GALV STL

Notes:
(1) Outdoor classified areas require dual rating of NEMA 4X and 7.

PART 3 EXECUTION

3.01 EXAMINATION

A. Portions of this Project involve installation in existing facilities and interfaces to existing circuits, power systems, controls, and equipment:
   1. Perform and document comprehensive and detailed field investigations of existing conditions (circuits, power systems, controls, equipment, etc.) before starting any Work.

2. Determine information necessary to document, interface with, modify, upgrade, or replace existing circuits, power systems, controls, and equipment.
3. Provide and document interface with, modifications to, upgrades, or replacement of existing circuits, power systems, controls, and equipment.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Demolition:
   1. As specified in Technical Sections or as indicated on the Drawings.
   2. Disconnect utilities:
      a. Disconnect electrical equipment.
   3. Remove and dispose of conduit, wire, electrical equipment, controls, etc., associated with the items and/or areas to be demolished as indicated on the Drawings unless otherwise indicated.
   4. Salvage electrical equipment as specified in Section 01738 - Selective Alterations and Demolition.
   5. For each piece of equipment to be removed, remove ancillary components (e.g., instruments, solenoid valves, disconnect switches, etc.).
   6. Conduit:
      a. Where conduit removal, other than associated with equipment to be removed, is indicated on the Drawings:
         1) Remove exposed conduit to the point of encasement or burial.
         2) Cut conduit flush and plug or cap encased or buried conduit.
      b. Where conduits are to remain in place and removal is not indicated on the Drawings:
         1) Cap conduit open ends.
         2) Re-label empty conduits as spare.
   7. Remove wire back to the source for conduits to be removed or abandoned in place.
   8. Provide new nameplates for modified electrical distribution equipment, motor control centers etc., to identify equipment and circuits that are no longer used as spares.
   9. Provide new typewritten schedules for modified panelboards.

B. Equipment:
   1. Where the Drawings do not show dimensions for locating equipment, install equipment in the approximate locations indicated on the Drawings.

C. Provide NEC required working space in front of electrical equipment as if it could be worked on energized.

D. Circuits of different service voltage:
   1. Voltage and service levels:
      a. Medium voltage: Greater than 1.0 kV.
      b. Low voltage:
         1) Power and controls: 120 V to 480 V.
         2) Instrumentation: Less than 50 VDC.
      c. Fiber.

2. Install different service voltage circuits in separate raceways as well as underground manholes and hand holes.
3. Install different service voltage circuits in separate junction boxes and pullboxes or provide physical dividers where boxes can be divided.

E. Conductors shall not pass through equipment they are not terminating in unless indicated on the Drawings or approved by the Engineer.

3.04 COMMISSIONING

A. General:
1. As specified in Section 01756 - Commissioning, and Technical Sections.
2. Provide onsite assistance for troubleshooting and correcting electrical issues discovered during commissioning.

3.05 FIELD QUALITY CONTROL

A. Workmanship:
1. Leave wiring in panels, manholes, boxes, and other locations neat, clean, and organized:
   a. Neatly coil and label spare wiring lengths.
   b. Shorten, re-terminate, and re-label excessively used, as well as spare, wire and cable lengths, as directed by the Engineer.

Inspection activities conducted during construction do not satisfy the inspection or testing requirements specified in Section 16950 - Field Electrical Acceptance Tests.

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. General:
1. Clean and vacuum enclosures to remove metal filings, surplus insulation and any visible dirt, dust, or other matter before energization of the equipment or system start-up:
   a. Use of compressors or air blowers for cleaning is not acceptable.
2. Clean luminaries in the areas affected by the construction.

END OF SECTION

SECTION 16052

HAZARDOUS CLASSIFIED AREA CONSTRUCTION

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Executing and completing Work in hazardous and/or classified areas as defined by the NEC, NFPA 820, and as indicated on the Drawings and specified in the Specifications.

1.02 REFERENCES

A. Definitions:
   1. For the purposes of these Specifications, the terms “Hazardous” and “Classified” will be considered synonymous.

B. Standards:
   1. National Electrical Manufacturers Association (NEMA).
   2. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
      b. 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
   3. Underwriters Laboratories (UL):
      a. 1203 - Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS (NOT USED)

1.05 QUALITY ASSURANCE

A. Regulatory requirements:
   1. Wiring in hazardous and/or classified locations shall comply with applicable articles of the NEC.
   2. Except as modified in Articles 500 through 516, all other applicable rules contained in the NEC shall apply to electric equipment and wiring installed in hazardous and/or classified locations.
   3. Devices used in Class II, Division 1 or Division 2 areas shall have visible manufacturer installed nameplates specifically stating the Class, Division, and Group for which the device is approved.
   4. PVC-coated fittings for hazardous locations shall be UL 1203 listed after the coating is applied and have a red metal tag attached to the fitting to signify compliance.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. A list of hazardous areas is specified in Section 16050 - Common Work Results for Electrical.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Conduit seals shall be filled prior to the introduction of process or gas to the equipment/area.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Conduit installation:
   1. As specified in Section 16130 - Conduits.
   2. Wrench tighten conduit joints to minimize sparking when fault current flows through the conduit system.
   3. Make conduit connections so that there are a minimum of 5 threads fully engaged in the connection.
   4. Flexible conduit:
      a. Class II, Division 1 hazardous areas:
         1) Approved and marked suitable for Class II, Division 1.
         2) Listed for compatibility with the group type atmosphere where used.
      b. Class II, Division 2 areas:
         1) Liquidtight metal conduit with approved fittings.
         2) Dusttight flexible connectors.
      c. Maximum length as specified in Section 16130 - Conduits.

B. Sealing fittings:
   1. Provide an approved seal, no more than 12 inches from the enclosure, for conduits entering an enclosure containing switches, circuit breakers, fuses, relays, resistors, or any other apparatus which may produce arcs, sparks, or high temperatures:
      a. Only dusttight proof unions, couplings, elbows, capped elbows, and conduit bodies similar to “L”, “T”, and “X” may be installed between the sealing fitting and the enclosure.
   2. Provide entire assemblies approved for Class II locations for self-sealing or factory sealed assemblies where the equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the

compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other:
    a. Seals are required in all conduit connections to the compartment containing splices and must be within 12 inches of the enclosure.
3. Install a conduit seal within 12 inches of the boundary in each conduit run entering or leaving a classified location. No union, coupling, box, or fitting is allowed in the conduit between the sealing fitting and the point at which the conduit leaves the classified location.
4. For underground conduits entering or leaving a classified location or between Class II, Division 1 and Division 2 locations:
    a. Provide a conduit seal at both points where the conduit emerges from the ground:
        1) Place the conduit seal within 18 inches of finished grade.
        2) No union, coupling, box, or fitting is allowed in the conduit system between the seal fitting and the point at which the conduit enters the ground.
5. Separate conductors within the conduit system and seal using an approved packing dam installed to both hold the sealing compound and to maintain the separation between the wires:
    a. Remove the outer jacket of multi-conductor non-shielded cables in the area of the sealing fitting and separate each conductor from the cable and seal individually.
6. Install seals with drains in electrical control stations, low points of conduit, or any place where moisture may condense and accumulate.
7. Install the sealing compound in accordance with the manufacturer's instructions.

C. Boxes and fittings:
1. Class II, Division 1 areas:
    a. Utilize threaded connections for metallic boxes, fittings, and joints to the conduit system.
2. Class II, Division 2 areas:
    a. Provide approved grounding bushings on conduits entering and exiting metallic boxes to bond the conduits together.

D. Outlet boxes and conduit bodies:
1. Suitable for the conduit system as specified in Section 16130 - Conduits.
2. Class II, Division 2 areas:
    a. Boxes not containing arcing parts:
        1) Material and NEMA ratings as specified in Section 16050 - Common Work Results for Electrical.
        2) Pressed metal boxes are not allowed.
    b. Boxes containing arcing parts:
        1) Rated for Class II, Division 1.

E. Motor connections:
1. Conduit installation in Class II, Division 1 and Class II, Division 2 locations for motors that contain arcing parts, shall be as follows:
    a. First - Conduit.
    b. Second - Dusttight flexible coupling.
    c. Third - Sealing fitting.
    d. Fourth - Dusttight union.

e. Fifth - Connection to the motor terminal box.

2. Wiring connections to motor leads shall be as specified in Section 16150 - Low Voltage Wire Connections.

F. Bond the non-current-carrying metal parts of equipment, raceways and other enclosures as required by the NEC to ensure electrical continuity.

3.04 FIELD QUALITY CONTROL

A. Obtain inspection and approval before and after each seal is poured.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Grounding materials and requirements.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. B3 - Standard Specification for Soft or Annealed Copper Wire.
   2. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

D. Underwriters Laboratories, Inc. (UL):
   1. 467 - Ground and Bonding Equipment.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.

1.05 QUALITY ASSURANCE

A. Grounding components and materials shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Ground equipment and raceway systems so that the completed installation is in accordance with applicable code requirements.

B. Provide a complete electrical grounding system as indicated on the Drawings and as specified including but not limited to:
   1. Grounding electrodes.
   2. Bonding jumpers.
   3. Ground connections.

2.03 MANUFACTURERS

A. Compression connectors: One of the following or equal:
   1. ABB.
   2. Burndy.
   3. Erico.
   4. Harger.
   5. Panduit.

B. Ground rods: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring.

C. Ground cable: One of the following or equal:
   1. Erico.
   2. Harger.
   3. Nehring.
   4. Southwire.

D. Precast ground well boxes: One of the following or equal:
   1. Brooks Products, 3-RT Valve Box.
   2. Christy Concrete Products, G12 Valve Box.

2.04 MATERIALS

A. Ground rod:
   1. Minimum: 3/4-inch diameter, 10-feet long.
   2. Uniform 10 mil covering of electrolytic copper metallically bonded to a rigid steel core:
      a. Copper-to-steel bond shall be corrosion resistant.

3. In accordance with UL 467.
4. Sectional type joined by threaded copper alloy couplings.
5. Fit the top of the rod with a threaded coupling and steel-driving stud.

B. Ground cable:
1. Requirements:
a. Soft drawn (annealed).
b. Concentric lay, coarse stranded in accordance with ASTM B8.
c. Bare copper in accordance with ASTM B3.
2. Size is as indicated on the Drawings, but not less than required by the NEC. Use the following type of wire unless otherwise indicated on the Drawings:
a. Size #6 AWG and smaller; solid conductor.
b. Size #4 AWG and larger; stranded conductor.

C. Compression connectors:
1. Manufactured of high copper alloy specifically for the particular grounding application.
2. Suitable for direct burial in earth and concrete.
3. Identifying compression die number inscription to be impressed on compression fitting.

D. Grounding electrode conductors:
1. Minimum size in accordance with the NEC.

E. Main bonding jumpers and bonding jumpers:
1. Minimum size in accordance with the NEC.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Precast ground well boxes:
1. Minimum 10-inch interior diameter.
2. Traffic-rated cast iron cover.
3. Permanent “GROUND” marking on cover.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Provide bonding jumpers and wire, grounding bushings, clamps and appurtenances required for complete grounding system to bond equipment and raceways to equipment grounding conductors.

B. Provide a separate grounding conductor for each motor and connect at motor terminal box. Do not use bolts securing motor box to frame or cover for grounding connectors:
   1. When grounding motors driven by variable frequency drives (VFD) comply with the requirements of the VFD manufacturer.

C. Provide a grounding type bushing with lug for connection of grounding conductor for conduits that originate from each motor control center section, switchboard, or panelboard:
   1. Individually bond these raceways to the ground bus in the equipment.

D. Provide grounding type bushings with lugs for connection of grounding conductor at both ends of metallic conduit runs. Bond ground bushings to the grounding system.

E. Provide a green insulated wire-grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

F. Interconnect the secondary switchgear, switchboard, or panelboard neutral bus to the ground bus in the secondary switchgear, switchboard, or panelboard compartment, only at service entrance point or after a transformer.

G. Duct bank ground system:
   1. Provide a bare copper grounding conductor the entire length of each duct bank, embedded in the concrete of the duct bank as indicated on the Drawings and specified in the Specifications.
   2. Bond duct bank ground conductors together where duct banks join, merge, intersect, or split.

H. Grounding at service (600 V or Less):
   1. Connect the neutral to ground only at one point within the enclosure of the first disconnecting means on the load side of the service transformer.

I. Ground connections:
   1. Connections to the ground grid system, the duct bank grounding system, equipment, ground rods, etc., shall be made using compression type grounding connectors as indicated on the Drawings, UL listed, and labeled for the application.
   2. Make ground connections in accordance with the manufacturer’s instructions.

3. Do not conceal or cover any ground connections until the Engineer or authorized representative has established and provided written confirmation that every grounding connection is as indicated on the Drawings and specified in the Specifications.

J. Grounding electrode system:
   1. Ground ring:
      a. Provide trenching and materials necessary to install the ground ring as indicated on the Drawings.
      b. Ground ring conductor shall be in direct contact with the earth, or where embedded, concrete, of the size as indicated on the Drawings.
      c. Minimum burial depth 36 inches or as indicated on the Drawings.
      d. Re-compact disturbed soils to original density in 6-inch lifts.
   2. Ground rods:
      a. Locations as indicated on the Drawings.
      b. Length of rods forming an individual ground array shall be equal in length.
      c. Drive ground rods and install grounding conductors before construction of concrete slabs and duct banks.
      d. Pre-crimp ground rods, as recommended by the manufacturer, before crimping connector to ground rod.

   3. Metal underground water pipe:
      a. Bond metal underground domestic water pipe to grounding electrode system.
      b. Cathodically protected systems: Bond in accordance with cathodic protection system design requirements.
   4. Metal frame of building or structure:
      a. Bond metal frame of building or structure to grounding electrode system.
   5. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.
   6. Where grounding conductors are exposed and subject to physical damage, install in Schedule 80 PVC conduit for protection.
   7. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

K. Shield grounding:
   1. Analog signal cables shields shall only be grounded at a single point in the loop. Unless otherwise noted, ground signal cable shields at control panel.
   2. For communication and data line signal cable shields and drain wires should be grounded at both ends of the cable run.
   3. Insulate the shielding and exposed drain wire for each signal cable with heat-shrink tubing.
   4. Terminate the signal cable shield on a dedicated grounding terminal block.

L. Where indicated on the Drawings, install ground rods in precast ground wells.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL

A. Ground system resistance (electrode to ground) of the completed installation, as determined by tests, shall be:
   1. 5 ohms or less for industrial systems.
   2. 1 ohm or less for electrical buildings.

B. Measure grounding electrode system resistance to ground in accordance with IEEE 81.

3.06 ADJUSTING

A. Under the direction of the Engineer, add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurement meets the specified resistance requirements:
   1. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

SECTION 16070

HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Mounting and supporting electrical equipment and components.

1.02 REFERENCES

A. American National Standards Institute (ANSI).

B. ASTM International (ASTM):
   1. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   3. A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   4. E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Anchor: Elements (including hardware) connecting hangers and supports to the structure.
   2. Hardware: Nuts, bolts, straps, clamps, threaded rod, etc.
   3. Supports: Preformed channel or other structural member on which the electrical equipment or raceway is mounted.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Supports:
      a. Materials.
      b. Geometry.

c. Manufacturer.
2. Hardware:
   a. Materials.
   b. Manufacturer.

C. Shop Drawings:
1. Dimensioned and scalable Shop Drawings of hangers and supports for distribution systems and equipment.
2. Complete details for:
   a. Member sizes and arrangement in hangers and support assemblies.
   b. Connections between members in hangers and support assemblies.
   c. Anchoring hangers and supports to structures.
   d. Bracing for hangers and supports and anchoring of bracing to structures.
3. Include data on connections, attachment hardware and construction to demonstrate that hangers and supports will satisfy the design loading, bracing, and anchoring criteria.

D. Delegated Design Submittals:
1. Hangers and supports - General:
   a. Locations and conditions:
      1) Hangers and supports inside structures.
      2) Hangers and supports that resist cable pulling/rigging loads.
   b. Required Submittals: Details with supporting calculations for:
      1) Support member arrangement, sizes, and connections.
      2) Bracing to resist cable pulling/rigging loads.
      3) Connections of hangers, supports, and bracing to the structure.
      4) Connections between supports and the equipment or raceway(s) thereon.
2. Hangers and supports - Exterior and seismic conditions:
   a. Locations and conditions:
      1) Hangers and supports at structures designated as Seismic Design Category (SDC) C, D, E, or F in Section 01850 - Design Criteria.
      2) Hangers and supports for outdoor installations.
   b. Required Submittals:
      1) Interior: Bracing to resist seismic design loads specified in Section 01850 - Design Criteria.
      2) Exterior: Bracing to resist seismic, wind, and other environmental loads specified in Section 01850 - Design Criteria.
3. Hangers and supports anchored to concrete and masonry:
   a. Locations and conditions:
      1) Post-installed mechanical anchors in tension.
      2) Post-installed adhesive-bonded all-thread rods in tension.
   b. Required Submittals:
      1) Calculations demonstrating that anchors have a demand/capacity ratio (D/C) not greater than the following when anchor capacity is adjusted for moisture conditions, anchor spacing and edge distances, and sustained loading conditions present at the location of installation.
         a) Post-installed mechanical anchors maximum: 85 percent.
         b) Post-installed adhesive-bonded anchors maximum: 75 percent.

1.06 QUALITY ASSURANCE (NOT USED)

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Mount raceways, cabinets, boxes, fixtures, instruments, and devices on Contractor-fabricated supports unless otherwise indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Hangers and supports individually and as a system shall resist weights and code-required forces without deflections and deformations that would damage the supporting elements, the raceway or equipment supported, or the surrounding construction.
   1. Provide the necessary sway bracing to keep support structures from swaying due to lateral forces including wire and cable pulling forces.
   2. Lateral deflection at top of slab mounted supports shall not exceed support height divided by 240, unless otherwise approved by the Engineer.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Preformed channel:
      a. Cooper B-line.
      b. Power-Strut.
      c. Robroy.
      d. Tyco.
      e. Unistrut.
   2. Nonmetallic cable rack:
      a. Hubbell.
      b. Underground Devices Inc.
      c. Unistrut.

2.04 MATERIALS

A. Hot dip galvanized steel:
   1. Supports:
      a. In accordance with ASTM A123 or A153.
      b. Minimum zinc coating thickness of 2.5 mils.

c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
2. Hardware:
a. Electro-galvanized.
b. In accordance with ASTM A153.

B. Stainless steel:
1. Supports:
a. In accordance with ASTM A240.
b. ANSI Type 316 material.
c. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
2. Hardware:
a. ANSI Type 316 material.

C. Fiberglass:
1. Supports:
a. Vinyl ester.
b. Nominal dimensions: 1-5/8 inch by 1-5/8 inch.
c. Flame spread rating of 25 or less in accordance with ASTM E84.
d. Tested in accordance with ASTM D635.
2. Hardware:
a. Polypropylene.
b. Thermal plastic elastomer.
c. Fiberglass reinforced plastic.

D. Non-metallic cable rack:
1. Consists of stanchions and cable support arms.
2. Stanchions:
a. 50 percent glass reinforced nylon or other non-metallic material.
b. Capable of supporting multiple arms.
c. Recessed bolt mounting holes.
d. Length as required.
3. Arms:
a. 50 percent glass reinforced nylon or other non-metallic material.
b. Size the arms based on the length and weight of the cable to be supported.
4. Stainless steel mounting hardware.

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. Fabricated metal supports: As specified in Section 05500 - Metal Fabrications.

2.08 ACCESSORIES

A. Anchors:
1. As specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.

2.09 FABRICATION (NOT USED)

2.10 FINISHES

A. Paint and finish structures as specified in Section 09960 - High-Performance Coatings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. Use materials appropriate for the area as specified in Section 16050 - Common Work Results for Electrical.

B. General:
   1. Refer to the Drawings for details. Equipment, cabinets, boxes, instruments, and devices in damp or wet locations on minimum of 7/8-inch preformed mounting channel.
   2. Mount channel vertically along the length of the device so that water or moisture may run freely behind the device.

C. Corrosion protection:
   1. Isolate dissimilar metals, except where required for electrical continuity.
      a. Use neoprene washers, 9-mil polyethylene tape, or gaskets for isolation.

D. Anchoring methods:
   1. Solid concrete:
      a. Anchor bolts, anchor rods or post-installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   2. Metal surfaces: Machine screws or bolts.
   3. Hollow masonry units:
      a. Post installed anchors as specified in Section 05190 - Mechanical Anchoring and Fastening to Concrete and Masonry.
   4. Wood and metal studs:
      a. When supporting devices on metal or wood stud construction, bridge studs with preformed channel, and mount the devices to the channel.

E. Recoat or seal drilled holes, cut or scratched surfaces or with products recommended by the manufacturer.

F. Group raceway and position on racks to minimize crossovers.

G. Non-metallic cable rack:
   1. Install the non-metallic cable rack in accordance with the manufacturer's recommendations.
   2. Provide at least 2 stanchions and 2 arms at each installation.
   3. Mount the cable rack so that the supported cable does not interfere with access to manhole or handhole and so that the supported cable does not lie on the floor.
   4. Do not exceed the cable manufacturer's minimum bending radius.
   5. Use nylon cable ties to secure the cable to the supports.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16075

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Identification of electrical equipment, devices and components.
   2. Material, manufacturing and installation requirements for identification devices.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

B. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

C. Occupational Safety and Health Administration (OSHA).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Nameplates:
      a. Color.
      b. Size:
         1) Outside dimensions.
         2) Lettering.
      c. Material.
      d. Mounting means.
   2. Nameplate schedule:
      a. Show exact wording for each nameplate.
      b. Include nameplate and letter sizes.
   3. Wire numbers:
      a. Manufacturer’s catalog data for wire labels and label printer.

C. Record documents:
   1. Update the conduit schedule to reflect the exact quantity of wire numbers including spares and destination points for all wires.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

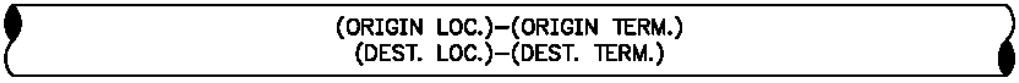
2.01 GENERAL

A. Nameplates:
   1. Provide for control panel operator devices (e.g., pushbuttons, selector switches, pilot lights, etc.):
      a. Same material and same color and appearance as the device nameplates to achieve an aesthetically consistent and coordinated system.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Nameplates:
   1. Provide for each piece of electrical equipment, device, control panel, and control panel components.
   2. Identical style, color, and material throughout the facility.
   3. Device nameplates information:
      a. Equipment tag number as indicated on the Drawings.

B. Wire numbers:
   1. Coordinate the wire numbering system with vendors of equipment so that every field wire has a unique number associated with it for the entire system:
      a. Correspond to the wire numbers on the control drawings or the panel and circuit numbers for receptacles and lighting.
      b. Correspond to the terminal block number to which they are attached in the control panel.
      c. Internal panel wires on a common terminal shall have the same wire number.
      d. Multi-conductor cables shall be assigned a cable number that shall be attached to the cable at intermediate pull boxes and stub-up locations beneath freestanding equipment. Multi-conductor and instrumentation cables shall be identified at pull points as described above:
         1) Label armored multi-conductor cable using the conduit number as indicated on the Drawings, following the requirements for conduit markers specified in Section 16130 - Conduits.
   2. Provide the following wiring numbering schemes throughout the project for field wires between process control module (PCM), vendor control panels (VCP), motor control centers (MCC), field starters, field instruments, etc.



OR:

Where:

ORIGIN LOC. = Designation for originating panel or device

ORIGIN TERM. = Terminal designation at originating panel or device

DEST. LOC. = Designation for destination panel or device

DEST. TERM. = Terminal designation at destination panel or device or PLC

3. I/O address at destination panel:
   a. Identify equipment and field instruments as the origin.
   b. PCMs are always identified as the destination.
   c. Location is the panel designation for VCP, LCP, or PCM. For connections to MCCs, location is the specific starter tag and loop number. Location is the tag and loop number for motor starters, field instruments and equipment. Any hyphen in the panel designation or tag and loop number shall be omitted.
   d. Terminal designation is the actual number on the terminal block where the conductor terminates at field devices and vendor control panels. For multi-conductor cables, all terminal numbers shall be shown, separated by commas.
   e. Terminal designations at motor leads shall be the motor manufacturer's standard terminal designation (e.g., T1, T2, T3, etc.).
   f. Terminal designations at PCMs where the field conductor connects to field terminal blocks for a PLC input or output shall be the PLC address (Note: The following PLC I/O numbering scheme is typical for Allen-Bradley. The numbering scheme should be modified to match that of the actual PLC manufacturer used for the Project):

      Discrete Point: W:X:Y/Z.

      Analog Point: W:X:Y.Z.

      Where:

      W = I for input, O for output.

      X = PLC number (1, 2, 3…)

      Y = Slot number (01, 02, 03…)

      Z = Terminal number (00, 01, 02…) for a discrete point or a word number for an analog point (1, 2, 3…)

   g. Terminal designations at PCMs where the conductor does not connect to a PLC I/O point shall be the terminal number with a "C" prefix (e.g., C0010). For common power after a fuse or neutrals after a switch, the subsequent points shall have and capital letter suffix starting with "A" (e.g., C0010A).

4. **Case 1**: Vendor control panel (VCP) to process control module (PCM):

   Field wire number/label: A-B/C-D:

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within VCP (manufacturer's or vendor's standard terminal number)

   C = Process control module number without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   Examples:

   VCP#-10/PCM#-I: 1:01/01

   VCP#-10/PCM#-O: 1:10/07

   VCP#-10/PCM#-C0100

5. **Case 2**: Field instrument to process control module (PCM):

   Field wire number/label: E-F/C-D:

   C = Process control module number without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   E = Field mounted instrument tag and loop numbers without hyphen (EDV#)

   F = Manufacturer's standard terminal number within instrument. Use both terminal numbers for analog points separated by a comma

   Examples:

   TIT#-2,3/PCM#-I: 1:01.1

   TSH#-1/PCM#-I: 2:01/00

6. **Case 3**: Motor control center (MCC) to process control module (PCM):

   Field wire number/label: G-B/C-D:

   B = Terminal number within Motor Control Center (manufacturer's or vendor's standard terminal number)

   C = Process control module without hyphen (PCM#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Examples:

   MMS#-10/PCM#-I: 1:01/01

MMS#-10/PCM#-O: 1:10/07

MMS#-10/PCM#-C0100

7. **Case 4**: Motor control center (MCC) to vendor control panel (VCP):

   Field wire number/label: G-B/A-B:

   A = Vendor control panel number without hyphen (VCP#)

   B = Terminal number within motor control center or vendor control panel (manufacturer's or vendors standard terminal number)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   Example:

   MMS#-X2/VCP#-10

8. **Case 5**: Motor leads to a motor control center (MCC):

   Field wire number/label: H-I/G-B:

   B = Terminal number within motor control center (manufacturer's standard terminal number)

   G = Actual starter designation in the motor control center without hyphen (MMS#)

   H = Equipment tag and loop number without hyphen (PMP#)

   I = Motor manufacturer's standard motor lead identification (e.g., T1, T2, T3, etc.)

   Example:

   PMP-#-T3/MMS#-T3

9. **Case 6**: Remote or separately mounted starter or variable frequency drive (VFD) to process control module (PCM):

   Field wire number/label: J-B/C-D:

   B = Terminal number within starter or variable frequency drive (manufacturer's standard terminal number)

   C = Process control module number without hyphen (VCP#)

   D = Either the PLC address if the field terminal is connected directly to a PLC input or output point or the terminal number with a "C" prefix if not connected directly to a PLC I/O point (C0010)

   J = Starter or variable frequency drive tag and loop number without hyphen (MMS#)

   Examples:

   MMS#-10/PCM#-I: 1:01/01

   MMS#-10/PCM#-O: 2: 10/07

   MMS#-10/PCM#-C0010

10. Identify spare conductors as required for other field wires with an “S” prefix:

    Example:

    S MMS#-10/PCM#-C011

2.03 MANUFACTURERS

A. Nameplates and signs:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

B. Conductor and cable markers:
   1. Heat-shrinkable tubing:
      a. One of the following or equal:
         1) Brady.
         2) Kroy.
         3) Panduit.
         4) Raychem.

C. Conduit and raceway markers:
   1. Non-metallic: One of the following or equal:
      a. Almetek: Mini Tags.
      b. Lapp Group: Maxi System.

D. Medium voltage raceway voltage labels:
   1. One of the following or equal:
      a. Brady.
      b. Seton.

2.04 MATERIALS

A. Nameplates:
   1. Colors:
      a. Warning: White-center, red face.
      b. Other: Black-center, white face.
   2. Laminated plastic engraving stock:
      a. 3/32-inch-thick material.
      b. 2-ply.
   3. With chamfered edges.
   4. Lettering:
      a. Block style engraved characters of adequate size to be read easily from a distance of 6 feet:
      b. Minimum letter height: 1/8-inch.

B. Signs:
   1. Automatic equipment and high voltage signs:
      a. Suitable for exterior use.
      b. In accordance with OSHA regulations.

C. Conductor and cable markers:
   1. Lettering:
      a. Machine printed black characters on white tubing.
      b. Minimum letter height: 10-point type or larger.

D. Conduit and raceway markers:
   1. Non-metallic:
      a. UV resistant holder and letters.
      b. Black letters on yellow background.
      c. Minimum letter height: 1/4-inch.
      d. Adhesive labels are not acceptable.

E. Medium voltage circuit raceway labels:
   1. Vinyl plastic.
   2. Minimum letter height: 1-inch.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Nameplates:
   1. Attach to equipment with rivets, bolts, or sheet metal screws, approved waterproof epoxy-based cement or install in metal holders welded to the equipment.
   2. Provide for each disconnecting means with the following:
      a. Equipment served, voltage, and fuse size as required.
      b. Identification of the circuit source that supplies the disconnecting means.
   3. On NEMA Type 4, NEMA Type 4X, or NEMA Type 7 enclosures, use epoxy-based cement to attach nameplates.
   4. Aligned and level or plumb to within 1/64 inch over the entire length:
      a. Misaligned or crooked nameplates shall be remounted or provide new enclosures at the discretion of the Engineer.

B. Conductor and cable markers:
   1. Apply before termination.
   2. Heat-shrinkable tubing:
      a. Shrunk using a heat gun that produces low temperature heated air.
      b. Tight on the wire after it has been heated.
      c. Characters shall face the open panel and shall read from left to right or top to bottom.
      d. Marker shall start within 1/32 inch of the end of the stripped insulation point.

C. Conduit markers:
   1. Furnish and install markers for every conduit in the electrical system that is identified in the conduit schedule or part of the process system:
      a. Markings shall match the conduit schedule.
   2. Mark conduits at the following locations:
      a. Each end of conduits that are greater than 10 feet in length.
      b. The middle of conduits that are 10 feet or less in length.
      c. Where the conduit penetrates a wall or structure.
      d. Where the conduit emerges from the ground, slab, etc.
   3. Mark conduits after the conduits have been fully painted.
   4. Position conduit markers so that they are easily read from the floor.
   5. Attach non-metallic conduit markers with nylon cable ties:
      a. Provide ultraviolet resistant cable ties for conduit markers exposed to direct sunlight.
   6. Mark conduits before construction review by the Engineer for punch list purposes.
   7. Label intrinsically safe conduits in accordance with the requirements of the NEC.

D. Medium voltage raceway labels:
   1. Apply at 50-foot intervals stating the voltage level contained within the raceway.

E. Signs and labeling:
   1. Furnish and install permanent warning signs at mechanical equipment that may be started automatically or from remote locations:
      a. Fasten warning signs with round head stainless steel screws or bolts.
      b. Locate and mount in a manner to be clearly legible to operations personnel.
   2. Furnish and install permanent and conspicuous warning signs on equipment (front and back), doorways to equipment rooms, pull boxes, manholes, etc., where the voltage exceeds 600 volts.
   3. Furnish and install warning signs on equipment that has more than one source of power.
      a. Warning signs to identify every panel and circuit number of the disconnecting means of external power sources.
   4. Place warning signs on equipment that has 120 VAC control voltage source used for interlocking.
      a. Identify panel and circuit number or conductor tag for control voltage source disconnecting means.
   5. Label service entrance equipment, switchgear, switchboards, MCCs, panelboards, and transfer switches with the available short circuit current, equipment label, and date of application in accordance with NEC. Coordinate with Section 16305 - Electrical System Studies for available fault current data.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.05 FIELD QUALITY CONTROL

A. Replace any nameplates, signs, conductor markers, cable markers, or raceway labels that in the sole opinion of the Engineer do not meet the Engineer's aesthetic requirements.

END OF SECTION

SECTION 16123

600-VOLT OR LESS WIRES AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. 600-volt class or less wire and cable.

1.02 REFERENCES

A. Abbreviations:
   1. AWG: American wire gauge.
   2. BCCS: Bare copper-covered steel.
   3. CPE: Chlorinated polyethylene.
   4. FHDPE: Foam high-density polyethylene.
   5. FPE: Foam polyethylene.
   6. OD: Outside diameter.
   7. PVC: Polyvinyl chloride.
   8. XHHW: Cross-linked high heat water resistant insulated wire.

B. Standards:
   1. ASTM International (ASTM):
      a. B3 - Standard Specification for Soft or Annealed Copper Wire.
      b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. CSA International (CSA).
   3. Insulated Cable Engineer's Association (ICEA):
      a. S-90-661 - Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems.
   4. National Electrical Code (NEC).
   5. National Electrical Manufacturers Association /Insulated Cable Engineers Association (NEMA/ICEA):
      a. NEMA WC 66/ICEA S-116-732 - Standard for Category 6 and 6A, 100 Ohm, Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in LAN Communication Wiring Systems.
      b. NEMA WC 70/ICEA S-95-658-1999 - Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
   6. National Fire Protection Association (NFPA):
      a. 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
   7. Telecommunications Industry Association (TIA):
      a. 568.2-D - Balanced Twisted-Pair Telecommunications Cabling and Components Standard.
      b. 569-B - Commercial Building Standards for Telecommunications Pathways and Spaces.

8. Underwriter's Laboratories Inc., (UL):
    a. 44 - Standard for Thermoset-Insulated Wires and Cables.
    b. 1277 - Electrical Power and Control Tray Cables with Optional-Fiber Members.
    c. 1666 - Standard for Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
    d. 2225 - Cables and Cable-Fittings for Use in Hazardous (Classified) Locations.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
1. Manufacturer of wire and cable.
2. Insulation:
    a. Type.
    b. Voltage class.
3. AWG size.
4. Conductor material.
5. Pulling compounds.

C. Shop Drawings:
1. Show splice locations.
    a. For each proposed splice location provide written justification describing why the splice is necessary.

D. Test reports:
1. Submit test reports for meg-ohm tests.

E. Calculations:
1. Submit cable pulling calculations to the Engineer for review and comment for cables that will be installed using mechanical pulling equipment. Show that the maximum cable tension and sidewall pressure will not exceed manufacturer recommended values:
    a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
    b. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

F. Cable lengths:
1. Submit installed cable lengths using a conduit measuring tape for 3-phase circuits.
2. Submit installed lengths of cable for the following single-phase circuits:
    a. Circuits feeding single-phase transformers.
    b. Circuits feeding single-phase panelboards.

1.05 QUALITY ASSURANCE

A. Wires and cables shall be UL listed and labeled.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. General site and project conditions:
   1. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Color-coding:
   1. Color-coding shall be consistent throughout the facility.
   2. The following color code shall be followed for 240/120 volt and 208/120-volt systems:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Single phase system: Black for 1 hot leg, red for the other.
      e. Neutral: White.
      f. High phase or wild leg: Orange.
      g. Equipment ground: Green.
   3. The following color code shall be followed for 480/277-volt systems:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Equipment ground: Green.
   4. The following color code shall be followed for 120 VAC control wiring:
      a. Power: Red.
      b. Neutral: White.
   5. The following color code shall be followed for general purpose DC control circuits:
      a. Ground conductors: Black.
      b. Ungrounded conductors: Red.
   6. The following color code shall be followed for general purpose control wiring inside a control cabinet:
      a. Digital Inputs: 16 AWG Yellow.
      b. Digital Outputs: 16 AWG Orange.
      c. Analog signals 18 AWG shielded (+) White or Red.

d. Analog signals 18 AWG shielded (-) Black.
e. DC power supply 16 AWG MTW (+) Red / (-) Blue.

7. Switch legs shall be violet. 3-way switch runners shall be Pink.
8. Wires in intrinsically safe circuits shall be Light blue.
9. Wire colors shall be implemented in the following methods:
   a. Wires manufactured of the desired color.
   b. Continuously spiral wrap the first 6 inches of the wire from the termination point with colored tape:
      1) Colored tape shall be wrapped to overlap half of the width of the tape.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Furnish and install the complete wire and cable system.

2.03 MANUFACTURERS

A. One of the following, or equal:
   1. 600-volt class wire and cable:
      a. Okonite Co.
      b. Prysmian General Cable.
      c. Service Wire.
      d. Southwire Co.
   2. 600-volt VFD cable:
      a. Prysmian General Cable.
      b. Service Wire.
      c. Southwire Co.
   3. Instrumentation class wire and cable:
      a. Alpha Wire Co.
      b. Belden CDT.
      c. Okonite Co.
      d. Prysmian General Cable.
      e. Rockbestos Surprenant Cable Corp.
   4. Network cables:
      a. Belden.
      b. CommScope.
      c. General Cable.

2.04 MATERIALS

A. Conductors:
   1. Copper in accordance with ASTM B3.

2.05 MANUFACTURED UNITS

A. General:
   1. Provide new wires and cables manufactured within 1 year of the date of delivery to the Site.
   2. Permanently mark each wire and cable with the following at 24-inch intervals:
      a. AWG size.
      b. Voltage rating.
      c. Insulation type.

d. UL symbol.
e. Month and year of manufacture.
f. Manufacturer's name.

3. Identify and mark wire and cable as specified in Section 16075 - Identification for Electrical Systems:
   a. Use integral color insulation for #2 AWG and smaller wire.
   b. Wrap colored tape around cable larger than #2 AWG.

B. 600-volt class wire and cable:
1. Provide AWG or kcmil sizes as indicated on the Drawings or in the Conduit Schedules:
   a. When not indicated on the Drawings, size wire as follows:
      1) In accordance with the NEC:
         a) Use 75-degree Celsius ampacity ratings.
         b) Ampacity rating after derating factors, equal to or greater than rating of the overcurrent device.
      2) Provide #12 AWG minimum for power conductors.
      3) Provide #14 AWG minimum for control conductors.
2. Provide Class B stranding in accordance with ASTM B8:
   a. Provide Class C stranding where extra flexibility is required.
3. Insulation:
   a. XHHW-2.
   b. 90-degree Celsius rating.

C. 600-volt VFD cables:
1. Conductor:
   a. Provide Class B stranding in accordance with ASTM B3 and B8.
   b. Copper conductor.
2. Insulation:
   a. Cross-linked Polyethylene, XLPE.
   b. 90-degree Celsius rating.
   c. UL 44 Type RHH/RHW-2 or XHHW-2.
   d. 2,000 volts.
3. Ground:
   a. Provide Class B compressed stranded bare copper in accordance with ASTM B3 and B8.
   b. 3 symmetrically placed bare copper conductors in direct contact with shield.
   c. Equivalent ground size 50 percent of the phase conductor size.
4. Filler:
   a. Cable sizes 8 and 6 use polypropylene filler.
   b. Other cable sizes use paper filler.
5. Metallic shield:
   a. Overall 5 mil bare copper tape shield with 50 percent overlap.
6. Outer jacket:
   a. UL 1277 Type PVC.
7. Cable tray rated, UL Type TC-ER.

D. Instrumentation class cable:
1. Type TC.
2. Suitable for use in wet locations.

3. Voltage rating: 600 volts.
4. Temperature rating:
    a. 90 degree Celsius rating in dry locations.
    b. 75 degree Celsius rating in wet locations.
5. Conductors:
    a. Insulation:
        1) Flame-retardant PVC, 15 mils nominal thickness, with nylon jacket 4 mils nominal thickness.
    b. #16 AWG stranded and tinned.
    c. Color code: ICEA Method 1:
        1) Pair: Black and white.
        2) Triad: Black, white and red.
        3) Multiple pairs or triads:
            a) Color-coded and numbered.
6. Drain wire:
    a. #18 AWG.
    b. Stranded, tinned.
7. Jacket:
    a. Flame retardant, moisture and sunlight resistant PVC.
    b. Ripcord laid longitudinally under jacket to facilitate removal.
8. Shielding:
    a. Individual pair/triad:
        1) Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
    b. Multiple pair or triad shielding:
        1) Group shield: Minimum 1.35-mil double-faced aluminum foil-polyester tape overlapped to provide 100 percent coverage.
        2) Completely isolate group shields from each other.
        3) Cable shield: 2.35 mils double-faced aluminum and synthetic polymer backed tape overlapped to provide 100 percent coverage.
    c. Shielding to be in contact with the drain wire.

E. Network cables:
1. Copper Ethernet cable:
    a. Provide copper Ethernet cable types as indicated on the Drawings and Specifications.
    b. General requirements:
        1) Cables shall meet the standards set by TIA-568.2-D and verified by third-party testing laboratory.
        2) Conductors:
            a) 4 balanced twisted pairs.
                (1) #22 to #24 AWG thermoplastic insulated solid copper conductors enclosed by a thermoplastic jacket. Copper clad aluminum is not allowed.
        3) Insulation:
            a) Non-Plenum: Polyolefin.
            b) Plenum: Fluoropolymer.
        4) Color coded per T568B.
        5) Outer jacket with ripcord.

6) Shielding:
   a) Provide F/UTP cables with drain wire for cables inside any equipment or enclosure with 480 VAC and above, outdoor installations, and where indicated on the Drawings.
7) Voltage rating:
   a) At a minimum provide 300 VAC rated jacket.
   b) 600 VAC rated jacket when cables are inside equipment or enclosures that contain 480 VAC power.
8) Approvals and listings:
   a) Meets any necessary NEC and NFPA requirements for each application.
   b) Riser applications: CMR in accordance with UL 1666.
   c) Plenum applications: CMP in accordance with NFPA 262.
9) Certification:
   a) Provide Category 5e cables with ICEA S-90-661 certification.
   b) Provide Category 6 cables with NEMA WC 66/ICEA S-116-732 certification.
   c) Provide Category 6A cables with NEMA WC 66/ICEA S-116-732 certification.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Wire ties:
   1. One of the following, or equal:
      a. Panduit, cable ties.
      b. T&B, “Ty-Rap” cable ties.

B. Wire markers:
   1. As specified in Section 16075 - Identification for Electrical Systems.

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Assembly and testing of cable shall comply with the applicable requirements of NEMA WC 70/ICEA S-95-658-1999.

B. Test Type XHHW-2 in accordance with the requirements of UL 44.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install conductors only after the conduit installation is complete, and enclosures have been vacuumed clean, and the affected conduits have been swabbed clean and dry:
   1. Install wires only in approved raceways.
   2. Do not install wire:
      a. In incomplete conduit runs.
      b. Until after the concrete work and plastering is completed.

B. Properly coat wires and cables with pulling compound before pulling into conduits:
   1. For #4 AWG and larger, use an approved wire-pulling lubricant while cable is being installed in conduit:
      a. Ideal Products.
      b. Polywater Products.
      c. 3M Products.
      d. Greenlee Products.
      e. Or equal, as recommended by cable manufacturer.
      f. Do not use oil, grease, or similar substances.

C. Cable pulling:
   1. Prevent mechanical damage to conductors during installation.
   2. For cables #1 AWG and smaller, install cables by hand.
   3. For cables larger than #1 AWG, power pulling winches may be used if they have cable tension monitoring equipment.
   4. Provide documentation that maximum cable pulling tension was no more than 75 percent of the maximum recommended level as published by the cable manufacturer. If exceeded, the Engineer may, at his discretion, require replacement of the cable.
   5. Ensure cable pulling crews have calculations and cable pulling limitations while pulling cable.
   6. Make splices or add a junction box or pullbox where required to prevent cable pulling tension or sidewall pressure from exceeding 75 percent of manufacturer’s recommendation for the specified cable size:
      a. Make splices in manholes or pull boxes only.
      b. Leave sufficient slack to make proper connections.

D. Use smooth-rolling sheaves and rollers when pulling cable into cable tray to keep pulling tension and bending radius within manufacturer’s recommendations.

E. Install and terminate wire in accordance with manufacturer's recommendations.

F. Neatly arrange and lace conductors in switchboards, panelboards, pull boxes, and terminal cabinets by means of wire ties:
   1. Do not lace wires in gutter or panel channel.

2. Install wire ties with a flush cutting wire tie installation tool:
    a. Use a tool with an adjustable tension setting.
3. Do not leave sharp edges on wire ties.

G. Terminate stranded conductors on equipment box lugs such that conductor strands are confined within the lug:
1. Use ring type lugs if box lugs are not available on the equipment.

H. Lighting circuits:
1. Each circuit shall have a dedicated neutral.

I. Splices:
1. Provide continuous circuits from origin to termination whenever possible:
    a. Obtain Engineer's approval prior to making any splices.
2. Lighting and receptacle circuit conductors may be spliced without prior approval from the Engineer.
3. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths:
    a. Splice box NEMA rating requirements as specified in Section 16050 - Common Work Results for Electrical.
    b. Make splices in labeled junction boxes for power conductors.
    c. Make splices for control and instrument conductors in terminal boxes:
        1) Provide terminal boards with setscrew pressure connectors, with spade or ring lug connectors.
4. Power and control conductors routed in common raceways may be spliced in common junction boxes.
5. Clearly label junction and terminal boxes containing splices with the word "SPLICE LOCATED WITHIN".
6. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduits.
7. Install splices with compression type butt splices and insulate using a heat-shrink sleeve:
    a. In NEMA Type 4 or NEMA Type 4X areas, provide heat-shrink sleeves that are listed for submersible applications.
8. Splices in below grade pull boxes, in any box subject to flooding, and in wet areas shall be made waterproof using:
    a. A heat shrink insulating system listed for submersible applications.
    b. Or an epoxy resin splicing kit.

J. Apply wire markers to wires at each end after being installed in the conduit and before meg-ohm testing and termination.

K. Instrumentation class cable:
1. Install instrumentation class cables in separate raceway systems from power cables:
    a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
    b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
2. Do not make intermediate terminations, except in designated terminal boxes as indicated on the Drawings.

3. Shield grounding requirements as specified in Section 16060 - Grounding and Bonding.

L. Copper Ethernet cables:
   1. In accordance with TIA-568.2-D.
   2. Pathways:
      a. For initial installation, the maximum fill capacity for pathways (i.e., conduit, raceways, trays, baskets) is 40 percent. The maximum fill capacity of 60 percent is allowed to accommodate future additions after initial installation.
      b. Conduit should be run in the most direct route possible with no more than two 90-degree bends between pull boxes and serve no more than 3 outlet boxes.
   3. Cable bend radius:
      a. Proper cable bend radius control must be maintained throughout the pathways. Bend radius needs to be at a minimum 10 times the cable diameter.
   4. Cable pulling:
      a. Provide cable pulling swivel system to prevent winding and tangling of rope and cables during pull.
      b. Maximum pulling tension is not to exceed manufacturer recommendations. Cable installation should not in any way deform the cable jacket.
      c. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   5. Cable management:
      a. Organize and manage cables for quick and easy moves, adds and changes.
   6. Cable termination:
      a. Install equipment outlet connector hardware (e.g., RJ45, M12, etc.), and connect to field equipment outlet (e.g., instrument, VFD, actuator, etc.).
      b. Use shielded connectors as required by the installation.
      c. Coordinate cable termination at copper patch panels with ICSC and General Contractor.
   7. Testing:
      a. Copper Ethernet cable testing requirements as specified in Section 16950 - Field Electrical Acceptance Tests.
   8. Separation from EMI sources:
      a. Comply with TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
      b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
         1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
         2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
         3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
    2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.

M. Signal cable:
1. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.

N. Wiring allowances:
1. Equipment locations may vary slightly from the Drawings. Include an allowance for necessary conductors and terminations for motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of locations indicated on the Drawings.
2. Locations for pull boxes, manholes, and duct banks may vary slightly from the Drawings. Include an allowance for necessary conductors and related materials to provide conductors to pull boxes, manholes and duct banks within 20-linear feet of locations indicated on the Drawings.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
1. As specified in Section 16950 - Field Electrical Acceptance Tests.

END OF SECTION

SECTION 16124

MEDIUM VOLTAGE CABLES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Medium voltage cables rated 5,000 through 35,000 volts.

1.02 REFERENCES

A. Definitions:
   1. Definitions of terms and other electrical considerations as set forth by:
      a. ICEA.
      b. ASTM.

B. Standards:
   1. Association of Edison Illuminating Companies (AEIC):
      a. CS8 - Specification for Extruded Dielectric, Shielded Power Cables Rated 5 through 46 kV.
   2. ASTM International (ASTM):
      a. B3 - Standard Specification for Soft or Annealed Copper Wire.
      b. B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
      c. B496 - Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
   3. Insulated Cable Engineers Association (ICEA):
      a. S-93-639 - 5-46 kV Shielded Power Cable for Use in the Distribution of Electrical Energy.
      b. S-94-649 - Standard for Concentric Neutral Cables Rated 5 Through 46 kV.
      c. S-97-682 - Standard for Utility Shielded Power Cables Rated 5 Through 46 kV.
   4. National Electrical Code (NEC).
   5. National Electrical Manufacturers Association (NEMA).
   6. Underwriter's Laboratories (UL):
      a. 1072 - Standard for Safety for Medium-Voltage Power Cables.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer.
   2. Voltage class.

3. Conductor:
    a. Size.
    b. Material.
    c. Stranding.
4. Insulation:
    a. Type.
    b. Level.
5. Shielding.
6. Temperature rating.
7. Jacket material.

C. Shop drawings:
    1. Show splice locations.
    2. Provide details on the pull plan:
        a. Show splice locations, if applicable.
        b. Cable layout locations, if applicable.
        c. Actions for protecting cables at each phase of the installation.

D. Calculations:
    1. Submit cable pulling calculations to the Engineer for review and comment showing that the maximum cable tension and sidewall pressure will not exceed Manufacturer recommended values:
        a. Provide a table showing the manufacturer's recommended maximum cable tension and sidewall pressure for each cable type and size included in the calculations.
            1) Increase the coefficient of friction for the calculation until either maximum cable tension or maximum sidewall pressure is reached. If maximum sidewall pressure is reached before maximum tension, the tension at which the maximum sidewall pressure is reached will be the maximum pull tension for the pull.
    2. Submit the calculations to the Engineer a minimum of 2 weeks before conduit installation.

E. Qualifications:
    1. Submit qualifications for the individual(s) that will be performing medium voltage cable splices and terminations at least 30 calendar days before splicing or terminating.
    2. Documentation that the individual has received training by splice/termination Manufacturer or an independent testing laboratory.
    3. A statement of the number of years in which the individual has been splicing and terminating medium voltage cable.

F. Test reports:
    1. Submit AC withstand partial discharge (corona) test x-y plots after manufacture and prior to shipment.
    2. Submit field test reports as specified in Section 16950 - Field Electrical Acceptance Tests.

G. Cable lengths:
    1. Submit installed cable lengths using a conduit measuring tape for all medium voltage circuits.

H. Record documents:
   1. Submit record documents with any field modification.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications: Minimum of 10 years of experience in manufacturing medium voltage power cables.

B. Medium voltage cables shall be UL listed and labeled.

1.06 DELIVERY STORAGE AND HANDLING

A. Cables stored and or cut on site shall have the ends turned down, and sealed with cable manufacturer's standard cable end seals, or field installed heat-shrink cable end seals.

1.07 PROJECT OR SITE CONDITIONS

A. General site and project conditions:
   1. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Do not install cables until the Engineer reviews the Contractor prepared cable-pulling calculations:

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Furnish and install the complete medium voltage cable system.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Okonite Co.
   2. Prysmian General Cable.
   3. Southwire Co.

2.04 MATERIALS

A. Conductors:
   1. Annealed uncoated copper in accordance with ASTM B3.
   2. Compact stranded in accordance with ASTM B496.

B. Insulation:
   1. Ethylene propylene rubber, (EPR).

C. Jacket:
   1. Polyvinyl chloride (PVC).

2.05 MANUFACTURED UNITS

A. General:
   1. Permanently mark each cable with the following at 24-inch intervals:
      a. American Wire Gauge (AWG) size or circular mill area.
      b. Voltage rating.
      c. Grade of insulation.
      d. UL symbol.
      e. Manufacturer's name.

B. Medium voltage cable:
   1. Provide cables manufactured in the last 12 months.
   2. Voltage ratings as indicated on the Drawings or on the conduit schedule.
   3. Type MV-105:
      a. Rated for 105 degrees Celsius.
   4. Single conductor:
      a. Stranding:
         1) In accordance with ASTM B3 and B8 Class B.
   5. Conductor screen:
      a. Extruded semiconducting thermosetting compound.
      b. Applied directly over the conductor.
      c. In accordance with:
         1) AEIC CS8.
         2) UL 1072.
   6. Insulation level:
      a. 133 percent.
      b. Insulation screen:
         1) Extruded semiconducting thermosetting compound.
         2) Applied directly over the insulation.
         3) In accordance with:
            a) ICEA S-93-639 and ICEA S-97-682.
            b) Free-stripping.
         4) Provide color differentiation between semi-conducting layers and insulation.
   7. Concentric neutral:
      a. Concentric neutral shield consisting of solid bare copper wires helically applied and uniformly spaced over the insulation screen.
   8. Applications:
      a. Suitable for use in wet and dry locations in conduit and underground duct systems.
      b. Cables larger than AWG 1/0 suitable for CT use in cable tray.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Manufacturer cable in accordance with the latest standards of the ASTM and ICEA and test full cable length by these standards:
   1. AC withstand partial discharge (corona) test per AEIC CS8 and ICEA S-94-649.
      a. Results not to exceed 5 picocoulombs.

B. Provide cable reels with both ends of cables available for high-potential testing before installation.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Install and terminate cable per manufacturer recommendations:
   1. Use proper stripping and terminating tools to ensure integrity of insulation.
   2. Ground shield at all terminations and splices.
   3. Maintain the manufacturer’s or NEC minimum bending radius, whichever is larger.
   4. Do not bend, kink, or nick cable jacket or insulation.
   5. Properly coat wires and cables with pulling compound recommended by cable manufacturer before pulling into conduits and prevent mechanical damage to conductors during installation:
      a. Other lubricants substituted must be accompanied by a statement from cable manufacturer as to its acceptable use with cables being installed.
   6. Do not exceed the pulling tension and sidewall pressures recommended by cable manufacturer. Install additional pull boxes as required to meet cable manufacturer's recommendations.
   7. Electrical identification: As specified in Section 16075 - Identification for Electrical Systems.
   8. Use only tools that are recommended by the termination or splice manufacturer.
   9. Use a dynamometer during cable pulling operations to monitor cable pulling tensions.

B. Cable pulling requirements:
   1. Cable pulling crew shall have “in hand” all cable pulling calculations and cable pulling limitations.
   2. Pull cable directly from reels into the ducts.
   3. Cable may not be laid on the ground or otherwise handled for cutting or sorting without protection from debris or physical damage.
   4. Follow cable manufacture installation instructions for proper handling.
   5. Do not pull cables through more than one intermediate manhole on one pull.
   6. Seal all cable ends against moisture or lubricant prior to pulling.
   7. Use non-metallic pull ropes to prevent cutting of duct materials.
   8. Pull cables from conductor, do not use cable pulling socks that attach to the insulation.
   9. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture.

C. Installation of cables in manholes and handholes:
   1. Install cables not utilizing the shortest route but routed along those walls providing the longest route and the maximum spare cable lengths.
   2. Run all cables closely parallel to the walls, not interfering with duct entrances.
   3. Support cables on brackets and cable insulators spaced at a maximum of four feet.
   4. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required for a neat and workmanlike installation with all cables properly arranged and supported.

D. Splices:
   1. Provide continuous circuits from origin to termination:
      a. Provide where necessary when cable pulling tension or sidewall pressure exceeds manufacturer recommendation for the cable.
   2. Make splices in manholes or pull boxes only:
      a. Leave sufficient slack to make proper connections.
      b. Do not pull splices into conduit.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Functional Testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL

A. After cable installation, test in accordance with ICEA/NEMA, including voltage tests, hi-potential tests, before energizing the circuits.
   1. Verify that no equipment is connected to the cables during tests.

END OF SECTION

SECTION 16125

FIBER OPTIC CABLE AND APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Fiber optic cable.
   2. Fiber splices and terminations.
   3. Accessories.

1.02 REFERENCES

A. Abbreviations:
   1. N/Cm: Newtons per centimeter.
   2. OTDR: Optical Time Domain Reflectometer (Tier 2 test).
   3. OLTS: Optical Loss Test Set (Tier 1 test).

B. Standards:
   1. Bellcore Standards:
      a. GR-409 - Generic Requirements for Indoor Fiber.
   2. Electronic Industry Association (EIA):
      a. FOTP-25 - Impact testing of Fiber Optic Cables and Cable Assemblies.
      b. FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test.
      c. FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables.
      d. FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable.
      e. FOTP-104 - Fiber Optic Cable Cyclic Flexing Test.
      f. FOTP-181 - Lightning Damage Susceptibility Test for Fiber Optic Cables with Metallic Components.
   3. Insulated Cable Engineer's Association (ICEA):
      a. S-83-596 - Optic Fiber Premises Distribution Cables.
      b. S-87-640 - Optic Fiber Outside Plant Communications Cable.
      c. S-104-696 - Indoor-Outdoor Optic Fiber Cable.
   4. TIA/EIA Standards:
      a. 598 - Optical Fiber Cable Color Coding.
      b. 11801 - Information technology - Generic cabling for customer premises.
   5. Underwriters Laboratories, Inc. (UL):
      a. 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.
      b. 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.

1.03 TERMINOLOGY

A. As specified in Section 17050 - Common Work Results for Process Control and Instrumentation Systems.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Complete manufacturer's brochures that identify materials and options.
   2. Completed datasheets, including catalog number and source for determining catalog number.
   3. Manufacturer's installation instructions.
   4. Include the following:
      a. Manufacturer's data on testing equipment used on this project.
      b. Manufacturer's specifications and datasheets for all fiber types.
      c. Manufacturer's specifications and datasheets for all connectors, bulkheads, splicing kits, breakout devices, and appurtenances used in connecting and terminating fiber spans.
   5. Catalog data on testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the NIST.
   6. Manufacturer's test procedures and quality assurance procedures:
      a. After review, Engineer may require that additional tests be performed before installation.

C. Shop Drawings:
   1. Interconnection cabling diagrams for the complete system including every fiber in each cable.
   2. Drawings indicating locations of all pull boxes including pull box identifiers and lengths.
   3. Submit optical power budget calculations for fiber segments. Include the following:
      a. Minimum transmit power of active devices.
      b. Minimum receive sensitivity.
      c. Available power, in dBm.
      d. Loss for each segment in dBm, including cable attenuation and connector losses. Use manufacturer's data for cable attenuation, at the wavelength to be used. Assume 0.5 dB per connector.
      e. Demonstrate that remaining power budget at each receiver is equal to or greater than 3.0 dBm.

D. Installation instructions:
   1. Submit a cable pulling and splicing work plan that includes the following:
      a. Pull tension calculations.
      b. Detailed description of pull operation methods for conduit runs.
      c. Tools and equipment to be used for cable installation and testing.
      d. Physical location of equipment setup and type.
      e. Exact locations of splice points.
      f. Safety and manual assist cable-pulling operations.
      g. Detailed schedule for pulling and testing cables.
      h. Name and qualifications of the supervisory personnel directly responsible for installation of the conduit system.
      i. Sample fiber optic cable test sheets.

j. Signed test sheet results.

E. Commissioning Submittals:
1. As specified in Section 01756 - Commissioning, including the following:
a. Manufacturer's representative qualifications.
b. Certificates:
1) Requirements as specified in this Section.
c. Test Plans:
1) Test requirements as specified in this Section.
d. Test Reports.
e. Manufacturer's representatives field notes and data.

F. Operation and maintenance manuals:
1. Compile completed test reports, instruction manuals, and manufacturer's information into the operating manuals and submitted in accordance with Section 01782 - Operation and Maintenance Manuals.

G. Test reports:
1. Submit results of specified tests to the Engineer.
2. Submit 3 copies of test reports showing results of tests specified in this Section or in Section 16950 - Field Electrical Acceptance Tests:
a. Test forms shall include the following information at a minimum:
1) Test type.
2) Test location.
3) Test date.
4) Wavelength.
5) Index of refraction.
6) Cable identification.
7) Fiber type.
8) Fiber number.
9) Fiber color.
10) Result of the value of the tested parameter.
3. Furnish hard copy and electronic copy for OTDR traces.
4. Submit certification that the fiber optic cable has passed each testing stage:
a. Submit separate documentation for each testing stage result.

H. Record documents:
1. Furnish updated electrical drawings, network diagrams, and fiber cable block diagrams at the end of construction and submit as record drawings.

I. Calculations:
1. Cable pulling calculations for conduit runs:
a. Indicate on the Submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

1.06 QUALITY ASSURANCE

A. Furnish cable and appurtenances manufactured within 1 year of installation.

B. Proof test optical fibers by the fiber manufacturer at a minimum load of 50 kpsi.

C. Provide 100 percent attenuation testing for optical fibers:
   1. Include with each cable reel the attenuation of each fiber.

D. Provide information on at least 5 successful fiber optic cable installations of comparable size and complexity in the past 3 years with name, address, and telephone number of facility owner, name of project with completion date, and type of conduit system and length of cable pulled.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Package cable for shipment on wooden reels:
   1. Seal both ends of cable to prevent ingress of moisture.
   2. Place fiber cable assemblies on reels such that both cable ends are available for testing.
   3. Weatherproof cable reel markings shall include the following:
      a. Manufacturer.
      b. Date of manufacture.
      c. Shipping date.
      d. Cable identification.
      e. Cable configuration/fiber count.
      f. Cable length.
      g. Gross weight.
      h. Cable test date.
      i. Handling instructions.
      j. Direction to unreel.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Submit a cable pulling and splicing work plan a minimum of 45 days before the planned initiation of cable pulling. Cable pulling and splicing work plan must be approved a minimum of 15 days before pulling cable.
   2. Testing sequence:
      a. Perform testing of each fiber in each cable as follows:
         1) At factory before shipment.
         2) At project site upon delivery.
         3) Submit copies of test results to the Engineer within 5 days after the delivery to the site.
         4) After installation, before breakout and terminations.
         5) After installation is complete.
      b. Submit test reports following each set of tests as specified in this Section.

B. Scheduling:
   1. Schedule Engineer, 5 days before installation, to witness cable installations.
   2. Notify the Engineer and Owner a minimum of 15 days before post-installation testing.

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish a complete fiber optic network as indicated on the Drawings.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Install fiber optic system components in accordance with the recommendations of the manufacturer.

2.03 MANUFACTURERS

A. Acceptable manufacturers are indicated with each component type as listed in the remainder of this Specification.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. General fiber cable requirements:
   1. Suitable for the installed environment.
   2. Color-coded fibers according to EIA/TIA-598.
   3. Color-coded buffer tubes according to EIA/TIA-598.
   4. Furnish buffer tubes of a single layer nylon construction or of a material with similar mechanical performance.
   5. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
   6. Apply binders with sufficient tension to secure buffer tubes to the central member without crushing the buffer tubes:
      a. Provide binders that are:
         1) Non-hygroscopic.
         2) Non-wicking (or rendered so by the flooding compound).
         3) Dielectric with low shrinkage.
   7. Provide a minimum of 1 ripcord under the cable sheath.
   8. Provide high tensile strength Aramid yarns, Kevlar, and/or fiberglass helically stranded evenly around the cable core:
      a. No metallic elements whatsoever are allowed in non-armored cable.
   9. Jacket or sheath shall be free of holes, splits, and blisters.
   10. Mark jacket or sheath with:
      a. Manufacturer's name.
      b. “Optical Cable”.
      c. Year of manufacture.
      d. Sequential meter marks.
      e. Repeat markings every 1-meter.
      f. Actual length of the cable to be within 1 percent of the length marking.

g. Marking must be in a contrasting color to the cable jacket.
h. Height of the marking:
1) Approximately 2.5 millimeters.

11. Shipping, storage, and operating temperature range of the cable shall be -40 degrees Celsius to +70 degrees Celsius.
12. General performance characteristics:
a. Rated tensile load of the cables:
1) Indoor/outdoor:
a) Short term: 1,330 N.
b) Long term: 400 N.
b. Non-armored fiber optic cables: Compressive load withstand of 220 N/cm applied uniformly over the length of the cable.
c. Armored fiber optic cables: Compressive load withstand of 440 N/cm applied uniformly over the length of the cable.
d. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm for a cable subjected to this load:
1) With no measurable increase in attenuation after load removal.
e. Test in accordance with EIA FOTP-41 except that the load must be applied at the rate of 3 millimeters to 20 millimeters per minute and maintained for 10 minutes.
f. Capable of withstanding 25 cycles of mechanical flexing at a rate of 30 within 1 cycles/minute.
g. Average increase in attenuation for the fibers: Less than or equal to 0.10 dB at 1,550 nm at the completion of the test.
h. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 millimeters constitutes failure.
i. Outer cable jacket cracking or splitting observed under 10X times magnification, constitutes failure.

B. Indoor/outdoor cable:
1. Cable construction:
a. General:
1) Cable type: Indoor/Outdoor - Flame retardant, low smoke, zero halogen, UV resistant.
2) Fiber count: As indicated on the Drawings.
3) Fiber type: As indicated on the Drawings.
4) Buffer tube: Loose tube.
5) Armoring: None.
6) Waterproofing: Water blocking layer.
7) Strength member:
a) Loose tube: Utilize a central, nonmetallic strength member with a coefficient of thermal expansion similar to the fibers as the central anti-buckling member.
8) Approvals and listings: UL 1666 and UL 1685.
9) Design and test criteria: In accordance with ICEA S-104-696.
b. Testing:
1) Fibers in the cable:
a) Proof test of 100 kpsi.
b) Each optical fiber: Bellcore GR-409 strip force testing.
c) No gaps are allowed between the coating material and the buffer material visible under a 50-power microscope.

c. Outer jacket material:
1) Linear low-density polyethylene.
2) Meet requirements of the NEC for use in indoor/outdoor areas (excluding plenums) without being enclosed in conduit.
3) Flame retardant OFNR riser rated conforming to UL 1666.
4) Printed with necessary UL marks and manufacturer identification.
5) Sequential printing of footage in 2-foot increments.
6) With a ripcord incorporated under the cable jacket.

C. Multimode fibers:
1. Fibers in the cable must be usable fibers and meet required specifications.
2. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.
3. Multimode fiber characteristics:
a. Category: OM4 compliant with ISO/IEC 11801.
b. Jacket color: Aqua or black.

D. Indoor/outdoor:
1. Loose tube:
a. Corning Cable Systems, Freedm®.
b. CommScope, LazrSPEED/TerraSPEED.
c. Maximum cable diameter: 0.3 inches.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Patch cords:
1. General:
a. Connector types to match supplied equipment and patch panel terminations.
b. Maximum length of patch cords: 25 feet.
c. Provide 2 spare patch cords (or 1 duplex patch cord) of each type used at each PLC or network cabinet.
d. Factory assembled and optically tested.
e. Provide mode-conditioning cords for multimode fibers operating at 1,310 nm.
2. Manufacturers: One of the following or equal:
a. CommScope.
b. Corning Cable Systems.

B. Fiber connectors:
1. As specified in Section 17733 - Control Systems: Network Materials and Equipment.

C. Fiber optic identification/warning tags:
    1. Black letters on orange or yellow background.
    2. UV resistant polyethylene or other suitable material:
        a. Manufacturers: The following or equal:
            1) Almetek.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify the condition of the conduit system before installation of the fiber optic cable or inner duct.

B. Pass a test mandrel through fiber optic conduits prior to pulling fiber or installing inner duct.
    1. Run the mandrel in both directions.

C. Examine materials and equipment before installation and verify they are free from physical damage and defects.

3.02 PREPARATION

A. Equipment support and anchoring to structures:
    1. Prepare anchor setting template(s) and use to position anchors during construction of supporting structures.
    2. Install anchors of type and material indicated on approved anchoring designs.
    3. Install anchors with embedment indicated on approved anchoring designs.

B. Before fiber splicing terminating or testing activities, verify sufficient workspace is available to perform the activity without interferences from other trades.

C. Pre-installation test:
    1. Upon arrival at the site:
        a. Inspect the cable and reel for damage.
        b. Test fibers with an optical time domain reflectometer (OTDR) for fiber integrity.
        c. Verify that the fiber lengths are consistent with the cable manufacture.
        d. Verify that traces yield no point discontinuities.
    2. Complete test sequence and obtain approval from the Engineer of submitted test results before cable installation.

3.03 INSTALLATION

A. Install fiber optic patch cords in open network trays or in dedicated conduits no longer than 25 feet in length.

B. Install fiber optic cable in continuous lengths without intermediate splices, except where approved by the Engineer.

C. Cable installation:
   1. Properly attach the fiber optic cable's strength elements to a 600-pound breakaway swivel containing tension or shear pins using Kellums pulling grips that are a minimum of 18 inches long.
   2. Certify that cable tensile limits do not exceed cable pull tension and bend limits using tension monitoring devices.
   3. Leave an extra loop of fiber optic cable in each pull box.
   4. Conform with the cable manufacturer's specifications, practices, and the following requirements:
      a. When power equipment is used to install fiber optic cables, use low speeds and do not exceed a rate of 30 meters per minute.
      b. Do not exceed the tensile and bending limitation for fiber optic cables under any circumstances.
      c. Use large diameter wheels, pulling sheaves, and cable guides to maintain the specified bending radius.
      d. Use commercial dynamometers or load cells to monitor pulling tension.
      e. A nonfreezing type of swivel inserted between the pulling line and cable pulling grip to prevent twisting under strain.
      f. Cable to be installed using a breakaway swivel.
   5. Apply to conduits a lubricant at each conduit ingress and egress location during the pull operation:
      a. Pour or pump lubricant into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1,000 feet of cable.
      b. If the conduit is open at intermediate locations, then apply the appropriate proportion of lubricant at each opening.
      c. Continuously lubricate the cable as it is being pulled by pouring or pumping the lubricant into the conduit at the feed location and at each intermediate location.
      d. Station workers at each intermediate location as required.
      e. Remove excess lubricant that has collected.
      f. Remove and clean the surrounding area after cable installation.
   6. Install using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions:
      a. Use pulling equipment with slip-load capability to allow the winch to maintain a constant pulling force without taking up the winch line.
      b. Use pulling equipment equipped with a hydraulic bypass set so that a maximum tension of 600 pounds is not exceeded.
      c. Use only equipment designed to prevent a preset pulling tension from being exceeded.
      d. Fiber optic cable manufacturer to provide the pulling tension setpoint.
      e. If during the pulling operation excessive tension is detected, cease operations and notify the Engineer.
   7. Position the cable reel at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system:
      a. Use of a cable feeder is required unless the cable is hand-pulled.
   8. Supply bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation:
      a. Cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.

9. Minimize the use of snatch blocks and rollers to guide the cable into the conduit at the feed point:
    a. Slack feed by hand the cable into the feed point and raceway without the use of rollers.
10. Tend the cable reel at all times and turn by hand to provide the required cable slack:
    a. Under no circumstances shall the cable tension be allowed to turn the cable reel.
11. Use a rim roller, with a wheel radius greater than the minimum cable bending radius placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.
12. Perform a continuous thorough visual inspection for flaws, breaks, and abrasions in the cable sheath as the cable leaves the reel and maintain a slow pulling speed to permit this inspection.
13. Damage to the sheath or finish of the cable is cause for rejecting the cable:
    a. Replace any cable damaged in any way during installation.
14. If the cable becomes damaged during installation, stop operations and notify the Engineer immediately:
    a. Engineer to determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.
15. Document pulls by a graph which is annotated with the following information:
    a. Reel number.
    b. Pull point ID.
    c. Date and time.
    d. Explanations for abnormalities in readings or interruptions.
    e. Sign-off by Contractor and Engineer.
16. Under no conditions shall the fiber optic cable be left exposed or unattended.

D. Provide inner duct in fiber optic conduits as indicated on the Drawings, cable schedule, and as specified in Section 16130 - Conduits:
    1. Provide a pull rope in each unused inner duct.

E. After the cables are installed and spliced:
    1. Rack the cables:
        a. Loosely secure in racked position with wire ties.
        b. Attach imprinted plastic-coated cloth identification/warning tags to each cable in at least 2 locations in each handhole/manhole.

F. Splices:
    1. Provide field splices in a splice tray located in a waterproof splice enclosure:
        a. Manufacturers: The following or equal:
            1) Tyco/Raychem, FOSC style splice enclosure.
    2. Loop the individual fibers a minimum of 1 full turn within the splice tray to avoid macro/micro bending.
    3. After completion of cable terminations, neatly dress cables.
    4. Protect splices with a thermal shrink sleeve.
    5. Provide fusion type fiber optic cable splicing meeting the following requirements:
        a. Joins multimode or single mode fibers.
        b. Establishes a permanent fusion splice.
        c. Waterproof.
        d. Re-enterable, rearrangeable, and reusable.

e. Splice loss less than 0.10 dB.
f. Protected by a splice enclosure.

6. Requirement for outdoor fiber splice enclosures:
   a. Seal.
   b. Bond.
   c. Anchor.
   d. Protect fiber optic cable splices.
   e. Stand-alone unit that does not require an outer enclosure.
   f. Provide for a maximum of 6 cable entries in a butt-end configuration.
   g. Used in aerial, underground, and direct buried applications.
7. Requirement for indoor fiber splice enclosures:
   a. Anchor.
   b. Protect fiber optic cable splices.
   c. Stand-alone unit that does not require an outer enclosure.
   d. Suitable for the minimum number of splices at that location plus additional capacity for reconfigurations.
8. Re-splice any splice that has a loss greater than 0.10 dB.
9. Leave a minimum of 20 feet of fiber optic cable at each end of splice.

G. Terminations:
1. Terminate fiber inside a patch panel:
   a. Direct landing to a switch, router hub, or PLC will not be allowed.
2. Terminate outdoor cables using a breakout kit that seals the cable and provides physical protection for the fiber strands.
3. Terminate indoor cables using breakout kits with field installed terminators.
4. Labeling:
   a. Permanently label cable terminations. Use labels produced by a wire printer using pressure sensitive polyester labels.
   b. Label patch panels as specified in Section 16075 - Identification for Electrical Systems.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing:
1. Before shipment and while on the shipping reel, test 100 percent of fibers for attenuation:
   a. Copies of the results shall be:
      1) Maintained on file.
      2) Attached to the cable reel in a waterproof pouch.
      3) Submitted before the delivery of the cable to the job site to Engineer for approval.
2. Conduct the flex test in accordance with EIA FOTP-104 test condition I and III with a maximum sheave diameter of 20 times the cable OD.
3. Verify that the cable withstands 25 impact cycles with:
   a. Average increase in attenuation for fibers less than 0.20 dB at 1,550 nm.
   b. No evidence of cracking or splitting.
   c. Conduct test in accordance with EIA FOTP-25.

4. Certify that the cable withstands a tensile load of 2,700 N (600 pounds):
    a. Without exhibiting an average increase in attenuation of greater than 0.10 dB.
    b. Test in accordance with EIA FOTP-33 using a maximum mandrel and sheave diameter of 560 millimeters.
    c. Apply the load for 1 hour in Test Condition II.
5. Certify that the cable withstands a simulated lightning strike:
    a. Peak value of the current pulse greater than 105kA.
    b. Use a test current with a damped oscillatory maximum time-to-peak value of 15 µs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
    c. Time to half-value of the waveform envelope 40 to 70 µs.
    d. Conduct the test in accordance with the EIA FOTP-181.
    e. In addition to the analysis criterion set forth in EIA FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e., core tube) and strength members must be intact after removal of the cable specimens from the test box.
6. Furnish test reports and Manufacturer's Certificate of Source Testing.

C. Installation Verification:
1. Furnish Manufacturer's Certificate of Installation Verification.

D. Functional Testing:
1. Conduct post-installation tests of the fiber optic system as specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL

A. Utilize personnel certified by the manufacturer with specific knowledge of the cable manufacturer's recommended installation procedures.

B. General:
1. Test results shall meet or exceed manufacturer specifications:
    a. Test each fiber of each cable for breaks, abnormalities, and overall attenuation characteristics.
2. Pre-installation tests and post-installation tests to be witnessed and signed off by Engineer and Owner.
3. Perform OLTS test with equipment capable and calibrated to show anomalies of 0.1 dB as a minimum:
    a. Test multimode fibers at 850 nm and 1,300 nm.
    b. Test single mode fibers at 1,310 and 1,550 nm.
4. Perform OTDR tests on fiber cables less than 100 meters with the aid of a launch cable:
    a. Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10 nanoseconds.

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. Clean fiber optic connectors after termination and before testing. After cleaning, cover unterminated connectors with a protective boot.

B. At the completion of construction, touch up the finish on fiber patch panels and enclosures.

3.08 PROTECTION

A. Protect the fiber system from physical damage and the encroachment of dust, before, during, and after installation.

3.09 SCHEDULES (NOT USED)

END OF SECTION

SECTION 16130

CONDUITS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Metallic conduits.
   2. Nonmetallic conduits.
   3. Conduit bodies.
   4. Conduit fittings and accessories.
   5. Conduit installation.

1.02 REFERENCES

A. Abbreviations:
   1. EFLX: Explosion proof flexible conduit.
   2. GRC: Galvanized rigid steel conduit.
   3. NPT: National pipe thread.
   4. PCS: Polyvinyl chloride (PVC) coated rigid steel conduit.
   5. PVC: Polyvinyl chloride rigid nonmetallic conduit.
   6. SLT: Sealtight-liquidtight flexible conduit.

B. Standards:
   1. American National Standards Institute (ANSI):
      a. C80.1 - Electrical Rigid Steel Conduit.
   2. National Electrical Manufacturers Association (NEMA).National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
   3. Underwriters Laboratories (UL), Inc.:
      a. 6 - Standard for Safety Electrical Rigid Metal Conduit - Steel.
      b. 1203 -Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Conduit bodies: A separate portion of a conduit system that provides access through a removable cover to the interior of the system at a junction of 2 or more conduit sections. Includes, but not limited to, shapes C, E, LB, T, X, etc.
   2. Conduit fitting: An accessory that primarily serves a mechanical purpose. Includes, but not limited to, bushings, locknuts, hubs, couplings, reducers, etc.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures and Section 16070 - Hangers and Supports.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Furnish complete manufacturer's catalog sheets for every type and size of conduit, fitting, conduit body, and accessories to be used on the Project.
   2. Furnish complete manufacturer's recommended special tools to be used for installation, if required.

C. Shop Drawings:
   1. Furnish conduit routing plans for conduits before the installation of any conduit.
   2. Detail the intended routing of each conduit, conduit material and include supporting methods.
   3. Number conduits in accordance with the Contract Documents.
      a. Provide conduit labels as specified in Section 16075 - Identification for Electrical Systems.

D. Delegated Design Submittals:
   1. As specified in Section 16070 - Hangers and Supports.

E. Certifications:
   1. Furnish PVC-coated conduit manufacturer's valid, unexpired certification for each installer.

1.06 QUALITY ASSURANCE

A. Conduits, conduit bodies, and fittings shall be UL listed and labeled.

B. Every installer of PVC-coated metallic conduit shall be certified by the manufacturer for installation of the conduit, and be able to present a valid, unexpired installer certification card prior to installation beginning.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Do not expose non-metallic conduit to direct sunlight.

B. Do not store conduit in direct contact with the ground.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Before performing any trenching locate existing underground utilities.

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide conduits, conduit bodies, fittings, junction boxes, and necessary components, whether or not indicated on the Drawings, as required, to install a complete electrical raceway system.

B. Provide location and protection of existing underground utilities, underground conduit trenching, conduit and backfill necessary for the complete installation of underground conduits.

2.03 MANUFACTURERS

A. Galvanized rigid steel conduit:
   1. One of the following or equal:
      a. Allied Tube and Conduit.
      b. Western Tube and Conduit.
      c. Wheatland Tube Co.

B. PVC-coated rigid steel conduit:
   1. One of the following or equal:
      a. Allied.
      b. Calbond.
      c. NEC, Inc. BlackGuard.
      d. Ocal, Inc.
      e. Robroy Ind.

C. Sealtight-liquidtight flexible conduit:
   1. One of the following or equal:
      a. AFC Cable Systems.
      b. Anaconda.
      c. Electri-Flex Co.
      d. Southwire.

D. Explosion proof flexible conduit:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. Hubbell Killark.

E. Rigid nonmetallic PVC conduit:
   1. One of the following or equal:
      a. Cantex.
      b. Carlon.
      c. Triangle Conduit and Cable.

F. Inner duct:
   1. One of the following or equal:
      a. Carlon.
      b. Endot Ind.
      c. MaxCell.

G. Conduit bodies:
   1. One of the following or equal:
      a. Appleton.
      b. Calbond.
      c. Carlon.
      d. Crouse-Hinds.
      e. O-Z/Gedney.
      f. Ocal, Inc.
      g. Robroy Ind.

H. Joint compound:
   1. As recommended by the conduit manufacturer.

I. Galvanized rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

J. PVC-coated rigid steel conduit expansion fittings:
   1. One of the following or equal:
      a. NEC, Inc. BlackGuard.
      b. Ocal, Inc.
      c. Robroy Ind.

K. Conduit seals:
   1. One of the following or equal:
      a. Appleton.
      b. Crouse-Hinds.
      c. O-Z/Gedney.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS

A. GRC:
   1. NPT standard conduit threads with a 3/4-inch taper per foot:
      a. Running conduit threads are not acceptable.
   2. Hot-dip galvanized inside and out:
      a. Ensures complete coverage and heats the zinc and steel to a temperature that ensures the zinc alloys with the steel over the entire surface.
      b. Electro-galvanizing is not acceptable.
   3. Manufactured in accordance with:
      a. UL 6.
      b. ANSI C80.1.

B. PCS:
   1. Steel conduit, before PVC coating, shall be new, unused, hot-dip galvanized material, in accordance with to the requirements for Type GRC.
   2. Coated conduit NEMA Standard RN-1:
      a. Galvanized coating may not be disturbed or reduced in thickness during the cleaning and preparatory process.
   3. Factory-bonded PVC jacket:
      a. Exterior galvanized surfaces shall be coated with primer before PVC coating to ensure a bond between the zinc substrate and the PVC coating.
      b. Nominal thickness of the exterior PVC coating shall be 0.040 inch except where part configuration or application of the piece dictates otherwise.
      c. PVC coating on conduits and associated fittings shall have no sags, blisters, lumps, or other surface defects and shall be free of holes and holidays.
      d. PVC adhesive bond on conduits and fittings shall be greater than the tensile strength of the PVC plastic coating:
         1) Confirm bond with certified test results.
   4. Urethane coating shall be uniformly and consistently applied to the interior of conduits and fittings:
      a. Nominal thickness of 0.002 inch.
      b. Conduits having areas with thin or no coating are not acceptable.
      c. Threads shall be coated with urethane.
   5. PVC exterior and urethane interior coatings applied to the conduits shall afford sufficient flexibility to permit field bending without cracking or flaking at temperature above 30 degrees Fahrenheit (-1 degree Celsius).
   6. PCS conduit bodies and fittings:
      a. Malleable iron.
      b. Conduit body, before PVC coating, shall be new, unused material and shall be in accordance with appropriate UL standards.
      c. PVC coating on the outside of conduit bodies shall be 0.040-inch thick and have a series of ribs to protect the coating from tool damage during installation.
      d. 0.002-inch interior urethane coating.
      e. Utilize PVC coating as an integral part of the gasket design.
      f. Stainless steel cover screw heads shall be encapsulated with plastic to ensure corrosion protection.

g. PVC sleeve extending 1 conduit diameter or 2 inches, whichever is less, shall be formed at each female conduit opening.
    1) Inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used.
    2) Sleeve shall provide a vapor- and moisture resistant seal at every connection.
    3) Fittings shall be Form 8 and supplied with plastic encapsulated stainless steel cover screws. Fittings shall be UL Type 4X. Fittings shall be from the same manufacturer as the conduit in order to maintain system continuity and warranty.

C. SLT:
1. Temperature rated for use in the ambient temperature at the installed location but not less than the following:
    a. General purpose:
        1) Temperature range: -20 degrees Celsius to +80 degrees Celsius.
    b. Oil-resistant:
        1) Temperature range: -20 degrees Celsius to +60 degrees Celsius.
2. Sunlight-resistant, weatherproof, and watertight.
3. Manufactured from single strip steel, hot-dip galvanized on all 4 sides before conduit fabrication.
4. Strip steel spiral wound resulting in an interior that is smooth and clean for easy wire pulling.
5. Overall PVC jacket.
6. With integral copper ground wire, built in the core, in conduit trade sizes 1/2 inch through 1-1/4 inch.

D. EFLX:
1. Suitable for the hazardous Class and Group where installed:
    a. As specified in Section 16050 - Common Work Results for Electrical.
2. Metallic braid shall provide continuous electrical path.
3. Stainless steel construction.
4. Provide fittings and unions as required for the installation.

E. PVC:
1. Extruded from virgin PVC compound:
    a. Schedule 40 unless otherwise specified.
    b. Schedule 80 extra-heavy wall where specified.
2. Rated for 90 degrees Celsius conductors or cable.
3. Rated for use in direct sunlight.

F. Inner duct:
1. HDPE and fabric inner duct are considered interchangeable.
2. HDPE inner duct:
    a. High-density polyethylene.
    b. Corrugated.
    c. Resin properties:
        1) Density, g/cm^3: 0.941 to 0.955.
        2) Melt index g/10-minute Condition E: 0.05 to 0.5.
        3) Flexural modulus, MPa (pounds per square inch): 80,000 minimum.
        4) Tensile strength at yield (pounds per square inch): 3,000 minimum.

5) Environmental stress crack resistance condition B, F_{10}: 96 hours minimum.
6) Brittleness temperature: -75 degrees Celsius.
d. Size: 1.25 inch.
e. Colors: Orange.
3. Fabric inner duct:
a. White polyester and nylon resin polymer textile.
b. Standard outdoor textile inner duct:
1) 3-inch multi-cell inner duct containing pull tape in each cell.
c. Color-coded.
d. Pull tape:
1) 1,250 pound.
2) Synthetic fiber polyester, flat woven.
3) Printed sequential footage marks.

G. Conduit bodies:
1. Material consistent with conduit type:
a. Malleable iron bodies and covers when used with Type GRC.
b. PVC-coated malleable iron bodies and covers when used with Type PCS.
c. Malleable iron bodies with pressed steel.
2. Conduit bodies to be in accordance with to Form 8, Mark 9, or Mogul design:
a. Mogul design in accordance with NEC requirements for bending space for large conductors for conduit trade sizes of 1 inch and larger with conductors #4 AWG and larger, or where required for wire-bending space.
3. Gasketed covers attached to bodies with stainless steel screws secured to threaded holes in conduit body.

2.08 ACCESSORIES

A. Connectors and fittings:
1. Manufactured with compatible materials to the corresponding conduit.

B. Insulated throat metallic bushings:
1. Construction:
a. Malleable iron or zinc-plated steel when used with steel conduit.
b. Positive metallic conduit end stop.
c. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
d. Use fully insulated bushings on nonmetallic conduit system made of high-impact 150 degrees Celsius rated non-combustible thermosetting phenolic.

C. Insulated grounding bushings:
1. Construction:
a. Malleable iron or steel, zinc-plated, with a positive metallic end stop.
b. Integrally molded non-combustible phenolic-insulated surfaces rated at 150 degrees Celsius.
c. Tin-plated copper grounding saddle for use with copper or aluminum conductors.

D. Electrical unions (Erickson Couplings):
    1. Construction:
        a. Malleable iron for use with steel conduit.
        b. PVC-coated malleable iron for use with PCS conduit.
        c. Concrete tight, 3-piece construction.
        d. Rated for Class I Division 1 Group D in hazardous areas.

E. SLT fittings:
    1. Construction:
        a. Malleable iron.
        b. Furnished with locknut and sealing ring.
        c. Liquidtight, raintight, oiltight.
        d. Insulated throat.
        e. Furnish as straight, 45-degree elbows, and 90-degree elbows.
        f. Designed to prevent sleeving:
            1) Verify complete bonding of the raceway jacket to the plastic gasket seal.
        g. Equipped with grounding device to provide ground continuity irrespective of raceway core construction. Grounding device, if inserted into raceway and directly in contact with conductors, shall have rolled-over edges for sizes under 5 inches.
        h. Where terminated into a threadless opening using a threaded hub fitting, a suitable moisture-resistant/oil-resistant synthetic rubber gasket shall be provided between the outside of the box or enclosure and the fitting shoulder. Gasket shall be adequately protected by and permanently bonded to a metallic retainer.
    2. Corrosion-resistant and outdoor SLT fittings:
        a. Construction:
            1) PVC-coated liquidtight fittings with a bonded 0.040-inch-thick PVC coating on the metal connector to form a seal around the SLT conduit.
            2) Insulated throat and an integral sealing ring.

F. Hubs for threaded attachment of steel conduit to sheet metal enclosures:
    1. Construction:
        a. Insulated throat.
        b. PVC-coated when used in corrosive areas.
        c. Bonding locknut.
        d. Recessed neoprene O-ring to ensure watertight and dusttight connector.
        e. 1/2-inch through 1-1/4-inch steel zinc electroplated.
        f. 1-1/2-inch through 6-inch malleable iron zinc plated.
    2. Usage:
        a. Conduits in damp, wet, outdoor, and corrosive areas shall use threaded hubs for connections to sheet metal enclosures.

G. Sealing fittings:
    1. Construction:
        a. 40-percent wire fill capacity.
        b. PVC-coated when used in corrosive areas.
        c. PVC Coated Hazardous (Classified) Location fittings must be UL 1203 listed after the coating is applied and have a red metal tag attached to the fitting to signify compliance.
        d. Malleable ductile iron with steel conduit.
        e. Type EYDX where drains are required.
        f. Type EYSX where drains are not required.
        g. UL 1203 listed for use in Class I, Division 1, Groups A, B, C, D; Class I, Division 2, Groups A, B, C, D; and Class II, Divisions 1 and 2, Groups E, F, and G.
    2. Sealing compound:
        a. Fiber filler and cement as recommended by the sealing fitting manufacturer.
        b. Approved for the conditions and use.
            1) Not affected by surrounding atmosphere or liquids.
        c. Melting point shall be 200 degrees Fahrenheit minimum.

H. Expansion/deflection couplings:
    1. Use to compensate for movement in any direction between 2 conduit ends where they connect.
    2. Shall allow movement of 3/4 inch from the normal in all directions.
    3. Shall allow angular movement for a deflection of 30 degrees from normal in any direction.
    4. Constructed to maintain electrical continuity of the conduit system.
    5. Materials:
        a. End couplings: Bronze or galvanized ductile iron.
        b. Sleeve: Neoprene.
        c. Bands: Stainless steel.
        d. Bonding jumper: Tinned copper braid.

I. Expansion couplings:
    1. Shall allow for expansion and contraction of conduit:
        a. Permitting 8-inch movement, 4 inches in either direction.
    2. Constructed to maintain electrical continuity of the conduit system.
    3. Materials:
        a. Head: Malleable or ductile iron.
        b. Sleeve: Steel.
        c. Insulating bushing: Phenolic.
        d. Finish: Hot-dip galvanized.
        e. PVC-coated steel when used with Type PCS.

J. Inner duct couplings and fittings:
    1. HDPE inner duct:
        a. Couplings:
            1) Self-threading.
            2) Nonmetallic.

b. Fittings:
1) Multi-access fitting:
a) 3-hole.
b) Sized for conduit containing inner duct.
2) Duct plugs:
a) Sized for inner duct diameter.
b) Install in both ends of unused ducts.
3) Split plugs:
a) Sized for inner duct and cable diameters.
b) Install at both ends of utilized ducts.

2. Fabric inner duct:
a. Termination bags:
1) Inflation-type bags for sealing and securing around 1 or more textile inner ducts and cables within 2-inch outside diameter or larger conduit.

K. Conduit markers:
1. As specified in Section 16075 - Identification for Electrical Systems.

PART 3 EXECUTION

3.01 EXAMINATION

A. Before installing any conduit or locating any device box:
1. Examine the complete set of Drawings and Specifications, and applicable Shop Drawings.

B. Verify all dimensions and space requirements and make any minor adjustments to the conduit system as required to avoid conflicts with the building structure, other equipment, or the work of other trades.

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
1. Conduit routing:
a. Electrical drawings are diagrammatic in nature:
1) Install conduit runs as specified with schematic representation indicated on the Drawings and as specified.
2) Modify conduit runs to suit field conditions, as accepted by the Engineer:
a) Make changes in conduit locations that are consistent with the design intent but are dimensionally different, or routing to bypass obstructions.
b) Make changes in conduit routing due to the relocation of equipment.
c) Install conduits and equipment in such a manner as to avoid obstructions and to preserve headroom and keep openings and passageways clear.

3) Where the Drawings do not indicate the exact mounting and/or supporting method to be used, use materials and methods similar to the mounting details indicated on the Drawings.
4) Electrical drawings do not indicate all required junction boxes and pull boxes:
a) Provide junction boxes and pull boxes to facilitate wire pulling as required:
(1) To meet cable manufacturer's pulling tension requirements.
(2) To limit total conduit bends between pull locations.
b) Install junction boxes and pull boxes at locations acceptable to the Engineer.

b. Contractor is responsible for any deviations in general location, conduit size, routing, or changes to the conduit schedule without the express written approval or direction by the Engineer:
1) Engineer is the sole source in determining whether the change is constituted as a deviation.
2) Perform any changes resulting in additional conduits, or extra work from such deviations.
3) Incorporate any deviations on the Record Documents.

2. Use only tools recommended by the conduit manufacturer for assembling the conduit system.
3. Provide adequate clearances from high-temperature surfaces for conduit runs. Provide minimum clearances as follows:
a. Clearance of 6 inches from surfaces 113 degrees Fahrenheit to 149 degrees Fahrenheit.
b. Clearance of 12 inches from surfaces greater than 149 degrees Fahrenheit.
c. Keep conduits at least 6 inches from the coverings on hot water and steam pipes, 18 inches from the coverings on flues and breechings, and 12 inches from fuel lines and gas lines.
d. Where it is necessary to route conduits close to high-temperature surfaces, provide a high-reflectance thermal barrier between the conduit and the surface.
4. Support conduit runs on water-bearing walls a minimum of 7/8-inch away from wall on an accepted preformed channel:
a. Do not run conduits within water-bearing walls unless otherwise indicated on the Drawings.
5. Do not install 1-inch or larger conduits in or through structural members unless approved by the Engineer.
6. Run conduits exposed to view parallel with or at right angles to structural members, walls, or lines of the building:
a. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends.
b. Make changes in direction with long radius bends or with conduit bodies.
7. Install conduits with total conduit bends between pull locations less than or equal to 270 degrees.
8. Route exposed conduits to preserve headroom, access space and workspace, and to prevent tripping hazards and clearance problems:
a. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and do not block or interfere with ingress or egress, including equipment-removal hatches.

b. Route conduits to avoid drains or other gravity lines. Where conflicts occur, relocate the conduit as required.

9. Conduits may be run in concrete members or slabs with permission of the Engineer or as indicated on the Drawings:
   a. Refer to the typical details for conduit spacing and size requirements.
10. When installing conduits through existing slabs or walls, make provisions for locating any possible conflicting items where the conduit is to penetrate. Use tone signal or X-ray methods to make certain that no penetrations will be made into the existing conduits, piping, cables, post-tensioning cables, etc.
11. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture.
12. Install conduits through wall and floor seals where indicated on the Drawings.
13. For existing and new 2-inch and larger conduit runs, snake conduits with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of the conduit:
    a. Remove and replace conduits through which mandrel will not pass.
14. Provide sleeves and openings required for the passage of electrical raceways or cables even when these openings or sleeves are not specifically indicated on the Drawings.
15. Install complete conduit systems before conductors are installed.
16. Provide metallic conduits terminating in transformer, switchgear, motor control center, or other equipment conduit windows with grounding bushings and ground with a minimum No. 6 AWG ground wire.
17. Underground conduits:
    a. Install underground conduits, including conduit runs below slabs-on-grade in concrete-reinforced duct bank construction:
       1) As specified in Section 16133 - Duct Banks.
    b. Make underground conduit size transitions at handholes and manholes.
    c. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and handholes.
    d. Seal around conduit penetrations of below grade walls with a mechanical seal.
18. Underground conduit trenching:
    a. Perform trenching as specified in Section 02318 - Trenching.
    b. Trench must be uniformly graded with the bottom, rock free and covered with select material.
    c. Damage occurring to existing ducts, conduits, cables, and other utilities during underground conduit installation shall be remediated to the satisfaction of the Owner.
    d. Whenever possible, use the walls of the trench as forms for concrete encasement:
       1) Forms are required where the soil is not self-supporting.

B. Equipment grounding conductors:
   1. Provide a separate, green insulated, grounding conductor in each raceway independent of raceway material:
      a. Multi-conductor power and control cables shall include an integral green insulated grounding conductor.
      b. Provide a separate grounding conductor in each individual raceway for parallel feeders.

2. Conductors shall be the same type and insulation as the circuit conductors:
   a. Use 600-volt insulation for the equipment grounding conductors for medium voltage systems.
3. Minimum size in accordance with the NEC.

C. Lighting and receptacle conduits:
1. Provide conduit runs for lighting and receptacle circuits, whether or not indicated on the Drawings.
2. Install conduits in accordance with the requirements of this Section unless otherwise indicated.
3. Minimum conduit size:
   a. 3/4-inch for exposed conduits.
   b. 1-inch for underground or in-slab conduits.
4. Provide conduit materials for the installed location as specified in Section 16050 - Common Work Results for Electrical.

D. Hazardous areas:
1. As specified in Section 16050 - Common Work Results for Electrical for hazardous areas and specific Class and Division.

E. Conduit usage:
1. Exposed conduits:
   a. Rigid conduit:
      1) Install the rigid conduit type for each location as specified in Section 16050 - Common Work Results for Electrical.
      2) Minimum size: 3/4-inch.
   b. Flexible conduit:
      1) Use flexible conduit for final connections between rigid conduit and motors, vibrating equipment, instruments, control equipment, or where required for equipment servicing:
         a) Use Type SLT with rigid metallic conduit.
         b) Use Type EFLX in Class I Division 1 locations.
      2) Minimum size: 3/4-inch:
         a) 1/2 when required for connection to instruments.
      3) Maximum length:
         a) Fixed equipment:

Conduit Trade Size	Flexible Conduit Length (inch)
3/4	18
1	18
1-1/4	18
1-1/2	18
2	36
2-1/2	36
3	36
3-1/2	38
4	40

b) Removable instruments or hinged equipment:
(1) As required to allow complete removal or full movement without disconnecting or stressing the conduit.

2. Concrete-encased and embedded conduits:
   a. Straight runs and bends less than 45 degrees:
      1) Type PVC Schedule 40.
   b. Bends with total deflection greater than 45 degrees:
      1) PCS.
   c. Entering and exiting duct bank, underground or embedded conduit runs a minimum 12 inches above and below grade, finished floor, or entering equipment:
      1) PCS.
   d. Minimum size:
      1) Two-inch in duct banks.
      2) One-inch for in-slab conduits.
      3) Provide conduit fittings to enlarge the conduit from the exposed size in the conduit schedule as required.
3. Direct-buried and sand-bedded duct bank conduits:
   a. Type PCS.
   b. Minimum size: 1-inch.
4. Concrete capped, pea gravel-bedded duct bank conduits:
   a. Type PVC40.
   b. Minimum size: 1-inch.
5. PVC-coated rigid metallic conduit:
   a. Use specifically manufactured or machined threading dies to manufacturer's specifications to accommodate the PVC jacket.
   b. Repair damage to PVC coatings with manufacturer supplied touchup compound or PVC Coating Repair Kit for PVC Coated Raceway Systems.
6. GRC:
   a. Conduit shall be cut square and reamed before threading.
7. Inner duct (applicable for fiber optic cable only):
   a. Install inner duct in conduits as indicated on the Drawings.
   b. Each inner duct conduit shall be a separate color.

F. Conduit joints and bends:
   1. General:
      a. Where conduit is underground, under slabs on grade, exposed to the weather, or in NEMA Type 4 or NEMA Type 4X locations, make joints liquidtight.
      b. Keep bends and offsets in conduit runs to an absolute minimum.
      c. Bends shall be symmetrical.
      d. For all types of high-voltage conductors, provide bends as required for lead-covered conductors of equivalent outside diameter.
      e. The following conduit systems shall use large-radius sweep elbows:
         1) Underground conduits.
         2) Conduits containing medium-voltage cables.
         3) Conduits containing shielded cables.
         4) Conduits containing fiber optic cables.
      f. Provide large-radius factory-made bends for 1-1/4-inch trade size or larger.

g. Make field bends with a radius of not less than the requirements found in the NEC:
    1) Minimum bending radius of the cable must be less than the radius of the conduit bend.
    2) Make field bends with power bending equipment or manual benders specifically intended for the purpose:
        a) Make bends so that the conduit is not damaged and the internal diameter is not effectively reduced.
        b) For the serving utilities, make bends to meet their requirements.

h. Replace deformed, flattened, or kinked conduit.

2. Threaded conduit:
    a. Cut threads on rigid metallic conduit with a standard conduit-cutting die that provides a 3/4-inch per foot taper and to a length such that bare metal exposed by the threading operation is completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that joints become secure and wrench-tight just preceding the point where the conduit ends would butt together in couplings or where conduit ends would butt into the ends or shoulders of other fittings.
    b. Thoroughly ream conduit after threads have been cut to remove burrs.
    c. Use bushings or conduit fittings at conduit terminations.
    d. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar™," or CRC "Zinc It."
    e. Coat conduit threads with an approved electrically conductive sealant and corrosion inhibitor that is not harmful to the conductor insulation:
        1) Apply to the male threads and tighten joints securely.
        2) Clean excess sealant from exposed threads after assembly.
    f. Securely tighten threaded connections.
    g. Any exposed threaded surfaces must be cleaned and coated with a galvanizing solution so that exposed surfaces have a galvanized protective coating.

3. PVC:
    a. Use approved solvent-weld cement specifically manufactured for the purpose. Spray-type cement is not allowed.
    b. Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required to ensure full inside diameter at bends:
        1) Utilize a heater specifically for PVC conduit as recommended by the conduit manufacturer.

G. Conduit sealing and drainage:
1. Other than required for hazardous and classified areas:
    a. Provide sealing and drainage in vertical drops of long (in excess of 20 feet), exterior, above-grade conduit runs at the points at which the conduit enters buildings, switchgear, control panels, lighting panelboards, and other similar enclosures.
    b. Provide seal fittings with drains in vertical drops directly above grade for exterior and above-grade conduit runs that are extended below grade.
    c. Provide conduit seals with drains in areas of high humidity and rapidly changing temperatures:
        1) Where portions of an interior raceway pass through walls, ceilings, or floors that separate adjacent areas having widely different temperatures.

d. Provide conduit seals similar to O-Z/Gedney (Type CSM) on conduits between corrosive and non-corrosive areas.
e. Seal 1 end only of underground conduits at highest point with O-Z/Gedney sealing (non-hazardous) filling, or equal.

2. Install seals with drains at any location along conduit runs where moisture may condense or accumulate. This requirement includes, but is not limited to, the following locations: Control panels, junction boxes, pullboxes, or low points of the conduit.

H. Hangers and supports:
1. General:
a. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications:
1) As specified in Section 16070 - Hangers and Supports.
2) Provide support materials consistent with the type of conduit being installed as specified in Section 16050 - Common Work Results for Electrical.
b. Support conduit at the intervals required by the NEC.
c. Perforated strap and plumbers' tape are not acceptable for conduit supports.
2. Conduit on concrete or masonry:
a. Use 1-hole malleable iron straps with metallic or plastic expansion anchors and screws or support from preset inserts.
b. Use preset inserts in concrete when possible.
c. Use pipe spacers (clamp backs) in wet locations.
3. Suspended conduit:
a. Use malleable-iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf, or equal.
b. For grouped conduits, construct racks with threaded rods and tiered angle iron or preformed channel cross members. Clamp each conduit individually to a cross member. Where rods are more than 2-feet long, provide rigid sway bracing.
4. Supports at structural steel members:
a. Use beam clamps.
b. Drilling or welding may be used only as specified or with approval of the Engineer.
5. PVC-coated rigid metal systems:
a. Provide right-angle beam clamps and "U" bolts specially formed and sized to snugly fit the outside diameter of the coated conduit. Provide "U" bolts with PVC-encapsulated nuts that cover the exposed portions of the threads.
b. Securely fasten exposed conduits with Type 316 stainless steel clamps or straps.

I. Expansion or expansion/deflection fittings:
   1. General:
      a. Align expansion coupling with the conduit run to prevent binding.
      b. Follow manufacturer's instructions to set the piston opening.
      c. Install expansion fittings across concrete expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction.
      d. Furnish fittings of the same material as the conduit system.
   2. For metallic conduit, provide expansion or expansion/deflection couplings, as appropriate, where:
      a. Install expansion fittings a minimum of every 200 feet in straight conduit runs.

J. Empty conduits:
   1. Provide a pull tape in each empty conduit more than 10 feet in length.
   2. Seal ends of conduits with approved, manufactured conduit seals, caps, or plugs immediately after installation:
      a. Keep ends sealed until immediately before pulling conductors.

K. Miscellaneous:
   1. Seal roof penetrations for raceways and other items that penetrate the roof in accordance with roofing manufacturer's instructions and as indicated on the Drawings.
   2. Provide electrical unions at all points of union between ends of rigid conduit systems that cannot otherwise be coupled:
      a. Running threads and threadless couplings are not allowed.
   3. Replace any conduits installed that the Engineer determines do not meet the requirements of this Specification.
   4. Provide conduit housekeeping curb around embedded or below-grade conduits exiting or entering the slab, in accordance with the Typical Details.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16133

DUCT BANKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Electrical underground duct banks.
   2. Duct bank installation requirements.

1.02 REFERENCES

A. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. PVC conduit spacers.
   2. Detectable underground marking tape.
   3. Pull line.

C. Shop Drawings:
   1. Submit site plan drawings of duct banks including underground profiles indicating underground utilities.
   2. Submit cross section of each duct bank with dimensions.
   3. For duct bank routings crossing under building footers or foundations alternative to designed routings indicated on the Drawings:
      a. Submit Shop Drawings detailing the new building footer crossing locations and plan drawings labeling equipment to be installed on top of the new routing for approval by the Project structural Engineer.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Before performing any trenching locate existing underground utilities.

B. Scheduling:
   1. Schedule a coordination meeting to adjust duct bank configurations and routing for each duct bank section after trenching and exposure of any underground utilities withing the vicinity of the duct bank route. Meeting shall determine the final configuration of the duct bank before installation.

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Duct bank sections indicated on the Drawings are an initial arrangement and may need to be modified due to existing site conditions, existing underground utilities, and infrastructure.
   1. Reorganize duct bank section with approval of the Engineer.
   2. Make changes required to accommodate duct bank configuration and routing changes due to field conditions.
      a. Where changes in a duct bank configuration extend to a manhole or handhole, coordinate manhole/handhole block outs and size with the new configuration.

B. Provide location and protection of existing underground utilities, duct bank, trenching, forming, rebar, spacers, conduit, concrete, backfill, and compaction necessary for the complete installation of the duct banks.

C. Provide reinforced concrete duct banks for conduits installed below grade, on the site, below structures, or in contact with the earth, unless otherwise indicated on the Drawings.

2.03 MANUFACTURERS

A. Conduit spacers:
   1. One of the following or equal:
      a. Cantex.
      b. Osburn Associates, Inc.

B. Detectable underground marking tape:
   1. One of the following or equal:
      a. Blackburn Manufacturing Co.
      b. Panduit.

C. Pull line:
   1. One of the following or equal:
      a. Arnco.
      b. Greenlee.
      c. Osburn Associates, Inc.

D. Duct seal:
   1. The following or equal:
      a. O-Z/Gedney type DUX.

2.04 MATERIALS

A. Provide conduit as specified in Section 16130 - Conduits.

B. Provide reinforcing steel as specified in Section 03200 - Concrete Reinforcing:
   1. Provide minimum Number 4 reinforcing steel.

C. Concrete:
   1. Mix requirements as specified in Section 03300 - Cast-in-Place Concrete.
   2. Provide a red-oxide conduit encasement coloring agent as specified in Section 03300 - Cast-in-Place Concrete.

2.05 MANUFACTURED UNITS

A. Conduit spacers:
   1. Recommended by the conduit manufacturer or specified above.
   2. Saddle type.
   3. Non-metallic, non-corrosive, non-conductive.
   4. Interlocking type:
      a. Vertical interlocking.
      b. Horizontal interlocking.
   5. Suitable for concrete encasement.
   6. Molded-in rebar holder.
   7. Accommodates 2-inch through 6-inch conduit sizes.
   8. Relieves the conduit from both horizontal and vertical stresses.

B. Pull line:
   1. Minimum 1/4-inch wide, flat design.
   2. Polyester.
   3. Minimum pulling strength 1,200 pounds.
   4. Sequential footage markings.

C. Detectable marking tape:
   1. Locatable by a cable or metal detector from above the undisturbed grade.
   2. Aluminum core laminated between polyethylene film.
   3. 6-inch-wide red tape imprinted with black lettering stating “CAUTION - BURIED ELECTRIC LINE BELOW”, or equivalent.

D. Duct seal:
   1. Non-hardening sealing compound.
   2. Flexible, can be applied by hand.

3. UL Listed for use with installed conductors.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Duct banks:
   1. Encased in concrete at least 24 inches below finish grade, unless otherwise indicated on the Drawings.
   2. Damage minimization:
      a. Conduit should not be left exposed in an open trench longer than is necessary.
      b. Protect underground duct banks against damage during pouring of concrete or backfilling.
   3. Plastic conduit fittings to be joined should be exposed to the same temperature conditions for a reasonable length of time before assembly.
   4. Provide No. 4/0 American Wire Gauge bare copper ground wire the entire length of duct bank and bond to the grounding system at each end of the duct bank:
      a. Where duct bank terminates at structures with a grounding electrode, bond duct bank ground wire to the grounding electrode.
      b. Where duct bank terminates at electrical equipment, bond duct bank ground wire to the equipment ground bus.
      c. Where duct bank terminates at structure without either a grounding electrode or electrical equipment, provide ground rod adjacent to structure and bond duct bank ground wire to ground rod.
   5. Install underground ducts to be self-draining:
      a. Slope duct banks away from buildings to manholes, handholes, or pullboxes.
      b. Slope duct banks uniformly from manholes, handholes, or pullboxes to manholes, handholes, or pullboxes or both ways from high points between manholes, handholes, or pullboxes.
      c. Slope a minimum of 1/4 inch per 10 feet.
   6. Where new duct banks join to existing manholes, handholes, or pullboxes, make the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions, as indicated on the Drawings.
   7. Install pull line in spare conduits:
      a. Provide adequate pull line at both ends of conduits to facilitate conductor pulling.
      b. Cap above ground spare conduit risers at each end with screw-on conduit caps.

B. Trenching:
   1. Perform as specified in Section 02318 - Trenching.
   2. Trench must be uniformly graded with the bottom rock free and covered with select material.

3. Whenever possible, use the walls of the trench as forms for concrete encasement:
    a. Forms are required where the soil is not self-supporting.
4. Damage occurring to existing ducts, conduits, cables, and other utilities during duct bank installation shall be remediated to the satisfaction of the Owner.

C. Duct spacing:
1. Separate conduits with manufactured plastic spacers using a minimum space between the outside surfaces of adjacent conduits of 2 inches, 3 inches for medium voltage conduits 4-inch and smaller, unless otherwise indicated on the Drawings:
    a. Separate medium voltage ducts a minimum of 7.5 inches on center.
2. Install spacers to maintain uniform spacing of duct assembly a minimum of 4 inches above the bottom of the trench during concrete pour. Install spacers on 8-foot maximum intervals:
    a. Due to some distortion of conduit from heat, and other means, it may be necessary to install extra spacers within the duct bank:
        1) Install the intermediate set of spacers within normal required spacing to maintain the proper horizontal clearance:
            a) Clearance is required to allow the proper amount of concrete to infiltrate vertically among the duct to ensure proper protection.
3. Spacers shall not be located at the center of a bend:
    a. Locate spacer in the tangent, free of the coupling on fabricated bends.
    b. Locate spacers midway between the tangent and the center bend on trench formed sweeps.

D. Terminating:
1. Use bell ends in duct at entrances into cable vaults.
2. Make conduit entrances into cable vaults tangential to walls of cable vault.
3. Form trapezoidal transitions between duct bank and cable vaults as needed in order to ensure adequate cable bending radius for the duct bank-to-vault transition.
4. Install duct seal in all conduits, including spare conduits, at entrance to manholes/handholes, and building/equipment stub-ups. Form by hand to conduit and around cables to develop moisture barrier.
5. New manhole or handhole applications, provide a single opening or “window” per duct bank, sized to accommodate the duct bank envelope.

E. Concrete:
1. Install concrete as specified in Section 03300 - Cast-in-Place Concrete.
2. Provide tie wires as specified in Section 03200 - Concrete Reinforcing to prevent displacement of the conduits during pouring of concrete:
    a. Tie wire shall not act as a substitute for spacers.
3. Install minimum 3-inch cover around conduit and rebar.
4. Consolidation of encasement concrete around duct banks shall be by hand puddling. Mechanical vibrators are acceptable for use outside of the rebar cage.
5. Conduit is subject to temperature rise. As concrete cures, allow the free end to expand by pouring the concrete from the center of the run or from one tie in point.

F. Marking tape:
   1. Install a detectable marking tape 12 inches above the duct bank the entire length of the duct bank.

G. For conduit installations beneath building slabs:
   1. Duct banks shall be continued under building slabs to the final destination of the conduits.
      a. Construct separate duct banks as required.
      b. Concrete for encasement under building slabs need not be colored red.
      c. For duct banks crossing under building footers or foundations, install the top of the duct bank a minimum of 12inches below the footer.
      d. Where duct banks enter through building walls, foundation walls, stem walls, etc., make connections as indicated on the Drawings.
      e. Where duct banks terminate with conduit risers entering building walls, install an expansion/deflection fitting or a flat-wise elbow (elbow parallel to building wall) in order to accommodate differential movement between the conduits and structure.

H. Restore surfaces to their original condition as specified in Section 02952 - Pavement Restoration and Rehabilitation unless otherwise specified.

I. Marking piers:
   1. Provide permanent concrete cylinder marking piers, on grade, centered on duct bank and located at every bend in duct bank or wherever duct bank enters a building, vault, or other structure:
      a. Provide a cylinder, 6 inches in diameter:
         1) Top of cylinder 1/2 inch below the top of finished grade.
      b. Provide a 3-inch high “E” embossed in top of cylinder:
         1) Minimum of 2 inches deep.
      c. Provide 2-inch arrows embossed in top of cylinder showing the direction of the duct bank:
         1) Minimum of 2 inches deep.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

3.05 FIELD QUALITY CONTROL (NOT USED)

3.06 ADJUSTING (NOT USED)

3.07 CLEANING

A. Clean conduits of dirt and debris by use of an appropriately sized steel mandrel no less than 1/2 inch smaller than the inside diameter of the conduit.

3.08 PROTECTION

A. Provide shoring and pumping to protect the excavation and safety of workers.

B. Protect excavations with barricades as required by applicable safety regulations.

END OF SECTION

SECTION 16134

BOXES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Device boxes.
   2. Raceway system boxes.

1.02 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. Standard Specifications for Highway Bridges.

B. ASTM International (ASTM):
   1. A47 - Standard Specification for Ferritic Malleable Iron Castings.

C. Joint Industry Conference (JIC).

D. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

E. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).

F. Underwriters Laboratories, Inc. (UL).

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Arcing parts: Circuit breakers, motor controllers, switches, fuses, or any device intended to interrupt current during its operation.
   2. Raceway system boxes: Boxes that are used for wire and cable pullboxes, conduit junction boxes, or terminal boxes.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Manufacturer.
   2. Materials.
   3. Dimensions:
      a. Height.

b. Width.
c. Depth.
d. Weight.
e. NEMA rating.
4. Conduit entry locations.
5. Catalog cutsheets.
6. Installation instructions.

C. Shop Drawings:
1. Include identification and sizes of pullboxes.

1.06 QUALITY ASSURANCE

A. Regulatory requirements:
1. Outlet boxes shall comply with applicable standards of:
a. JIC.
b. NEC.
c. NEMA.
d. UL.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide outlet boxes for wiring devices, security systems, junction, and pullboxes for use in the raceway systems, etc.

B. Provide boxes as indicated on the Drawings or as needed to complete the raceway installation.

C. Size pullboxes in accordance with NEC requirements and to provide sufficient room for any future conduits, components, and cables as indicated on the Drawings.

D. Provide materials and construction suitable for environmental conditions at the location of the box as specified in Section 16050 - Common Work Results for Electrical.

E. For boxes not indicated:
   1. Provide types and mountings as required to suit the equipment and that will be consistent with the conduit system and environmental conditions as indicated in Section 16050 - Common Work Results for Electrical.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Pressed steel boxes and concrete boxes:
      a. ABB
      b. Appleton.
      c. Crouse - Hinds.
   2. Plastic coated boxes:
      a. OCAL.
      b. Rob Roy.
   3. Cast device boxes:
      a. Appleton.
      b. Crouse - Hinds.
      c. O-Z/Gedney.
   4. Explosionproof enclosures:
      a. Adalet.
      b. Crouse-Hinds.
      c. O-Z/Gedney.
   5. Formed steel enclosures:
      a. Hoffman.
      b. Rittal
      c. Stahlin.
   6. Stainless steel enclosures:
      a. Hoffman.
      b. Rittal.
      c. Stahlin.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Pressed steel boxes:
   1. 1-piece galvanized pressed steel.
   2. Knockout type boxes.
   3. Minimum size 4-inch square by 2-1/8-inch deep.

B. Cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Tapered threaded hubs with integral bushing.
   2. Malleable iron boxes:
      a. In accordance with ASTM A47 Grade 32510.

C. Plastic coated cast device boxes:
   1. Construction:
      a. With internal green ground screw.
      b. Furnished with a suitable gasketed cover.
      c. With integral cast mounting lugs when surface mounted.
      d. Conduit sizes range from 3/4 inch to 1 inch.
      e. Double coated with a nominal 0.002-inch (2 mil) urethane on both the interior and exterior before application of PVC coating.
      f. With a minimum 0.040-inch (40 mil) PVC coating bonded to exterior.
      g. With pressure sealing sleeve to protect the connection with conduit.

D. Explosionproof enclosures:
   1. Dual rated NEMA Type 9 and NEMA Type 4X.
   2. Cast iron box and cover.
   3. Precision machined flame path between box and cover with O-ring.
   4. Cast-in-place or bolt-on stainless steel slotted mounting feet for horizontal or vertical mounting.
   5. For applications requiring hinged cover, provide flexible hinge mounting either left or right side.
   6. External flange.
   7. Provisions for mounting pan.
   8. Stainless steel cover bolts and hardware.
   9. Ground lug.

E. Formed steel enclosures:
   1. Steel:
      a. NEMA Type 12.
      b. Fabricated from 14-gauge steel, minimum.
      c. Seams continuously welded ground smooth.
      d. Door:
         1) Rolled lip around 3 sides.
         2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
      e. Neoprene door gasket to provide a watertight, dusttight, oiltight seal:
         1) Attached with an adhesive.
         2) Retained by a retaining strip.
      f. Fabricate external removable hardware for clamping the door to the enclosure body from zinc-plated heavy gauge steel:
         1) With a hasp and staple for padlocking.
      g. Provide large enclosures with door and body stiffeners for extra rigidity.
      h. No holes or knockouts.
      i. Finish:
         1) ANSI 61 gray electrostatically applied polyester powder inside and out over cleaned and primed surfaces.
         2) White electrostatically applied polyester powder mounting plate.
      j. Heavy gauge steel external mounting brackets when surface mounted.
   2. Stainless steel:
      a. NEMA Type 4X:
         1) Boxes in locations subject to flooding or temporary submersion:
            a) NEMA Type 6.
      b. Fabricated from 14-gauge Type 316 stainless steel.

c. Seams continuously welded.
d. Door:
    1) Rolled lip around 3 sides.
    2) Attached to enclosure by means of a continuous stainless steel hinge and pin.
e. Neoprene door gasket to provide a watertight seal:
    1) Attached with an adhesive.
    2) Retained by a retaining strip.
f. Fabricate external removable hardware for clamping the door to the enclosure body from heavy gauge stainless steel:
    1) With a hasp and staple for padlocking.
g. Provide large enclosures with door and body stiffeners for extra rigidity.
h. No holes or knockouts.
i. Finish:
    1) Brushed.
j. Stainless steel external mounting brackets when surface mounted.

F. Cast iron junction boxes:
1. NEMA Type 4.
2. Recessed cover boxes.
3. Suitable for use outdoors where subject to rain, dripping, or splashing water.
4. Designed for flush mounting in walls or floors:
    a. Can be surface mounted using mounting lugs.
5. Construction:
    a. Cast iron box.
    b. Covers:
        1) Checkered plate covers suitable for foot traffic.
        2) When used in areas subject to vehicular traffic, design to support an AASHTO Standard Specifications for Highway Bridges, H-20 vehicle loading.
    c. Hot dip galvanized.
    d. Neoprene gasket.
    e. Stainless steel screw covers.

2.06 EQUIPMENT (NOT USED)

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Fasteners:
1. Electroplated or stainless steel in boxes with wiring devices.
2. Screws, nuts, bolts, and other threaded fasteners:
    a. Stainless steel.

B. Provide breather and drain fittings where appropriate.

C. Internal panels:
1. Provide internal panels where required for mounting of terminal strips or other equipment.
2. With plated steel shoulder studs.

3. Steel with white polyester powder finish.

D. Floor stand kit when shown:
   1. Fabricated from 12-gauge steel.
   2. Bottom plate 11-gauge.
   3. Heights:
      a. 12 inches.
   4. Do not provide external mounting brackets, when a floor stand kit is used.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. General:
   1. Provide outlet box materials to match the conduit system:
      a. GRC - Cast ferrous boxes.
      b. PCS - PVC coated cast ferrous boxes.
   2. Solid type gang boxes:
      a. For more than 2 wiring devices.
      b. For barriered outlets.
   3. Support wall mounted NEMA Type 4 or NEMA Type 4X boxes to maintain a minimum of 7/8-inch free air space between the back of the enclosure and the wall:
      a. Use machined spacers to maintain air space; built-up washers are not acceptable.
      b. Use stainless steel or nylon materials for spacers.
   4. Use cast malleable iron boxes when box must support other devices.
   5. Boxes serving luminaires or wiring devices:
      a. Use as pullboxes wherever possible.
   6. Fit cast boxes and pressed steel boxes for flush mounting in concrete with cast, malleable box covers and gaskets.
   7. In terminal boxes, furnish terminals as indicated on the Drawings with a minimum of 50 percent spare terminals:
      a. Furnish wireways for discrete and analog/DC wiring.
      b. Separate analog wiring from 120 V discrete or power wiring.
   8. For fire-rated construction, provide materials and installation for use in accordance with the listing requirements of the classified construction.

B. Outlet boxes:
   1. Locate outlet boxes as indicated on the Drawings:
      a. Adjust locations so as not to conflict with structural requirements or other trades.
   2. Use deep threaded-hub malleable iron boxes:
      a. In hazardous areas.
      b. Where exposed to the weather.
      c. In unheated areas.

d. Where subject to mechanical damage:
    1) Defined as exposed boxes less than 10 feet above the floor.
e. To act as a pullbox for conductors in a conduit system.
f. Accommodate wiring devices.

3. Use deep threaded-hub plastic coated malleable iron boxes in corrosive and NEMA Type 4X area and when the exposed conduit system is PVC coated steel.
4. Outlet boxes may be used as junction boxes wherever possible.

C. Pullboxes and junction boxes:
1. Install pullboxes such that access to them is not restricted.
2. Outlet, switch, and junction boxes for flush mounting in general purpose locations:
    a. One-piece, galvanized, pressed steel.
3. Outlet, switch, and junction boxes where surface mounted in exposed locations:
    a. Cast ferrous boxes with mounting lugs, zinc or cadmium plating finish.
4. Outlet, control station, and junction boxes for installation in corrosive locations:
    a. Fiberglass reinforced polyester, stainless steel, or plastic-coated steel to match the conduit system.
    b. Furnished with mounting lugs.
5. Fire rated construction: Use materials and methods to comply with the listing requirements for the classified construction.

D. Recessed boxes:
1. Support recessed boxes in suspended ceilings or stud partitions with galvanized steel box hangers of types made specifically for the purpose or attach directly to wood members or blocking.
2. Secure hangers or boxes to wood with 1-inch-long cadmium-plated Type A pan head screws:
    a. Fully or partially hammer-driven screws are not acceptable.

E. Hazardous locations:
1. Class II Division 1 areas:
    a. Provide boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
        1) Approval ratings must be permanently marked on each item.
2. Class II Division 2 areas:
    a. For boxes not containing arcing parts:
        1) As specified in Section 16050 - Common Work Results for Electrical.
        2) Pressed metal boxes are not allowed.
    b. For boxes containing arching parts provide:
        1) Boxes designed and listed for Class I Division 1 locations and group type atmosphere in which they will be used:
            a) Approval ratings must be permanently marked on each item.
3. Metallic boxes, fittings, and joints shall utilize threaded connections to the conduit system.
4. Threaded connections shall be wrench tightened so that at least 5 threads are fully engaged.
5. Conduits entering and exiting metallic boxes in Class II Division 2 areas shall utilize approved grounding bushings to bond the conduits together.

6. Provide the following types of conduit bodies and boxes:
    a. Malleable iron bodies and boxes with GRC or IMC conduit systems.
    b. PVC coated conduit bodies and boxes with PCS conduit systems.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Switches.
   2. Receptacles.
   3. Plates.

1.02 REFERENCES

A. Federal Specifications (FS):
   1. W-C 596 - Connector, Electrical, Power, General Specification for.
   2. W-S 896/2 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).

B. National Electrical Manufacturers Association (NEMA):
   1. 250 - Enclosures for Electrical Equipment (1,000 V Maximum).

C. Telecommunications Industry Association (TIA):
   1. T568A - Eight-position jack pin/pair assignment.
   2. T568B - Optional eight-position jack pin/pair assignment.

D. Underwriters Laboratories, Inc. (UL):
   1. 20 - General Use Snap Switches.
   2. 498 - Standard for Attachment Plugs and Receptacles.
   3. 943 - Ground-Fault Circuit-Interrupters.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. GFCI: Ground fault circuit interrupter.

1.04 DELEGATED DESIGN (NOT USED)

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.

C. Shop Drawings:
   1. Engraving schedule:
      a. Furnish complete engraving schedule for engraved nameplates.

1.06 QUALITY ASSURANCE

A. Wiring devices shall be UL listed and labeled.

1.07 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Switches, receptacles, and plates as indicated on the Drawings, wired and operable to form a complete system.

2.03 MANUFACTURERS

A. Switches:
   1. One of the following or equal:
      a. Cooper Wiring Devices.
      b. Hubbell.
      c. Leviton.
   2. Switches for hazardous areas:
      a. One of the following or equal:
         1) Appleton.
         2) Crouse-Hinds.
   3. Occupancy sensor switches:
      a. One of the following or equal:
         1) Cooper Wiring Devices.
         2) WattStopper.
   4. Dimmer switches:
      a. One of the following or equal:
         1) Cooper Wiring Devices.
         2) Lutron.

B. Receptacles:
   1. General purpose:
      a. One of the following or equal:
         1) Cooper Wiring Devices.
         2) Hubbell.

3) Leviton.
2. Hazardous areas:
a. One of the following or equal:
1) Appleton.
2) Crouse-Hinds.

C. Plates:
1. General location:
a. One of the following or equal:
1) Cooper Wiring Devices.
2) Legrand.
2. Wet or corrosive areas:
a. One of the following or equal:
1) ABB.
2) Cooper Wiring Devices.
3) Hubbell.
4) Pass and Seymour.
3. In-use covers:
a. One of the following or equal:
1) ABB.
2) Cooper Wiring Devices.
3) Pass and Seymour.
4) TayMac.

D. Data and communications jacks:
1. Network jacks:
a. One of the following or equal:
1) Belden; REVConnect Connectivity System.
2) Hubbell.
3) Leviton; Quickport series.
4) Panduit.
2. Wall plates:
a. One of the following or equal:
1) Belden; REVConnect Connectivity System.
2) Leviton; Quickport series.
3) Optical Cable Corporation (OCC).
4) Panduit.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS

A. Switches:
1. General:
a. 120 to 277 VAC.
b. 20-amp.
c. Listed in accordance with UL 20.
d. Designed and constructed in accordance with FS W-S-896/2.
e. Back and side wired unless otherwise indicated.
f. Integral grounding terminal.

g. Totally enclosed:
1) Color-coded body with color corresponding to amp rating.
h. Provide switches with the operator style and contact arrangement as indicated on the Drawings and as required for proper operation.
i. Color:
1) White in finished areas.
2) White in all other areas.

2. General purpose switches:
a. Toggle type.

3. Switches for office areas:
a. Rocker type.
b. Rectangular.

4. Switches for use with photocell:
a. Maintained contact.
b. 2 circuit.
c. 3 position:
1) Center off.

5. Switches for hazardous areas:
a. Suitable for use in Class II Division 1 and Class II Division 2 locations.
b. Factory sealed.
c. Through-feed or dead-end as required.

6. Occupancy sensor switches:
a. Wall switch with dual-technology passive infrared and ultrasonic sensor.
1) Configured such that lights turn on only when both infrared and ultrasonic sensors detect activity, but do not turn off as long as either sensor detects activity.
b. Selectable “automatic-on” mode activated by sensors or “manual-on” mode activated by pushbutton.
c. Adjustable 5- to 30-minute time delay.
d. Selectable audible alert as a warning before lights turn off.
e. Rated for fluorescent lighting loads of up to 800 W.
f. True multi-way switching allowing identical controls at any location for multi-way switching applications.

7. Dimmer switches:
a. Shall be rectangular design with LED light level indicators.
b. Suitable for use with type of lamp switched.

B. Receptacles:
1. General purpose receptacles:
a. Single or duplex as indicated on the Drawings.
b. 125 VAC.
c. 20 amp or as indicated on the Drawings.
d. NEMA Type 5-20R configuration for 20 amp receptacles.
e. Other NEMA configurations as indicated on the Drawings.
f. Listed in accordance with UL 498.
g. Designed and constructed in accordance with FS W-C-596.
h. Back and side wired.
i. 1-piece, rivet-less mounting strap.
j. Color:
1) White in finished areas.
2) White in all other areas.

3) Red when powered by a UPS.

2. Ground fault interrupter receptacles (GFCI):
   a. 125 VAC.
   b. 20 amp.
   c. Trip level 4 to 6 mA.
   d. Individual and feed through protection.
   e. UL 943 and UL 498 listed.
   f. NEMA Type 5-20R configuration.
   g. For damp or wet locations:
      1) Weather resistant, in accordance with UL 498.
3. Receptacles for hazardous areas:
   a. 125 VAC.
   b. 20 amp.
   c. Factory sealed.
   d. Single receptacle.
   e. 2-wire, 3-pole.
   f. Grounded through extra pole and shell.
   g. Dead-front construction.
   h. Interlocked to prevent plug from being withdrawn until circuit has been broken.

C. Plates:
1. General location:
   a. Type 302 or 304 stainless steel.
   b. Brushed satin finish.
   c. Minimum thickness: 0.032 inches.
   d. Rectangular or square shape.
   e. Engraving:
      1) Engrave each switch plate with the following:
         a) Area served.
         b) Panelboard and Circuit.
      2) Engrave each receptacle plate with the following:
         a) Panelboard and Circuit.
      3) Treat engraving to improve visibility.
      4) Characters shall be block letter pantograph engraved with a minimum character height of 1/8-inch.
   f. Coordinate the number of gangs, number, and type of openings with the specific location.
2. Outdoor and wet areas requiring NEMA Type 4 or NEMA Type 4X enclosures:
   a. General:
      1) UL listed for wet locations.
      2) Gasketed.
      3) Die cast metal:
         a) Match material to box material.
   b. Switches:
      1) Lever operated:
         a) Provide toggle switch.
   c. Receptacles:
      1) Weatherproof in-use cover:
         a) Die cast metal construction with electrostatic powder coating for corrosion resistance.

b) Gasketed.
c) Lockable.
d) UL listed and in accordance with NEC.

3. Corrosive areas:
   a. Neoprene.
   b. Gasketed.
   c. Weatherproof.

D. Data and communications jacks:
   1. Process network jacks - conduit body mounted:
      a. Network jacks located in process areas shall have a NEMA Type 4 rating (with closure cap).
      b. Mounting of network jacks in conduit bodies adapter (with minifast connector) shall be accomplished using conduit body insert and environmental enclosure caps.
      c. PC board connections are not to be allowed.
      d. Furnish 10 RJ-45 to minifast connector patch cable 3 feet in length.
      e. Manufacturers: The following or equal:
         1) InterlinkBT.
   2. Network/phone jacks:
      a. Meets or exceeds TIA standards for the Category of Ethernet cable connected.
      b. Accommodates TIA T568A and TIA T568B wiring schemes.
      c. UL listed or rated.
      d. Provide different colors for each network unless otherwise indicated on the Drawings.
      e. Power over Ethernet up to 100 watts.
      f. Interchangeable icons to identify function.
      g. Shall comply with NEC requirements.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Mounting heights:
   1. Process and production areas:
      a. Switches and receptacles 48 inches from finished floor to top of plate.
   2. Offices and finished areas:
      a. Switches: 48 inches from finished floor to top of plate.
      b. Receptacles: 18 inches from finished floor to center of plate.

B. Switches:
   1. Over 300 volts:
      a. Where switches used in systems of more than 300 volts between conductors, are to be ganged in outlet boxes, provide switches having no exposed live parts or use barriers between the individual switches.

2. Terminate wires under back wire clamps. Do not wrap wires around the screws.

C. Receptacles:
   1. Provide GFCI receptacles as indicated on the Drawings.
      a. Provide weather resistant GFCI receptacles in wet or damp areas.
   2. Mount receptacles vertically:
      a. Ground slot down.
   3. 3-phase receptacles shall be consistent with respect to phase connection at the receptacle terminals. Correct errors in phasing at the source and not the receptacle.
   4. Terminate wires under back wire clamps. Do not wrap wires around the screws.

D. Ensure plates make a firm seal with wall for recessed mounted devices:
   1. Outside edges of plates parallel with building lines.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16150

LOW VOLTAGE WIRE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Wire connecting devices.
   2. Terminations.
   3. Splices.
   4. Power distribution blocks.

1.02 REFERENCES

A. ASTM International (ASTM):
   1. D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.

B. CSA International (CSA):
   1. C22.2 - No. 197-M1983 (R2208) - PVC Insulating Tape.

C. Underwriters Laboratories, Inc. (UL):
   1. 486A-B - Standard of Safety for Wire Connectors.
   2. 510 - Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   3. 1953 - Outline of Investigation for Power Distribution Blocks.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.

1.05 QUALITY ASSURANCE

A. Materials shall be UL listed.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Conduct the initial fault current study as specified in Section 16305 - Electrical System Studies and submit results for the Engineer's review.
   2. After successful review of the initial fault current study, submit complete equipment submittal.

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide a complete system of wiring connectors, terminators, fittings, etc., for a complete wiring system suitable for the cables and conductors used.

2.03 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Control connections:
   1. Use insulated ring type wire terminators for connections to screw terminals:
      a. With chamfered/funneled terminal barrel entry.
      b. Deep internal serrations.
      c. Long barrel design to reduce electrical resistance and increased insulator-barrel surface area to ensure that the insulator remains in contact with the barrel.
      d. Electroplated-tin copper conductor.
      e. Manufacturers: The following or equal:
         1) ABB, Sta-Kon.
   2. For process equipment connections, work from manufacturer's drawings.

B. Joints, splices, taps, connections, and terminations:
   1. 600-volt conductors:
      a. Use solderless connectors.
      b. Copper pigtail adaptors.
         1) For use on select applications as approved by the Engineer.
         2) 600 volt, 90 degrees Celsius rated.

3) UL 486A/B listed.
4) Manufacturers: The following or equal:
a) Burndy APY series.
b) ILSCO CPM series.

c. Use only plated copper alloy connectors or lugs:
1) Aluminum connectors or lugs are not acceptable for copper conductors.

d. Under those specific conditions where aluminum conductors have been allowed or are specified then the connectors for aluminum conductors shall be specifically designed for that purpose.

e. For wire Number 10 AWG and smaller, use compression splice caps, with insulating caps:
1) Manufacturers: The following or equal:
a) Buchanan, 2006S or 2011S, with 2007 or 2014 insulating caps.

f. For wire Number 8 AWG and larger, use heavy duty copper compression connectors:
1) Manufacturers: One of the following or equal:
a) ABB.
b) Burndy.

g. Heat shrink tubing:
1) Suitable for indoors, outdoors, overhead, direct burial or submerged applications.
2) Minimum shrink ratio: 4 to 1.
3) Continuous operating temperature: -55 degrees Celsius to 110 degrees Celsius.
4) Internally applied adhesive sealant.
5) Cross-linked polyolefin:
a) Manufacturers: One of the following or equal:
(1) 3M, ITCSN.
(2) ABB, Shrink-Kon.

2. Instrumentation class cable splices:
a. Suitable for indoor, outdoors, weather exposed, direct buried, or submersed applications.
b. Utilizing an epoxy, polyurethane, and re-enterable compounds.
c. For use with shielded or unshielded plastic- and rubber-jacketed, signal, control, and power cables rated up to 1 kilovolt.
d. Two-part mold body with tongue and groove seams and built-in spacer webbing.
e. Manufacturers: The following or equal:
1) 3M, Scotchcast 72-N.

C. Insulating tape:
1. General purpose insulating tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application in an ambient of -18 degrees Celsius (0 degrees Fahrenheit).
c. Operating range up to 105 degrees Celsius (220 degrees Fahrenheit).
d. Flame retardant, hot- and cold-weather resistant, UV resistant.
e. For use as a primary insulation for wire cable splices up to 600 VAC.
f. Meeting and complying with:
1) ASTM D3005 Type I.

2) UL 510.
3) CSA C22.2.

g. Manufacturers: The following or equal:
1) 3M, Scotch Number Super 33+.

2. General purpose color-coding tape:
a. Minimum 7 mil vinyl tape.
b. Suitable for application on PVC and polyethylene jacketed cables.
c. For use indoors and outdoors in weather protected enclosures.
d. Available with the following colors:
1) Red.
2) Yellow.
3) Blue.
4) Brown.
5) Gray.
6) White.
7) Green.
8) Orange.
9) Violet.
e. For use as phase identification, marking, insulating, and harnessing.
f. Meeting and complying with:
1) UL 510.
2) CSA C22.2.
g. Manufacturers: The following or equal:
1) 3M, Scotch Number 35.

D. Power distribution blocks:
1. UL 1953 listed.
2. Short circuit rating: Not less than the system maximum available fault current at the point of application.
3. Provide fuses or circuit breakers in enclosure as required to meet the fault current requirements.
4. Voltage rating: 600 VAC.
5. IP 20 finger safe enclosure.
6. Tin-plated aluminum or copper terminals suitable for copper conductors.
7. Manufacturers: One of the following or equal:
a. Eaton CHDB series.
b. Rockwell Automation 1492 PD series.
c. Schneider Electric LB series.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Load connections:
1. Connect loads to the circuits as indicated. Color-code branch circuits as specified in Section 16123 - 600-Volt or Less Wires and Cables.

B. Zero to 600-volt systems:
   1. Make connections with the proper tool and die as specified by the device manufacturer.
   2. Use only tooling and dies manufactured by the device manufacturer.
   3. Insulate connections and splices with Scotch 33+ tape and Scotchfill, or pre-molded plastic covers, or heat shrink tubing and caps.
   4. Number power and control wires before termination.

C. Motor connections (600 volts and below):
   1. Terminate leads and wires with compression type ring lugs.
   2. Terminations on motor leads, including leads that are connected together to accommodate the motor voltage, and the machine wires entering the motor terminal box from the power source, shall have ring type compression lugs.
   3. Cover bolted connectors with a heat shrinkable, cross-linked polyolefin material formed as a single opening boot:
      a. In damp and wet locations, use a complete kit containing mastic that shall seal out moisture and contamination.
      b. Shrink cap with low heat as recommended by the manufacturer.
   4. Wire markers shall be readable after boot installation.
   5. Manufacturers: The following or equal:
      a. Raychem, MCK.

D. Power distribution terminal blocks:
   1. Connect fuses or circuit breakers on the line side of power distribution terminal blocks as required to meet short circuit requirements.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16151

MEDIUM VOLTAGE CABLE CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Terminations.
   2. Splices.
   3. Junctions.

1.02 REFERENCES

A. Abbreviations:
   1. BIL - Basic insulation level.

B. Standards:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. 48 - IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.
      b. 386 - Standard for Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV.
      c. 404 - IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV.
   2. Underwriters Laboratories, Inc. (UL).

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Catalog cutsheets.
   2. Installation instructions.
   3. Medium voltage systems:
      a. Documentation demonstrating compliance with the required tests.
      b. Characteristics and installation procedures for splices, terminators, and junction modules.

C. Shop Drawings:
   1. Showing the installation of splices, terminators, and junction modules.

D. Operation and maintenance manuals:
   1. Drawings and data for medium voltage cable connectors, splices, terminators, and junction modules.

1.05 QUALITY ASSURANCE

A. Materials shall be UL listed where applicable.

1.06 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide a complete system of cables, connectors, terminators, fittings, etc., for a complete cabling system suitable for the cables and conductors used.

2.03 MANUFACTURERS

A. Manufacturers for each type of technology are specified with the equipment in this Section.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Tape:
   1. Fire and electric arc proofing tape:
      a. Minimum 30-mil, flexible, elastomer tape that expands in fire to form an insulating firewall between flame and cable.
      b. Bind in place with glass cloth electrical tape.
      c. Manufacturers: The following or equal:
         1) 3M, Scotch Number 77.
   2. Glass cloth electrical tape:
      a. Thermosetting, 7.4-mil silicone adhesive that performs at Class H temperatures 180 degrees Celsius (356 degrees Fahrenheit).

b. Use for the following applications:
    1) To secure non-PSA insulations such as glass in high-temperature areas.
    2) Splice wire rated at 150 degrees Celsius, 180 degrees Celsius, and 200 degrees Celsius.
    3) For binding fire and electric arc proofing tape.
c. Meeting and complying with:
    1) UL recognized component listing for 200 degrees Celsius (Guide OANZ2, File E17385).
d. Manufacturers: The following or equal:
    1) 3M, Scotch Number 69.

3. Self-fusing silicone rubber tape:
    a. High-temperature, 12-mil, track resistant, insulating tape.
    b. Composed of fully cured inorganic silicone rubber.
    c. Use as a protective overwrap for terminating medium voltage cables.
    d. Manufacturers: The following or equal:
        1) 3M, Scotch Number 70.

B. Lugs:
1. Tin-plated copper.
2. Compression type.
3. 2-hole blade.
4. UL listed.

C. Cable splices and terminations:
1. Cold shrink splices:
    a. Permanent in-line cold shrink splice.
    b. Suitable for submersible, direct burial applications.
    c. Splice body shall be a pre-expanded one-piece molded cold shrink design of silicone rubber with spiral holdout. Splice shall be covered with a cold shrink jacket tube made of EPDM rubber for physical protection.
    d. Electrical requirements:
        1) Continuous current rating equal to cable.
        2) 5 to 8 kV voltage class:
            a) Voltage rating phase-ground: 4.6 kV-rms.
            b) Minimum partial discharge voltage (less than 3 pC): 7 kV-rms.
            c) AC withstand, 1 minute: 23 kV-rms.
            d) AC withstand, 5 minutes: 21 kV-rms.
            e) AC withstand, 5 hours: 16 kV-rms.
            f) DC withstand, 15 minutes: 45 kV.
            g) Impulse withstand, 1.2 by 50 microseconds: 95 kV (crest).
        3) 15 kV voltage class:
            a) Voltage rating phase-ground: 8.7 kV-rms.
            b) Minimum partial discharge voltage (less than 3 pC): 13 kV-rms.
            c) AC withstand, 1 minute: 35 kV-rms.
            d) AC withstand, 5 minutes: 39 kV-rms.
            e) AC withstand, 5 hours: 31 kV-rms.
            f) DC withstand, 15 minutes: 70 kV.
            g) Impulse withstand, 1.2 by 50 microseconds: 110 kV (crest).
    e. Power cable splices for shielded solid dielectric plastic-insulated cables shall utilize factory-engineered kits containing necessary components to

maintain primary cable insulation level and metallic shielding/grounding systems.

f. Splice shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the splice shall be capable of passing the electrical test in accordance with:
   1) IEEE 48.
   2) IEEE 404.

g. Manufacturers: One of the following or equal:
   1) 3M.
   2) Prysmian Group.
   3) TE Connectivity/Raychem.

2. Live front terminators (cold shrink):
   a. Terminators for shielded solid dielectric plastic-insulated cables shall utilize factory-engineered kits containing necessary components to terminate the primary cables and shield systems.
   b. All locations exterior of buildings shall be considered outdoors, and appropriate heat-shrinkable skirts of a non-tracking material shall be installed.
   c. Of a material that will relieve the voltage stresses at the point of termination.
   d. Non-tracking.
   e. Ultraviolet resistant.
   f. Terminator insulation shall be of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system.
   g. Electrical requirements:
      1) Continuous current rating equal to cable.
      2) 5 to 8 kV voltage class:
         a) Minimum partial discharge voltage (less than 3 pC) 9 kV.
         b) AC withstand, 1 minute: 35 kV.
         c) DC withstand, 15 minutes: 65 kV.
         d) Impulse withstand, 1.2 by 50 microseconds (outdoor): 95 kV (crest).
         e) Impulse withstand, 1.2 by 50 microseconds (indoor): 80 kV (crest).
         f) Wet withstand, 10 seconds: 30 kV rms.
         g) Dry withstand, 6 hours: 25 kV rms.
      3) 15 kV voltage class:
         a) Minimum partial discharge voltage (less than 3 pC) 13 kV.
         b) AC withstand, 1 minute: 50 kV.
         c) DC withstand, 15 minutes: 75 kV.
         d) Impulse withstand, 1.2 by 50 microseconds (outdoor): 110 kV (crest).
         e) Impulse withstand, 1.2 by 50 microseconds (indoor): 95 kV (crest).
         f) Wet withstand, 10 seconds: 45 kV rms.
         g) Dry withstand, 6 hours: 35 kV rms.
   h. Terminator kit shall accommodate a range of cable sizes and be completely independent of cable manufacturer's tolerances. When assembled on cables the terminator shall be capable of passing the electrical test in accordance with:
      1) IEEE 48.

i. Manufacturers: One of the following or equal:
    1) 3M.
    2) Burndy/Hubbell Power Systems.
    3) Prysmian Group.
    4) TE Connectivity/Raychem.

3. Dead front terminators (600 amps):
    a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory-engineered kits containing necessary components to terminate the primary cables and shield systems.
    b. Modular, pre-molded, fully shielded dead front system.
    c. Submersible.
    d. Capable of mating with any manufacturer's interface in accordance with IEEE 386.
    e. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
    f. To be used as an elbow or a "T".
    g. Cable stress relief adapters to connect the cable insulation to the dead front terminator.
    h. Heat shrink seal over the junction between the cable insulation and the terminator body.
    i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
    j. Bolted to the bushing or connector plug, with an insulating plug to cover the connection.
    k. Conductive cap covering the insulating plug.
    l. Conductive shield to provide reliable continuity between jacket of cable and connector.
    m. Conductive insert around connector to prevent corona.
    n. With a capacitive test point on the insulating plug to allow circuit testing without disturbing the connection.
    o. Electrical requirements:
        1) Voltage class: 15 kV:
            a) Maximum voltage:
                (1) Phase to Ground: 8.3 kV rms.
                (2) Phase to Phase: 14.4 kV rms.
            b) Withstand voltage:
                (1) Impulse (1.2 by 50 microseconds): 95 kV (crest).
                (2) AC 1 minute: 34 kV.
                (3) DC 15 minutes: 53 kV.
            c) Minimum corona extinction level:
                (1) 11 kV rms.
            d) Continuous current rating:
                (1) 600 amps rms.
            e) Momentary rating:
                (1) 25,000 amps rms at 0.17 seconds.
                (2) 10,000 amps rms at 3.0 seconds.
    p. Manufacturers: One of the following or equal:
        1) 3M.
        2) ABB/Elastimold.
        3) Eaton/Cooper.

4. Dead front terminators (200 amps):
    a. Terminators for shielded solid dielectric plastic-insulated cables shall be factory-engineered kits containing necessary components to terminate the primary cables and shield systems.
    b. Modular, pre-molded, fully shielded dead front system.
    c. Loadbreak type.
    d. Submersible.
    e. Capable of mating with any manufacturer's interface in accordance with IEEE 386.
    f. Crimp connector suitable for copper conductors using standard compression tools to join the conductor to the interface.
    g. To be used as an elbow or a "T".
    h. Heat shrink seal over the junction between the cable insulation and the terminator body.
    i. Conductor shield shall be grounded near the termination and connected to the conductive shield of the terminator.
    j. Conductive shield to provide reliable continuity between jacket of cable and connector.
    k. Conductive insert around connector to prevent corona.
    l. With a capacitive test point with protective cover to allow circuit testing without disturbing the connection.
    m. Electrical requirements:
        1) Voltage class 15 kV.
        2) Withstand voltage:
            a) Impulse (1.2 by 50 microseconds): 95 kV (crest).
            b) AC 1 minute: 34 kV.
            c) DC 15 minutes: 53 kV.
        3) Minimum corona extinction level:
            a) 11 kV rms.
        4) Continuous current rating:
            a) 200 amps rms.
        5) Momentary rating:
            a) 10,000 amps rms, symmetrical at 0.17 seconds.
            b) 3,500 amps rms, symmetrical at 3.0 seconds.
    n. Manufacturers: One of the following or equal:
        1) 3M.
        2) ABB/Elastimold.
        3) Eaton/Cooper.

D. Insulated protective cap:
    1. Cap unused bushings/taps to electrically insulate and mechanically seal taps with an insulating cap.
        a. Loadbreak type.
        b. Submersible.
    2. Fully compliant with IEEE 386.
        a. Electrical requirements:
            1) Voltage class 15 kV.
            2) Withstand voltage:
                a) Impulse (1.2 by 50 microseconds): 95 kV (crest).
                b) AC 1 minute: 34 kV.
                c) DC 15 minutes: 53 kV.

3) Minimum corona extinction level:
a) 11 kV rms.

b. Manufacturers: One of the following or equal:
1) 3M.
2) ABB/Elastimold.
3) Eaton/Cooper.
4) Hubbell Power Systems.

E. Insulated standoff bushings:
1. Rated for 200 amps.
2. Loadbreak type.
3. Submersible.
4. Fully compliant with IEEE 386.
a. Electrical requirements:
1) Voltage class 15 kV.
2) Withstand voltage:
a) Impulse (1.2 by 50 microseconds): 95 kV (crest).
b) AC 1 minute: 34 kV.
c) DC 15 minutes: 53 kV.
3) Minimum corona extinction level:
a) 11 kV rms.
5. Molded EPDM rubber body with stainless steel base bracket.
6. Eyebolt for securing the bushing in a parking stand.
7. Ground lug.
8. Manufacturers: One of the following or equal:
a. ABB/Elastimold.
b. Eaton/Cooper.
c. Hubbell Power Systems.

2.07 ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

A. Medium voltage systems:
1. Ground shield at all terminators, splices, and junctions.
2. Install cable lugs, terminators, splices, and junctions in accordance with the manufacturer's specifications.
3. Fireproof exposed portions of cables.
a. Half-lapped layer of fire and electric arc proofing tape, secured with double-wrapped band of glass cloth electrical tape at each end.

B. Insulated standoff bushings:
1. Provide an insulated standoff bushing in dead-front transformer parking stand.

C. Medium voltage switchgear connections:
   1. Tape or provide insulated boots on cable connections at medium voltage switchgear to maintain the switchgear BIL rating.
   2. Make the connections in accordance with the manufacturer's guidelines.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

END OF SECTION

SECTION 16222

LOW VOLTAGE MOTORS UP TO 500 HORSEPOWER

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Low voltage motors up to 500 horsepower (hp).

1.02 REFERENCES

A. Standards:
   1. American Bearing Manufacturers Association (ABMA):
      a. 9 - Load Ratings and Fatigue Life for Ball Bearings.
      b. 11 - Load Ratings and Fatigue Life for Roller Bearings.
   2. ASTM International (ASTM):
      a. B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
   3. Institute of Electrical and Electronic Engineers (IEEE):
      a. 43 - IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
      b. 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
      c. 303 - Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations.
      d. 841 - IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
   4. National Electrical Manufacturers Association (NEMA):
      a. MG-1 - Motors and Generators.
   5. Underwriters Laboratories Inc. (UL):
      a. 674 - Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.03 DELEGATED DESIGN (NOT USED)

1.04 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Submit completed motor data sheets for each motor supplied:
   1. As specified in Attachment A - Motor Data Sheet.
   2. Manufacturer’s or other data sheets are not acceptable.

C. Product data:
   1. Descriptive bulletins.
   2. Machine tag and loop number as indicated on the Drawings and in the specification section number of the driven machine.

3. Complete electrical data.
4. Manufacturer's storage recommendations.
5. Torque, current, and power factor versus speed curves:
    a. At 100 percent rated voltage for full voltage started and VFD-driven motors.
    b. For motors on reduced voltage start at 70, 80, 90, and 100 percent rated voltage.
6. Additional data for motors installed in classified areas:
    a. Temperature code.
    b. Hazardous area approval indicating Class, Division, and Group:
        1) For motors driven by variable frequency drives, provide manufacturer's certification that the motor is suitable for operation in the hazardous area when driven by a variable frequency drive.
7. Accessories data:
    a. Power factor correction capacitors:
        1) Size in KVAR for motors not connected to variable frequency drives.
    b. Motor winding heaters:
        1) Voltage.
        2) Watts.
    c. Winding temperature detectors:
        1) Type.
        2) Rating.
    d. Moisture detectors.
8. Mechanical data:
    a. Bearing design and bearing life calculations.
    b. Resonant frequencies for VFD-driven motors 50 hp or greater.

D. Shop Drawings:
1. Motor weight.
2. Frame size.
3. Conduit box(es), size(s), and location(s).
4. Outline drawings with dimensions.
5. Installation details for the project seismic criteria.

E. Commissioning Submittals:
1. As specified in Section 01756 - Commissioning, including the following:
    a. Certificates:
        1) Requirements as specified in this Section.
    b. Test Plans:
        1) Test requirements as specified in this Section.
    c. Test Reports.

F. Test reports:
1. Factory test reports with test reference standard identified.

G. Certification:
1. When motors are driven by variable speed drive systems, submit certification that selected motor:
    a. Is capable of satisfactory performance under the intended load.
    b. Meets the requirements of the latest edition of NEMA MG-1 Part 31.

H. Calculations:
   1. Where site conditions specified in Section 01850 - Design Criteria exceed manufacturer's ratings, provide derating calculations for each motor.

1.05 QUALITY ASSURANCE (NOT USED)

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store motors in accordance with the manufacturer's recommendations.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.08 ADMINISTRATIVE REQUIREMENTS (NOT USED)

1.09 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish and install electric motors and accessories as specified in this Section and the Sections specifying driven equipment to provide a complete and operable installation.

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the site elevation and operating environment where the equipment will be installed as specified in Section 01850 - Design Criteria and as indicated on the Drawings.

2.03 MANUFACTURERS

A. One of the following or equal:
   1. Baldor.
   2. General Electric.
   3. Reliance.
   4. Toshiba.
   5. US Motors.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. 3-phase induction motors - general:
   1. Voltage:
      a. Motors 1/2 hp and larger shall be rated 460 V, 3-phase unless otherwise indicated on the Drawings.
      b. Dual voltage motors rated 230/460 V; 3-phase are acceptable provided all leads are brought to the conduit box.
   2. Motors driving identical machines shall be identical.
   3. Motors greater than 1 hp and up to 500 hp shall meet the NEMA Premium Efficiency percent listed in NEMA MG-1.
   4. Horsepower as indicated on the Drawings:
      a. Horsepower ratings indicated on the Drawings are based on vendor's estimates. Provide motors sized for the load of the actual equipment furnished without operating in the service factor.
   5. Service factor:
      a. 1.15 service factor on sine wave power.
      b. 1.0 when driven by VFD.
   6. Torque:
      a. Provide motors that develop sufficient torque for acceleration to full speed at voltage 10 percent less than motor nameplate rating.
      b. When started using reduced voltage starters:
         1) Provide motors that develop sufficient torque for acceleration to full speed.
      c. NEMA Design B except where driven load characteristics require other than normal starting torque:
         1) In no case shall starting torque or breakdown torque be less than the values specified in NEMA MG-1.
   7. Enclosures:
      a. As specified in the individual equipment Specifications or in this Section.
      b. Totally enclosed fan cooled:
         1) Cast iron conduit box.
         2) Tapped drain holes with Type 304 stainless steel plugs for frames 286 and smaller, and automatic breather and drain devices for frames 324 and larger.
      c. Explosion proof:
         1) Tapped drain holes with corrosion resistant plugs for frames 286 and smaller and automatic breather and drain devices for frames 324 and larger.
      d. Lifting devices: Motors weighing 265 pounds (120 kilograms) or more shall have suitable lifting devices for installation and removal.
   8. Manufactured with cast iron frames in accordance with NEMA MG-1 or manufacturer's standard material for the specified rating.
   9. Nameplates:
      a. Provide motors with a permanent, stainless steel nameplate indelibly stamped or engraved with:
         1) NEMA standard motor data:
            a) Indicate compliance with NEMA MG-1 Part 31 for inverter duty motors.
         2) AFBMA bearing numbers and lubrication instructions.

10. Hardware:
    a. Type 304 stainless steel.
11. Conduit boxes:
    a. Cast iron or stamped steel.
    b. Split from top to bottom.
    c. Provide gaskets at the following interfaces:
        1) Frames and conduit boxes.
        2) Conduit boxes and box covers.
    d. Rotatable through 360 degrees in 90-degree increments:
        1) Where available based on the size of the conduit box.
    e. Exceeding the dimensions defined in NEMA MG-1.
    f. Provide grounding lugs inside conduit boxes for motor frame grounding.
12. Motor bearings:
    a. Antifriction.
    b. Regreasable and initially filled with grease for horizontal motors and vertical motors per manufacturer's standard design.
    c. Bearings and lubrication suitable for ambient temperature and temperature rise.
    d. Suitable for intended application and have a rate for ABMA 9 or 11, L-10 rating life of 60,000 hours or more.
    e. Fit bearings with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.
    f. Where specified in the equipment Specifications, provide split-sleeve type hydrodynamic radial bearings. Provide a bearing isolator to protect bearings from contaminants.
13. Insulation systems:
    a. Motors installed in ambient temperatures 40 degrees Celsius or less:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 40 degrees Celsius at the altitude where the motor will be installed.
    b. Motors installed in ambient temperatures between 40 degrees Celsius and 50 degrees Celsius:
        1) Provide Class F insulation.
        2) Design temperature rise consistent with Class B insulation.
        3) Rated to operate at an ambient temperature of 50 degrees Celsius at the altitude where the motor will be installed.
    c. Motors installed in ambient temperatures between 50 degrees Celsius and 65 degrees Celsius:
        1) Provide Class H insulation.
        2) Design temperature rise consistent with Class F insulation.
        3) Rated to operate at an ambient temperature of 65 degrees Celsius at the altitude where the motors will be installed.
14. Motor leads:
    a. Insulated leads with non-wicking, non-hydroscopic material. Class F insulation.
15. Noise:
    a. Maximum operating noise level in accordance with NEMA MG-1.

B. Submersible motors:
   1. Enclosures:
      a. Totally enclosed non-ventilated (TENV) watertight casing.
      b. Inner and outer shaft seals separated by an oil chamber.
   2. Cooling:
      a. Suitable for continuous operation in totally, partially, or nonsubmerged condition without overheating.
      b. Convection cooling by the surrounding environment or pump cooling by circulating a portion of the pumped media through a cooling water jacket as recommended by the manufacturer based on hp and application.
   3. Electrical cables:
      a. Wire unit without splices. Coordinate with Contractor to ensure cables of adequate length.
      b. Epoxy encapsulated cable entry into terminal box.
   4. Insulation:
      a. Sealed moisture resistant windings.
      b. Class H.
   5. Motor protection:
      a. Provide temperature detection in motor windings.
      b. Provide moisture detection in motor housing.
      c. Other detection and protection functions specified in the in the driven equipment Section.

C. Vertical motors:
   1. Enclosures:
      a. Totally enclosed fan cooled (TEFC) for motors 200 hp and less installed outdoors.
      b. Weather protected Type II (WPII) for motors greater than 200 hp installed outdoors.
      c. Weather protected Type I (WPI) where installed indoors.
   2. Thrust bearings:
      a. Selected for combined rotor and driven equipment loads.
      b. Coordinate with driven equipment supplier for maximum vertical thrust of driven equipment.
   3. Anti-reverse ratchet.

D. Motors driven by variable frequency drives:
   1. Compatible with the variable frequency drives specified.
   2. Inverter duty rated and labeled.
   3. Meet the requirements of NEMA MG-1 Part 31.
   4. Winding insulation meets the requirements of NEMA MG-1 Part 31.4.4.2.
   5. Capable of running continuously at 1/10th of full speed, with no harmful effects or overheating.
   6. Shaft grounding ring:
      a. Provide a manufacturer-installed shaft grounding ring for each VFD-driven motor.
      b. Aluminum frame and internal components.
      c. Conductive microfiber brushes.
      d. Maintenance free design.
      e. Colloidal silver compound installed on shaft under the shaft grounding ring.
      f. High frequency ground strap.

g. Grounding ring:
    1) Installed inside motor housing on drive end (DE).
    2) Installed on exterior of motor housing on drive end with written permission from the Engineer.
h. Refer to the following table for specific requirements based upon the driven motor:

Motor Size	<100 HP	100 HP to 500 HP	>500 HP
Voltage	<600 VAC	<600 VAC	<600 VAC
AEGIS® Ring	SGR	SGR	PRO
Bearing Insulation	No	NDE	NDE & DE
Colloidal Sliver	Recommended	Required	Required
HF Grounding Straps	Required	Required	Required

Notes:
DE - drive end.
HF - AEGIS® High Frequency Grounding Strap.
NDE - non-drive end.
PRO - AEGIS® PRO Series Shaft Grounding Rings.
SGR - AEGIS® Shaft Grounding Ring Series.

i. AEGIS® bearing protection ring, as manufactured by Electro Static Technology, or equal.

7. Insulated bearings:
    a. Provide motor manufacturer's standard insulated sleeve or ceramic bearings.
    b. Motors 100 hp to 500 hp: Provide insulated bearing on non-drive end (NDE) of the motor the end opposite the shaft grounding ring as recommended by the motor manufacturer.
    c. Motors larger than 500 hp: Provide insulated bearings on both the DE and NDE, and AEGIS® PRO Series shaft ground ring externally mounted on the DE.
8. Explosion proof motors:
    a. On motors less than or equal to 100 hp, provide insulated bearings on one end of the motor.
    b. On motors over 100 hp, provide insulated bearings on both ends of the motor.
    c. Shaft grounding ring:
        1) Installed inside the explosion proof enclosure in accordance with IEEE standard 303.

E. Motors installed in hazardous locations:
1. Class I, Division 1 or Class II, Division 1 areas:
    a. Enclosures:
        1) Explosion proof for 3-phase motors.
        2) UL listed in conformance with UL 674.
        3) UL approval with nameplate and serial number.
2. Other hazardous areas:
    a. Enclosures:
        1) TEFC for motors in Class I, Division 2 areas.
        2) Vertical motors as specified in this Section.

3) Hazardous area and temperature code approval stamped on nameplate.

3. Single-phase motors: Explosion proof motor enclosure.

F. Motors installed in corrosive environments:
1. Nameplate indicating conformance to IEEE 841.
2. Stator double dipped in varnish and baked.
3. Stator and rotor coated with corrosion resistant epoxy.
4. Frame, brackets, fan guard and conduit box coated with minimum of 2 coats of epoxy paint.
5. Withstand salt spray tests in accordance with ASTM B117.

G. Single-phase motors:
1. Capacitor start type rated for operation at 115 volts, 60 hertz, unless otherwise specified or as indicated on the Drawings.
2. Totally enclosed fan cooled (TEFC) motors manufactured in accordance with NEMA MG 1.
3. Ball bearings: Sealed.
4. 1/2 hp or less fan motors:
   a. Split-phase or shaded pole type when standard for the equipment.
   b. Open type when suitably protected from moisture, dripping water, and lint accumulation.
5. Wound rotor or commutator type single-phase motors only when their specific characteristics are necessary for application and their use is acceptable to the Engineer.
6. Integral overload protection.

H. Immersible motors:
1. Meet all general requirements for 3-phase induction motors, except as modified in this Section.
2. Inverter duty as indicated on the Drawings or in the driven equipment Specifications.
3. Enclosure:
   a. Cast iron.
   b. Designed and constructed to meet or exceed IP67.
   c. Epoxy paint finish:
      1) Withstands salt spray and corrosion tests in accordance with ASTM B117.
   d. Furnished with lifting plates or lugs.
   e. Vertical or horizontal mounting as required by the application.
4. Conduit box:
   a. Cast iron.
   b. Bolted and sealed cover.
   c. Rotatable in 90-degree increments.
   d. Watertight gland or potable hub for power cable entry.
5. Power cable:
   a. Type SOOW or W cable, non-shielded.
   b. Length as required for the installation.

6. Cooling blower:
    a. As required by the motor manufacturer.
    b. Washdown duty rated.
    c. Constant speed.
7. Humidity moisture detector.

2.07 COMPONENTS (NOT USED)

2.08 ACCESSORIES

A. Motor winding heaters:
    1. Provide 3-phase motors with belted or cartridge space heaters mounted within the motor enclosure.
    2. Space heater rating shall be 120 volts, single-phase, unless otherwise indicated on the Drawings.
    3. Power leads for heaters wired into conduit box.
    4. Installed within motor enclosure adjacent to core iron.

B. Winding temperature detectors:
    1. Temperature switches with normally closed contacts as indicated on the Drawings.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION (NOT USED)

3.03 INSTALLATION

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

B. Install shaft grounding ring on VFD-driven motors in accordance with the manufacturer's instructions.

3.04 COMMISSIONING

A. As specified in Section 01756 - Commissioning.

B. Source Testing:
    1. Motors less than 250 hp:
        a. Perform manufacturer's standard production tests, including, but not limited to:
            1) No load current.
            2) High potential test.
            3) Winding resistance.
        b. Furnish copies of standard test reports on prototype or identical units.
    2. Motors 250 hp and larger:
        a. Perform tests in accordance with IEEE 112 or IEEE 43.
        b. Tests shall include the following:
            1) Winding resistance (cold).
            2) Locked rotor test.

3) Temperature rise test.
4) Load test.
5) Breakdown torque test.
6) No-load test.
7) High-potential test.
8) Insulation resistance test.
9) Vibration test in accordance with NEMA MG-1.
10) Polarization index.
11) Speed-torque curve.
12) Shaft voltage.
13) Bearing insulation resistance.
14) Efficiency and power factor versus load test performed at rated speed and 50 percent, 75 percent, 90 percent, and 100 percent of rated load. Curves from the motor tests shall be submitted for information.
15) Maximum allowable residual unbalance in each correction plane (journal) shall be calculated using the following equation:

U = 4 W/N

where:

U = residual correction plane unbalance, in ounces-inches
W = static correction plane journal loading, in pounds
N = maximum specified operating speed, in revolutions per minute

c. Furnish test reports and Manufacturer's Certificate of Source Testing.

C. Functional Testing:
1. As specified in Section 16950 - Field Electrical Acceptance Tests.

3.05 FIELD QUALITY CONTROL

A. Before start-up, perform insulation resistance test on each motor furnished or installed on this project:
1. Windings energized to 1,000 volts DC for 1 minute.
2. Resistance measured at the end of the test, recorded, and submitted to the Engineer for review.
3. Inform the Engineer of any unusual or unacceptable test results.
4. This test is in addition to the acceptance tests in Section 16950 - Field Electrical Acceptance Tests.

END OF SECTION

ATTACHMENT A - MOTOR DATA SHEET

MOTOR DATA SHEET

MOTOR/ EQUIPMENT TAG _____ MOTOR NUMBER _____

SPECIFICATION NUMBER OF DRIVEN MACHINE _____

MOTOR NAMEPLATE DATA

MANUFACTURER _____ MODEL/SERIES _____ MODEL NO. _____

FRAME _____ ENCLOSURE _____ NEMA DESIGN _____

HP _____ SERVICE FACTOR _____ RPM _____

INSULATION CLASS _____ VOLTS _____ FULL LOAD AMPS _____

AMBIENT TEMP _____ PHASE _____ NO LOAD AMPS _____

DESIGN TEMP _____ HERTZ _____ LOCK ROTOR AMPS _____

INRUSH CODE LETTER _____

	100% LOAD	75% LOAD	50% LOAD
GUARANTEED MINIMUM EFFICIENCIES:			
GUARANTEED MINIMUM POWER FACTOR:			

MAXIMUM SIZE OF POWER FACTOR CORRECTION CAPACITOR: _____ KVAR

ACCESSORIES

MOTOR WINDING HEATER _____ VOLTS _____ WATTS

WINDING THERMAL PROTECTION:

WINDING TEMP SWITCHES (YES/NO) _____

RTD:

TYPE _____ QUANTITY PER PHASE _____ # OF WIRES _____

NOMINAL RESISTANCE _____ NOMINAL TEMP _____ COEFFICIENT _____

RECOMMENDED ALARM _____ DEGREES CELSIUS RECOMMENDED TRIP _____ DEGREES CELSIUS

SPECIAL APPLICATIONS

INVERTER DUTY* (YES/NO) _____ PART WINDING (YES/NO) _____ WYE - DELTA (YES/NO) _____

2 SPEED, 1 WINDING (YES/NO) _____ 2 SPEED, 2 WINDING (YES/NO) _____

AREA CLASSIFICATION:

CLASS _____ DIVISION _____ GROUP _____ TEMP CODE _____

* Conforms to NEMA MG-1 Part 31.

SECTION 16235

SINGLE SPARK-IGNITED GENERATOR SET

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Packaged automatic “standby” spark-ignited engine generator systems.

1.02 REFERENCES

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard.
   2. ASTM International (ASTM):
      a. A106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   3. International Fire Code.
   4. National Electrical Manufacturers Association (NEMA):
      a. MG-1 - Motor and Generators.
   5. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC).
      b. 110 - Standard for Emergency and Standby Power Systems.
   6. Underwriters Laboratories, Inc. (UL):
      a. 508 - Standard for Industrial Control Equipment.
      b. 2200 - Standard for Stationary Engine Generator Assemblies.

1.03 TERMINOLOGY

A. The words and terms listed below are not defined terms that require initial capital letters, but, when used in this Section, have the indicated meaning.
   1. Equipment supplier: Manufacturer of at least one of the following items:
      a. Engine.
      b. Alternator (generator).
      c. Control system.
   2. Standby rated duty: Continuous operation for the duration of any power outage.

1.04 DELEGATED DESIGN

A. As specified in Section 01357 - Delegated Design Procedures.

B. Anchoring and bracing.

1.05 SUBMITTALS

A. Furnish Submittals as specified in Section 01330 - Submittal Procedures.

B. Product data:
   1. Weight of engine generator skid.
   2. Dimensions of engine generator skid, including length, width, and height.
   3. Type and grade of fuel recommended.
   4. Fuel and lubricating oil consumption at:
      a. 50-percent load.
      b. 75-percent load.
      c. 100-percent load.
   5. Type and grade lubricating oil recommended.
   6. Amount of lubricating oil required per oil change.
   7. Normal lubricating oil consumption.
   8. Recommended lubricating oil change periods:
      a. By hours run.
      b. By time.
   9. Combustion air required.
   10. Cooling air required.
   11. Gauges to be furnished with engine and the normal operating range of each:
      a. Oil pressure.
      b. Coolant temperature.
      c. Fuel pressure.
   12. Time interval from start-up contact closure until full load capabilities are available.
   13. List of at least 4 installations using major components of the same type furnished for this application:
      a. Include name and telephone number of the persons most familiar with this equipment who can be contacted during the Submittal review.
   14. Number of cylinders, bore, stroke, and piston speed.
   15. Displacement in cubic inches.
   16. Compression ratio.
   17. RPM at 60 hertz.
   18. Size of exhaust outlet.
   19. The following gaseous exhaust emissions in grams/BHP-HR and Lbs/BHP-HR:
      a. NOx.
      b. HC.
      c. CO.
      d. PM.
      e. Other exhaust emissions as required by the local air quality management district issuing the permit for the engine generator system.
      f. These levels shall be reported at rated speed and load as measured by SAE J177 and J215 recommended practices.
   20. Voltage and frequency variation and duration with the step application and removal of 25 percent, 50 percent, 75 percent, and 100 percent of resistive load maximum.
   21. Time-overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided by the output circuit breaker.

22. Battery discharge ampere ratings at the 8-hour rate and the 1-minute rate to 1.75 volts per cell.
23. Certified published engine horsepower curves showing the manufacturer's engine rating for generator set standby and prime power application.
24. Free field mechanical noise level at 23 feet. Provide overall decibels (A) rating.
25. Exhaust noise level at 5 feet from discharge end of silencer.
26. Start battery catalog number and descriptive bulletin.
27. Recommended spare parts.
28. Space and ambient temperature requirements for the engine control panel.
29. Manufacturer of:
    a. Engine.
    b. Generator.
    c. Generator control panel.
    d. Radiator.
    e. Enclosure.
30. Estimated number of days to ship complete unit.
31. Jacket water heater.
32. Strip heaters.
33. Crank case heaters.

C. Shop Drawings:
1. Provide detailed dimensional and to-scale layout drawings, including:
    a. A single drawing incorporating all equipment furnished:
        1) Submittals that consist solely of individual drawings for each component and require that these sheets be compiled by the Engineer in order to view the entire piece of equipment are not acceptable.
2. Detailed electrical wiring diagrams of the engine and generator, including:
    a. Engine interconnection terminal box.
    b. Generator interconnection terminal box.
    c. Fuel system drawings.
    d. Interface drawings between the engine driven generator skid and the transfer equipment.
    e. Wiring diagrams to show wire numbers and terminal block identifications:
        1) Wire numbers are to correspond to the wire number on the equipment.
        2) Wires are to be numbered.
    f. Complete interior and exterior control panel layout:
        1) Scaled.
        2) With device descriptions.
        3) With nameplates.

D. Calculations:
1. Complete loading calculations to support the recommended size of the engine-generator based upon actual facility loads.
2. Documentation identifying the maximum static pressure acceptable for the radiator fan. It is the manufacturer's responsibility to then provide calculations as part of the layout drawings, to ensure that the transition ductwork at the discharge of the radiator does not exceed the maximum static pressure acceptable for the radiator fan.
3. Certification that a torsional analysis has been completed.
4. Exhaust system silencer noise attenuation curves.
5. Factory certification of the radiator ambient capability.

6. Exhaust system pressure loss calculations: Include piping, fittings, silencer, and rain cap in loss calculations.

E. Delegated Design Submittals:
   1. Project-specific calculations with anchoring and bracing details based on support conditions and requirements to resist loads specified in Section 01850 - Design Criteria:
      a. Vibration isolator selection calculations.
      b. Vibration isolator anchoring calculations.
      c. Exhaust silencer structural support calculations where the silencer is not mounted to the generator or generator enclosure.

F. Installation instructions:
   1. Detail the complete installation of the equipment, including rigging, moving, and setting into place.
   2. Provide manufacturer's installation instructions.

G. Quality Control Submittals:
   1. Manufacturer's representative qualifications.
   2. Manufacturer's Certificate of Source Testing as specified in Section 01756 - Commissioning.
   3. Manufacturer's Certificate of Installation Verification as specified in Section 01756 - Commissioning.
   4. Test reports.
      a. Prototype test results.

H. Owner Training Submittals:
   1. As specified in Section 01756 - Commissioning.

I. Operation and maintenance manuals:
   1. As specified in Section 01782 - Operation and Maintenance Manuals.
   2. Operating instructions:
      a. Printed and framed instruction chart shall be permanently mounted in the generator enclosure. Chart must detail the operational functions of normally used controls that have been placed on the front of the control equipment.
   3. Maintenance manual:
      a. Printed and bound instructions covering details pertaining to care and maintenance of equipment, as well as data identifying all parts.
      b. These manuals must include, but are not limited to, the following:
         1) Electrical controls:
            a) Adjustment and test instructions covering the steps involved in the initial test, adjustment, and start-up procedures.
            b) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.
            c) Description of the sequence of operation that outlines the steps, which the controls follow during normal power failure and normal power return conditions.

d) Schematic, wiring, and external diagrams. Also, internal device wiring and schematic diagrams for sub-assemblies used in the equipment:
(1) Drawing to be furnished in a reduced 11-inch by 17-inch format and shall be fully legible at that drawing size.

2) Engine and generator:
a) Standard operational manuals normally furnished by the manufacturer.
b) Repair parts manuals normally furnished by the manufacturer:
(1) Detailing parts and sub-assemblies, which are available as repair parts.

3) Shop maintenance manuals:
a) Provide 1 shop manual on site that is equivalent to the manual used by factory-authorized shop repair personnel.
b) Manuals for the following equipment:
(1) Engine.
(2) Radiator.
(3) Generator.
(4) Engine generator control panel.

c. Furnish a minimum of 6 manuals of each type identified, except for the shop maintenance manual. Provide 1 additional copy on compact disc (CD) as specified in Section 01782 - Operation and Maintenance Manuals.

1.06 QUALITY ASSURANCE

A. Coordinate the generator control design with the switchgear or transfer switches specified in the electrical Specifications and as indicated on the Drawings.

B. Manufacturer qualifications:
1. Manufacturer of the engine, generator, and major items of auxiliary equipment must be in current production of such equipment.
2. Factory authorized parts and service facility located within 100 miles of the Project Site.

C. Regulatory requirements:
1. Meet NFPA 110 Type 10 (ten second) transfer requirements.
2. Regulations of the Fire Prevention Bureau of the Fire Department Having Jurisdiction.
3. International Fire Code.
4. Other applicable state and local codes.
5. EPA approved.
6. Requirements of local Air Quality Management District or Air Pollution Control District.

D. Generator set shall be manufactured to the applicable specifications on file with Underwriters Laboratories and labeled with the UL 2200 mark.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Ship the engine-driven generator skid and associated equipment to the jobsite on equipment that will allow the Contractor to use the equipment he has on site to efficiently unload the engine-driven generator skid.
   1. Must be equipped with removable lifting and jacking angles, eye bolts, etc., to facilitate unloading and move-in operations.

B. Engine-driven generator skid is to be shipped from the factory complete with lifting eyes, jacking angles, etc., attached to the structural base.

C. Provide the services of a manufacturer's authorized representative to:
   1. Be present at the jobsite when the engine-driven generator arrives:
      a. Act as an advisor in assisting the Contractor regarding the unloading and move-in operations.
   2. Coordinate the delivery of the shipment with the Contractor.
   3. Before start-up, furnish written certification that the entire installation and connections, both mechanical and electrical, have been inspected and are proper and consistent with Drawings and Specifications.

1.08 PROJECT OR SITE CONDITIONS

A. As specified in Section 01850 - Design Criteria.

1.09 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Complete factory prototype and factory acceptance tests in accordance with NFPA 110 and submit results for the Engineer's review.
   2. Conduct factory acceptance test and submit certified test results for the Engineer's review.
   3. Ship equipment to Project Site after successful completion of factory acceptance test.
   4. Assemble equipment in the field.
   5. Conduct field acceptance test and submit results for the Engineer's review.
   6. Submit manufacturer's certification that equipment has been properly installed and is fully functional for the Engineer's review.
   7. Conduct Owner Training sessions.
   8. Commissioning and start-up as specified in Section 01756 - Commissioning.

1.10 WARRANTY

A. As specified in Section 01783 - Warranties and Bonds.

B. Extended warranty:
   1. Generator set and associated equipment shall be warranted for a period of not less than 2 years from the date of commissioning against defects in materials and workmanship.

1.11 SYSTEM START-UP

A. Provide manufacturer services, including, but not limited to:
   1. Furnish the services of manufacturer-certified technicians during the start-up and adjustment period to ensure that items furnished are in proper operating condition:
      a. Engine technician must be completely knowledgeable in the operation, maintenance, and start-up of the mechanical system.
      b. Electrical technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
      c. Provide training in accordance with the Owner Training article of this Section.
      d. Engine technician and electrical technician may be the same individual if certified by the respective equipment manufacturers in both engine and electrical fields.
   2. Furnish a written report after the start-up:
      a. Report must state that the installation is complete and satisfactory:
         1) List the items requiring additional attention.
   3. Minimum required time on site by technician for start-up:
      a. One day to inspect entire installation, start-up, test operation, and conduct acceptance tests.

1.12 MAINTENANCE

A. Furnish the following spare parts:
   1. Sufficient coolant so that entire system may be flushed and replaced after initial burn-in period.
   2. Sufficient lubrication products so that the entire system may be flushed and replaced after initial burn-in period.
   3. Three sets of lube oil filters, fuel filters, and gaskets.
   4. Two sets of air filters.
   5. Two sets of belts.
   6. Twelve spare lamps of each different lamp type.
   7. Two fuses (for each control circuit).
   8. Provide a 2-pronged battery test voltmeter.
   9. One set of crankcase breather filters.

B. Special tools: Furnish a set of specialty tools necessary for routine maintenance of the equipment.

C. Maintenance service: Provide manufacturer’s standard service and maintenance contract for the Owner’s review and/or acceptance.

PART 2 PRODUCTS

2.01 GENERAL (NOT USED)

2.02 DESIGN AND PERFORMANCE CRITERIA

A. Provide equipment and components that are fully rated for the Site elevation and operating environment where the equipment will be installed as specified in Section 01850 - Design Criteria and as indicated on the Drawings.

B. Provide a complete automatic standby spark-ignited combination natural gas/LP vapor fueled engine driven generator system with necessary components to make a complete and operating engine-driven power supply.

C. Include the supply of such minor details of electrical, plumbing, or mechanical work not specified or indicated on the Drawings, which are necessary for the successful operation of the combination natural gas/LP vapor fueled engine-driven generator required by these Specifications.

D. Description of operation:
   1. As specified in Section16491 - Transfer Switches.

E. Step sequence:
   1. Step 1: Non-controllable loads:
      a. PNL-AVV-P, 30kW.
      b. PNL-ROS-P, 25 kVA.
      c. XFMR-PNL-CPS, 45 kVA.
   2. Step 2:
      a. CWP-5161, 100 Hp (RVSS).
   3. Step 3:
      a. CWP-5162, 100 Hp (RVSS).

2.03 MANUFACTURERS

A. Engine generators:
   1. One of the following or equal:
      a. Caterpillar.
      b. Onan-Cummins.

B. Governor:
   1. One of the following or equal:
      a. Isochronous electronic by engine manufacturer.
      b. Woodward, digital type, Model 723, with EGP type actuator sized for the engine.

C. Battery:
   1. The following or equal:
      a. Hawker.

D. Exhaust system:
    1. One of the following or equal:
        a. Silencer:
            1) Harco Manufacturing.
            2) Silex Innovations.
        b. Expansion joint:
            1) DME.
        c. Exhaust pipe insulation:
            1) As specified in Section 15082 - Piping Insulation.
        d. Expansion joint insulation:
            1) Pittsburgh-Corning, Temp-Mat.

2.04 MATERIALS (NOT USED)

2.05 MANUFACTURED UNITS (NOT USED)

2.06 EQUIPMENT

A. Generator system performance requirements:
    1. Power output rating: Minimum kilowatts and voltage as indicated on the Drawings, delivered at 0.8 power factor, 3-phase, 4-wire, 60 hertz, without exceeding NEMA MG-1 temperature rise limits.
    2. It is the manufacturer's responsibility to properly size the engine generator based upon Site conditions and actual loads. Drawings and Specifications indicate a minimum size that the Engineer has determined based upon non-certified information.
        a. Size the engine generator for a maximum voltage drop at any load step of no more than 10 percent.
        b. No increase in Contract amount will be considered if the equipment size needs to be increased to meet the load requirements after bids have been submitted.
        c. Increases in size as a result of manufacturer sizing shall include any and all conduit and wire size changes.

B. Characteristics of assembled unit:
    1. Engine-driven generator consists of a spark-ignited, combination natural gas/LP vapor -fueled engine directly coupled to an electric generator providing continuous electric power for the duration of any power failure of the normal utility power supply.
    2. Engine must start, attain full speed, voltage, and assume full load within a maximum of 10 seconds, with jacket water at 85 degrees Fahrenheit.
    3. Furnish the engine-driven generator on a steel sub-base to support engine, generator, and accessories as a unit:
        a. Base: Welded construction.
        b. Engine direct connected through a flexible coupling to a single bearing generator.
        c. System free of injurious torsional and bending vibrations within a speed range from 10 percent below to 10 percent above synchronous speed.
        d. Balanced such that the peak-to-peak amplitude of vibration velocity in any direction does not exceed the engine or generator manufacturer's published limits.

e. If shims are required under the feet of the generator for alignment purposes, use 1-piece laminated shim stock that covers at least 90 percent of the foot.
f. Provide a complete assembled engine-driven generator skid requiring only the following field mechanical connections:
    1) Power leads from generator to the automatic transfer equipment.
    2) Control connections to:
        a) Plant control system.
        b) Generator control system.
        c) Automatic transfer equipment.
    3) Exhaust system.
    4) Fuel lines.
g. Connections to engine-driven generator skid:
    1) Flexible connections are required on connections to the engine generator and are to be supplied by the manufacturer.
    2) These connections include, but are not limited to:
        a) Exhaust.
    3) Length of flexible connections to exceed the flexible connector manufacturer's minimum length recommendations for the diameter used and for the misalignment as measured after installation.

2.07 COMPONENTS

A. Engine generator base:
    1. Support system:
        a. Bolt the engine-driven generator to steel pads that are an integral part of structural support base.
        b. Vibration isolators shall be provided between the engine generator and welded steel base or between the base and the floor:
            1) As recommended by the manufacturer.
        c. Support system design must meet the seismic requirements of the Project Site.
        d. Vibration isolators to properly support the engine driven generator skid on its concrete base:
            1) Isolators located for equal load distribution and deflection per isolator.
            2) Spring type designed for the load and seismic conditions as identified for the Site.

B. Engine:
    1. Spark-ignited, 4-cycle low emission unit, turbocharged, and aftercooled.
    2. Rated net horsepower of the engine with accessories, including radiator fan, must not be less than that required to produce the minimum specified generator capacity at Site altitude.
    3. For dual fuel systems, changeover from primary to secondary fuel shall be automatic.
    4. Equipped and designed as follows:
        a. Dual spin-on type replaceable lube oil filter cartridges.
        b. Replaceable fuel filters.
        c. Heat treated forged steel crankshaft:
            1) Dynamically balanced.
        d. Forged steel connecting rods.

e. Crankshaft driven gear type lubricating pump.
f. Fuel system:
    1) Natural gas pressure regulator.
        a) Install before gas inlet connection.
        b) Set pressure to 15” W.C.
    2) Electric fuel shut-off valve.
g. Engine air cleaner: Dry type replaceable filter.
h. 12- or 24-volt direct current positive engagement solenoid shift-starting motor:
    1) Starting equipment must include the necessary devices to prevent an overcrank and lockout if the starter pinion fails to engage the flywheel ring gear on the initial crank attempt.
    2) This starter disconnect is to electronically sense the speed of the flywheel and when the flywheel setpoint speed has been reached, the electronic control signals the starter disconnect to disengage.
i. Oil level dip stick and oil drainpipe with valve and pipe plug:
    1) Oil drainpipe and valve are to extend 3 inches beyond edge of engine base.
j. Dry electrical contacts to report:
    1) Low oil pressure.
    2) Over speed.
    3) High water temperature.
k. Engines requiring glow plugs are not acceptable.
l. Crankcase breather filter:
    1) Provide crankcase ventilation system with coalescing filter/trap for blowby:
        a) Coalescing filter to be replaceable.
    2) If the engine manufacturer recommends an open crankcase breather system, route outlet of breather filter to outside at 3 inches above grade and away from engine components:
        a) Provide on breather outlet Nelson “EcoVent” or equal, sized to match engine breather flow.
    3) If the engine manufacturer recommends a closed crankcase breather system, provide integral crankcase pressure regulator with an automatic internal filter bypass and bypass indicator:
        a) Unit to be Racor Model CCV 4500 or equal.
m. Governor:
    1) Isochronous type to maintain engine speed:
        a) Within 0.5 percent for steady state conditions.
        b) Within 5 percent for a no load to full load step with recovery to within 2 seconds of step load application.
        c) Suitable for use on combination natural gas/LP vapor-fueled engines.
        d) Electronic governor control of fuel.
        e) Suitable for automatic, unattended starts.
        f) Speed sensing failure circuit to signal actuator to close if speed pick-up signal is lost.
        g) With speed pick-up sensor.
        h) With capabilities of local or remote speed settings.
        i) Adjustable acceleration rate control from 0 to 8 seconds.
        j) Personnel guards over exposed moving parts.

n. Equipped with a continuous duty shutdown system for normal remote stopping.
o. Equipped with gauges to indicate:
1) Lube oil pressure.
2) Fuel pressure.
3) Gauges are to be mounted such that vibration will not cause premature failure.
p. Monitor engine coolant temperature by a thermometer with thermometer well or a temperature gauge.

5. Regulatory requirements:
a. Specifically designed to meet the discharge of gaseous pollutants to the atmosphere as required by the EPA and local agency issuing the permit for the engine generator system.

C. Exhaust system:
1. Provide a complete exhaust system following the general scheme as indicated on the Drawings and as specified.
2. Back pressure:
a. Provide components such that the maximum backpressure in the exhaust system, including piping and silencer is as required by the engine manufacturer, measured at the exhaust manifold header:
1) Reduce allowable back-pressure when recommended by the engine manufacturer.
b. Provide each exhaust manifold header with a lugged, tapped connection for the attachment of a test manometer.
3. Exhaust piping:
a. Type: Schedule 40 high temperature black steel pipe in accordance with ASTM A106.
b. Drainage: Slope piping to a drain point and provide drain plug.
c. Finishes: Sand blast and coat outside of exhaust piping with not less than 6 mils of inorganic zinc prime.
1) Finish coat in the field as specified in Section 09910 - Painting.
d. Insulation: As specified in Section 15082 - Piping Insulation for engine exhaust piping.
4. Exhaust expansion joints:
a. Type:
1) Metal with convoluted portion of 0.038-inch-thick Type 321 stainless steel.
2) Non-convoluted portions of expansion joint to be Type 304 stainless steel, Schedule 10S pipe.
3) Provide flanged ends with ASME B16.5, Class 150 bolt hole drilling.
b. Length: Minimum of 18 inches in length.
c. Movement:
1) Rated for a minimum of 1-inch lateral movement, and 1/2-inch axial movement.
2) Rated movement defined as plus or minus travel from neutral or free position.
d. Design life: Infinite cycle life with 1,200 degrees Fahrenheit exhaust, no insulation over the expansion joint, and continuous duty service.

e. Insulation:
1) Insulate expansion joints with custom fitted, removable with reusable fastening system, ceramic fiber insulation blankets enclosed between inner and outer high temperature fabric cover rated for 1,200 degrees Fahrenheit continuous duty.

5. Exhaust silencer:
a. Type: Heavy-duty industrial type fabricated of welded steel with ported tubes and snubbing chambers, and a rating meeting the specified sound attenuation.
b. Mounting: As indicated on the Drawings.
c. End connections: Steel flanges with Class 150-pound drilling pattern.
d. Shell:
1) Sufficiently heavy and reinforced to eliminate excessive vibration, stress, or deflection, and to support operating loads with the silencer at elevated temperatures and insulated as specified.
2) Loads include insulation weight and connecting piping.
e. Drain: Provide threaded, plugged condensate drain.
f. Sound attenuation: Attain the following minimum sound attenuation at the listed octave band center frequencies with the engine at full load:

Frequency (Hz)	63	125	250	500	1,000	2,000	4,000	8,000
Attenuation (dB)	39	42	42	40	38	38	38	38

g. Supports: Provide shell lug supports suitable for supporting and mounting the silencer as indicated on the Drawings; support design to account for elevated temperatures under insulated shell.
h. Insulation: As specified for engine exhaust piping in Section 15082 - Piping Insulation.
i. Pressure drop not to exceed 7-inch water column at maximum engine rating.

D. Weatherproof acoustical housing:
1. Provide engine enclosure to protect engine, generator, starting system, batteries, and other specified accessories from weather exposure.
2. Meet wind requirements at the Project Site.
3. Meet seismic requirements at the Project Site.
4. Construction:
a. Not less than 14-gauge steel panel thickness.
b. Panels and members hot dip galvanized after fabrication.
c. Enclosure removable to allow for maintenance.
d. Fitted with lockable latches.
e. Stainless steel latches and hinges.
5. Finishing: Factory or shop finished in epoxy and urethane coating system as specified in Section 09910 - Painting.
6. Noise reduction:
a. Provide acoustical insulation and acoustical enclosure ventilation louvers and fan discharge silencers as necessary to achieve a measured sound pressure level of 70 dBA when measured at 23 feet from the enclosure.
b. Protect acoustical insulation with perforated metal covers and plastic bagging to prevent damage from abrasion or weather elements.

E. Engine jacket water heater:
   1. Provide an in-line thermostat that disconnects power when coolant temperature exceeds an adjustable setpoint.
   2. Contacts from the oil pressure switch to disconnect the heater power when the engine is running.
   3. Equip the water heater with shutoff valves and unions to allow heater replacement without draining the cooling system.
   4. Water heater connections with Aeroquip type hoses and fittings.
   5. Size heater such that the engine block temperature is maintained at 85 to 100 degrees Fahrenheit in a 40 degree Fahrenheit ambient temperature.
   6. Connect water heater and thermostat are to be connected to the engine in such a manner as to minimize heated water circulation through the radiator circuit.
   7. Water heater power is to be supplied from a normal (utility) power source:
      a. Heaters larger than 3,000 watts shall be 460 volts, 3-phase.

F. Alternator (generator):
   1. Brushless synchronous alternator.
   2. Re-connectable 12 lead, if available.
   3. Self-ventilated.
   4. Full amortisseur windings.
   5. Skewed for smooth voltage waveform.
   6. With permanent magnet generator pilot exciter.
   7. Drip-proof enclosure.
   8. Protected against corrosion.
   9. Single bearing design.
   10. Insulation:
      a. For continuous operation at 50 degrees Celsius ambient temperature.
      b. Class F (105 degrees Celsius rise by resistance) for medium voltage or Class H (125 degrees Celsius rise by resistance) for low voltage generators.
      c. Vacuum impregnated with epoxy varnish to be fungus resistant in accordance with MIL I-24092.
      d. Multiple dipped and baked with a non-hygroscopic varnish with a final dip of epoxy.
   11. Terminate alternator power leads using compression lugs on an insulator and bus bar system within the alternator junction box:
      a. These terminations must not require any taping to complete the connection.
      b. Utilize copper locomotive type cables to connect from the alternator to the load bank manual transfer equipment:
         1) Sized for 125 percent of the alternator full load current.
         2) Neutral conductors shall be sized at 100 percent of the alternator full load rating.
      c. Provide a ground terminal inside the junction box to terminate the ground cables between the alternator to the automatic transfer equipment ground bus:
         1) Minimum size of the equipment-grounding conductor: 12-1/2 percent of the size of the phase conductors.
   12. 120 VAC integral motor winding heaters wired to and powered from the engine control panel.
   13. Maximum balanced telephone interference factor not to exceed 50.

G. Alternator voltage regulator:
    1. Located in the engine control panel.
    2. Performance requirements:
        a. Maintain the steady state voltage within 0.5 percent:
            1) From 40 degrees Fahrenheit to 120 degrees Fahrenheit.
            2) From no load to full load conditions.
    3. Constant volts per hertz characteristics.
    4. Static type.
    5. Sized to match the power requirements at the permanent magnet generator pilot exciter.
    6. Include manual control to adjust voltage drop, voltage level, and voltage gain.
    7. With 3-phase sensing.
    8. Sealed from the environment and isolated from the load to prevent tracking when connected to SCR loads.
    9. Include loss of sensing shutdown to protect the generator against uncontrolled voltage output when the sensing circuit to the regulator is opened.
    10. Shut down regulator when the sensing circuit to the regulator does not have continuity.
    11. Include over-excitation shutdown to protect the generator against damage caused by prolonged field forcing.

H. Radiator and cooling system:
    1. Unit mounted:
        a. Furnish a skid mounted closed type radiator system for the engine driven generator:
            1) Sized and selected by the engine manufacturer.
        b. Provide necessary coolant specifically suitable for the location and conditions of service throughout the year:
            1) Ship both the engine and the radiator with the coolant installed.

I. Wiring:
    1. External wiring connection to and from the engine and alternator shall be made via 2 engine mounted junction boxes:
        a. Boxes shall be NEMA Type 12.
        b. One box shall be used for control and direct current power connections.
        c. Other box shall be used for the alternator output connections:
            1) Alternator output breaker may be used for these connections.
    2. Enclose wiring in an NEC approved and recognized conduit system selected and sized by the engine generator manufacturer:
        a. Suitable for the temperatures, vibrations, and conditions on the engine-driven generator skid.
    3. Control wiring shall terminate on terminal blocks in the control junction box:
        a. Connections shall be made to terminal blocks:
            1) 600-volt rated.
            2) Wires terminated on box with compression type ring type lugs, installed with proper tooling.
            3) Terminal blocks shall be numbered.
            4) Wiring in terminal box, both internal and field connections, shall be routed in plastic wire duct.
    4. Terminate wires using solderless compression type lugs:
        a. Lug manufacturer’s termination methods and tools must be used.

5. Splices are not allowed:
    a. Connections are to be made at the terminal blocks in the control junction boxes.

J. Battery system:
    1. Installed on the engine-driven generator skid.
    2. Provide extra flexible minimum 4/0 welding cable to make the connection between the battery and the engine:
        a. Proper compression lugs and tooling must be used to terminate these cables.
    3. Provide a 24-volt lead acid recombination no maintenance engine start battery system:
        a. Battery rated such that the 90-second cranking current to 1.0 volts per cell exceeds the starter rolling current at 40 degrees Fahrenheit:
            1) For the above ratings to be valid, the starter breakaway current must not exceed the rolling current by a factor of more than 2.5.
            2) Increase the battery size in order to supply power to the room ventilation louvers, automatic transfer equipment relaying and controls, and any direct current lighting.
    4. Charger:
        a. Sized to provide sufficient power to fully charge a drained battery and power the automatic transfer equipment relaying and controls.
        b. Located on the engine skid.
        c. With direct current ammeter and direct current voltmeter.
        d. With On-Off switch.
        e. Solid-state device with adjustable float voltage control.
        f. Constant voltage design with current limit.
        g. With an equalize switch which will allow the battery to be overcharged for maintenance purposes.
        h. Designed to meet the charge, float, and equalize requirement of the battery furnished.
        i. Overload and short circuit protection.

K. Generator control panel:
    1. Enclosure:
        a. Skid mounted.
        b. NEMA Type 12.
    2. Power supply to panel: 120/208-volt, 3-phase.
    3. Provide an integral flange-mounted disconnect to disconnect the 208 VAC power from all controls within the panel.
    4. Distribute power to devices required for the complete engine generator system.
    5. Provide, as a minimum, all needed transformers, relays, power supplies, overload, and short circuit protection needed in order to provide a complete and operating system:
        a. Engine generator controls.
        b. Interior light.
        c. Water heater.
        d. Battery charger.
        e. Motor winding heater.

L. Miscellaneous engine generator skid items:
    1. Provide the following items:
        a. Sectionalized drip pans.
        b. Rain shields for exhaust lines.
        c. Roof jacks.

M. Automatic generator control equipment:
    1. Provide a microprocessor-based control system for automatic starting, monitoring, and control functions for the engine generator system:
        a. UL 508 listed and labeled.
    2. Control system features and functions:
        a. Control switches:
            1) Mode selector switch: Initiates the following control modes:
                a) Provide a rotary switch or control panel keypads with status indicators.
                b) RUN or Manual position:
                    (1) Generator set starts, and accelerates to rated speed and voltage.
                c) OFF or STOP position:
                    (1) Generator set immediately stops, bypassing all time delays.
                d) AUTO position:
                    (1) Generator set accepts a signal from a remote device to start and accelerate to rated speed and voltage.
            2) EMERGENCY STOP switch:
                a) Red “mushroom-head” pushbutton.
                b) Activating the emergency stop switch causes the engine to immediately stop, and be locked out from automatic restarting.
            3) RESET switch:
                a) Clears all faults and allow restarting the engine generator after it has shut down for any fault condition.
            4) PANEL LAMP switch or automatic display panel illumination.
        b. Alternating current output metering: Provide the control system with metering, including the following features and functions:
            1) Voltmeter:
                a) RMS voltage.
                b) Line-to-line.
                c) Line-to-neutral.
            2) Ammeter:
                a) RMS current.
            3) Frequency.
            4) Power factor.
            5) Kilowatts (kW):
                a) kW-hours.
                b) Output kW.
            6) Kilovars (kVars):
                a) kVar-hours.
                b) Output kVar.
            7) Provide digital metering:
                a) 1.0 percent accuracy.

c. Generator alarm and status display:
    1) Provide high-intensity LED alarm and status indication lamps. Functions indicated include:
        a) Red alarm-indicating lamps.
        b) Red common shutdown lamp.
        c) 2 green lamps:
            (1) One to indicate the engine generator is running at rated frequency and voltage based on actual sensed voltage and frequency on the output terminals of the generator set.
            (2) The second to indicate a remote start signal has been received.
        d) Flashing red lamp to indicate that the control is not in automatic state.
        e) Amber common warning indication lamp.
    2) Display the following alarm and shutdown conditions on an alphanumeric digital display panel:
        a) Low oil pressure (alarm).
        b) Low oil pressure (shutdown).
        c) Oil pressure sender failure (alarm or indication).
        d) Low coolant temperature (alarm).
        e) High coolant temperature (alarm).
        f) High coolant temperature (shutdown).
        g) High oil temperature (warning).
        h) Engine temperature sender failure (alarm or indication).
        i) Low coolant level (alarm or shutdown - selectable).
        j) Fail to crank (shutdown).
        k) Fail to start/overcrank (shutdown).
        l) Overspeed (shutdown).
        m) Low direct current voltage (alarm).
        n) High direct current voltage (alarm).
        o) High alternating current voltage (shutdown).
        p) Low alternating current voltage (shutdown).
        q) Under frequency (programmable for alarm or shutdown).
        r) Overcurrent (programmed for warning or shutdown).
        s) Short circuit - circuit breaker function (trip).
        t) Emergency stop (shutdown).
    3) Control shutdown fault conditions shall be configurable for fault bypass.
d. Engine status monitoring:
    1) Display the following status conditions on an alphanumeric digital display panel:
        a) Engine oil pressure (pounds per square inch or kilopascal).
        b) Engine coolant temperature (degrees Fahrenheit or Celsius).
        c) Engine oil temperature (degrees Fahrenheit or Celsius).
        d) Engine speed (revolutions per minute).
        e) Number of start attempts.
        f) Battery voltage (direct current volts).
e. Data logging and display provision:
    1) Log the last 10 warning or shutdown indications on the engine generator.

2) Monitor the total load on the generator:
    a) Maintain data logs of total operating hours at specific load levels ranging from 0 to 110 percent of rated load, in 10 percent increments.
    b) Display total hours of operation at less than 30 percent load and total hours of operation at more than 90 percent of rated load.
3) Control system to log:
    a) Total number of operating hours.
    b) Total kW hours.
    c) Total control on hours.
    d) Total values since reset.

f. Engine control functions:
1) Provide a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles:
    a) Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
2) Provide an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this Specification, including adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
3) Provide time delay start (adjustable 0 to 300 seconds) and time delay stop (adjustable 0 to 600 seconds) functions.

g. Battery monitoring system:
1) Initiate alarms when the direct current control and starting voltage is less than 25 VDC or more than 32 VDC.
2) Disable the low voltage limit during engine cranking (starter engaged).
3) Monitor direct current voltage as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

h. Remote control interfaces:
1) Provide a minimum of 4 programmable output relays:
    a) Configurable for any alarm, shutdown, or status condition.
2) Provide a minimum of 4 programmable inputs.

N. Generator output circuit breaker:
1. Engine generator skid mounted and line side connected to alternator.
2. Manually resettable.
3. Line current sensing.
4. Inverse time versus current response.
5. Sized and coordinated to protect the generator from damage from overload and/or short circuit:
    a. Coordinated with down-stream devices:
        1) As specified in Section 16305 - Electrical System Studies.
6. Breakers shall be furnished as specified in Section 16412 - Low Voltage Molded Case Circuit Breakers.

2.08 ACCESSORIES (NOT USED)

2.09 FABRICATION (NOT USED)

2.10 FINISHES (NOT USED)

2.11 SOURCE QUALITY CONTROL

A. Minimum design prototype tests:
   1. Perform tests in accordance with NFPA.
   2. Maximum power in kW.
   3. Maximum starting kilovolt-ampere at 35 percent instantaneous voltage dip.
   4. Alternator temperature rise:
      a. By embedded thermocouple.
      b. By resistance method.
      c. In accordance with NEMA MG1-22.40 and 16.40.
   5. Governor speed regulation under steady state and transient conditions.
   6. Fuel consumption at 25 percent, 50 percent, 75 percent, and 100 percent load.
   7. Harmonic analysis, voltage wave form deviation, and telephone influence factor.
   8. Cooling airflow.
   9. Torsional analysis testing to verify that the generator set is free of harmful torsional stresses.
   10. Endurance testing.

B. Source Testing:
   1. Not witnessed.
   2. Test each engine generator under varying loads with machine safety guards and exhaust system in place. Complete engine generator system is to be tested at full load in the manufacturer's establishment:
      a. Owner's representative to observe the tests. Tests shall include:
         1) Radiator.
         2) Engine control panel.
         3) Single-step load pickup.
         4) Transient and steady-state governing.
         5) Safety shutdown device testing.
         6) Rated power.
         7) Maximum power.
      b. During the full load tests, re-circulate the radiator cooling air through the radiator as necessary to test the system under the maximum ambient conditions specified in this Section.
      c. Run the unit for 4 hours at 100-percent load with the following recordings made hourly:
         1) Frequency.
         2) Voltage.
         3) Amperage.
         4) Kilowatts.
         5) Room temperature as measured at the generator end of the unit.
         6) Radiator air inlet temperature.
         7) Coolant temperature.
         8) Oil pressure.
         9) Time engine takes to start in seconds.
      d. Record the following items:
         1) Maximum block load capabilities of the unit.
         2) Maximum fuel pump vacuum in inches of mercury as measured with the fuel suction line closed.
         3) Point at which over temperature shutdown occurs:
            a) By actual test of over temperature switch remote from engine.

4) Point at which over speed shutdown occurs:
   a) By actual test of speed switch remote from engine.
5) Point at which low oil pressure shutdown occurs:
   a) By actual test of low oil pressure switch remote from engine.
6) Point at which overcrank shutdown occurs.
7) Point at which overspeed shutdown occurs.
8) Low water temperature alarm.
9) Low fuel level alarm.
10) Fuel leak alarm.
11) Overvoltage alarm and shutdown.
12) Undervoltage alarm and shutdown.
13) Under frequency alarm and shutdown.
14) Low battery voltage alarm.

e. Test results must record any minor adjustments made during the test.
f. If major changes, as determined by the Engineer, are made, the 4-hour test must be repeated.

3. Furnish test reports and Manufacturer's Certificate of Source Testing.

PART 3 EXECUTION

3.01 EXAMINATION (NOT USED)

3.02 PREPARATION

A. Anchoring and bracing to structures:
   1. Prepare equipment anchor setting template(s) and use to position anchors during construction of supporting structure(s).
   2. Install anchors of type and material indicated on approved anchoring designs.
   3. Install anchors with embedment indicated on approved anchoring designs.

3.03 INSTALLATION

A. General:
   1. Install the equipment as indicated on the Drawings.
   2. Perform Work in accordance with the manufacturer's instructions and Shop Drawings.

B. By personnel experienced and regularly engaged in field installation of power generation systems:
   1. Make field mechanical and electrical connections.

C. Mount fuel tank at the elevation relative to the engine recommended by the manufacturer to achieve proper engine fuel flow.

D. Installation Verification:
   1. Furnish Manufacturer's Certificate of Installation Verification.

3.04 FIELD QUALITY CONTROL

A. As specified in Section 16050 - Common Work Results for Electrical.

B. Field electrical acceptance testing:
   1. As specified in Section 16950 - Field Electrical Acceptance Tests.
   2. Perform field acceptance tests as specified in Section 16950 - Field Electrical Acceptance Tests.

C. Test actual backpressure during acceptance testing of the system.

D. Provide the services of a manufacturer's representative for the following:
   1. Before start-up, inspect both mechanical and electrical installations, are complete and consistent with the Drawings and Specifications.
   2. Furnish the services of factory-certified technicians during the start-up and adjustment period to make sure items furnished are in proper operating condition:
      a. Engine technician must be completely knowledgeable in the operation, maintenance, and start-up of the mechanical system.
      b. Electrical technician must be completely knowledgeable in the operation, maintenance, and start-up of the electrical system.
   3. Perform installation check, start-up, and load test.
   4. Certify that fuel, lubricating oil, and antifreeze conform to the manufacturer's recommendations under the environmental conditions present.
   5. Check accessories that normally function while the equipment is in standby mode for proper operation, before cranking the engine. These accessories include, but are not limited to:
      a. Jacket water heaters.
      b. Fuel heaters, when used.
      c. Battery charger.
      d. Generator strip heaters, when used.

E. Start-up under manual mode:
   1. Check for the following items:
      a. Exhaust leaks.
      b. External path for exhaust gases.
      c. Cooling airflow.
      d. Movement during starting and stopping.
      e. Vibration during running.
      f. Normal and emergency line-to-line voltage and phase rotation.

F. Automatic start-up:
   1. By means of simulated power outage, test the following:
      a. Set timers for proper system coordination.
      b. Remote automatic starting.
      c. Transfer of load.
      d. Automatic shutdown.
   2. Continuously monitor the following parameters during this test:
      a. Engine temperature.
      b. Oil pressure.
      c. Battery charge level.
      d. Generator voltage.
      e. Generator amperes.
      f. Frequency.

3.05 OWNER TRAINING

A. Perform Owner Training as specified in Section 01756 - Commissioning.
   1. Number of sessions:
      a. Operations: 2.
      b. Maintenance: 2.

3.06 ADJUSTING

A. Make adjustments as necessary and recommended by the manufacturer, Engineer, or testing firm.

END OF SECTION