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**END OF SECTION**

**SECTION 03 30 00**  
**CAST-IN-PLACE CONCRETE**

**PART 1 GENERAL**

1.01 SECTION INCLUDES

- A. Concrete mix products including cementitious materials, aggregate, admixtures, mix design requirements, and concrete placing requirements.

1.02 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
  - 1. Alabama Department of Transportation (ALDOT):
    - a. Standard Specifications for Highway Construction (Standard Specification).
  - 2. American Concrete Institute (ACI):
    - a. 117, Specification for Tolerances for Concrete Construction and Materials.
    - b. 301, Specifications for Structural Concrete.
    - c. 305.1, Specification for Hot Weather Concreting.
    - d. 306.1, Standard Specification for Cold Weather Concreting.
  - 3. ASTM International (ASTM):
    - a. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
    - b. C33/C33M, Standard Specification for Concrete Aggregates.
    - c. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
    - d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
    - e. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
    - f. C150/C150M, Standard Specification for Portland Cement.
    - g. C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
    - h. C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete.
  - 4. National Ready Mixed Concrete Association (NRMCA).

1.03 DEFINITIONS

- A. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.

- B. Defective Area: Surface defects that include honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4 inch in diameter, cracks in liquid containment structures and below grade habitable spaces that are 0.005-inch wide and wider, and cracks in other structures that are 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances and include but are not limited to fins, form pop-outs, and other projections. At exposed concrete, defective areas also include texture irregularities, stains, and other color variations that cannot be removed by cleaning.
- C. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained.
- D. Hot Weather: As defined in ACI 305.1.
- E. New Concrete: Less than 60 days old.

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

- A. Class A Concrete shall be formed, reinforced concrete having a 28 day minimum compressive strength of 4,000 psi.
  - 1. Class A concrete shall be cast-in-place in forms for foundations, pipe collars, footings, piers, headwalls, manholes, junction boxes, and similar structures.
  - 2. Mix design shall be “Concrete Class- Type A-1c” in accordance with Section 206 of the ALDOT, Standard Specifications.
- B. Class B Concrete shall be non-formed, non-reinforced concrete having a 28-day minimum compressive strength of 3,000 psi.
  - 1. Class B concrete shall be used for pipe protection, encasement, anchors, massive sections, and similar structures.
  - 2. Mix design shall be “Concrete Class- Type A-1a” in accordance with Section 206 of the ALDOT, Standard Specifications.
- C. Class C shall be non-formed non-reinforced cement mortar flowable fill having a 28 day minimum compressive strength of 1,000 psi.
  - 1. Class C flowable fill shall be used for trench bottom stabilization, backfill around pipe and above pipe.
  - 2. Mix design shall be “Mix 4” in accordance with Section 260 of the ALDOT, Standard Specifications.

- D. Other classes, types or design for cast-in-place concrete may be approved by the ESD as circumstances require.

## 2.02 MATERIALS

### A. Cementitious Materials:

- 1. Cement:
  - a. Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.
  - b. Furnish from one source.
- 2. When used for construction of manholes pump stations and locations where in contact with wastewater, the Tri Calcium Aluminate content must be less than 5.5 percent.

### B. Aggregates: Furnish from one source for each aggregate type used in a mix design.

- 1. Normal-Weight Aggregates:
  - a. In accordance with ASTM C33/C33M, except as modified herein.
- 2. Fine Aggregates:
  - a. Natural sand consisting of clean, hard, durable, uncoated grains.
  - b. ASTM C33/C33M.
- 3. Coarse Aggregate:
  - a. Uncoated particles of sound, durable rock of uniform quality, without any excess of flat, elongated or laminated pieces.
  - b. No surface, yellow or soft stone shall be permitted.
  - c. Specific gravity of the stone shall be not less than 2.55.

### C. Water: Mixing water for concrete shall be potable water.

## 2.03 ANCILLARY MATERIALS

### A. Reinforcing Material for Cast-In-Place Concrete:

- 1. Reinforcing bars shall conform to the requirements of ASTM A614.
- 2. Reinforcing bars shall be grade 60 deformed bars, or as specified by Design Engineer.
- 3. Welded wire fabric or cold-drawn wire for concrete reinforcement shall conform to the requirements of ASTM A185 or ASTM A82, respectively.

### B. Grout: Grout shall consist of mixture of water and cement or water and one-part cement to two parts mortar sand, by volume. The water may be adjusted to produce a mixture suitable for field conditions.

### C. Water Stop Grout/Hydraulic Cement: Shall be Bonsal Instant Hydraulic Cement, or BASF MasterSeal 590. No other products will be allowed.

## 2.04 CONCRETE MIXING

- A. General: In accordance with ACI 301, except as modified herein.
- B. Truck Mixers:
  - 1. For every truck, test slump of samples taken per ASTM C94/C94M, paragraph 12.5.1.
  - 2. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer, unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

## **PART 3 EXECUTION**

### 3.01 PLACING CONCRETE

- A. Preparation: Meet requirements ACI 301, except as modified herein.
- B. Placement into Formwork:
  - 1. Reinforcement: Secure in position before placing concrete.
  - 2. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
  - 3. Use placement devices, for example chutes, pouring spouts, and pumps as required to prevent segregation.
  - 4. Vertical Free Fall Drop to Final Placement:
    - a. Forms 8 Inches or Less Wide: 5 feet.
    - b. Forms Wider than 8 Inches: 8 feet, except as specified.
  - 5. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.
    - a. Limit free fall to prevent segregation caused by aggregates hitting steel reinforcement.
  - 6. Do not use aluminum conveying devices.
  - 7. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
  - 8. Joints in Footings and Slabs:
    - a. Ensure space beneath plastic waterstop completely fills with concrete.
    - b. During concrete placement, make visual inspection of entire waterstop area.

- c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, and place remaining concrete to full height of slab.
      - d. Apply procedure to full length of waterstop.
    - 9. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.
    - 10. Cure concrete in accordance with ACI 308.
  - C. Conveyor Belts and Chutes:
    - 1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
    - 2. Do not use chutes longer than 50 feet.
    - 3. Minimum Slopes of Chutes: Angled to allow concrete to readily flow without segregation.
    - 4. Conveyor Belts:
      - a. Wipe clean with device that does not allow mortar to adhere to belt.
      - b. Cover conveyor belts and chutes.
  - D. Retempering: Not permitted for concrete where cement has partially hydrated.
  - E. Pumping of Concrete:
    - 1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
    - 2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
    - 3. Replace pumping equipment and hoses (conduits) that are not functioning properly.
  - F. Maximum Size of Concrete Placements: Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
  - G. Hot Weather:
    - 1. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 301, ACI 305.1, and as follows:
      - a. Maintain concrete temperature below 90 degrees F at time of placement, or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.

- b. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.

H. Cold Weather Placement:

1. Unless otherwise permitted, shall be in accordance with requirements of ACI 306.1 and as follows:
  - a. Cold weather requirements shall apply when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling.
  - b. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth shall be thawed to acceptance of Engineer.
  - c. Unless otherwise permitted, do not place concrete in contact with surfaces less than 35 degrees F; requirement is applicable to all surfaces including reinforcement and other embedded items.
  - d. Provide supplemental external heat as needed when other means of thermal protection are unable to maintain minimum surface temperature of concrete as specified in ACI 306.1.
  - e. Maintain minimum surface temperature of concrete as specified in ACI 306.1 for no less than 3 days during cold weather conditions.

3.02 TESTING

A. Strength Tests During the Work:

1. If concrete is being poured, the Contractor will make four concrete test cylinders for each 50 cubic yards poured or for each days pour, whichever amount of concrete is smaller.
2. Cylinders will be made and tested in accordance with ASTM C31, ASTM C172 and ASTM C39.
3. The standard age of the test shall be 28 days with the first cylinder broken at 7 days.
4. If the 7-day break exceeds the specified strength, then no further tests will be made until the 28<sup>th</sup> day.
5. If the 7-day break does not meet the specified strength, then the second cylinder will be tested at the 14<sup>th</sup> day.
6. In either event, the remaining cylinder(s) will be tested at the 28<sup>th</sup> day.
7. When the test cylinders fail to conform to the compressive strength requirements, the ESD shall have the right to order a change in the concrete mix for the remaining portions of the work. The Contractor may wish to make additional cylinders at his own expense as verification.



B. Test of Hardened Concrete In, or Removed From the Structure:

1. When the results of the strength tests of the control specimens indicate the concrete as placed does not meet specification requirements or where there is other evidence that the quality of the concrete is below specification requirements, core-boring tests shall be made in conformance with ASTM C42.
2. Core specimens will be tested by a certified testing laboratory approved by the ESD.
3. All deficiencies shall be corrected, or, if the Contractor elects, he may submit a proposal, for approval, that load tests be made.
4. If the proposal is approved, the load test shall be made by the Contractor and the test results evaluated by the ESD.
5. If any concrete shows evidence of failure during the load test, or fails the core test as evaluated, the deficiency shall be corrected. Any deficiency shall be corrected in a manner approved by the ESD.

**END OF SECTION**



**SECTION 03 40 00**  
**PRECAST CONCRETE STRUCTURES**

**PART 1 GENERAL**

1.01 SUMMARY

- A. This Specification details the requirements for precast concrete wet wells and vaults. As an alternate the Engineer/Designer can also design these structures in accordance with the requirements of ASTM 478 and Section 33 05 13, Factory-Built Fiberglass Modular Pump Station Enclosure.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
  - 1. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
  - 2. ASTM International (ASTM):
    - a. A36, Standard Specification for Structural Steel.
    - b. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
  - 3. Precast/Prestressed Concrete Institute (PCI): MNL-116, Standard for Quality Control of Precast and Prestressed Products.

1.03 QUALITY ASSURANCE

- A. Qualifications of Precasting Manufacturers:
  - 1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
  - 2. Precast Plant: PCI certified plant with current certification.

**PART 2 PRODUCTS**

2.01 MATERIALS

- A. Formwork: One-piece, full length and without seams.
- B. Reinforcing Steel: As specified in Section 03 30 00, Cast-in-Place Concrete.
- C. Cement: As specified in Section 03 30 00, Cast-in-Place Concrete.
- D. Aggregates: As specified in Section 03 30 00, Cast-in-Place Concrete, for 3/4-inch maximum size.

- E. Admixtures: As specified in Section 03 30 00, Cast-in-Place Concrete.
- F. Embedded Items:
  - 1. ASTM A36 steel unless otherwise noted.
  - 2. Anchor Studs: Headed anchor studs (HAS), deformed bar anchors (DBA), or threaded studs as manufactured by Nelson Stud Welding Co., Lorain, OH.
  - 3. Furnish inserts for lifting as required.
- G. Roof Hatches:
  - 1. Hot-dip galvanized steel access hatch and frame designed for appropriate loading at installation site/location.
  - 2. Hatch shall be manufacturers standard lockable hinged access cover with hold open arm and shall be provided with removable topside key wrench and inside fixed lever handle.
- H. Grout: Nonshrink, nonmetallic Type II grout.
- I. Waterproofing:
  - 1. One-component moisture curing polyurethane elastomer.
  - 2. Manufacturers and Products:
    - a. 3M Co., St. Paul, MN; Scotch-Clad Waterproof Coating.
    - b. Gaco Western, Seattle, WA; Gacoflex P-50.

## 2.02 CONCRETE MIX

- A. As specified in Section 03 30 00, Cast-in-Place Concrete and as follows:
  - 1. Design Strength: 4,500 psi at 28 days.
  - 2. Water/Cement Ratio: 0.38 maximum.

## 2.03 DESIGN REQUIREMENTS

- A. Precast Concrete Structures:
  - 1. Precast concrete structures shall comply with ASTM C858 except as modified herein.
  - 2. Design live loads shall be in accordance with ASTM C857. Design precast concrete structures to withstand site soil conditions and traffic loading of A-16 per Table 1 of ASTM C857 with a 30 percent increase due to impact. Soil lateral loads shall be as determined by ASTM C857.

3. Design shall also comply with the following restrictions:
  - a. The maximum reinforcing ratio allowed is one-half the reinforcement ratio that produces a balanced strain condition.
  - b. Earth pressure used in design shall be undrained fluid pressure at rest as indicated in the General Structural Notes on the Drawings.
  - c. Include a live load surcharge of 2 feet of soil in the design of the walls.
  - d. Structures shall be designed to be resistant to buoyant forces with ground water elevation at the top of the structure. A factor of safety of 1.1 shall be used against uplift utilizing only dead weight of the structure for resistance (structure weight divided by 1.1 shall be greater than or equal to the total buoyant force). A factor of safety of 1.5 shall be used against uplift when utilizing the weight of soil above the base extensions (the sum of the structure weight divided by 1.1 plus the soil weight above the base extensions divided by 1.5 shall be greater than or equal to the total buoyant force). Structure weight shall include only weight of walls and slabs. Weight of fillets, baffle walls, pump pads, and equipment shall not be used in the calculation of the structure weight. Unit weight of soil shall be 120 pcf. Unit weight of concrete shall be 145 pcf. Unit weight of water shall be 62.4 pcf.
4. Precast construction shall be in the form of monolithic walls or horizontal sections. Do not use panel walls.
5. Minimum wall thickness shall be 6 inches. Design knockout wall panels to accommodate loading pressures defined above.
6. Design and construct walls to be watertight.
7. Provide openings in structures for pipes and access openings as shown.

## 2.04 FABRICATION

### A. General:

1. Comply with PCI MNL-116.
2. Reinforcing Steel:
  - a. Place in position before concrete is cast.
  - b. Keep clean and free from form oil or other substances harmful to bond.
3. Forms: Produce smooth surfaces.
4. Concrete: Deposit, vibrate, finish, and cure in accordance with recommended practices of ACI 304R. Steam curing is permitted.
5. Coordinate dimensions, determine type, quantity, size, and location of, and furnish necessary embedded items in precast concrete. Coordinate location of embedded items in cast-in-place concrete necessary to connect precast items.

- B. Waterproofing:
  - 1. Apply to exterior surfaces of walls, at precast plant site or at Site, in accordance with manufacturer's instructions.
  - 2. Protect surface until installed in the Work.
  - 3. Repair damage as approved by manufacturer.

## 2.05 SOURCE QUALITY CONTROL

- A. Prepare minimum three standard concrete test cylinders for each 50 cubic yards or fraction thereof of concrete placed in the precast work in accordance with ASTM C31.
- B. Test and record concrete strengths.

## **PART 3 EXECUTION**

### 3.01 ERECTION

- A. Verify that anchorage inserts are in correct locations.
- B. Handle and erect precast concrete with care as recommended by manufacturer.
- C. Erect precast units plumb, straight, level, square, and in proper alignment.
- D. Fasten units securely in place and brace to maintain position, stability, and alignment until permanently connected and structure is complete and stable.
- E. Field Cutting: Not allowed without prior approval of Engineer.

### 3.02 EXCAVATING AND BACKFILLING

- A. Complete applicable Work specified in Sections 31 23 16, Excavation, prior to placing fill or backfill.
- B. Provide 6-inch minimum thickness of structural fill as specified in Section 31 23 23, Trench Backfill over full width and length of structure base and extend a minimum 12 inches beyond the limits of the base. Backfill around the vault with structural fill.
- C. Excavated material may be used for earth fill provided it conforms to the requirements processed earth fill as specified in Section 31 23 23, Trench Backfill.

3.03 PATCHING

- A. Mix and place patching mixture to match color and texture of surrounding concrete and to minimize shrinkage.
- B. Demonstrate patching method and obtain acceptance and approval.

3.04 FIELD QUALITY CONTROL

- A. Inspection: With ESD, inspect precast structures for chips, cracks, and other damage.
- B. Resolution:
  - 1. Repair damage to satisfaction of ESD.
  - 2. Perform re-inspection and obtain acceptance by ESD.

3.05 PROTECTION

- A. Protect precast units from chipping, spalling, cracking, or other damage to the units after delivery to Site, during and after installation.

**END OF SECTION**





**SECTION 09 66 01**  
**MONOLITHIC LINING OF MANHOLES**  
**AND PUMP STATION WET WELLS**

**PART 1 GENERAL**

1.01 SUMMARY

- A. To provide protection from hydrogen sulfide induced corrosion, a monolithic lining shall be applied:
  - 1. To all pump station wet wells.
  - 2. New and/or existing manholes where a new force main will discharge
  - 3. All manholes with inside or outside drops.
  - 4. All manholes that receive flow from a main sewer at a slope greater than 10 percent.
  - 5. Manholes and other structures where the Owner/Owners Representative has determined that turbulence may result in the release of hydrogen sulfide.
- B. This Specification addresses sealing of existing structures that have inflow and infiltration or have been damaged by hydrogen sulfide induced corrosion. Where new structures show signs of inflow and infiltration they shall be replaced and/or repaired in accordance with the direction of the Owner/Owners Representative.

1.02 SECTION INCLUDES

- A. The materials and application of a corrosion-resistant, spray- or roller-applied, monolithic lining system.

1.03 QUALITY ASSURANCE

- A. Applicator's Experience: Minimum 3 years of practical experience in the application of specified products.
- B. Qualification of Contractor's Personnel:
  - 1. Underlayment Trowel Applicators:
    - a. Demonstrated capability of troweling underlayment in a manner that yields a strong, uniform, well-bonded substrate for lining application as specified herein, subject to the Owner/Owners Representative, Engineer/Designer and Manufacturer's approval prior to start of underlayment application.
    - b. Minimum of 3 years' continuous experience on similar type trowel underlayment projects.

- c. Shall be certified/trained by the underlayment manufacturer.
- 2. Lining Spray Applicators:
  - a. Demonstrated capability of applying lining material in a manner that yields a strong, uniform thickness, well-bonded, pin-hole free coating as specified herein, subject to the Owner/Owners Representative, Engineer/Designer and Manufacturer's approval prior to start of lining application.
  - b. Minimum 3 years' continuous experience on similar type plural component lining projects.
  - c. Shall be certified/trained by the lining manufacturer.

#### 1.04 WARRANTY

- A. Material Warranty: A written guarantee of 5-year shall be provided by the manufacturer against any breakdown of the material effectiveness of the structural repair elements.
- B. Workmanship Warranty: A written guarantee of 5-year minimum shall be provided by the Contractor against any shortcomings of the workmanship.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver lining products to the Project Site in unopened containers that plainly show, at time of use, the designated name, date of manufacture, batch number, and name of manufacturer.
- B. Store lining products in a suitable protected area that is heated or cooled as required to maintain temperatures within the range recommended by lining manufacturer.

#### 1.06 PROJECT CONDITIONS

- A. Environmental Requirements:
  - 1. Provide bypass pumping as required.
  - 2. Control the environment within the facility that is to be lined. This includes maintaining the required application temperature and humidity for the linings being applied.
  - 3. Provide illumination for surface preparation and application and curing of all underlayment and lining materials.
  - 4. Provide equipment to ventilate the facilities during the application and cure of the lining materials.

#### 1.07 SEQUENCING AND SCHEDULING

- A. Lining shall not be applied until new concrete has reached its 28-day strength unless otherwise approved by the manufacturer.

## **PART 2      PRODUCTS**

### **2.01      MANUFACTURER**

- A. Lining and underlayment materials shall have a documented, proven performance record in similar facilities and exposure conditions.
- B. Manufacturers shall be regularly engaged in the production of such materials for identical service conditions and have a minimum of 5 years' verifiable experience in manufacture of these products. The following manufacturer's products that have been approved by the Owner/Owners Representative are acceptable:

- 1. Urethane Resin Liner:

- Spray Wall
  - Sprayroq, Inc.
  - 4707 Alton Court
  - Birmingham, AL 35210
  - Contact: Mr. Brad Bell
  - Telephone: (205) 957-0020

- 2. Multi-Component Stress Skin Panel Liner:

- Spectra-Shield Liner System
  - CCI Spectrum, Inc.
  - 9716 Florida Mining Blvd. W.
  - Jacksonville, FL 32257
  - Contact: Bob Klopfenstein
  - Telephone: (904) 268-4951
  - Fax:           (904) 268- 4923

- 3. Cured-In-Place Epoxy Resin Liner:

- Poly-Triplex Liner System
  - SunCoast Environmental International, Inc.
  - 907 Orange Hill Road
  - Chipley, Florida 32428
  - Contact: Kathy Jones
  - Telephone: (800) 395-4637

- 4. Sprayed Applied Epoxy Resin Liner:

- Raven 405
  - Reynolds, Inc.
  - 5120 Selkirk Drive, STE 140
  - Birmingham, Alabama 35242
  - Contact: Mr. Ken Thompson
  - Telephone: (205) 408-5949
  - Fax:           (205) 408-5907

Warren Environmental System M-201 and S-301  
Warren Environmental, Inc.  
P.O. Box 125  
South Carver, MA 02330  
Contact: Danny Warren  
Telephone: (508) 866-5721

5. Fiberglass Insert:

L.F. Manufacturing Fiberglass Insert  
R.E. Inman & Associates, Inc.  
2910-M Cole Court  
Norcross, GA 30071  
Contact: Mr. Robert E. Inman  
Telephone: (770) 446-5656

6. Fiberglass Reinforced Epoxy Resin Liner:

PerpetuWall Protective Liner Systems  
261 Douglas Road East  
Oldsmar, FL. 34677  
Contact: Mr. Jerry Trevino  
Telephone: (813) 855-6550

## 2.02 TEST EQUIPMENT

- A. Before construction begins, the Contractor shall obtain and be knowledgeable in the use of the following equipment:
1. U.S. Weather Bureau Psychrometric Tables for determining dew point from wet and dry bulb temperatures, as available from KTA-Tator, Inc., Pittsburgh, PA.
  2. A portable, self-contained, hand-held sling psychrometer with thermometers ranging from 20 degrees F to 120 degrees F and built-in slide rule for determination of relative humidity as manufactured by Bacharach instrument Co., Pittsburgh, PA; or Taylor Co.
  3. A hand-held digital thermometer, range minus 20 degrees F to 200 degrees F, and interchangeable surface temperature and air temperature probes as manufactured by Atkins.
  4. A high voltage holiday detector for thick film coatings as manufactured by Tinker and Razor, Model AP/W, San Gabriel, CA.
  5. Ten hand-held pH pencils suitable for measuring pH of concrete surfaces as manufactured by Burrel Scientific, Model Insta-Check Surface pH pencil, No. P-13N, Pittsburgh, PA.

- B. This test equipment shall be used for monitoring and testing requirements.
- C. The test equipment shall be stored at the Project Site for the Contractor's daily use and shall be maintained in accurate, working conditions at all times. The test equipment shall be available to the Owner/Owners Representative for testing purposes.

## 2.03 CHEMICAL PRESSURE GROUTING SYSTEMS

- A. Where the pressurized injection of chemical grout behind the manhole chimney and joints is required to control and eliminate inflow or infiltration, the material supplied shall be a urethane gel or polyurethane resin with properties as follows:
  - 1. While being injected, the chemical sealant must be able to react/perform in the presence of infiltrating water.
  - 2. The cured sealant must be capable of withstanding submergence in water without degradation.
  - 3. The cured sealant must prevent the passage of water through the manhole defect.
  - 4. The cured sealant must be flexible as opposed to brittle or rigid.
  - 5. In place, the cured sealant shall be able to withstand freeze/thaw and wet/dry cycles without adversely affecting the seal.
  - 6. The cured sealant must not be biodegradable. Additives may be used to meet this requirement, without affecting long-term strength.
  - 7. The cured sealant shall be chemically stable and resistant to concentrations of acids, alkalis, and organics found in normal sewage.
  - 8. Packaging of component materials must be compatible with field storage and handling requirements. Packaging must provide for worker safety and minimize spillage during handling.
  - 9. In the event that the chemical sealant may be harmful by passing through the unbroken skin, by inhalation of dust, vapor or mist, or by swallowing, the handling and mixing shall be performed with proper equipment, with adequate ventilation, and by personnel thoroughly familiar with the chemicals involved and shall be in strict accordance with the manufacturer's recommendations and with the provisions of all safety regulations.
  - 10. Mixing of component materials must be compatible with field conditions.
  - 11. Residual sealing materials must be easily removable from the bench of manhole to prevent reduction or blockage of the sewer flow.
  - 12. No grouting operations shall be performed at temperatures below 40 degrees F or where the temperature of the groundwater is below 40 degrees F.
  - 13. Urethane gel grout or Polyurethane resin grout shall be utilized for the entire manhole.

14. Urethane Gel: Urethane gel shall have the following properties and characteristics:
  - a. One part urethane prepolymer thoroughly mixed with between 5 and 10 parts water by weight. The recommended mix ratio is 1 part urethane prepolymer to 8 parts of water (11 percent prepolymer).
  - b. A liquid prepolymer having a solids content by weight of 77 percent to 83 percent, specific gravity of 1.04 (8.65 pounds per gallon), and flash point of 200 degrees F.
  - c. A liquid prepolymer having a viscosity of 600 to 1,200 centipoise at 70 degrees F, that can be pumped through 500 feet of 1/2-inch hose with a 1,000 psi head at a 1-ounce per second flow rate.
  - d. The water used to react the prepolymer should be in the pH range of 6.5 to 8.0.
  - e. A cure time of 80 seconds at 40 degrees F, 55 seconds at 60 degrees F, and 30 seconds at 80 degrees F, when 1 part prepolymer is reacted with 8 parts of water only. Higher water ratios give longer cure times.
  - f. A cure time that can be reduced to 10 seconds for water temperatures of 40 degrees F to 80 degrees F when 1 part prepolymer is reacted with 8 parts water containing gel control agent.
  - g. A relative rapid viscosity increase of the prepolymer/water mix. Viscosity increases from about 10 to 60 centipoise in the first minute for 1 to 8 prepolymer/water ratio at 50 degrees F.
  - h. A reaction (curing) which produces a chemically stable, non-biodegradable, tough, flexible gel.
  - i. The ability to increase mix viscosity, density, gel strength and resistance to shrinkage by using additives in the water component of the grout.
  - j. The ability to accept suspended additives such as two, 6-dichlorobenzonitrile root control.
  - k. Contain a minimum of 15 percent shrink control agent supplied by the same manufacturer.
15. Polyurethane Resin Grout: Polyurethane resin grout shall have the following properties and characteristics:
  - a. Viscosity: 120 – 350 cps.
  - b. Weight Per Gallon: 8.65 to 9.48 lbs./gal.
  - c. Solids Content: 88 percent to 100 percent (ASTM D2834).
  - d. Induction Time: 3 to 4 minutes.
  - e. Cure Time: 5 to 6 minutes.
  - f. Tensile Strength: 40 to 450 psi (ASTM D3574).
  - g. Elongation: 3 percent to 350 percent (ASTM D3574).

- h. Shrinkage: Less than 2 percent (ASTM D1042/D756).
- i. Initial Linear Shrinkage: 9 percent.
- j. Tear Resistance: 21 lbs./in. (ASTM D3574).
- k. Density: 38 to 119 lbs./ft<sup>3</sup> (ASTM D3574).
- l. No catalyst required; single component product.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

#### **A. Surface Preparation Inspection:**

- 1. Provide the Owner/Owners Representative Inspector a minimum of 3 days' advance notice prior to start of surface preparation work or coating application work.
- 2. Perform surface preparation only in presence of Engineer/Designer unless otherwise approved.
- 3. Inspect and provide substrate surfaces prepared in accordance with these Specifications and the printed directions and recommendations of the lining manufacturer.
- 4. The cleaned substrate shall be inspected and approved by the Engineer/Designer and a representative of the manufacturer prior to the application of any underlayment or lining materials.

B. Obtain a full cure of the entire system before the area is placed back in service. Consult lining manufacturer's written instructions for these requirements. Do not immerse lining for any purpose until completion of curing cycle.

C. Contractor shall provide adequate means to prevent concrete debris generated during the surface preparation interfering with the Owner's treatment process or equipment. Water free of sediment and deleterious compounds may be diverted to the Owner's treatment process upon approval by the Owner.

### **3.02 PREPARATION OF SURFACES**

A. Surfaces to receive this lining system shall be free of dust, loose particles, oils, grease, chemical contaminants, attacked concrete, and previously applied protective coatings and have a minimum pH of 10 for concrete surfaces.

B. All surfaces to be lined shall be cleaned by hydroblasting and/or abrasive blasting. Hydroblasting shall be completed using potable water. Only non-silica abrasives shall be used for abrasive blasting. Contractor shall provide provisions to keep material from falling into the sewer.

- C. During surface preparation activities, the Contractor shall regularly (approximately every 100 square feet) measure the surface pH using pH test pencils to verify compliance with these Specifications. Surfaces not meeting the requirements shall be marked and reblasted.
- D. Following completion of surface preparation, all active hydrostatic leaks shall be plugged by use of a water-stop material. All structural defects, voids, or cracks in the substrate shall be repaired prior to the application of the underlayment or monolithic lining. Repair materials shall be approved by the lining manufacturer.
- E. The attacked or rough concrete substrate, including voids, crevices, and holes, shall be resurfaced with the underlayment material to return it to pre-existing levels. Mix and apply underlayment in accordance with the lining manufacturer's written recommendations.
- F. If any reinforcing steel is exposed during the surface preparation operation, the Engineer/Designer shall be notified and the reinforcing steel shall be repaired per Engineer/Designer's instructions. Exposed rebar shall be abrasive blasted (SSPC SP10) and coated with at least 3 mils of epoxy.
- G. Mark and protect embedded anchors prior to blasting.

### 3.03 LINING APPLICATION

- A. Mix and apply monolithic lining in accordance with the lining manufacturer's recommendations.
- B. The lining thickness will vary by system but shall be a minimum thickness of 125 mils. Follow lining manufacturer's specific recommendations to ensure installation of the minimum thickness and a pinhole free surface.

### 3.04 MANHOLE CHEMICAL PRESSURE GROUTING

- A. General: Pressure grouting shall be done in accordance with the Drawings and will be performed on any sections that have evidence of rain-derived inflow and infiltration. Any structurally unsound manholes observed by Contractor shall be replaced as directed by Engineer/Designer.
  - 1. The existing manhole structure designated for pressure grouting for pipe seals or for precast joints shall be thoroughly cleaned prior to grouting. Contractor shall dispose of all debris and prevent any debris from entering the existing sewer lines.



2. Grade adjustments, frame and cover replacements, chimney repairs, frame seals and other repairs shall be performed prior to pressure grouting. Pressure grouting shall be done prior to interior lining. All roots exposed in the manhole shall be removed.
3. Pressure chemical grouting of the manhole may include chimney and pipe seals.

B. Grouted and Coated Pipe Sealing:

1. Injection holes shall be drilled with a minimum of three holes around the pipe/manhole wall connection. After removal of the grouting probe, activated oakum rope shall be used to fill the injection hole. Injection hole shall be patched with waterproof, quick setting mortar and covered with a moisture resistant two-part epoxy adhesive coating. Any pipe damaged by Contractor while drilling the injection hole shall be replaced.
2. Contractor shall replace any portion of the existing manhole or pipe which is damaged during pipe sealing.
3. The deteriorated area of the pipe seal shall be removed to sound material. Care shall be taken to avoid damaging other parts of the manhole structure. Loose and broken brick, mortar, concrete or debris, and pipe shall be removed from the manhole.
4. A Bonding agent, Weld-Crete as manufactured by Larsen Products Company or approved equal, shall be applied to existing surfaces to provide a firm adhesion between original and new cementitious materials in accordance with manufacturer's recommendation.
5. Contractor shall place rapid-set grout, Octocrete, as manufactured by IPA, or approved equal, to the area. Rapid-set grout shall be placed in such a manner that it is consolidated, fills existing voids, and creates a smooth, dense surface in accordance with the Drawings.
6. Wastewater flow shall be maintained by methods which prevent contact with new pipe seal after Rapid-set grout placement in accordance with manufacturer's recommendations.
7. The pipe seal shall form a water tight seal with the manhole wall, bench, trough, and pipe. The manhole and pipes shall be cleaned of all debris and foreign matter.
8. Contractor is responsible to stop all active inflow and infiltration leaks in the manhole prior to placing the interior coating. Work and materials required to stop leaks in the manhole are considered subsidiary to Interior Chimney Lining and will not be paid for directly.

3.05 TESTING

A. General:

1. Perform testing, document and submit results to the Owner/Owners Representative.

2. Provide the Owner/Owners Representative 24 hour's notice of start of testing.
3. Manufacturer/manufacturer's representative shall be present for testing as required for preparation of proper installation documentation.

B. Air, Concrete Substrate, and Lining Materials:

1. Temperatures:
  - a. Measure and record twice daily air, concrete substrate, and lining surface temperatures within structure during mixing, application, and curing of materials; verify compliance with manufacturer's temperature ranges.
  - b. Take measurements in morning and afternoon in presence of Engineer.
  - c. If outside acceptable range, make adjustments to return to and maintain manufacturer's required temperatures prior to continuing lining application.
2. Humidity:
  - a. Measure and record twice daily relative humidity within structure during mixing, application, and curing of materials; verify compliance with manufacturer's requirements.
  - b. Take measurements in morning and afternoon in presence of Engineer/Designer.
  - c. If outside acceptable range, make adjustments to return to and maintain manufacturer's required relative humidity prior to continuing lining application.

C. Epoxy Lining and Polyurethane/Polymer Lining System:

1. Wet Film Thickness Gauge: During application, use wet film thickness gauge; meet ASTM D4414 to ensure monolithic coating and uniform thickness.
2. Holiday Detection:
  - a. In accordance with NACE SPO 188.
  - b. After 24 hours minimum, spark test lining system to ensure pinhole-free lining.
  - c. Mark defects and repaired per manufacturer's instructions.
3. Adhesion Test:
  - a. Test 10 percent minimum of manholes for adhesion/bond of coating to substrate. Engineer/Designer will select manholes to be tested.
  - b. Conduct in accordance with ASTM D4542 as modified herein.
    - 1) Prepare coating and dollies to receive adhesive.

- 2) Attach three 20-millimeter dollies minimum. Adhesive used to attach dollies to coating shall be rapid setting with tensile strength in excess of coating product and permitted to cure in accordance with manufacturer's recommendations.
  - 3) Failure of dolly adhesive shall be deemed a nontest and require retesting.
  - 4) Prior to performing pull test, score coating to within 30 mils of substrate by mechanical means without disturbing dolly or bond within test area.
  - 5) Two of the three adhesion pulls shall exceed 200 psi or concrete failure with more than 50 percent of subsurface adhered to coating.
  - 6) Should a structure fail to achieve two successful pulls as described above, perform additional testing at discretion of Engineer/Designer.
  - 7) Areas detected to have inadequate bond strength shall be evaluated by Engineer/Designer.
  - 8) Further bond tests may be performed in area to determine extent of potentially deficient bonded area.
  - 9) Repairs deficient areas.
4. Vacuum Test: Vacuum test conforming to the requirements of ASTM C1244 shall be performed for every lined manhole unless otherwise approved by the Engineer/Designer.

### 3.06 MANUFACTURERS' FIELD SERVICES

- A. Manufacturer's Authorized Technical Representative: Coordinated by the Contractor and present at the work site for the construction activities indicated below for observation of product application, verification of quality assurance, and to determine compliance with manufacturer's instructions. The minimum person-days are listed below, travel time excluded.
- B. Minimum Services at the Start of the Work shall Include:
1. 0.5 person-day for start of surface preparation.
  2. 1 person-day for start of underlayment application and lining application.
  3. 1 person-day for start of lining spray application.
- C. Additional person-days as may be necessary to resolve field problems attributable to or associated with, manufacturer's products furnished under this Contract.

**END OF SECTION**



**SECTION 13 34 23**  
**FACTORY-BUILT FIBERGLASS**  
**MODULAR PUMP STATION ENCLOSURE**

**PART 1 GENERAL**

1.01 SECTION SUMMARY

- A. This section details the basic requirements for a pump station fiberglass enclosure. Drawings and other documents prepared by the Engineer/Designer further detail the requirements.

**PART 2 PRODUCT**

2.01 MODULAR PUMP STATION ENCLOSURE

- A. Enclosure Construction and Design:
1. The enclosure is to be square/rectangular with outside dimensions of as detailed on the drawings and having a height of 9 feet at the roof peak.
  2. A minimum of (4) four lifting eyes arranged on the corners shall be provided to ease handling and installation onto a concrete pad furnished by the contractor.
  3. Enclosure walls and roof shall be seamless, one-piece sprayed fiberglass panels laminated to form a structural composite as follows: 1/8-inch thick fiberglass outside surface, 1-inch thick urea-foam polyurethane core, 7/16-inch oriented strand board (OSB), and 3/32-inch thick fiberglass inside surface. OSB shall replace foam at all cut-out openings and penetration points.
  4. Each wall panel shall overlap at the corner and form an internal connection joint using stainless steel hardware. All panel joints shall be thoroughly sealed with silicone caulk. The enclosure shall have a minimum R-10 insulation factor and shall be capable of withstanding 150 mph wind loads.
  5. All exterior surfaces shall be textured (green, tan, or gray colored) isophthalic gel coat finish incorporating ultra-violet inhibitors.
  6. All interior surfaces shall be sprayed white isophthalic gel coat finish offering the same characteristics as the exterior surfaces.
  7. The roof panel shall be an arched, one-piece design incorporating the same materials of construction as the side walls. The roof shall be removable as a unit, allowing for complete access to the pumping equipment with a crane. The pitch of the roof shall be sufficient for good moisture drainage, and withstand a minimum snow load of 40 pounds per square foot.

8. The 3-feet 0 inches wide by 6-feet 8 inches high entrance door(s) shall be constructed of the same laminated fiberglass and foam core materials as the remainder of the station. OSB will replace the insulation in areas where auxiliary equipment will be mounted. Each door shall be hung with (3) three stainless steel ball bearing type hinges incorporating a three point closure system with a lockable door handle. An adjustable door positioner and holder shall be mounted at the top of the door. A gasket consisting of solid rubber and sponge shall seal the door while closed. The door and all hardware shall be mounted to withstand 150 mph winds. A wall mounted drip molding will be installed above each door.
9. After the pumping equipment is installed, the fully assembled station enclosure shall be positioned on the concrete mounting pad and sealed with butyl sealant tape as furnished by the pump station manufacturer. The interior base flange shall be drilled positioning and fastened to the pad using expansion anchors on 24 inches maximum centers.

B. Enclosure Functional Equipment:

1. The interior of the station shall be illuminated by factory installed 120 volt fluorescent light fixtures. All lights will be prewired and run to a load center through PVC conduit and a weatherproof switch shall be installed adjacent to each station entrance. The lighting circuit shall be protected by a thermal-magnetic circuit breaker.
2. A thermostatically controlled 120V ac exhaust fan with screen and weatherproof shutters shall be installed in the wall approximately opposite the fresh air intake vent. The fan shall have a minimum capacity of 1,600 CFM at free air and be capable of changing the air in the enclosure a minimum of six times per hour. The exhaust fan shall be protected by a thermal-magnetic circuit breaker.
3. The enclosure will be complete with one (1) set of intake louvers. The intake louvers will be completely self-contained and shall not require the use of motors, solenoids, or other electrically operated devices. Intake louver will consist of two (2) 15-inch wide and 18-7/8-inch high shutters that open automatically at 75 degrees F, and close at 60 degrees F. Shutter operation will be the result of the expansion and contraction of wax in an enclosed plunger which shall drive the louver vanes through a mechanical linkage. The intake shutters will have the actuator mounted out of the flow of the intake air and shall maintain the shutter vanes in the open position. Intake shutter frame will be constructed of anodized aluminum with zinc plated steel actuator mounting and linkage. The shutter vanes will pivot on plastic bearings. The two (2) intake shutters will be mounted in an aluminum fixed vane louver assembly to prevent the entrance of rain or snow.

4. The enclosure will be complete with one (1) set of exhaust louvers. The exhaust louvers will be completely self-contained and shall not require the use of motors, solenoids, or other electrically operated devices. Exhaust louver will consist of four (4) 15 inches wide and 18-7/8-inch high shutters that open automatically at 75 degrees F, and close at 60 degrees F. Shutter operation will be the result of the expansion and contraction of wax in an enclosed plunger which shall drive the louver vanes through a mechanical linkage. The exhaust shutter will have the actuator mounted in the flow of the exhaust air and shall maintain the shutter vanes in the open position. Exhaust shutter frame will be constructed of anodized aluminum with zinc plated steel actuator mounting and linkage. The shutter vanes will pivot on plastic bearings. The four (4) intake shutters will be mounted in two aluminum fixed vane louver assemblies to prevent the entrance of rain or snow.
5. A battery back-up 12 volt DC emergency lighting system shall provide 50 watts of illumination for 1-1/2 hours in the event of power outage. The system shall be fully self-contained for automatic operation of (2) two sealed beam lamps powered by a maintenance free pure-lead 12 volt battery. An automatic solid state battery charger with integral transfer circuit shall maintain the battery in a constant state of readiness. A charge rate pilot light and test switch shall be provided. The charging circuit shall be protected by a thermal-magnetic circuit breaker.
6. A high capacity electric blower type station heater shall be provided for the protection of the pumping equipment. The heater shall maintain an inside/outside differential temperature of 60 degrees F while operating on the primary voltage supplied to the station. The heater shall be provided with an adjustable thermostat, circuit breaker, and contactor.
7. The pump station enclosure shall incorporate an optional insulation package which increases the standard R10 insulation rating to R20 by doubling the thickness of the urea-foam polyurethane core in the wall and roof panels.
8. The station enclosure shall be furnished with extra wide doors. A double hung door design with 3-point locking hardware, door closer, and hinges on each section shall allow complete access to the 6 foot-0-inch by 6 foot-8-inch full door opening without the need for a center sill.
9. A wall mounted duplex GFI utility receptacle providing 120-volt ac power shall be installed and prewired through PVC conduit with the station lighting. The receptacle shall be protected by thermal magnetic circuit breaker.
10. Consists of a three piece assembly including duck bill check valve, stainless steel strainer top, and PVC spacer to provide a gas and water tight drain receptacle for use in concrete pad within Modular Enclosure.

11. The station enclosure shall include limit switches with defeater switch alarm circuit and time delay, mounted and wired in the station enclosure to indicate that there has been a door left open or unauthorized entry to the station. There shall be an adjustable time period for the operator to disable alarm with an unmarked pushbutton located inside the station. The notification shall be activated when a station door is opened. Includes dry contacts pre-wired to a terminal strip for remote monitoring.

### **PART 3 EXECUTION**

#### **3.01 GENERAL**

- A. Install structure in accordance with the manufacturer's recommendations.

**END OF SECTION**



**SECTION 26 05 01**  
**ELECTRICAL**

**PART 1 GENERAL**

1.01 SUMMARY

- A. This section details basic electrical materials and methods for small residential and commercial pump station Projects.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway Transportation Officials (AASHTO).
  2. ASTM International (ASTM):
    - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
    - b. A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
    - c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
    - d. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
    - e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
  3. Electronic Industries Association (EIA/TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
  4. Federal Specifications (FS):
    - a. W-C-596, Connector, Electrical, Power, General Specification for.
    - b. W-S-896, Switch, Toggle (Toggle and Lock), Flush Mounted (General Specification).
  5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    - a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
    - b. PC62.41.1, Draft Guide on the Surge Environment in Low-Voltage (1,000V and less) AC Power Circuits.
    - c. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
    - d. 114, Standard Test Procedures for Single-Phase Induction Motors.
  6. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

7. National Electrical Contractor's Association, Inc. (NECA): 1, Standard Practices for Good Workmanship in Electrical Contracting.
8. National Electrical Manufacturers Association (NEMA):
  - a. C80.1, Rigid Steel Conduit-Zinc Coated.
  - b. C80.3, Electrical Metallic Tubing-Zinc Coated.
  - c. C80.6, Intermediate Metal Conduit-Zinc Coated (IMC).
  - d. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
  - e. CC1, Electrical Power Connectors for Substations.
  - f. ICS 1, Industrial Control and Systems: General Requirements.
  - g. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC.
  - h. ICS 2.3, Industrial Control and Systems: Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers.
  - i. MG 1, Motors and Generators.
  - j. PB 1, Panelboards.
  - k. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
  - l. ST 20, Dry Type Transformers for General Applications.
  - m. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
  - n. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
  - o. WC 55, Instrumentation Cables and Thermocouple Wire.
  - p. WC 70, Standard for Non-Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy.
  - q. WC 71, Standard for Non-Shielded Cables Rated 2001-5000 Volts for use in the Distribution of Electrical Energy.
  - r. WC 74, 5-46 KV Shielded Power Cable for use in the Transmission and Distribution of Electric Energy.
  - s. WD 1, General Color Requirements for Wiring Devices.
9. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
10. Underwriters Laboratories, Inc. (UL):
  - a. 1, Flexible Metal Conduit.
  - b. 6, Electrical Rigid Metal Conduit—Steel.
  - c. 13, Power-Limited Circuit Cables.
  - d. 44, Thermoset Insulated Wires and Cables.
  - e. 62, Flexible Cord and Fixture Wire.
  - f. 67, Panelboards.
  - g. 98, Enclosed and Dead-Front Switches.
  - h. 198C, High Interrupting Capacity Fuses, Current Limiting Types.
  - i. 198E, Class R Fuses.
  - j. 360, Liquid-Tight Flexible Steel Conduit.
  - k. 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors.
  - l. 486C, Splicing Wire Connectors.

- m. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
- n. 508, Industrial Control Equipment.
- o. 510, Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
- p. 514B, Fittings for Cable and Conduit.
- q. 651, Schedule 40 and 80 PVC Conduit.
- r. 674, Electric Motors And Generators for use in Division 1 Hazardous (Classified) Locations.
- s. 797, Electrical Metallic Tubing.
- t. 854, Service-Entrance Cables.
- u. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
- v. 943, Ground-Fault Circuit Interrupters.
- w. 1059, Terminal Blocks.
- x. 1242, Intermediate Metal Conduit.
- y. 1277, Electrical Power and Control Tray Cables with Optional Optical-Fibre Members.
- z. 1449, Transient Voltage Surge Suppressors.
- aa. 1561, Dry-Type General Purpose and Power Transformers.
- bb. 2111, Overheating Protection for Motors.

### 1.03 DEFINITIONS

- A. AHJ: Authority Having Jurisdiction.
- B. MCOV: Maximum Allowable Continuous Operating Voltage.
- C. MOV: Metal Oxide Varistor.
- D. SASD: Silicon Avalanche Suppressor Diode.
- E. SVR: Surge Voltage Rating.
- F. TVSS: Transient Voltage Surge Suppressor.

### 1.04 APPROVAL BY AUTHORITY HAVING JURISDICTION

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

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

- A. Products shall comply with all applicable provisions of NFPA 70.
- B. Equipment and Devices Installed Outdoors or in Unheated Enclosures: Capable of continuous operation within ambient temperature range of 0 degrees F to 104 degrees F.
- C. Hazardous Areas: Products shall be acceptable to the regulatory authority having jurisdiction for the class, division, and group of hazardous area indicated.
- D. Equipment Finish: Manufacturer's standard finish color, except where specific color is indicated.

### **2.02 SERVICE ENTRANCE EQUIPMENT AND METERING**

- A. Equipment, installation arrangement, and scope of work shall be provided in accordance with requirements of the local electric utility.

### **2.03 OUTLET AND DEVICE BOXES**

- A. Cast Metal:
  - 1. Box: Cast ferrous metal.
  - 2. Cover: Gasketed, weatherproof, and cast ferrous metal with stainless steel screws.
  - 3. Hubs: Threaded.
  - 4. Lugs: Cast Mounting.
  - 5. Manufacturers and Products, Nonhazardous Locations:
    - a. Crouse-Hinds; Type FS or FD.
    - b. Appleton; Type FS or FD.
  - 6. Manufacturers and Products, Hazardous Locations:
    - a. Crouse-Hinds; Type GUA or EAJ.
    - b. Appleton; Type GR.
- B. PVC-Coated Cast Metal:
  - 1. Type: One-piece.
  - 2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
  - 3. Coating:
    - a. All Exterior Surfaces; 40 mils PVC.
    - b. All Interior Surfaces, 2 mils urethane.
  - 4. Manufacturers:
    - a. Robroy Industries.
    - b. Ocal.

## 2.04 JUNCTION AND PULL BOXES

### A. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250, Type 7 or 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished, or copper-free aluminum with drilled and tapped conduit entrances.
3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
4. Manufacturers and Products:
  - a. Crouse-Hinds; Type EJB.
  - b. Appleton; Type EJB.

### B. Large Stainless Steel Box:

1. NEMA 250, Type 4X.
2. Box: 14-gauge, ASTM A240, Type 304 stainless steel.
3. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
4. Manufacturers:
  - a. Hoffman Engineering Co.
  - b. Robroy Industries.

### C. Concrete Box, Nontraffic Areas:

1. Box: Reinforced, cast concrete with extension.
2. Cover: Steel diamond plate with locking bolts.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Size: 10 inch by 17 inch (minimum).
5. Manufacturer and Product: Utility Vault Co.; Series 36-1017PB, with cover DP.

## 2.05 WIRING DEVICES

### A. Switches:

1. NEMA WD 1 and FS W-S-896.
2. Industrial grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.
3. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
4. Rating: 20 amps, 120/277 volts.
5. Automatic grounding clip and integral grounding terminal on mounting strap.
6. Manufacturers and Products:
  - a. Leviton; 1221 Series.
  - b. Bryant; 4901 Series.
  - c. Hubbell; 1221 Series.

B. Receptacle, Single and Duplex:

1. NEMA WD 1 and FS W-C-596.
2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
3. High strength, thermoplastic base color.
4. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
5. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
6. One-piece mounting strap with integral ground contact (rivetless construction).
7. Manufacturers and Products:
  - a. Arrow Hart; 5262 Series.
  - b. Leviton; 5262/5362 Series.
  - c. Bryant; 5262/5362 Series.
  - d. Hubbell; 5262/5362 Series.

C. Receptacle, Ground Fault Circuit Interrupter:

1. Duplex, listed Class A to UL Standard 943, tripping at 5 mA.
2. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
3. Size: For 2-inch by 4-inch outlet boxes.
4. Impact resistant nylon face.
5. Manufacturers:
  - a. Bryant.
  - b. Hubbell.
  - c. Leviton.

2.06 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Metal:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

C. Cast Metal:

1. Material: Malleable ferrous metal or copper-free aluminum, with gaskets.
2. Screw: Oval-head stainless steel.

- D. Weatherproof:
  - 1. For Receptacles, Wet Locations:
    - a. Impact-resistant, nonmetallic, single-gang, horizontal-mounting, providing, while in-use, NEMA 3R rating.
    - b. Stainless steel mounting and hinge hardware.
    - c. Lockable, paintable.
    - d. Color: Gray.
    - e. Manufacturers:
      - 1) Carlon.
      - 2) Leviton.
  - 2. For Switches:
    - a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
    - b. Mounting Screw: Stainless steel.
    - c. Manufacturers and Products:
      - 1) Crouse-Hinds; DS-181 or DS-185.
      - 2) Appleton; FSK-1VTS or FSK-1VS.

## 2.07 LIGHTING AND POWER DISTRIBUTION PANELBOARD

- A. NEMA PB 1, NFPA 70, and UL 67.
- B. Panelboards and Circuit Breakers: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- C. Short-Circuit Current Equipment Rating: Fully rated; series connected unacceptable.
- D. Cabinet:
  - 1. NEMA 250, Type 3R.
  - 2. Material: Code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
  - 3. Wiring Gutter: Minimum 4-inch square; both sides, top and bottom.
  - 4. Front: Fastened with adjustable clamps.
    - a. Trim Size: As required by mounting.
    - b. Finish: Manufacturer's standard.
  - 5. Interior:
    - a. Factory assembled; complete with circuit breakers.
    - b. Spaces: Cover openings with easily removable metal cover.
  - 6. Door Hinges: Concealed.
  - 7. Locking Device:
    - a. Flush type.
    - b. Doors Over 30 Inches in Height: Multipoint.
    - c. Identical keylocks, with two milled keys each lock.
  - 8. Circuit Directory: Metal frame with transparent plastic face and enclosed card on interior of door.

E. Bus Bar:

1. Material: Copper full sized throughout length.
2. Neutral: Insulated, rated same as phase bus bars with at least one terminal screw for each branch circuit.
3. Ground: Copper, installed on panelboard frame, bonded to box with at least one terminal screw for each circuit.
4. Lugs and Connection Points:
  - a. Suitable for either copper or aluminum conductors.
  - b. Solderless main lugs for main, neutral, and ground bus bars.
  - c. Subfeed or through-feed lugs as shown.

F. Circuit Breakers:

1. UL 489.
2. Thermal-magnetic, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
3. Type: Bolt-on circuit breakers in all panelboards.
4. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.
5. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Circuit Interrupter (GFCI): UL Class A GFCI, 5 mA trip, and 10,000 amps interrupting capacity circuit breakers.
7. Ground Fault Equipment Protector (GFEP): 30 mA trip, 10,000 amps interrupting capacity circuit breaker, and UL listed for equipment ground fault protection.

G. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

2.08 MINI-POWER CENTER (MPC)

A. General: Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 3R enclosure.

B. Transformer:

1. Type: Dry, self-cooled, encapsulated.
2. Insulation: Manufacturer's standard, with UL 1561 temperature rise.
3. Full capacity, 2-1/2 percent voltage taps, two above and two below normal voltage.



- C. Panelboard: UL 489, fully-rated.
  - 1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
  - 2. Number and Breaker Ampere Ratings: Refer to Panelboard Schedule.
- D. Manufacturers:
  - 1. Eaton.
  - 2. General Electric Co.
  - 3. Square D Co.

2.09 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

- A. UL 489 listed for use at location of installation.
- B. Thermal-magnetic, quick-make, quick-break, indicating type showing ON/OFF and TRIPPED indicating positions of operating handle.
- C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- D. Locking: Provisions for padlocking handle.
- E. Enclosure: As specified under Execution.
- F. Interlock: Enclosure and switch shall interlock to prevent opening cover with breaker in the ON position.
- G. Manufacturers:
  - 1. Eaton.
  - 2. General Electric Co.
  - 3. Square D Co.

2.10 FUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

- A. UL 98 listed for use and location of installation.
- B. NEMA KS 1 and UL 98 Listed for application to system for available short-circuit current.
- C. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

- E. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.
- F. Enclosure: As specified under Execution.
- G. Interlock: Enclosure and switch to prevent opening cover with switch in ON position.
- H. Manufacturers:
  - 1. Eaton.
  - 2. General Electric Co.
  - 3. Square D Co.

2.11 NONFUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

- A. NEMA KS 1.
- B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- D. Enclosure: As specified under Execution.
- E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.
- F. Manufacturers:
  - 1. Eaton.
  - 2. General Electric Co.
  - 3. Square D Co.

2.12 FUSE, 0 TO 600 VOLTS

- A. Current-limiting, with 200,000 ampere rms interrupting rating.
- B. Provide to fit mountings specified with switches and features to reject Class H fuses.
- C. Motor and Transformer Circuits, 0 to 600 Volt:
  - 1. Amperage: 0 to 600.
  - 2. UL 198E, Class RK-1, dual element, with time delay.
  - 3. Manufacturers and Products:
    - a. Bussmann; Type LPS-RK.
    - b. Littelfuse, Inc.; Type LLS-RK.

- D. Feeder and Service Circuits, 0 to 600 Volt:
  - 1. Amperage: 0 to 600.
  - 2. UL 198E, Class RK-1, dual element, with time delay.
  - 3. Manufacturers and Products:
    - a. Bussmann; Type LPS-RK.
    - b. Littelfuse, Inc.; Type LLS-RK.

- E. Feeder and Service Circuits, 0 to 600 Volt:
  - 1. Amperage: 601 to 6,000.
  - 2. UL 198C, Class L, double O-rings and silver links.
  - 3. Manufacturers and Products:
    - a. Bussmann; Type KRP-C.
    - b. Littelfuse, Inc.; Type KLPC.

### 2.13 PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES

- A. Type: Heavy-duty, oiltight. Provide contact arrangements, colors, inscriptions, and functions as shown.
- B. Contact Rating: NEMA ICS 2, Type A600.
- C. Unless otherwise shown, provide the following features:
  - 1. Selector Switch Operating Lever: Standard.
  - 2. Indicating Lights: Push-to-test, transformer-type.
  - 3. Pushbutton Color:
    - a. ON or START: Black.
    - b. OFF or STOP: Red.
  - 4. Pushbuttons and selector switches lockable in OFF position where indicated.
- D. Legend Plate:
  - 1. Material: Aluminum.
  - 2. Engraving: Indicating specific function, or as shown.
  - 3. Letter Height: 7/64 inch.
- E. Manufacturers and Products:
  - 1. General Electric Co.; Type CR 104P.
  - 2. Square D Co.; Type T.
  - 3. Eaton; Type 10250T.

## 2.14 TERMINAL BLOCKS

- A. Type: UL 1059. Compression screw clamp, with current bar providing direct contact with wire and yoke, with individual rail mounted terminals. Marking system shall permit use of preprinted or field-marked tags.
- B. Yokes and Clamping Screws: Zinc-plated, hardened steel.
- C. Rating: 600V ac.
- D. Manufacturers:
  - 1. Weidmuller, Inc.
  - 2. Ideal.

## 2.15 MAGNETIC CONTROL RELAYS

- A. NEMA ICS 2, Class A600 (600 volts, 10 amperes continuous, 7,200VA make, 720VA break), machine tool type with field convertible contacts.
- B. Manufacturer and Model:
  - 1. Eaton; Type M-600.
  - 2. General Electric; Type CR120B.

## 2.16 TIME DELAY RELAY

- A. Industrial Relay Rated: 150 volts, 5 amps continuous, (3600 VA make, 360 VA break).
- B. Solid-state electronic, field convertible ON/OFF delay.
- C. Two Form-C contacts (minimum).
- D. Repeat accuracy plus or minus 2 percent.
- E. Timer Adjustment: Multiple adjustable ranges, including 1 second to 60 seconds, unless otherwise shown.
- F. Manufacturers:
  - 1. Omron.
  - 2. Eaton.
  - 3. General Electric Co.

## 2.17 PHASE MONITOR RELAY

- A. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
- B. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
- C. Adjustable trip and time delay settings.
- D. Transient Protection: 1,000V ac.
- E. Mounting: Multipin plug-in socket base.
- F. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

## 2.18 DRY TYPE POWER TRANSFORMERS (0- TO 600-VOLT PRIMARY)

- A. Type: Self-cooled, two-winding.
- B. UL 1561 and NEMA ST 20.
- C. Insulation Class, Temperature Rise, and Impedance: Manufacturer's standard.
- D. Core and Coil:
  - 1. 30 kVA or Less: Encapsulated.
  - 2. 37.5 kVA and Larger: Varnish impregnated.
- E. Enclosure:
  - 1. 30 kVA or Less: NEMA 250, Type 3R, nonventilated.
  - 2. 37.5 kVA and Larger: NEMA 250, Type 2, ventilated.
- F. Voltage Taps: Full capacity, 2-1/2 percent, two above and two below normal voltage rating.
- G. Sound Level: Not to exceed NEMA ST 20 levels.
- H. Vibration isolators to minimize and isolate sound transmission.
- I. Manufacturers:
  - 1. General Electric.
  - 2. Eaton.
  - 3. Square D.

## 2.19 SUPPORT AND FRAMING CHANNELS

- A. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge.
- B. Manufacturers:
  - 1. B-Line Systems, Inc.
  - 2. Unistrut Corp.

## 2.20 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) EQUIPMENT

- A. General:
  - 1. Units shall be suitable for the service voltage and configuration (phases and wires) shown.
  - 2. Protection Modes:
    - a. Normal, differential, and common.
    - b. Bipolar or bi-directional.
  - 3. Ratings: Short-circuit current rating shall equal or exceed that of protected distribution equipment. Surge Voltage Rating (SVR) shall not exceed those specified under UL 1449 for the associated nominal system voltage. Maximum Allowable Continuous Operating Voltage (MCOV) shall be at least 115 percent of the nominal system voltage.
  - 4. Unit shall be UL-listed.
  - 5. Provide status indicators for unit ON-LINE and unit operation NORMAL.
  - 6. Provide common alarm contact output.
  - 7. Provide fusible disconnect switch (integral with TVSS unit, where available) where not shown connected via branch circuit device of protected distribution equipment.
  - 8. Minimum Enclosure Rating: NEMA 250, Type 2. Provide Type 4/4X for outdoor or wet locations.
- B. Type 1 TVSS:
  - 1. Requirements: High surge current device designed for location/exposure Category C3, per IEEE C62.41. Provide surge current rating per phase as shown. Unit shall utilize symmetrically balanced Metal Oxide Varistor (MOV) technology.
  - 2. Manufacturer and Product: Transtector; Model Aegis SP.

C. Type 2 TVSS:

1. Requirements: Designed for critical loads at service equipment (Category C3/B3) or distribution panelboard (Category C2/B3) locations. Unit shall utilize voltage-matched Silicon Avalanche Suppressor Diode (SASD) technology. Unit shall utilize modular, plug-in suppressor design.
2. Manufacturer and Product: Transtector; Model Apex III (nonservice entrance distribution panelboard) or Apex IV (service equipment).

D. Type 3 TVSS:

1. Requirements: Designed for noncritical loads at distribution panelboards with location/exposure Category C3. Unit shall utilize symmetrically balanced Metal Oxide Varistor (MOV) technology. Unit shall utilize modular, plug-in suppressor design.
2. Manufacturer and Product: Transtector; Model SPD.

2.21 CONDUIT AND FITTINGS

A. Rigid Aluminum Conduit:

1. Rigid Aluminum Conduit of 6063 alloy in temper designation T-1. The fittings are of the same alloy. Provide threaded Rigid Aluminum Conduit to Underwriters Laboratories U.L. 6A, "Standard for Electrical Rigid Metal Conduit and manufactured to ANSI C80.5.
2. Provide threaded aluminum conduit fittings, of 6063 alloy, cast copper free aluminum with integral insulated throat as manufactured by Allied, OZ Gedney, T&B, Crouse-Hinds, Killark or Appleton.
3. Provide supplementary corrosion protection for aluminum conduit imbedded in concrete or in contact with soil. Where aluminum conduits are in contact with or penetrate concrete, coat conduit with asphaltic or bitumastic type coating.

B. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1.
2. Material:
  - a. Meet requirements of NEMA C80.1 and UL 6.
  - b. Exterior Finish: PVC coating, 40 mils nominal thickness, bond to metal shall have tensile strength greater than PVC.
  - c. Interior finish: Urethane coating, 2 mils nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to either interior or exterior coating.

- C. Flexible Metal, Liquid-Tight Conduit:
  - 1. UL 360 listed for 105 degrees C insulated conductors.
  - 2. Material: Galvanized steel, with an extruded PVC jacket.
  
- D. Flexible Coupling, Hazardous Locations:
  - 1. Approved for use in the atmosphere involved.
  - 2. Rating: Watertight and UL listed for use in Class I, Division 1 and Division 2 areas.
  - 3. Outer bronze braid and an insulating liner.
  - 4. Conductivity equal to a similar length of rigid metal conduit.
  - 5. Manufacturers and Products:
    - a. Crouse-Hinds; Type ECGJH or ECLK.
    - b. Appleton; EXGJH or EXLK.
  
- E. Fittings:
  - 1. Provide bushings, grounding bushings, conduit hubs, conduit bodies, couplings, unions, conduit sealing fittings, drain seals, drain/breather fittings, expansion fittings, and cable sealing fittings, as applicable.
  - 2. Rigid Galvanized Steel Conduit:
    - a. Meet requirements of UL 514B.
    - b. Type: Threaded, galvanized.
  - 3. PVC-Coated Rigid Galvanized Steel Conduit:
    - a. Meet requirements of UL 514B.
    - b. Fittings: Rigid galvanized steel type, PVC-coated by conduit manufacturer.
    - c. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC-coated by conduit manufacturer.
    - d. Finish: 40-mil PVC exterior, 2-mil urethane interior.
    - e. Overlapping pressure sealing sleeves.
    - f. Conduit Hangers, Attachments, and Accessories: PVC-coated.
    - g. Manufacturers:
      - 1) Robroy Industries.
      - 2) Ocal.
    - h. Expansion Fitting Manufacturer and Product: Ocal; Ocal-Blue XJG.
  - 4. Flexible Metal, Liquid-Tight Conduit:
    - a. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
    - b. Insulated throat and sealing O-rings.
  - 5. Flexible Coupling, Hazardous Locations:
    - a. Approved for use in the atmosphere involved.
    - b. Rating: Watertight and UL listed for use in Class I, Division 1 and Division 2 areas.



- c. Outer bronze braid and an insulating liner.
- d. Conductivity equal to a similar length of rigid metal conduit.
- e. Manufacturers and Products:
  - 1) Crouse-Hinds; Type ECGJH or ECLK.
  - 2) Appleton; EXGJH or EXLK.

## 2.22 CONDUCTORS AND CABLES

### A. Conductors 600 Volts and Below:

- 1. Conform to applicable requirements of NEMA WC 71, WC 72, and WC 74.
- 2. Conductor Type:
  - a. 120- and 277-Volt Lighting, No. 10 AWG and Smaller: Solid copper.
  - b. 120-Volt Receptacle Circuits, No. 10 AWG and Smaller: Solid copper.
- 3. Insulation: Type THHN/THWN, except for sizes No. 6 and larger, with XHHW-2 insulation.
- 4. Direct Burial and Aerial Conductors and Cables:
  - a. Type USE/RHH/RHW insulation, UL 854 listed or Type RHW-2/USE-2.
  - b. Conform to physical and minimum thickness requirements of NEMA WC 70.
- 5. Flexible Cords and Cables:
  - a. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
  - b. Conform to physical and minimum thickness requirements of NEMA WC 70.

### B. 600-Volt Rated Cable:

- 1. General:
  - a. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
  - b. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
  - c. Suitable for installation in open air, in cable trays, or conduit.
  - d. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
  - e. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

2. Type TSP, No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
  - a. Outer Jacket: 45 mils nominal thickness.
  - b. Individual Pair Shield: 1.35 mils, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
  - c. Dimension: 0.31-inch nominal outside diameter.
  - d. Conductors:
    - 1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    - 2) 20 AWG, seven-strand tinned copper drain wire.
    - 3) Insulation: 15 mils nominal PVC.
    - 4) Jacket: 4 mils nominal nylon.
    - 5) Color Code: Pair conductors black and red.
  - e. Manufacturers: Okonite Co.

C. Accessories:

1. Tape:
  - a. General Purpose, Flame Retardant: 7 mils, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
  - b. Flame Retardant, Cold and Weather Resistant: 8.5 mils, vinyl plastic, Scotch Brand 88.
  - c. Arc and Fireproofing:
    - 1) 30 mils, elastomer.
    - 2) Manufacturers and Products:
      - a) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      - b) Plymount; Plyarc 53, with Plyglas 77 glass cloth tapebinder.
2. Identification Devices:
  - a. Sleeve-type, permanent, PVC, yellow or white, with legible machine-printed black markings.
  - b. Manufacturer and Products: Raychem; Type D-SCE or ZH-SCE.
3. Connectors and Terminations:
  - a. Nylon, Self-Insulated Crimp Connectors:
    - 1) Manufacturers and Products:
      - a) Thomas & Betts; Sta-Kon.
      - b) Burndy; Insulug.
      - c) ILSCO.
4. Self-Insulated, Freespring Wire Connector (Wire Nuts):
  - a. Plated steel, square wire springs.
  - b. UL Standard 486C.

- c. Manufacturers and Products:
  - 1) Thomas & Betts.
  - 2) Ideal; Twister.
- 5. Cable Lugs:
  - a. In accordance with NEMA CC 1.
  - b. Rated 600 volts of same material as conductor metal.
  - c. Uninsulated Crimp Connectors and Terminators:
    - 1) Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
    - 2) Manufacturers and Products:
      - a) Thomas & Betts; Color-Keyed.
      - b) Burndy; Hydent.
      - c) ILSCO.
  - d. Uninsulated, Bolted, Two-Way Connectors and Terminators:
    - 1) Manufacturers and Products:
      - a) Thomas & Betts; Locktite.
      - b) Burndy; Quiklug.
      - c) ILSCO.
- 6. Cable Ties:
  - a. Nylon, adjustable, self-locking, and reusable.
  - b. Manufacturer and Product: Thomas & Betts; TY-RAP.
- 7. Heat Shrinkable Insulation:
  - a. Thermally stabilized, crosslinked polyolefin.
  - b. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

## 2.23 MOTORS

### A. Three-Phase:

- 1. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.
- 2. Meet requirements of NEMA MG 1.
- 3. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.
- 4. Motors shall be specifically designed for use and conditions intended, with a NEMA design letter classification to fit application.
- 5. Lifting lugs on motors weighing 100 pounds or more.
- 6. Operating Conditions: Maximum ambient temperature not greater than 40 degrees C.
- 7. Horsepower Rating: As required. Brake horsepower of the driven equipment at any operating condition shall not exceed motor nameplate horsepower rating, excluding any service factor.
- 8. Service Factor: 1.15 minimum at rated ambient temperature, unless otherwise shown.

9. Efficiency and Power Factor: Provide premium efficiency units, except for under 1 hp, multispeed, or short-time rated motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists. Provide standard power factor.
10. Insulation Systems: Unless otherwise indicated, Class B or Class F at nameplate horsepower and designated operating conditions, except EXP motors that shall be Class B with Class B rise.
11. Enclosures:
  - a. TEFC and TENV: Furnish with a drain hole with porous drain/weather plug.
  - b. Explosion-Proof (EXP):
    - 1) TEFC listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous locations.
    - 2) Drain holes with drain and breather fittings.
    - 3) Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
    - 4) Terminate thermostat leads in terminal box separate from main terminal box.
  - c. Equipment Finish: Manufacturer's standard.
12. Nameplates: In accordance with NEMA MG1.
13. Inverter Duty Motor:
  - a. Motor supplied power by adjustable frequency drives shall be inverter duty-rated.
  - b. Motor shall meet all applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.
  - c. Motor shall be suitable for operation over entire speed range indicated.
  - d. Provide forced ventilation where speed ratio is greater than published range for motor being installed. Provide and coordinate fan power supply and motor control requirements with associated drive.
  - e. Motor installed in Division 1 hazardous (classified) locations shall be identified as acceptable for variable speed when used in a Division 1 location.

B. Manufacturers:

1. General Electric.
2. Reliance Electric.
3. U.S. Electrical Motors.

C. Factory Testing:

1. Tests:
  - a. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.

- b. Provide routine (production) tests on all motors in accordance with NEMA MG 1. Test multispeed motors at all speeds.
  - c. For premium efficiency motors, test efficiency and power factor at 50, 75, and 100 percent of rated horsepower:
    - 1) In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraphs 12.54 and 12.57.
    - 2) Furnish a copy of a certified motor efficiency test report for identical motor.
2. Test Report Forms:
- a. Routine Tests: IEEE 112, Form A-1.
  - b. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Paragraph (table) 12.57.

## 2.24 GROUNDING

- A. Ground Rods: Provide copper-clad steel with minimum diameter of 5/8-inch, and length of 10 feet.
- B. Ground Conductors: As specified in Article Conductors and Cable.
- C. Connectors:
  - 1. Exothermic Weld Type:
    - a. Outdoor Weld: Suitable for exposure to elements or direct burial.
    - b. Indoor Weld: Utilize low-smoke, low-emission process.
    - c. Manufacturers:
      - 1) Erico Products, Inc.; Cadweld and Cadweld Exolon.
      - 2) Thermoweld.
  - 2. Compression Type:
    - a. Compress-deforming type; wrought copper extrusion material.
    - b. Single indentation for conductors 6 AWG and smaller.
    - c. Double indentation with extended barrel for conductors 4 AWG and larger.
    - d. Single barrels prefilled with oxide-inhibiting and antiseizing compound.
    - e. Manufacturers:
      - 1) Burndy Corp.
      - 2) Thomas and Betts Co.
      - 3) ILSCO.
  - 3. Mechanical Type:
    - a. Split-bolt, saddle, or cone screw type; copper alloy material.
    - b. Manufacturers:
      - 1) Burndy Corp.
      - 2) Thomas and Betts Co.

## 2.25 LOW VOLTAGE MOTOR CONTROL

### A. General:

1. Make adjustments as necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors and motor ratings actually provided.
2. Controllers: NEMA ICS 2, Class A.
3. Thermal Overload Protection:
  - a. Inverse-time-limit characteristic.
  - b. Heater: Bimetallic overload, adjustable trip.
  - c. Relay Trip: Standard, Class 20.
  - d. Manual reset.
  - e. Provide in each ungrounded phase.
  - f. Mount within starter unit.
4. Control Transformer:
  - a. Two winding, 120-volt secondary, primary voltage to suit.
  - b. Two current-limiting fuses for primary circuit.
  - c. One fuse in secondary circuit.
  - d. Mount within starter unit.
5. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
6. Phase Monitoring Relay: Provide three-phase monitoring relay to protect against low voltage, voltage unbalance, phase loss, and phase reversal.

### B. Combination Full-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for 22,000 amperes with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: As required.
4. Disconnect Type: Circuit breaker.
5. Enclosure: NEMA 250, Type 4X.
6. Padlockable operating handle.

### C. Manufacturers:

1. Eaton.
2. General Electric.
3. Square D.
4. Allen Bradley.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

- A. Install materials and equipment in accordance with manufacturer's instructions and recommendations.
- B. Work shall comply with all applicable provisions of NECA 1.
- C. Install materials and equipment in hazardous areas in a manner acceptable to regulatory authority having jurisdiction for the class, division, and group of hazardous areas shown.
- D. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

### **3.02 DEMOLITION**

- A. General Demolition:
  - 1. Where shown, de-energize and disconnect nonelectrical equipment for removal by others.
  - 2. Where shown, de-energize, disconnect, and remove electrical equipment.
  - 3. Remove affected circuits and raceways back to serving panelboard or control panel. Where affected circuits are consolidated with others, remove raceways back to first shared conduit or box. Where underground or embedded raceways are to be abandoned, remove raceway to 1 inch below surface of structure or 12 inches belowgrade and restore existing surface.

### **3.03 PROTECTION FOLLOWING INSTALLATION**

- A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation.
- B. Cap conduit runs during construction with manufactured seals.
- C. Close openings in boxes or equipment during construction.
- D. Energize space heaters furnished with equipment.

### **3.04 SERVICE ENTRANCE EQUIPMENT AND METERING**

- A. Unless otherwise specified or shown, schedule and coordinate work of serving utility as required to provide electric service to the Work.

### 3.05 OUTLET AND DEVICE BOXES

- A. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
- B. Size:
  - 1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
    - a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
  - 2. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.
  - 3. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.
- C. Install plumb and level.
- D. Flush Mounted:
  - 1. Install with concealed conduit.
  - 2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
- E. Support boxes independently of conduit by attachment to building structure or structural member.
- F. Box Type (Steel Raceway System):
  - 1. Outdoor Locations: Cast metal.
  - 2. Indoor Dry Locations:
    - a. Exposed Rigid Conduit: Cast metal.
    - b. Concealed Raceways: Sheet steel.
    - c. Class I, II, or III Hazardous Areas: Cast metal.
  - 3. Indoor Wet Locations:
    - a. Exposed Raceways: Cast metal.
    - b. Concealed Raceways: Cast metal.
    - c. Class I, II, or III Hazardous Areas: Cast metal.
  - 4. Cast-in-Place Concrete Slabs: Sheet steel.
- G. Box Type, Corrosive Locations (PVC-Coated rigid Galvanized Steel Raceway System): PVC-coated cast metal with matching cover.

### 3.06 JUNCTION AND PULL BOXES

- A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.



- B. Install pull boxes where necessary in raceway system to facilitate conductor installation.
- C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.
- D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
- E. Use conduit bodies as junction and pull boxes where no splices are required and their use is allowed by applicable codes.
- F. Installed boxes shall be accessible.
- G. Do not install on finished surfaces.
- H. Install plumb and level.
- I. Support boxes independently of conduit by attachment to building structure or structural member.
- J. At or Belowgrade:
  - 1. Install boxes for belowgrade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
  - 2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
  - 3. Use boxes and covers suitable to support anticipated weights.
- K. Flush Mounted:
  - 1. Install with concealed conduit.
  - 2. Holes in surrounding surface shall be no larger than required to receive box.
  - 3. Make edges of boxes flush with final surface.
- L. Mounting Hardware:
  - 1. Noncorrosive Indoor Dry Areas: Galvanized.
  - 2. Outdoor or Noncorrosive Indoor Wet Areas: Stainless steel.
  - 3. Corrosive Areas: Stainless steel.
- M. Location/Type:
  - 1. Indoor and Outdoor, Wet or Corrosive: NEMA 250, Type 4X, stainless steel.
  - 2. Indoor and Outdoor, Hazardous: NEMA 250 Type 7 as required for area.
  - 3. Underground Conduit: Concrete.

4. Corrosive: NEMA 250, Type 4X, stainless steel.
5. Outdoor, Where Indicated Weatherproof (WP): NEMA 250, Type 3R.

### 3.07 WIRING DEVICES

#### A. Switches:

1. Install with switch operation in vertical position.
2. Install single-pole, two-way switches such that toggle is in up position when switch is on.

#### B. Receptacles:

1. Weatherproof Receptacles:
  - a. Install in cast metal box.
  - b. Install such that hinge for protective cover is above receptacle opening.
2. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.

### 3.08 DEVICE PLATES

#### A. Securely fasten to wiring device; ensure a tight fit to box.

#### B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

#### C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

#### D. Install with alignment tolerance to box of 1/16 inch.

#### E. Types (Unless Otherwise Shown):

1. Outdoor: Weatherproof.
2. Indoor:
  - a. Flush Mounted Boxes: Metal.
  - b. Surface Mounted, Metal Boxes: Cast.

### 3.09 PANELBOARDS AND MINI-POWER CENTERS

#### A. Install securely, plumb, in-line and square with walls.

#### B. Install top of cabinet 6 feet above floor, unless otherwise shown.

- C. Provide typewritten circuit directory for each panelboard.
- D. Cabinet Location/Type:
  - 1. Wet or Outdoor: NEMA 250, Type 3R, Outdoor.

### 3.10 CIRCUIT BREAKERS AND SWITCHES

- A. Location and Enclosure Type:
  - 1. Hazardous Gas: NEMA 250, Type 7.
  - 2. Wet or Outdoor or Corrosive: NEMA 250, Type 4X.
  - 3. Where Denoted WP: NEMA 250, Type 3R.

### 3.11 TERMINAL BLOCKS

- A. Install for termination of control circuits entering or leaving equipment and local control panels.

### 3.12 DRY TYPE POWER TRANSFORMERS (0- TO 600-VOLT PRIMARY)

- A. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.
- B. Provide moisture-proof flexible conduit for electrical connections.
- C. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.
- D. Provide wall brackets where required.

### 3.13 SUPPORT AND FRAMING CHANNELS

- A. Install where required for mounting and supporting electrical equipment and raceway systems.

### 3.14 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) EQUIPMENT

- A. Install in accordance with manufacturer's instructions, including lead length, overcurrent protection, and grounding.

### 3.15 CONDUIT AND FITTINGS

- A. General:
  - 1. Crushed or deformed raceways not permitted.
  - 2. Maintain raceway entirely free of obstructions and moisture.
  - 3. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

4. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
5. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
6. Group raceways installed in same area.
7. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
8. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
9. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.
10. Install watertight fittings in outdoor, underground, or wet locations.
11. Paint threads and cut ends, before assembly of fittings, galvanized conduit, or PVC-coated galvanized conduit installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
12. Metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
13. Do not install raceways in concrete equipment pads, foundations, or beams.
14. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
15. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
16. Install conduits for fiber optic cables, telephone cables, and Category 5 data cables in strict conformance with the requirements of EIA/TIA 569.

B. Conduit Application:

1. Diameter Minimum: 3/4 inch.
2. Outdoor, Exposed: PVC-coated rigid galvanized steel.
3. Indoor, Exposed: Aluminum.
4. Direct Earth Burial: PVC-coated rigid galvanized steel.
5. Under Slabs-On-Grade: PVC-coated rigid galvanized steel.
6. Corrosive Areas: Aluminum.
7. Classified Areas: Aluminum.

C. Connections:

1. For motors-, wall-, or ceiling-mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
  - a. General: Flexible metal, liquid-tight conduit.
  - b. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.
  - c. Wet or Corrosive Areas: Flexible metal liquid-tight.
  - d. Length: 18 inches minimum, 60 inches maximum, sufficient to allow movement or adjustment of equipment.

2. Outdoor areas, process areas exposed to moisture, and areas required to be oiltight and dust-tight: Flexible metal, liquid-tight conduit.
- D. Penetrations:
1. Make at right angles, unless otherwise shown.
  2. Notching or penetration of structural members, including footings and beams, not permitted.
- E. Support:
1. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.
  2. Application/Type of Conduit Strap:
    - a. Steel Conduit: Zinc-coated steel, pregalvanized steel, or malleable iron.
    - b. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
- F. Bends:
1. Install concealed raceways with a minimum of bends in the shortest practical distance.
  2. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
  3. Install with symmetrical bends or cast metal fittings.
  4. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
  5. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
  6. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run and raceways are same size.
  7. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.
- G. Expansion and Deflection Fittings: Provide on all raceways at structural expansion joints and in long tangential runs.
- H. PVC-Coated Rigid Steel Conduit:
1. Install in accordance with manufacturer's instructions.
  2. All tools and equipment used in the cutting, bending, threading, and installation of PVC-coated rigid steel conduit shall be designed to limit damage to the PVC coating.
  3. Provide PVC boot to cover all exposed threading.

I. Termination at Enclosures:

1. Cast Metal Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
2. Nonmetallic, Cabinets, and Enclosures: Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
3. Sheet Metal Boxes, Cabinets, and Enclosures:
  - a. Rigid Galvanized Conduit:
    - 1) Provide one lock nut each on inside and outside of enclosure.
    - 2) Install grounding bushing.
    - 3) Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure.
    - 4) Install insulated bushing on ends of conduit where grounding is not required.
    - 5) Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
    - 6) Utilize sealing locknuts or threaded hubs on outside of NEMA 3R and NEMA 12 enclosures.
    - 7) Terminate conduits with threaded conduit hubs at NEMA 4 and 4X boxes and enclosures.
  - b. Flexible Metal Conduit: Provide two-screw type, insulated, malleable iron connectors.
  - c. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
4. Free-Standing Enclosures: Terminate metal conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad.

J. Underground Raceways:

1. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.
2. Cover: Maintain minimum 2-foot cover above conduit, unless otherwise shown.
3. Make routing changes as necessary to avoid obstructions or conflicts.
4. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
5. Union type fittings not permitted.

6. Spacers:
  - a. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench.
  - b. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
7. Support conduit so as to prevent bending or displacement during backfilling.
8. Installation with Other Piping Systems:
  - a. Crossings: Maintain minimum 12-inch vertical separation.
  - b. Parallel Runs: Maintain minimum 12-inch separation.
  - c. Installation over valves or couplings not permitted.
9. Metallic Raceway Coating: Along entire length, coat with raceway coating.

K. Empty Raceways:

1. Provide permanent, removable cap over each end.
2. Provide nylon pull cord.
3. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

L. Identification Devices:

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

M. Raceway Band:

1. Install wherever metallic conduit emerges from concrete slabs. Not required with PVC-coated RGS conduit. Center band at slab surface and install according to manufacturer's instructions.
  - a. Slip-on Type: Clean conduit surface at installation location. Cut tubing to 4-inch minimum lengths and slip onto raceway prior to slab placement and termination of conduit. Heat-shrink onto conduit.
  - b. Wrap-around Type: Use where slip-on access to conduit is not possible. Clean conduit surface at installation location. Apply primer. Apply wraps to provide two layers of tape. Neatly finish tape end to prevent unraveling.

### 3.16 CONDUCTORS AND CABLES

- A. Conductor storage, handling, and installation shall be in accordance with manufacturer's recommendations.
- B. Do not exceed manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- C. Conduit system shall be complete prior to drawing conductors. Lubricate prior to pulling into conduit. Lubrication type shall be as approved by conductor manufacturer.
- D. Terminate all conductors and cables, unless otherwise shown.
- E. Do not splice conductors, unless specifically indicated or approved by Engineer.
- F. Wiring within Equipment and Local Control Panels: Remove surplus wire, dress, bundle, and secure.
- G. Power Conductor Color Coding:
  - 1. No. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 to 2 inches wide.
  - 2. No. 8 AWG and Smaller: Provide colored conductors.
  - 3. Colors:
    - a. Neutral Wire: White.
    - b. Live Wires, 120/240-Volt, Single-Phase System: Black, red.
    - c. Live Wires, 120/208-Volt, Three-Phase System: Black, red, or blue.
    - d. Live Wires, 277/480-Volt, Three-Phase System: Brown, orange, or yellow.
    - e. Ground Wire: Green.
- H. Circuit Identification:
  - 1. Assign circuit name based on device or equipment at load end of circuit. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.
  - 2. Method: Identify with sleeves. Taped-on markers or tags relying on adhesives not permitted.



I. Connections and Terminations:

1. Install wire nuts only on solid conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control circuit conductors.
3. Tape insulate all uninsulated connections.
4. Install crimp connectors and compression lugs with tools approved by connector manufacturer.

3.17 GROUNDING

- A. Grounding shall be in compliance with NFPA 70 and as shown.
- B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.
- C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.
- D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.
- E. Shielded Instrumentation Cables:
  1. Ground shield to ground bus at power supply for analog signal.
  2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
  3. Do not ground instrumentation cable shield at more than one point.
- F. Equipment Grounding Conductors: Provide in all conduits containing power conductors and control circuits above 50 volts.
- G. Ground Rods: Install full length with conductor connection at upper end. Install one ground rod in each handhole.

3.18 LOW VOLTAGE MOTOR CONTROL

- A. Install equipment in accordance with NEMA ICS 2.3 and manufacturer's instructions and recommendations.
- B. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers. Adjust to approximately 11-times motor rated current.
- C. Select and install overload relay heaters or adjust electronic overload protection after the actual nameplate full-load current rating of motor has been determined.

### 3.19 FIELD QUALITY CONTROL

#### A. General:

1. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.
2. Test instrument calibration shall be in accordance with NETA ATS.
3. Perform inspection and electrical tests after equipment has been installed.
4. Perform tests with apparatus de-energized whenever feasible.
5. Inspection and electrical tests on energized equipment are to be:
  - a. Scheduled with ESD prior to de-energization.
  - b. Minimized to avoid extended period of interruption to the operating plant equipment.

#### B. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70.

#### C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

#### D. Adjust mechanisms and moving parts for free mechanical movement.

#### E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

#### F. Verify nameplate data for conformance to Contract Documents.

#### G. Realign equipment not properly aligned and correct unlevelness.

#### H. Properly anchor electrical equipment found to be inadequately anchored.

#### I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

#### J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

#### K. Provide proper lubrication of applicable moving parts.

- L. Investigate and repair or replace:
  - 1. Electrical items that fail tests.
  - 2. Active components not operating in accordance with manufacturer's instructions.
  - 3. Damaged electrical equipment.
  
- M. Electrical Enclosures:
  - 1. Remove foreign material and moisture from enclosure interior.
  - 2. Vacuum and wipe clean enclosure interior.
  - 3. Remove corrosion found on metal surfaces.
  - 4. Repair or replace, as determined by Engineer, door and panel sections having damaged surfaces.
  - 5. Replace missing or damaged hardware.
  
- N. Provide certified test report(s) documenting the successful completion of specified testing. Include field test measurement data.
  
- O. Test the following equipment and materials:
  - 1. Conductors: Insulation resistance, No. 4 and larger only.
  - 2. Panelboards, switches, and circuit breakers.
  - 3. Motor controls.
  - 4. Grounding electrodes.
  - 5. Motors.
  
- P. Controls:
  - 1. Test control and signal wiring for proper termination and function.
  - 2. Test local control panels and other control devices for proper terminations, configuration and settings, and functions.
  - 3. Demonstrate control, monitoring, and indication functions in presence of Owner and Engineer.
  
- Q. Balance electrical load between phases on panelboards and mini-power centers after installation.
  
- R. Voltage Testing:
  - 1. When installation is complete and facility is in operation, check voltage at point of termination of electric utility supply system to Project.
  - 2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.

3. If unbalance exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded conditions more than plus or minus 4 percent of nominal, make written request to electric utility to correct condition.
4. If corrections are not made, obtain written statement from a responsible electric utility official that voltage variations and/or unbalance are within their normal standards.

S. Equipment Line Current:

1. Check line current in each phase for each piece of equipment.
2. If electric utility makes adjustments to supply voltage magnitude or balance, make line current check after adjustments are made.

**END OF SECTION**

**SECTION 26 32 13**  
**DIESEL ENGINE GENERATOR SET**

**PART 1      GENERAL**

1.01      SUMMARY

- A.    Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic controls.
- B.    Provide factory test, startup by a supplier authorized by the manufacturer, and on-site testing of the system.
- C.    The generator set manufacturer shall warrant all equipment provided under this section so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1.02      REFERENCES

- A.    The following is a list of standards which may be referenced in this section:
  - 1.    ASTM International (ASTM): A335/A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service.
  - 2.    Code of Federal Regulations (CRF): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
  - 3.    National Electric Manufacturer's Association (NEMA):
    - a.    250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    - b.    MG 1, Motors and Generators.
  - 4.    National Electrical Contractors Association (NECA): 404, Recommended Practice for Installing Generator Sets.
  - 5.    National Fire Protection Association (NFPA):
    - a.    37, Installation and Use of Stationary Combustion Engines and Gas Turbines.
    - b.    70, National Electric Code.
    - c.    110, Emergency and Standby Power Systems.
  - 6.    SAE International (SAE): J1074, Engine Sound Level Measurement.
  - 7.    Underwriters Laboratories, Inc. (UL):
    - a.    142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
    - b.    508, Industrial Control Equipment.

- c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
- d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
- e. 2200, Stationary Engine Generator.

### 1.03 QUALITY ASSURANCE

#### A. Authority Having Jurisdiction (AHJ):

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

#### B. Manufacturer Special Requirements:

- 1. Generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
- 2. Manufacturer of generator set shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

### 1.04 AIR QUALITY PERMIT

- A. Obtain prior to releasing generator for production.

### 1.05 WARRANTY

- A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with the ESD named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.06 EXTRA MATERIALS

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

<u>Item</u>	<u>Quantity</u>
Diesel fuel line filter elements	3 complete sets
Lubricating oil filter elements with gasket	3 complete sets
Air cleaner filter element	1 complete set
Auxiliary fuel and jacket water pump packing/seals	1 complete set
Cooling fan drive belt (if applicable)	2 complete sets
Hydrometer	1 each
Two-pronged battery voltmeter	1 each
Spare fuses, if used in control panel	1 complete set
Spare indicating lamps (if applicable)	4 each type used
Touch up paint	1 quart each color used
Special tools required to maintain or dismantle engine generator set	1 complete set

**PART 2 PRODUCTS**

2.01 MANUFACTURERS

- A. Materials and equipment specified in this section shall be products of:
1. Cummins.
  2. Caterpillar.
  3. Kohler Power Series.

2.02 GENERAL

- A. Ratings: Standby service.
- B. Vibration Design:
1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.

2. Apply torsional analysis and design to mitigate torsional vibration.
3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

## 2.03 ENGINE

### A. General:

1. Manufacturer's standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.

### B. Type: Diesel Cycle, 4-stroke type with unit mounted radiator and fan cooling.

### C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
2. Starter shall be capable of three complete cranking cycles without overheating.
3. Batteries:
  - a. Sized as recommended by engine manufacturer.
  - b. Lead-acid type.
  - c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
  - d. Housed in acid-resistant frame isolated from engine generator main frame.
  - e. Located such that maintenance and inspection of engine is not hindered.
  - f. Complete with battery cables and connectors.
4. Battery Charger:
  - a. UL 1236 listed and labeled.
  - b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
  - c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
  - d. Locate charger in automatic transfer switch, generator control panel, or wall mounted in generator enclosure. Generator manufacturer shall coordinate location.
  - e. Include:
    - 1) Ammeter and voltmeter.
    - 2) Fused ac input and dc output.
    - 3) Power ON pilot light.



- 4) AC failure relay and light.
- 5) Low and high dc voltage alarm relay and light.
- f. Alarm relay dry contacts rated 4 amps at 120V ac.

D. Fuel System:

1. Engine driven, mechanical, positive displacement fuel pump.
2. Fuel filter with replaceable spin-on canister element.
3. As specified under Article Integral Subbase Fuel Tank.
4. Fuel Connections to Engine: Flexible hose, suitable for application.

E. Governing System:

1. Electro-mechanical or electro-hydraulic type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Accessories:
  - a. Manual speed control device.
  - b. Positive overspeed trip switch.

F. Jacket Water Cooling System:

1. Radiator:
  - a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
  - b. Cooling System: Rated for full load operation.
  - c. Fan: Suitable for use in a system with 0.5 in H<sub>2</sub>O restriction.
  - d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
3. Jacket Water Heater:
  - a. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
  - b. Thermostatically controlled.
4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

G. Lubrication System:

1. Type: Full-pressure.
2. Accessories:
  - a. Pressure switch to initiate shutdown on low oil pressure.
  - b. Oil filter with replaceable element.
  - c. Bayonet type oil level stick.
  - d. Valved oil drain extension.

3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

H. Exhaust System:

1. Muffler: Rated for critical silencing.
2. Exhaust Pipe: ASTM A335, Grade P11, standard wall, with fittings selected to match piping materials.
3. Pipe Connections: Welded.
4. Engine Connection:
  - a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
  - b. Length as required for flexibility and expansion in piping arrangement shown on Drawings.

- I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

## 2.04 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. Stator Windings:
  - a. Skewed for smooth voltage waveform.
  - b. Reconnectable, 12 lead.
4. Overspeed Capability: 125 percent.
5. Waveform Deviation from Sine Wave: 5 percent maximum.
6. Telephone Interference Factor: 50 maximum.
7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

B. Insulation System:

1. Class H, with a maximum rise of 125 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
2. Epoxy varnish.

C. Excitation System:

1. Field brushless type or permanent magnet generator (PMG) exciter.
2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.

D. Voltage Regulation:

1. Solid state, three-phase sensing type.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.

E. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
2. NEMA MG 1 Defined Transient Voltage Dip:
  - a. Less than 20 percent at rapid application of rated load.
  - b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

F. Motor Starting Capability: Shall be sized to handle all pumps starting in a single step.

G. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.

H. Main Circuit Breaker:

1. Type: Molded case.
2. Current Rating: As recommended by generator manufacturer.
3. Interrupt Rating: Suitable for amperes and voltage to match power service.
4. Enclosure: Mounted with vibration isolation from engine generator set.
5. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.

2.05 BASEPLATE

- A. Mount engine generator set on a rigid common steel base frame.
- B. Base frame shall be stiffened to minimize deflections.

2.06 INTEGRAL SUBBASE FUEL TANK

A. General:

1. Full load operation of generator set for a minimum of 100 gallons or 24 hours, whichever is larger.
2. UL 142 listed and labeled.

3. Installation shall be in compliance to NFPA 37.
4. Double-walled, steel construction and shall include the following features:
  - a. Emergency tank and basin vents.
  - b. Mechanical level gauge.
  - c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
  - d. Leak detection provisions, wired to generator set control for local and remote alarm indication.
  - e. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
  - f. Basin drain.
  - g. Integral lifting provisions.

#### 2.07 VIBRATION ISOLATORS

- A. Provide vibration isolators, spring/pad type.
- B. Include seismic restraints if required by Site location.

#### 2.08 AUTOMATIC LOAD TRANSFER CONTROL

- A. General:
  1. Automatic run controls shall be suitable for interface and control by automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided by the Automatic Transfer Switch.
  2. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008
  3. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.
  4. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads.
- B. Enclosure: Nonventilated NEMA 250, Type 4 with enclosure grounding terminal. Dead front, front accessible cabinet with 14-gauge welded steel construction. Continuously hinged single door, with handle and lock cylinder.
- C. Transfer Switch: Electrically operated, mechanically held, double-throw. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred. Mechanical interlock switch to ensure only one of two possible switch positions. Manual operating handle for transfer in either direction under either loaded or unloaded conditions.

D. Control Module:

1. Microprocessor for sensing and logic control with inherent digital communications capability.
2. Connected to transfer switch by wiring harness having keyed disconnect plug.
3. Adjustable solid state undervoltage sensors for all three phases of normal and for one phase of standby source. Pickup at 85 to 100 percent nominal. Dropout 75 to 98 percent pickup setting.
4. Adjustable frequency sensors for standby source. Pickup 90 to 100 percent nominal. Dropout 87 to 98 percent of pickup setting.
5. Control module with adjustable time delays:
  - a. 0.5 to 6 second engine start delay.
  - b. 0 to 5 minute load transfer to emergency delay.
  - c. 0 to 30 minute retransfer to normal delay.
  - d. 0 to 30 minute unload running time delay.
  - e. Switch to bypass any of the above time delays during testing.
6. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.
7. Adjustable 0 to 5 minutes time delay relay for engine starting signal.

2.09 CONTROL SYSTEM

A. Control Panel:

1. Rating: NEMA 250, Type 12.
2. Material: Steel.
3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.
4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.

B. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
4. Fault Indication Lamps: Manufacturer's standard.
5. Meters: Digital with analog display or Analog, 3.5 inches, 240-degree scale, plus or minus 2 percent accuracy.

C. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. FREQUENCY meter.
8. Engine OIL PRESSURE indicator.
9. Engine jacket WATER TEMPERATURE indicator.
10. Engine SPEED indicator (RPM).
11. Engine OIL TEMPERATURE indicator.
12. RUNNING TIME indicator.
13. DC battery voltage.
14. Emergency Stop button.

D. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.

E. External Interfaces:

1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
2. Output: Dry contact rated 5 amps at 120V ac.
3. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.

F. Functional Requirements:

1. Recracking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recracking for a preset period of time after engine stop.
2. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
3. Cooldown timer, adjustable from 5 minutes to 60 minutes.
4. Alarms:
  - a. Low coolant level.
  - b. Low fuel level.

- c. Low battery voltage
- d. High battery voltage.
- e. Battery charger failure.
- 5. Engine shutdown upon any of the following conditions:
  - a. Engine overspeed.
  - b. Emergency stop button depressed.
  - c. High jacket water temperature alarm setpoint and shutdown setpoint.
  - d. Low oil pressure alarm setpoint and shutdown setpoint.
- 6. Air Inlet Damper Opening:
  - a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
  - b. Air inlet dampers shall fail open.

G. Special Requirements: Mount battery charger in control panel.

H. Power Requirements: Manufacturers stands internally connected.

## 2.10 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. General:

- 1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.
- 2. Package shall comply with requirements of NEC for wiring materials and component spacing.
- 3. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
- 4. Housing:
  - a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
  - b. Doors:
    - 1) Hinged access doors as required to maintain easy access for operating and service functions.
    - 2) Lockable and include retainers to hold door open during service.
- 5. Roof: Cambered to prevent rainwater accumulation.
- 6. Openings: Screened to limit access of rodents into enclosure.
- 7. Electrical power and control interconnections shall be made within perimeter of enclosure.
- 8. Finishes:
  - a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.

- b. Prime and paint surfaces of metal parts. Painting process shall result in coating that meets the following requirements:
    - 1) Primer: 0.5 mil to 2.0 mils thick.
    - 2) Top Coat: 0.8 mil to 1.2 mils thick.
    - 3) Gloss:
      - a) Per ASTM D523, 80 percent plus or minus 5 percent.
      - b) Gloss retention after 1 year shall exceed 50 percent.
    - 4) Crosshatch Adhesion: Per ASTM D3359, 4B-5B.
    - 5) Impact Resistance: Per ASTM D2794, 120-inch to 160-inch pounds.
    - 6) Salt Spray: Per ASTM B117, plus 1,000 hours.
    - 7) Humidity: Per ASTM D2247, plus 1,000 hours.
    - 8) Water Soak: Per ASTM D2247, plus 1,000 hours.
  - c. Painting of hoses, clamps, wiring harnesses, and other nonmetallic service parts shall not be acceptable.
  - d. Fasteners used shall be corrosion-resistant and designed to minimize marring of painted surface when removed for normal installation or service work.
9. Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels.
10. Hardware and hinges shall be austenitic stainless steel.
11. Exhaust Silencer:
  - a. Install factory-mounted exhaust silencer inside enclosure.
  - b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
  - c. Exhaust connections to generator set shall be through seamless flexible connections.
12. Maintenance Provisions:
  - a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
  - b. External radiator-fill provision.
  - c. External fuel fill provision (if equipped with a subbased fuel tank).
13. Provide motorized louvers to minimize air flow through enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
14. Inlet ducts shall include rain hoods.
15. Sound Attenuation:
  - a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
  - b. Enclosure shall reduce sound level of generator set while operating at full rated load to a maximum of 82 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
  - c. Insulate enclosure with nonhydroscopic materials.



## 2.11 FACTORY FINISHING

- A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer's standard heat-resistant engine paint.

## 2.12 FACTORY TESTS

- A. General: Conform to NFPA 110.
- B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.
- C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.
- D. Harmonic Test: Conduct at full load conditions.
- E. Record and Report:
  - 1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
  - 2. Transient response.
  - 3. Load/speed stability.
  - 4. Engine fuel consumption.
  - 5. Power output.
  - 6. Harmonic analysis.

## **PART 3 EXECUTION**

### 3.01 INSTALLATION

- A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.
- B. Install in accordance with NECA 404.
- C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

### 3.02 FIELD FINISHING

- A. Touch up damaged coating with paint system compatible to existing.

### 3.03 FIELD TESTS

- A. General: Conform to NFPA 110.

B. Performance Test:

1. Perform upon completion of installation.
2. Operate 2 hours minimum.
3. Manufacturer's representative shall make necessary adjustments.
4. Demonstrate ability of engine generator set to carry specified loads.
5. Demonstrate engine generator set safety shutdowns.

C. Test Report: Record and report the following:

1. Electric load on generator.
2. Fuel consumption.
3. Exhaust temperature.
4. Ambient air temperature.
5. Safety shutdown performance results.
6. Noise levels at 7 meters and property line.

D. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to Engineer and the ESD electrical staff.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by the ESD for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 0.5 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 0.5 person-day for post-startup training ESD staff.

**END OF SECTION**

**SECTION 26 32 14**  
**NATURAL GAS ENGINE GENERATOR SET**

**PART 1      GENERAL**

1.01      SCOPE

- A.    Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic controls.
- B.    Provide factory test, startup by a supplier authorized by the manufacturer, and on-site testing of the system.
- C.    The generator set manufacturer shall warrant all equipment provided under this section so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1.02      REFERENCES

- A.    The following is a list of standards which may be referenced in this section:
  - 1.    ASTM International (ASTM): A335/A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service.
  - 2.    Code of Federal Regulations (CRF): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
  - 3.    National Electric Manufacturer's Association (NEMA):
    - a.    250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    - b.    MG 1, Motors and Generators.
  - 4.    National Electrical Contractors Association (NECA): 404, Recommended Practice for Installing Generator Sets.
  - 5.    National Fire Protection Association (NFPA):
    - a.    37, Installation and Use of Stationary Combustion Engines and Gas Turbines.
    - b.    70, National Electric Code.
    - c.    110, Emergency and Standby Power Systems.
  - 6.    SAE International (SAE): J1074, Engine Sound Level Measurement.
  - 7.    Underwriters Laboratories, Inc. (UL):
    - a.    142, Steel Aboveground Tanks for Flammable and Combustible Liquids.
    - b.    508, Industrial Control Equipment.

- c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
- d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
- e. 2200, Stationary Engine Generator.

### 1.03 QUALITY ASSURANCE

#### A. Authority Having Jurisdiction (AHJ):

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

#### B. Manufacturer Special Requirements:

- 1. Generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
- 2. Manufacturer of generator set shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

### 1.04 AIR QUALITY PERMIT

- A. Obtain prior to releasing generator for production.

### 1.05 WARRANTY

- A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with the ESD named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

1.06 EXTRA MATERIALS

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

<u>Item</u>	<u>Quantity</u>
Lubricating oil filter elements with gasket	3 complete sets
Air cleaner filter element	1 complete set
Cooling fan drive belt (if applicable)	2 complete sets
Hydrometer	1 each
Two-pronged battery voltmeter	1 each
Spare fuses, if used in control panel	1 complete set
Spare indicating lamps (if applicable)	4 each type used
Touch up paint	1 quart each color used
Special tools required to maintain or dismantle engine generator set	1 complete set

**PART 2 PRODUCTS**

2.01 MANUFACTURERS

- A. Materials and equipment specified in this section shall be products of:
1. Cummins.
  2. Caterpillar.
  3. Kohler Power Series.

2.02 GENERAL

- A. Ratings: Standby service.
- B. Vibration Design:
1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
  2. Apply torsional analysis and design to mitigate torsional vibration.
  3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

## 2.03 ENGINE

### A. General:

1. Manufacturer's standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.

### B. Type: Natural gas fueled, with unit mounted radiator and fan cooling.

### C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
2. Starter shall be capable of three complete cranking cycles without overheating.
3. Batteries:
  - a. Sized as recommended by engine manufacturer.
  - b. Lead-acid type.
  - c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
  - d. Housed in acid-resistant frame isolated from engine generator main frame.
  - e. Located such that maintenance and inspection of engine is not hindered.
  - f. Complete with battery cables and connectors.
4. Battery Charger:
  - a. UL 1236 listed and labeled.
  - b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
  - c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
  - d. Locate charger in automatic transfer switch, generator control panel, or wall mounted in generator enclosure. Generator manufacturer shall coordinate location.
  - e. Include:
    - 1) Ammeter and voltmeter.
    - 2) Fused ac input and dc output.
    - 3) Power ON pilot light.
    - 4) AC failure relay and light.
    - 5) Low and high dc voltage alarm relay and light.
  - f. Alarm relay dry contacts rated 4 amps at 120V ac.

D. Governing System:

1. Electro-mechanical or electro-hydraulic type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Accessories:
  - a. Manual speed control device.
  - b. Positive overspeed trip switch.

E. Jacket Water Cooling System:

1. Radiator:
  - a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
  - b. Cooling System: Rated for full load operation.
  - c. Fan: Suitable for use in a system with 0.5 in H<sub>2</sub>O restriction.
  - d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
3. Jacket Water Heater:
  - a. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
  - b. Thermostatically controlled.
4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

F. Lubrication System:

1. Type: Full-pressure.
2. Accessories:
  - a. Pressure switch to initiate shutdown on low oil pressure.
  - b. Oil filter with replaceable element.
  - c. Bayonet type oil level stick.
  - d. Valved oil drain extension.
3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

G. Exhaust System:

1. Muffler: Rated for critical silencing.
2. Exhaust Pipe: ASTM A335, Grade P11, standard wall, with fittings selected to match piping materials.
3. Pipe Connections: Welded.

4. Engine Connection:
  - a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting.
  - b. Length as required for flexibility and expansion in piping arrangement shown on Drawings.
  
- H. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

## 2.04 GENERATOR

### A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. Stator Windings:
  - a. Skewed for smooth voltage waveform.
  - b. Reconnectable, 12 lead.
4. Overspeed Capability: 125 percent.
5. Waveform Deviation from Sine Wave: 5 percent maximum.
6. Telephone Interference Factor: 50 maximum.
7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

### B. Insulation System:

1. Class H, with a maximum rise of 125 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
2. Epoxy varnish.

### C. Excitation System:

1. Field brushless type or permanent magnet generator (PMG) exciter.
2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.

### D. Voltage Regulation:

1. Solid state, three-phase sensing type.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.



- E. Voltage and Frequency Regulation Performance:
  - 1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
  - 2. NEMA MG 1 Defined Transient Voltage Dip:
    - a. Less than 20 percent at rapid application of rated load.
    - b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
  - 3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.
- F. Motor Starting Capability: Shall be sized to handle all pumps starting in a single step.
- G. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.
- H. Main Circuit Breaker:
  - 1. Type: Molded case.
  - 2. Current Rating: As recommended by generator manufacturer.
  - 3. Interrupt Rating: Suitable for amperes and voltage to match power service.
  - 4. Enclosure: Mounted with vibration isolation from engine generator set.
  - 5. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.

#### 2.05 BASEPLATE

- A. Mount engine generator set on a rigid common steel base frame.
- B. Base frame shall be stiffened to minimize deflections.

#### 2.06 VIBRATION ISOLATORS

- A. Provide vibration isolators, spring/pad type.
- B. Include seismic restraints if required by Site location.

#### 2.07 AUTOMATIC LOAD TRANSFER CONTROL

- A. General:
  - 1. Automatic run controls shall be suitable for interface and control by automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided by the Automatic Transfer Switch.
  - 2. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008

3. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.
  4. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads.
- B. Enclosure: Nonventilated NEMA 250, Type 4 with enclosure grounding terminal. Dead front, front accessible cabinet with 14-gauge welded steel construction. Continuously hinged single door, with handle and lock cylinder.
- C. Transfer Switch: Electrically operated, mechanically held, double-throw. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred. Mechanical interlock switch to ensure only one of two possible switch positions. Manual operating handle for transfer in either direction under either loaded or unloaded conditions.
- D. Control Module:
1. Microprocessor for sensing and logic control with inherent digital communications capability.
  2. Connected to transfer switch by wiring harness having keyed disconnect plug.
  3. Adjustable solid state undervoltage sensors for all three phases of normal and for one phase of standby source. Pickup at 85 to 100 percent nominal. Dropout 75 to 98 percent pickup setting.
  4. Adjustable frequency sensors for standby source. Pickup 90 to 100 percent nominal. Dropout 87 to 98 percent of pickup setting.
  5. Control module with adjustable time delays:
    - a. 0.5 to 6 second engine start delay.
    - b. 0 to 5 minute load transfer to emergency delay.
    - c. 0 to 30 minute retransfer to normal delay.
    - d. 0 to 30 minute unload running time delay.
    - e. Switch to bypass any of the above time delays during testing.
  6. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.
  7. Adjustable 0 to 5 minutes time delay relay for engine starting signal.

## 2.08 CONTROL SYSTEM

- A. Control Panel:
1. Rating: NEMA 250, Type 12.
  2. Material: Steel.
  3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.

4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.

B. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
4. Fault Indication Lamps: Manufacturer's standard.
5. Meters: Digital with analog display or Analog, 3.5 inches, 240-degree scale, plus or minus 2 percent accuracy.

C. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. FREQUENCY meter.
8. Engine OIL PRESSURE indicator.
9. Engine jacket WATER TEMPERATURE indicator.
10. Engine SPEED indicator (RPM).
11. Engine OIL TEMPERATURE indicator.
12. RUNNING TIME indicator.
13. DC battery voltage.
14. Emergency Stop button.

D. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.

E. External Interfaces:

1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
2. Output: Dry contact rated 5 amps at 120V ac.
3. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.

F. Functional Requirements:

1. Recracking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recracking for a preset period of time after engine stop.
2. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
3. Cooldown timer, adjustable from 5 minutes to 60 minutes.
4. Alarms:
  - a. Low coolant level.
  - b. Low battery voltage
  - c. High battery voltage.
  - d. Battery charger failure.
5. Engine shutdown upon any of the following conditions:
  - a. Engine overspeed.
  - b. Emergency stop button depressed.
  - c. High jacket water temperature alarm setpoint and shutdown setpoint.
  - d. Low oil pressure alarm setpoint and shutdown setpoint.
6. Air Inlet Damper Opening:
  - a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
  - b. Air inlet dampers shall fail open.

G. Special Requirements: Mount battery charger in control panel.

H. Power Requirements: Manufacturers stands internally connected.

2.09 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. General:

1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.
2. Package shall comply with requirements of NEC for wiring materials and component spacing.
3. Design total assembly of generator set and enclosure to be lifted into place using spreader bars.
4. Housing:
  - a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
  - b. Doors:
    - 1) Hinged access doors as required to maintain easy access for operating and service functions.

- 2) Lockable and include retainers to hold door open during service.
5. Roof: Cambered to prevent rainwater accumulation.
6. Openings: Screened to limit access of rodents into enclosure.
7. Electrical power and control interconnections shall be made within perimeter of enclosure.
8. Finishes:
  - a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.
  - b. Prime and paint surfaces of metal parts. Painting process shall result in coating that meets the following requirements:
    - 1) Primer: 0.5 mil to 2.0 mils thick.
    - 2) Top Coat: 0.8 mil to 1.2 mils thick.
    - 3) Gloss:
      - a) Per ASTM D523, 80 percent plus or minus 5 percent.
      - b) Gloss retention after 1 year shall exceed 50 percent.
    - 4) Crosshatch Adhesion: Per ASTM D3359, 4B-5B.
    - 5) Impact Resistance: Per ASTM D2794, 120-inch to 160-inch pounds.
    - 6) Salt Spray: Per ASTM B117, plus 1,000 hours.
    - 7) Humidity: Per ASTM D2247, plus 1,000 hours.
    - 8) Water Soak: Per ASTM D2247, plus 1,000 hours.
  - c. Painting of hoses, clamps, wiring harnesses, and other nonmetallic service parts shall not be acceptable.
  - d. Fasteners used shall be corrosion-resistant and designed to minimize marring of painted surface when removed for normal installation or service work.
9. Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels.
10. Hardware and hinges shall be austenitic stainless steel.
11. Exhaust Silencer:
  - a. Install factory-mounted exhaust silencer inside enclosure.
  - b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
  - c. Exhaust connections to generator set shall be through seamless flexible connections.
12. Maintenance Provisions:
  - a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
  - b. External radiator-fill provision.
13. Provide motorized louvers to minimize air flow through enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
14. Inlet ducts shall include rain hoods.

15. Sound Attenuation:
  - a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
  - b. Enclosure shall reduce sound level of generator set while operating at full rated load to a maximum of 82 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
  - c. Insulate enclosure with nonhydroscopic materials.

## 2.10 FACTORY FINISHING

- A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer's standard heat-resistant engine paint.

## 2.11 FACTORY TESTS

- A. General: Conform to NFPA 110.
- B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.
- C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.
- D. Harmonic Test: Conduct at full load conditions.
- E. Record and Report:
  1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
  2. Transient response.
  3. Load/speed stability.
  4. Engine fuel consumption.
  5. Power output.
  6. Harmonic analysis.

## **PART 3 EXECUTION**

### 3.01 INSTALLATION

- A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.
- B. Install in accordance with NECA 404.
- C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

### 3.02 FIELD FINISHING

- A. Touch up damaged coating with paint system compatible to existing.

### 3.03 FIELD TESTS

- A. General: Conform to NFPA 110.

- B. Performance Test:

1. Perform upon completion of installation.
2. Operate 2 hours minimum.
3. Manufacturer's representative shall make necessary adjustments.
4. Demonstrate ability of engine generator set to carry specified loads.
5. Demonstrate engine generator set safety shutdowns.

- C. Test Report: Record and report the following:

1. Electric load on generator.
2. Fuel consumption.
3. Exhaust temperature.
4. Ambient air temperature.
5. Safety shutdown performance results.
6. Noise levels at 7 meters and property line.

- D. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to Engineer and the ESD electrical staff.

### 3.04 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: Present at Site or classroom designated by the ESD for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 0.5 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 0.5 person-day for post-startup training ESD staff.

**END OF SECTION**





**SECTION 26 56 00**  
**EXTERIOR LIGHTING**

**PART 1 GENERAL**

1.01 REFERENCES

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

1. ASTM International (ASTM):
  - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
  - c. A572/A572A, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
  - d. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100-mm] Thick.
  - e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
  - f. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
  - g. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
  - h. D6576, Standard Specification for Flexible Cellular Rubber Chemically Blown.
  - i. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
2. American Wood Protection Association (AWPA): M6, Brands Used on Forest Products.
3. Illuminating Engineering Society of North America (IESNA): HB-9, Lighting Handbook.
4. The Institute of Electrical and Electronics Engineers, Inc. (IEEE): C2, National Electrical Safety Code.
5. Military Specification (MIL): DTL-83420M, Wire Rope, Flexible, for Aircraft Control, General Specification for.
6. National Electrical Manufacturers Association (NEMA):
  - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
  - b. ICS 6, Industrial Control and Systems: Enclosures.
7. National Energy Policy Act.

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

## 1.02 QUALITY ASSURANCE

### A. Authority Having Jurisdiction (AHJ):

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

### B. Standard Products:

1. Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship.
2. Products shall have been in satisfactory commercial or industrial use for 2 years prior to Bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
3. Material and Equipment Manufacturing Date: Products manufactured more than 3 years prior to date of delivery to Site shall not be used.

## 1.03 DELIVERY, STORAGE, AND HANDLING

### A. Aluminum Poles:

1. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.
2. Do not store poles on ground.

3. Support poles so they are at least 1 foot above ground level and growing vegetation.
4. Do not remove factory-applied pole wrappings until just before installing pole.
5. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

## **PART 2 PRODUCTS**

### **2.01 LUMINAIRES**

#### **A. General:**

1. Component Access: Accessible and replaceable without removing luminaire from its mounting.

#### **B. Exterior Installations:**

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

#### **C. Hazardous Classified Areas:**

1. UL Labeled: Class I, Division 1, Groups C and D. or Class II, Division 1, Groups F and G as applicable.
2. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL 844.

#### **D. Lamps:**

1. High-Intensity Discharge:
  - a. Type: High-pressure sodium and metal halide.
  - b. Color: Color corrected.
2. Manufacturers:
  - a. General Electric Company.
  - b. Osram Sylvania.
  - c. Phillips Lighting Company.

### **2.02 LIGHTING CONTACTOR**

#### **A. Features:**

1. Mechanically held contactor.
2. Provide contactor with hand-off-automatic selector switch.
3. Contactor shall be hermetically sealed.

## 2.03 PHOTOCCELL SWITCH

### A. Features:

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

## 2.04 POLES

### A. General:

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

### B. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.188-inch wall thickness.
2. Shape: Round.
3. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
4. Shaft Top: Fitted with cap.
5. Base:
  - a. Anchor bolt mounted and machined to receive lower end of shaft.
  - b. Joint between shaft and base shall be welded.
  - c. Base cover shall be cast aluminum alloy.
  - d. Hardware, except anchor bolts, shall be either anodized aluminum alloy or stainless steel.
  - e. Handhole.

6. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.
7. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.

#### 2.05 POLE FOUNDATIONS

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

#### 2.06 FACTORY FINISH

- A. Electrical equipment shall have factory-applied painting systems which shall, as a minimum.

### **PART 3 EXECUTION**

#### 3.01 INSTALLATION

- A. Electrical installations shall conform to IEEE C2 and requirements specified herein.
- B. Aluminum Poles: Install according to pole manufacturer's instructions.
  1. Provide cast-in-place concrete base.
  2. Provide branch circuit in-line fuses in pole base handhole.
- C. High Mast Lighting: Install according to manufacturer's instructions.
- D. Photocell Switch Aiming: Mount and aim switch according to manufacturer's recommendations.
- E. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

#### 3.02 FIELD QUALITY CONTROL

- A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

3.03 CLEANING

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

**END OF SECTION**

**SECTION 31 10 00  
SITE CLEARING**

**PART 1 GENERAL**

1.01 DEFINITIONS

- A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.
- B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.
- C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2-inch caliper to a depth of 6 inches below subgrade.
- D. Scalping: Removal of sod without removing more than upper 3 inches of topsoil.
- E. Stripping: Removal of topsoil remaining after applicable scalping is completed.
- F. Project Limits: Areas, as shown or specified, within which Work is to be performed.

**PART 2 PRODUCTS (NOT USED)**

**PART 3 EXECUTION**

3.01 GENERAL

- A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or Site improvements within limits shown or specified.
- B. Do not injure or deface vegetation that is not designated for removal.

3.02 CLEARING

- A. Clear areas within limits shown on the Design Drawings.
- B. Fell trees so that they fall away from facilities and vegetation not designated for removal.
- C. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.03 GRUBBING

- A. Grub areas within limits shown on the Design Drawings.

3.04 SCALPING

- A. Do not remove sod until after clearing and grubbing is completed and resulting debris is removed.
- B. Scalp areas within limits shown on the Design Drawings.

3.05 STRIPPING

- A. Do not remove topsoil until after scalping is completed.
- B. Strip areas within limits to minimum depths shown on the Design Drawings. Do not remove subsoil with topsoil.

3.06 DISPOSAL

- A. Clearing and Grubbing Debris: Dispose of debris offsite.
- B. Scalpings: As specified for clearing and grubbing debris.
- C. Strippings:
  - 1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil offsite.
  - 2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

**END OF SECTION**



**SECTION 31 23 16**  
**EXCAVATION**

**PART 1 GENERAL**

1.01 QUALITY ASSURANCE

- A. Provide adequate survey control to avoid unauthorized over excavation.

1.02 WEATHER LIMITATIONS

- A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.
- B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.03 SEQUENCING AND SCHEDULING

- A. Clearing, Grubbing, and Stripping: Complete applicable Work prior to excavating.
- B. Dewatering: Conform to applicable requirements of Section 31 23 19, Dewatering, prior to initiating excavation.
- C. Excavation Support: Install and maintain, in accordance with the requirements of OSHA, local and state regulations to ensure the safety of workers, support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

**PART 2 PRODUCTS (NOT USED)**

**PART 3 EXECUTION**

3.01 GENERAL

- A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be placed.
- B. Do not over excavate without written authorization of Engineer. In the event of over excavation backfill with Granular Backfill in accordance with Section 31 23 23, Trench Backfill.

- C. Where constructing within fill the services of a geotechnical engineer shall be employed to ensure that the material has been properly placed and compacted to prevent settlement of the main, manhole or structure.

### 3.02 UNCLASSIFIED EXCAVATION

- A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

### 3.03 TRENCH WIDTH

- A. Minimum Width of Trenches:
  - 1. 18 inches greater than outside diameter or width of the pipe.
  - 2. Increase trench widths by thicknesses of sheeting/excavation support system where system is required.
- B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

### 3.04 EMBANKMENT AND CUT SLOPES

- A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.
- B. Remove stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. Remove exposed roots from cut slopes.
- C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

### 3.05 STOCKPILING EXCAVATED MATERIAL

- A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.
- B. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.
- C. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.
- D. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.06 DISPOSAL OF SPOIL

- A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, offsite.

**END OF SECTION**



**SECTION 31 23 19  
DEWATERING**

**PART 1 GENERAL**

1.01 SECTION INCLUDES:

- A. Dewatering of excavations and other work sites including trench, and tunnel excavations.

**PART 2 PRODUCTS (NOT USED)**

**PART 3 EXECUTION**

3.01 GENERAL

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

3.02 SURFACE WATER CONTROL

- A. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

- A. Permit, provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.
- B. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.
- C. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering.

**END OF SECTION**



**SECTION 31 23 23  
TRENCH BACKFILL**

**PART 1 GENERAL**

1.01 SUMMARY

- A. Where required, modify the backfill requirement to meet local / state requirements.

1.02 REFERENCES

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

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
  - a. C33/C33M, Standard Specification for Concrete Aggregates.
  - b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
  - c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
  - d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
  - e. C150/C150M, Standard Specification for Portland Cement.
  - f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
  - g. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
  - h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)).
  - i. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
  - j. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>)).
  - k. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
  - l. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
  - m. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
  - n. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
  - o. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.

3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

## 1.03 DEFINITIONS

- A. Base Rock: Granular material upon which manhole bases and other structures are placed.
- B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.
- C. Imported Material: Material obtained by Contractor from source(s) offsite.
- D. Lift: Loose (uncompacted) layer of material.
- E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.
- F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.
- G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either as-compacted field dry density or maximum dry density, as determined by Engineer.
- H. Relative Density: As defined by ASTM D4253 and ASTM D4254.
- I. Selected Backfill Material: Material available onsite that the Owner/Owner's Representative determines to be suitable for a specific use.
- J. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:
  1. Coefficient of Curvature: Greater than or equal to 1 and less than or equal to 3.
  2. Coefficient of Uniformity: Greater than or equal to 4 for materials classified as gravel, and greater than or equal to 6 for materials classified as sand.



## **PART 2 PRODUCTS**

### **2.01 MARKING TAPE**

#### **A. Detectable:**

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
4. Width: 3 inches.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
  - a. Reef Industries; Terra Tape, Sentry Line Detectable.
  - b. Mutual Industries; Detectable Tape.
  - c. Presco; Detectable Tape.

#### **B. Color: Green in accordance with APWI Uniform Color Code.**

### **2.02 TRENCH STABILIZATION MATERIAL**

- A. Base Rock: Number 1 in accordance with the Course Aggregate Gradation Table, ALDOT Standard Specifications.
- B. Granular Backfill: Number 57 or 67 in accordance with the Course Aggregate Gradation Table, ALDOT Standard Specifications.

### **2.03 BEDDING MATERIAL AND PIPE ZONE MATERIAL**

- A. Number 57 or 67 in accordance with the Course Aggregate Gradation Table, ALDOT Standard Specifications.

### **2.04 CLASS C - EARTH BACKFILL**

- A. Soil, loam, or other excavated material suitable for use as backfill.
- B. Free from roots or organic matter, refuse, boulders and material larger than 1/2 cubic foot, or other deleterious materials.

### **2.05 CLASS A - PROCESSED EARTH BACKFILL**

- A. Class C Earth backfill, meeting the following additional requirement.
  1. Free of boulders and cobbles that would be retained on a 6-inch screen 3-inch sieve.

2.06 FLOWABLE FILL

- A. Class C Concrete as specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 CONCRETE BACKFILL

- A. Class C Concrete as specified in Section 03 30 00, Cast-in-Place Concrete.

2.08 GRAVEL SURFACING ROCK

- A. Number 67 in accordance with the Course Aggregate Gradation Table, ALDOT Standard Specifications.

2.09 TOPSOIL

- A. Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.
- B. Composition: In general accordance with ASTM D5268:
  - 1. Gravel-Sized Fraction: Maximum 5 percent by weight retained on a No. 10 sieve.
  - 2. Sand-Sized Fraction: Minimum 20 to 60 percent passing No. 10 sieve.
  - 3. Silt and Clay-Sized Fraction: Minimum 35 to 70 percent.
- C. Organic Matter: Minimum 1.5 percent by dry weight as determined in accordance with ASTM D2974.
- D. pH: Range 5.0 to 7.0.
- E. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

**PART 3 EXECUTION**

3.01 TRENCH PREPARATION

- A. Water Control:
  - 1. As specified in Section 31 23 19, Dewatering.
  - 2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
  - 3. Provide continuous water control until trench backfill is complete.

- B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

### 3.02 TRENCH BOTTOM

- A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.
- B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Owner/Owner's Representative. Owner/Owner's Representative will determine depth of overexcavation, if any required.

### 3.03 TRENCH STABILIZATION MATERIAL INSTALLATION

- A. Rebuild trench bottom with trench stabilization material.
- B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.
- C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

### 3.04 BEDDING

- A. Furnish imported bedding material where, in the opinion of Owner/Owner's Representative, excavated material is unsuitable for bedding or insufficient in quantity.
- B. Place over full width of prepared trench bottom in two equal lifts when required depth exceeds 8 inches.
- C. Hand grade and compact each lift to provide a firm, unyielding surface.
- D. Minimum Thickness: As follows, except increase depths listed by 2 inches in areas of rock excavation:
  - 1. Pipe 18 Inches and Smaller: 4 inches.
- E. Check grade and correct irregularities in bedding material. Loosen top 1 inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.
- F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

- G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

### 3.05 BACKFILL PIPE ZONE

- A. Upper limit of pipe zone shall not be less than 12 inches:
- B. Restrain pipe as necessary to prevent their movement during backfill operations.
- C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.
  - 1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2 pipe diameter.
  - 2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.
- D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.
- E. Each lift shall be compacted with a minimum of two passes by either a vibratory plate compactor. Take care to avoid damaging pipe and pipe coating.

### 3.06 MARKING TAPE INSTALLATION

- A. Continuously install detectable marking tape along centerline of buried piping, on top of last lift of pipe zone material.
  - 1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.

### 3.07 BACKFILL ABOVE PIPE ZONE

- A. General:
  - 1. Process excavated material to meet specified gradation requirements.
  - 2. Adjust moisture content as necessary to obtain specified compaction.
  - 3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
  - 4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.

5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
  6. Backfill around structures with same class backfill as specified for adjacent trench, unless otherwise shown or specified.
- B. Class A Processed Earth Backfill:
1. Place in lifts not exceeding thickness of 9 inches.
  2. Mechanically compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.
- C. Class C Earth Backfill:
1. Backfill with earth backfill.
  2. Leave trench with backfill material neatly mounded across the entire trench width, but not more than 6 inches above the adjacent ground surface.
  3. In lawn, garden, or similar type areas, maintain trench level with the existing adjacent grade.
  4. At Other Locations:
    - a. Estimate and provide amount of backfill material required so that after normal settlement, settled surface will match adjacent ground surface.
    - b. Neatly windrow material over trench, and remove excess.
    - c. Correct excess or deficiency of backfill material apparent after settlement and within correction period by regrading, and disposing of excess material or adding additional material where deficient.
- D. Class D Backfill: Backfill trench above pipe zone with granular backfill in lifts not exceeding 8 inches. Compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.
- E. Concrete Backfill:
1. Place above bedding.
  2. Minimum Concrete Thickness: 6 inches on top and sides of pipe.
  3. Do not allow dirt or foreign material to become mixed with concrete during placement.
  4. Allow sufficient time for concrete to reach initial set before additional backfill material is placed in trench.
  5. Prevent flotation of pipe.
  6. Begin and end concrete backfill within 4 inches of a pipe joint on each end.
  7. Do not encase pipe joints except within the limits of the concrete backfill.
- F. Controlled Low Strength Material:

1. Discharge from truck mounted drum type mixer into trench.
2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.
3. In traveled areas fill entire trench section to pavement finish grade for a temporary driving surface, and screed off excess and finish with a float.
4. In other areas fill trench section as shown.

### 3.08 REPLACEMENT OF TOPSOIL

- A. Replace topsoil in top 12 inches of backfilled trench.
- B. Maintain finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

### 3.09 MAINTENANCE OF TRENCH BACKFILL

- A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.
- B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.
- C. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.
- D. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

### 3.10 SETTLEMENT OF BACKFILL

- A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

**END OF SECTION**

**SECTION 32 12 16  
ASPHALT PAVING**

**PART 1 GENERAL**

1.01 REQUIREMENTS

- A. Pave width shown on the Drawings and as required for restoration damaged during completion of the Work detailed.

1.02 DEFINITIONS

- A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.
- B. RAP: Reclaimed asphalt pavement.
- C. Standard Specifications: Alabama Department of Transportation Standard Specifications for Highway Construction, 2006 Edition.

1.03 DESIGN REQUIREMENTS

- A. Prepare asphalt concrete mix design, meeting the following design criteria, tolerances, and other requirements of Section 410, of the Standard Specifications, Hot Mix Asphalt Pavement.

1.04 SUBMITTALS

- A. Informational Submittals:
  - 1. Asphalt Concrete Mix Formula:
    - a. Submit minimum of 15 days prior to start of production.
    - b. Submittal to include the following information:
      - 1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
      - 2) Bulk specific gravity for each aggregate constituent.
      - 3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
      - 4) Properties as stated in Section 410 of the Standard Specifications, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
      - 5) Percent of asphalt lost due to absorption by aggregate.

- 6) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
  - 7) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
  - 8) Optimum mixing temperature.
  - 9) Optimum compaction temperature.
  - 10) Temperature-viscosity curve of asphalt cement to be used.
  - 11) Brand name of any additive to be used and percentage added to mixture.
2. Test Report for Asphalt Cement:
    - a. Submit minimum 10 days prior to start of production.
    - b. Show appropriate test method(s) for each material and the test results.
  3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, for the following materials:
    - a. Aggregate: Gradation, source test results as defined in Section 410 of the Standard Specifications.
    - b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
    - c. Prime Coat: Type and grade of asphalt.
    - d. Tack Coat: Type and grade of asphalt.
    - e. Additives.
    - f. Mix: Conforms to job-mix formula.
  4. Statement of qualification for independent testing laboratory.
  5. Test Results:
    - a. Mix design.
    - b. Asphalt concrete core.
    - c. Gradation and asphalt content of uncompacted mix.
    - d. Field density.
    - e. Quality control.

## 1.05 QUALITY ASSURANCE

### A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

## 1.06 ENVIRONMENTAL REQUIREMENTS

- ### A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 10 degrees C (50 degrees F) or air temperature is lower than 4 degrees C (40 degrees F). Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.



- B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

## **PART 2 PRODUCTS**

### **2.01 MATERIALS**

- A. Tack Coat: Emulsified asphalt, conform to Section 405 of the Standard Specifications.
- B. Sand (Blotter Material): Clean, dry, with 100 percent passing 4.75-millimeter (No. 4) sieve, and a maximum of 10 percent passing 75 (m (No. 200) sieve.

### **2.02 ASPHALT CONCRETE MIX**

- A. General:
  - 1. Mix formula shall not be modified except with written approval of Engineer.
  - 2. Source Changes:
    - a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
    - b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Engineer to confirm that properties are in compliance with design criteria.
    - c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.
- B. Asphalt Concrete: As specified in Section 410 of the Standard Specifications.
- C. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.
- D. Aggregate: General: As specified in Section 410 of the Standard Specifications.
- E. Mineral Filler: In accordance with Section 410 of the Standard Specifications.
- F. Asphalt Cement: Paving Grade as specified in Section 410 of the Standard Specifications.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

#### **A. Traffic Control:**

1. In accordance with Section 01 50 00, Temporary Facilities and Controls.
2. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

#### **B. Driveways: Repave driveways from which pavement was removed. Leave driveways in as good or better condition than before start of construction.**

### **3.02 LINE AND GRADE**

#### **A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.**

#### **B. Shoulders: Construct to line, grade, and cross-section shown.**

### **3.03 APPLICATION EQUIPMENT**

#### **A. In accordance with Section 410 of the Standard Specifications.**

### **3.04 PREPARATION**

#### **A. Prepare subgrade as specified in Section 31 23 13, Subgrade Preparation.**

#### **B. Existing Roadway:**

1. Modify profile by grinding, milling, or overlay methods as approved, to provide meet lines and surfaces and to produce smooth riding connection to existing facility.
2. Remove existing material to a minimum depth of 1-inch.
3. Paint edges of meet line with tack coat prior to placing new pavement.

#### **C. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.**

### **3.05 PAVEMENT APPLICATION**

#### **A. General: Place asphalt concrete mixture on approved, prepared base in conformance with Section 410 of the Standard Specifications.**

B. Tack Coat:

1. Prepare material, as specified in Section 410 of the Standard Specifications, prior to application.
2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
3. Do not apply more tack coat than necessary for the day's paving operation.
4. Touch up missed or lightly coated surfaces and remove excess material.
5. Application Rate: Minimum 0.05 to 0.15 gallon per square yard of surface area.

C. Pavement Mix:

1. Prior to Paving:
  - a. Sweep primed surface free of dirt, dust, or other foreign matter.
  - b. Patch holes in primed surface with asphalt concrete pavement mix.
  - c. Blot excess prime material with sand.
2. Place asphalt concrete pavement mix in two equal lifts.
3. Compacted Lift Thickness:
  - a. Minimum: Twice maximum aggregate size, but in no case less than 1 inch.
  - b. Maximum: 4 inches.
4. Total Compacted Thickness: As shown.
5. Apply such that meet lines are straight and edges are vertical.
6. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
7. Joints:
  - a. Offset edge of each layer a minimum of 6 inches so joints are not directly over those in underlying layer.
  - b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
  - c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
8. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
9. After placement of pavement, seal meet line by painting a minimum of 6 inches on each side of joint with cut-back or emulsified asphalt. Cover immediately with sand.

D. Compaction: Roll until roller marks are eliminated and minimum percent compaction as stated in the Standard Specifications.

E. Tolerances:

1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
2. Completed Surface or Wearing Layer Smoothness:
  - a. Uniform texture, smooth, and uniform to crown and grade.
  - b. Maximum Deviation: 1/8 inch from lower edge of a 12-foot straightedge, measured continuously parallel and at right angle to centerline.
  - c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
3. Transverse Slope Maximum Deviation: 1/4-inch in 12 feet from rate of slope shown.
4. Finished Grade:
  - a. Perform field differential level survey on maximum 50-foot meter grid and along grade breaks.
  - b. Maximum Deviation: 0.02 foot from grade shown.

F. Seal Coat:

1. General: Apply seal coat of paving grade or emulsified asphalt to finished surface at longitudinal and transverse joints, joints at abutting pavements, areas where asphalt concrete was placed by hand, patched surfaces, and other areas as directed by Engineer.
2. Preparation:
  - a. Surfaces that are to be sealed shall be maintained free of holes, dry, and clean of dust and loose material.
  - b. Seal in dry weather and when temperature is above 2 degrees C (35 degrees F).
3. Application:
  - a. Fill cracks over 1/16-inch in width with asphalt-sand slurry or approved crack sealer prior to sealing.
  - b. When sealing patched surfaces and joints with existing pavements, extend minimum 6 inches beyond edges of patches.

### 3.06 PAVEMENT OVERLAY

A. Preparation:

1. Remove fatty asphalt, grease drippings, dust, and other deleterious matter.
2. Surface Depressions: Fill with asphalt concrete mix, and thoroughly compact.
3. Damaged Areas: Remove broken or deteriorated asphalt concrete and patch as specified in Article Patching.
4. Portland Cement Concrete Joints: Remove joint filler to minimum 1/2 inch below surface.

B. Application:

1. Tack Coat: As specified in this section.
2. Place and compact asphalt concrete as specified in Article Pavement Application.
3. Place first layer to include widening of pavement and leveling of irregularities in surface of existing pavement.
4. When leveling irregular surfaces and raising low areas, the actual compacted thickness of any one lift shall not exceed 2 inches.
5. Actual compacted thickness of intermittent areas of 120 square yards or less may exceed 2 inches, but not 4 inches.
6. Final wearing layer shall be of uniform thickness, and meet grade and cross-section as shown.

3.07 PATCHING

A. Preparation:

1. Remove damaged, broken, or unsound asphalt concrete adjacent to patches. Trim to straight lines exposing smooth, sound, vertical edges.
2. Prepare patch subgrade as specified in Section 410 of the Standard Specifications.

B. Application:

1. Patch Thickness: 3 inches or thickness of adjacent asphalt concrete, whichever is greater.
2. Place asphalt concrete mix across full width of patch in layers of equal thickness.
3. Spread and grade asphalt concrete with hand tools or mechanical spreader, depending on size of area to be patched.

C. Compaction:

1. Roll patches with power rollers capable of providing compression of 200 to 300 pounds per linear inch. Use hand tampers where rolling is impractical.
2. Begin rolling top course at edges of patches, lapping adjacent asphalt surface at least 1/2 the roller width. Progress toward center of patch overlapping each preceding track by at least 1/2 width of roller.
3. Make sufficient passes over entire area to remove roller marks and to produce desired finished surface.

D. Tolerances:

1. Finished surface shall be flush with and match grade, slope, and crown of adjacent surface.
2. Tolerance: Surface smoothness shall not deviate more than plus 1/4-inch or minus 0 millimeter when straightedge is laid across patched area between edges of new pavement and surface of old surfacing.

3.08 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests.

B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T230 and AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:

1. Quality Control Tests:
  - a. Asphalt Content, Aggregate Gradation: Once per every 500 tons of mix or once every 4 hours, whichever is greater.
  - b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 1,000 tons or once every 8 hours, whichever is greater.
2. Density Tests: Once every 500 tons of mix or once every 4 hours, whichever is greater.

**END OF SECTION**

**SECTION 32 31 13**  
**CHAIN LINK FENCES AND GATES**

**PART 1      GENERAL**

1.01      REFERENCES

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

1.      ASTM International (ASTM):
  - a.      A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
  - b.      A313/A313M, Standard Specification for Stainless Steel Spring Wire.
  - c.      A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
  - d.      A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
  - e.      A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
  - f.      A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
  - g.      A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
  - h.      A824, Standard Specification for Metallic-Coated Steel Marcellled Tension Wire for Use with Chain Link Fence.
  - i.      A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
  - j.      C94/C94M, Standard Specification for Ready-Mixed Concrete.
  - k.      C150, Standard Specification for Portland Cement.
  - l.      C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
  - m.      F552, Standard Terminology Relating to Chain Link Fencing.
  - n.      F567, Standard Practice for Installation of Chain-Link Fence.
  - o.      F626, Standard Specification for Fence Fittings.
  - p.      F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
  - q.      F900, Standard Specification for Industrial and Commercial Swing Gates.
  - r.      F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
  - s.      F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
  - t.      F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.

- u. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
  - v. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
  - w. F1379, Standard Terminology Relating to Barbed Tape.
  - x. F1911, Standard Practice for Installation of Barbed Tape.
  - y. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications.
2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: C2, National Electrical Safety Code.
  3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

## 1.02 DEFINITIONS

- A. Terms as defined in ASTM F552.

## 1.03 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

## 1.04 SCHEDULING AND SEQUENCING

- A. Complete necessary Site preparation and grading before installing chain link fence and gates.
- B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

## **PART 2 PRODUCTS**

### 2.01 GENERAL

- A. Match style, finish, and color of each fence component with that of other fence components.

### 2.02 CHAIN LINK FENCE FABRIC

- A. PVC-coated or Polymer-coated galvanized fabric conforming to ASTM F668, Class 1 or Class 2a over metallic-coated steel wire.
  1. Color: Black, complying with ASTM F934.
- B. Height: 84 inches, unless otherwise shown.



- C. Core Wire Gauge: No. 9.
- D. Pattern: 2-inch diamond-mesh.
- E. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.
- F. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.
- G. Wires of Twisted Selvages:
  - 1. Twisted in a closed helix three full turns.
  - 2. Cut at an angle to provide sharp barbs that extend minimum 1/4 inch beyond twist.

## 2.03 POSTS

- A. General:
  - 1. Strength and Stiffness Requirements: ASTM F1043, heavy industrial fence, except as modified in this section.
  - 2. Round Steel Pipe, Schedule 40: ASTM F1083.
  - 3. Roll-Formed Steel Shapes: Roll-formed from ASTM A1011/A1011M, Grade 45, High-Strength Low-Alloy steel.
  - 4. Lengths: Manufacturer's standard with allowance for minimum embedment below finished grade of 34 inches.
  - 5. Protective Coatings:
    - a. Zinc with Polymer Film Coating: ASTM F1043, Type B external and internal coating.
  - 6. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.
- B. Line Posts:
  - 1. Round Steel Pipe:
    - a. Outside Diameter: 2.375 inches.
    - b. Weight: 3.65 pounds per foot.
- C. End, Corner, Angle, and Pull Posts:
  - 1. Round Steel Pipe:
    - a. Outside Diameter: 2.875 inches.
    - b. Weight: 5.79 pounds per foot.
- D. Posts for Removable Fence Panels: As specified for end, corner, angle, and pull posts.

- E. Posts for Swing Gates 8 Feet High and Under:
  - 1. ASTM F900.
  - 2. Round Steel Pipe:
    - a. Outside Diameter: 4 inches.
    - b. Weight: 6.56 pounds per foot.
- F. Posts for Swing Gates Over 8 Feet High: As recommended by fence manufacturer.
- G. Posts for Horizontal Sliding Gates:
  - 1. ASTM F1184, Type II, Class 2.
  - 2. Round Steel Pipe:
    - a. Outside Diameter: 4 inches.
    - b. Weight: 6.56 pounds per foot.
  - 3. Guide posts for Class 1 horizontal-slide gates, equal gate post height, one size smaller, but weight is not less than 3.11 pounds per foot, installed adjacent to gate post to permit gate to slide in space between.

#### 2.04 TOP AND BRACE RAILS

- A. Galvanized Round Steel Pipe:
  - 1. ASTM F1083.
  - 2. Outside Diameter: 1.66 inches.
  - 3. Weight: 2.27 pounds per foot.
- B. Galvanized Roll-Formed Steel C Shapes:
  - 1. Roll formed from ASTM A1011/A1011M, Grade 45.
  - 2. Outside Dimensions: 1.625 inches by 1.25 inches.
  - 3. Weight: 1.40 pounds per foot.
- C. Protective Coatings: As specified for posts.
- D. Strength and Stiffness Requirements: ASTM F1043, top rail, heavy industrial fence.

#### 2.05 FENCE FITTINGS

- A. General: In conformance with ASTM F626, except as modified by this article.
- B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

- C. Tension and Brace Bands: No exceptions to ASTM F626.
- D. Tension Bars:
  - 1. One-piece vinyl-clad.
  - 2. Length not less than 2 inches shorter than full height of chain link fabric.
  - 3. Provide one bar for each gate and end post, and two for each corner and pull post.
- E. Truss Rod Assembly: 3/8-inch diameter, steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.
- F. Tie Wires, Clips, and Fasteners: According to ASTM F626.
- G. Barbed Wire Supporting Arms: Pressed steel or cast iron with clips, slots, or other means for attaching strands of barbed wire integral with post cap for each post, with single 45-degree arms for supporting three strands of barbed wire. Arms shall withstand 250 pounds of downward pull at outermost ends of the arms without failure.

#### 2.06 TENSION WIRE

- A. Zinc-coated steel marcelled tension wire conforming to ASTM A824, Type I.

#### 2.07 BARBED WIRE

- A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:
- B. Aluminum-Coated Steel Barbed Wire: ASTM A121, Type II.
  - 1. Line Wire: Two strands of No. 12-1/2 gauge.
  - 2. Barbs:
    - a. Number of Points: Four.
    - b. Length: 3/8 inch minimum.
    - c. Shape: Round.
    - d. Diameter: No. 14-gauge.
    - e. Spacing: 5 inches.

#### 2.08 BARBED TAPE

- A. Series 430 stainless steel hardened to Rockwell (30N) 35-40 minimum; 0.025-inch thick by 1-inch wide before fabrication, die stamped to produce clusters of four pointed needle-sharp barbs at 4 inches on center, minimum 1.2 inches long, offset in alternate directions 0.15 to 0.45 inch.
- B. Permanently cold clench stainless steel strip to minimum 230 degrees F around core wire.

- C. Core wire: 0.098-inch diameter, high-tensile-strength stainless steel complying with ASTM A313/A313M.
- D. Stainless steel strip between barb clusters shall be 1/4-inch wide minimum after cold clenching to create a flange extending out from the wire, tapering off adjacent to the barb cluster to allow maximum barb penetration.
- E. Fabrication: Continuous coils of barbed tape as defined in ASTM F1379 for the following characteristics:
  - 1. Configuration: Double coil.
  - 2. Style: Concertina pattern.
  - 3. Coil Diameters: 24-inch inner coil and 30-inch outer coil, plus or minus 2 inches, when coil compressed.
  - 4. Coil Loop Spacing: 12 inches.
- F. Clips: Stainless steel, 0.065-inch thick by 0.375-inch wide; capable of withstanding a minimum pull load of 200 pounds for a minimum of 30 seconds without separation, or other damage.
- G. Tie Wires: Stainless steel, 0.065-inch diameter.

## 2.09 GATES

- A. General:
  - 1. Gate Operation: Opened and closed easily by one person.
  - 2. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F1043 and ASTM F1083 for materials and protective coatings.
  - 3. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F900.
  - 4. Gate leaves more than 8-feet wide shall have intermediate tubular members and diagonal truss rods to provide rigid construction, free from sag or twist.
  - 5. Gate Fabric Height: Same as for adjacent fence height.
  - 6. Welded Steel Joints: Paint with zinc-based paint.
  - 7. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.
  - 8. Gate Posts and Frame Members: Extend gateposts and frame end members above top of chain-link fabric at both ends of gate frame to attach barbed wire assemblies.
  - 9. Latches: Arranged for padlocking so padlock will be accessible from both sides of gate.

- B. Swing Gates: Comply with ASTM F900 for single and or double swing gate types.
  - 1. Leaf Width: As shown.
  - 2. Hinges: Offset type, malleable iron.
    - a. Furnished with large bearing surfaces for clamping in position.
    - b. Designed to swing either 180 degrees outward, 180 degrees inward, or 90 degrees in or out, as shown, and not twist or turn under action of gate.
  - 3. Latches: Plunger bar arranged to engage stop, except single gates of openings less than 10 feet wide may each have forked latch.
  - 4. Gate Stops: Mushroom type or flush plate with anchors, suitable for setting in concrete.
  - 5. Locking Device and Padlock Eyes: Integral part of latch, requiring one padlock for locking both leaves of double gate.
  - 6. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.
  
- C. Cantilever and Overhead Horizontal Sliding Gates:
  - 1. Comply with ASTM F1184 for slide gate types I roller assemblies.
  - 2. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, designed to support size, weight, width, operation, and design of gate and roller assemblies.
  - 3. Roller Guards: As required per ASTM F1184 for Type II, Class 1 gate.
  - 4. Hangers, roller assemblies, and stops fabricated from galvanized malleable iron.

## 2.10 PRIVACY SLATS

- A. Material: Polyethylene tubular slats, not less than 0.023-inch thick, manufactured for chain link fences from virgin polyethylene containing UV inhibitor, sized to fit mesh specified for direction indicated, with vandal-resistant fasteners and lock strips.
  
- B. Color: Black unless otherwise directed by the ESD.
  
- C. Fabric Selvage: Knuckled.
  
- D. Hardware: Galvanized.

## 2.11 CONCRETE

- A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

## 2.12 FENCE GROUNDING

- A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
  - 1. Material above Finished Grade: Copper.
  - 2. Material on or below Finished Grade: Copper.
  - 3. Bonding Jumpers: Braided copper tape, 1-inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
- B. Connectors and Grounding Rods: Comply with UL 467.
  - 1. Connectors for Below-Grade Use: Exothermic welded type.
  - 2. Grounding Rods: Copper-clad steel.

## PART 3 EXECUTION

### 3.01 GENERAL

- A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.
- B. Provide necessary hardware for a complete fence and gate installation.
- C. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.
- D. Drainage Crossings: Where the chain-link fence must cross drainage ditches or swales, the main fence shall be carried across a ditch or swale with additional fence added below.
  - 1. Frames and Bracing: The fence added below shall be fabricated with galvanized round steel pipe conforming to the requirements for top and brace rails.
  - 2. The construction of the frame shall be welded or assembled with corner fittings. The frame shall be rigid and to the extent necessary to maintain a 2-inch clearance between bottom of the frame and finish grade. If necessary to maintain rigidity, attach to the frame a series of 3/8-inch diameter galvanized steel pipe stakes that are embedded a minimum of 2 feet to the sides and bottom of the ditch.
  - 3. Attach chain link fabric securely to frame at intervals not exceeding 12 inches.

### 3.02 PREPARATION

- A. Clear area on either side of fence to the extent as required. Eliminate ground surface irregularities along fence line to the extent necessary to maintain a 2-inch clearance between bottom of fabric and finish grade.
- B. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.
- C. Coat portion of galvanized or aluminum-coated steel posts that will be embedded in concrete with an approved system. Extend coating 1 inch above top of concrete.

### 3.03 POST SETTING

- A. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are not acceptable. Postholes shall be clear of loose materials. Waste materials from postholes shall be removed from Site or regraded into slopes on Site.
- B. Posthole Depth:
  - 1. Minimum 3 feet below finished grade.
  - 2. 2 inches deeper than post embedment depth below finish grade.
- C. Set posts with minimum embedment below finished grade of 34 inches and with top rail at proper height above finished grade. Verify posts are set plumb, aligned, and at correct height and spacing. Brace posts, as necessary, to maintain correct position and plumbness until concrete sets.
- D. Backfill postholes with concrete to 2 inches above finished grade. Vibrate or tamp concrete for consolidation. Protect above ground portion of posts from concrete splatter.
- E. Before concrete sets, crown and finish top of concrete to readily shed water.
- F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.
- G. Line Posts: Space line posts uniformly at 10 feet on centers between terminal end, corner, and gate posts.

### 3.04 POST BRACING

- A. Install according to ASTM F567, maintaining plumb position, and alignment of fencing. Install braces at gate, end, pull, and corner posts diagonally to adjacent line posts to ensure stability. Install braces on both sides of corner and pull posts.
  - 1. Locate horizontal braces at mid-height of fabric or higher, on fences with top rail, and 2/3-fabric height on fences without top rail. Install so posts are plumb when diagonal truss rod assembly is under proper tension.

### 3.05 TOP RAILS

- A. Install according to ASTM F567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

### 3.06 BARBED WIRE SUPPORTING ARMS

- A. Barbed wire supporting arms shall be installed as indicated and as recommended by manufacturer. Bolt or rivet supporting arm to top of post in a manner to prevent easy removal with hand tools. Angle single arms to outside of fence.

### 3.07 TENSION WIRE

- A. Install according to ASTM F567 and ASTM F1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with tie wires at a maximum spacing of 24 inches on center.
- B. Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

### 3.08 CHAIN LINK FABRIC

- A. Do not install fabric until concrete has cured minimum 7 days.
- B. Install fabric with twisted and barbed selvage at top.
- C. Apply fabric to outside of enclosing framework. Pull fabric taut to provide a smooth and uniform appearance free from sag, without permanently distorting fabric diamond or reducing fabric height. Tie fabric to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.



- D. Splicing shall be accomplished according to ASTM F1916 by weaving a single picket into the ends of the rolls to be joined.
- E. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.
- F. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches on center.
- G. Tie Wires: Fasten ties to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends of tie wire three full twists, and cut off protruding ends to preclude untwisting by hand.
  - 1. Maximum Spacing: Tie fabric to line posts at 12 inches on center and to brace and top rails at 24 inches on center.

### 3.09 BARBED WIRE

- A. Install barbed wire uniformly in configurations of three strands of barbed wire on supporting arms. Pull wire taut and install securely to supporting arms and secure to end terminal post or terminal arms.

### 3.10 GATES

- A. Install gates according to manufacturer's written instructions, level, plumb and secure for full opening without interference. Attach fabric and hardware to gate using tamper-resistant or concealed means. Adjust hardware for smooth operation and lubricate where necessary so gates operate satisfactorily from open or closed position.
- B. Set gate stops in concrete to engage center drop rod or plunger bar.

### 3.11 ELECTRICAL GROUNDING

- A. Ground fences at a maximum interval of 1,000 feet in accordance with applicable requirements of IEEE C2, National Electrical Safety Code.
- B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.
- C. Grounding Method: At each grounding location, drive a grounding rod vertically until top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

### 3.12 FIELD QUALITY CONTROL

- A. Post and Fabric Testing: Test fabric tension and line post rigidity according to ASTM F1916.
- B. Gate Tests:
  - 1. Prior to acceptance of installed gates, demonstrate proper operation of gates under each possible open and close condition specified.
  - 2. Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range.
  - 3. Confirm that latches and locks engage accurately and securely without forcing and binding.

### 3.13 CLEANUP

- A. Remove excess fencing materials and other debris from Site.

**END OF SECTION**

**SECTION 33 05 13**  
**MANHOLES**

**PART 1      GENERAL**

1.01      SECTION INCLUDES

- A.      Gravity sanitary sewer manholes and structures for housing valves.

1.02      REFERENCES

- A.      The following is a list of standards that may be referenced in this section:
  - 1.      American Association of State Highway and Transportation Officials (AASHTO): M198, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
  - 2.      ASTM International (ASTM):
    - a.      A36/A36M, Standard Specification for Carbon Structural Steel.
    - b.      A48/A48M, Standard Specification for Gray Iron Castings.
    - c.      A536, Standard Specification for Ductile Iron Castings.
    - d.      A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
    - e.      C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
    - f.      C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
    - g.      C150/C150M, Standard Specification for Portland Cement.
    - h.      C443, Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
    - i.      C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
    - j.      C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
    - k.      C990, Standard Specification for Joints in Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants.
    - l.      C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.

## **PART 2     PRODUCTS**

### **2.01     GENERAL**

- A. Unless otherwise specifically approved by the Owner/Owner's Representative, all manholes will be precast concrete manholes as specified herein.
- B. All manholes shall have precast openings in the manhole walls with integrated seal for incoming or outgoing sewers at the elevations and locations indicated on the Drawings.
- C. All components of a manhole for a particular location shall be clearly marked in order that the manhole may be correctly assembled to suit construction conditions existing at that particular location.
- D. Materials of Construction and Service Conditions:
  - 1. Screws, Bolts, or Nuts: Type 304 stainless steel conforming to ASTM F593 and ASTM F594.
  - 2. Gaskets: Internal and external seals shall be made of materials that have been proven to be resistant to the following exposures and conditions:
    - a. Sanitary sewage.
    - b. Corrosion or rotting under wet or dry conditions.
    - c. Gaseous environment in sanitary sewers and at road surfaces including common levels of ozone, carbon monoxide, and other trace gases at installation site.
    - d. Biological environment in soils and sanitary sewers.
    - e. Chemical attack by road salts, road oil, and common street spillages or solvents used in street construction or maintenance.
    - f. Temperature ranges, variations, and gradients in construction area.
    - g. Variations in moisture conditions and humidity.
    - h. Fatigue failure caused by a minimum of 30 freeze-thaw cycles per year.
    - i. Vibrations because of traffic loading.
    - j. Fatigue failure because of repeated variations of tensile, compressive and shear stresses, and repeated elongation and compression. Material shall remain flexible allowing repeated movement.
  - 3. Materials shall be compatible with each other and manhole materials.
  - 4. Designed to provide a 50-year service life.
- E. Structures shall meet requirements of ASTM C478, this Specification and the following:
  - 1. Concrete:
    - a. Cement: Meet requirements of ASTM C150/C150M.

- b. Compressive Strength:
  - 1) Minimum 4,000 psi.
  - 2) Minimum strength shall be confirmed at 7 days by making two standard cylinders per manhole for testing.
- c. Shall contain type II Portland with a C3A content of 5.5 percent or less.
- d. Concrete mix design shall include:
  - 1) Xypex C-500 or C-1000 at a dosage of 2 to 3 percent or based upon mix design at dosage recommended by manufacturer.
  - 2) Pink dye to indicate that the concrete mix / manhole contains the Xypex admixture
- 2. Reinforcement: Grade 60, unless otherwise specified.
- 3. Ring: Custom made with openings to meet indicated pipe alignment conditions and invert elevations.
- 4. Floor: Minimum 4 inches below pipe to provide clearance for grouting channels.
- 5. Joint:
  - a. Form joint contact services with machined castings.
  - b. Surfaces shall be parallel with nominal 1/16-inch clearing and tongue equipped with recess for installation of O-ring rubber gasket.
- 6. Gasket: Meet requirements of ASTM C443.
- 7. Surfaces: Interior and exterior surfaces shall have smooth hard finish and shall be free from cracks, chips and spalls.

## 2.02 PRECAST MANHOLES

### A. Riser Sections:

- 1. Fabricate in accordance with ASTM C478.
- 2. All riser sections shall be supplied with manhole Lift System inserts as manufacturer by Press-Seal Gasket Corporation. Lifting eyebolts, also manufactured by Press-Seal Gasket Corporation, shall be supplied to the Contractor upon request.
- 3. Diameter: Minimum 48 inches. Other acceptable diameters include 60-, 72-, 84- or 96-inch, depending on design requirements.
- 4. Heights: Range from 16- to 48-, in 16-inch multiples. The use of 16-inch risers shall be minimized and shall only be used to adjust to final grade.
- 5. Wall Thickness: Minimum 4 inches or 1/12 times inside diameter, whichever is greater.
- 6. Top and bottom surfaces shall be parallel.
- 7. Joints: Tongue-and-groove and confined O-ring with rubber gaskets meeting ASTM C443.

B. Cone Sections:

1. Shall be concentric. Eccentric and flat top slab sections will be allowed only with the approval of the Owner/Owner's Representative.
2. Same wall thickness and reinforcement as riser section.
3. Top and bottom surfaces shall be parallel.
4. Conical sections shall transition to a clear access opening for support of the manhole frame and be either 24, 36 or 46 inches high.
5. Section shall be supplied with manhole Lift System inserts as manufacturer by Press-Seal Gasket Corporation.
6. Where bolt-down manhole frame and covers are indicated on the Drawings, conical sections shall be supplied with four (4) stainless steel anchor bolts.

C. Base Sections and Base Slab:

1. Base slab integral with sidewalls.
2. Fabricate in accordance with ASTM C478.
3. May be supplied in 48-, 60-, 72-, 84- or 96-inch diameters.
4. Heights shall range from 24 inches to 94 inches depending on availability with diameter and as specified or approved by the Design Engineer.
5. All base sections shall be supplied with manhole Lift System inserts as manufacturer by Press-Seal Gasket Corporation. Lifting eyebolts, also manufactured by Press-Seal Gasket Corporation, shall be supplied to the Contractor upon request.
6. Pipes shall be sealed in base using flexible connection.
7. In areas with a high groundwater table an extended shall be used. Designer shall confirm that uplift will not be an issue.

D. Transition Sections:

1. Conical transition sections shall be supplied for 60 inch to 48 inch diameter transitions. Conical transitions shall be 32 inches high. Shorter conical transitions may only be used when specifically approved by the Owner/Owner's Representative. All conical transition sections shall be supplied with manhole Lift System inserts as manufacturer by Press-Seal Gasket Corporation.
2. Flat slab transitions shall be supplied for base sections 72 inches to 96 inches in diameter. Flat slab transitions shall be manufactured structurally to meet individual project requirements. Clear access openings shall be provided to accommodate riser sections as specified in individual Project Drawings and Specifications.

E. Joint Straps: The Contractor shall install manhole joint straps. Bolted together manhole joints shall be permanently strapped utilizing three (3) bitumastic coated steel strap anchors located 120 degrees circumferentially.

F. Joint Seal Manufacturers and Products:

1. Waterstop Sealant: Conseal CS-231 waterstop sealant as manufactured by Concrete Sealants.
2. Confined Plastic or Rubber O-Ring:
  - a. Meet requirements of ASTM C443.
  - b. Hamilton Kent, Sparks, NV; Tylox Super Seal pre-lubricated gasket.
3. External Wrap:
  - a. Sealing Systems, Inc., Loretto, MN; Gator Wrap.
  - b. Henry Company, Houston, TX; RU116 Rubr-Nek External Joint Wrap.
  - c. Trelleborg Engineered Solutions, Park Hills, MO; NPC External Joint Wrap.
  - d. Cretex Specialty.
4. Precast concrete manhole manufacturers: A list of approved manufacturers may be obtained from the Owner/Owner's Representative.

G. Polypropylene Steps:

1. Fabricate from minimum 1/2 inch, Grade 60, steel bar meeting ASTM A615/A615M.
2. Polypropylene encasement shall conform to ASTM D4101.
3. Minimum Width: 13 inches, center-to-center of legs.
4. Embedment: 3-1/2-inch minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.
5. Cast in manhole sections by manufacturer. Installed at maximum 16-inch intervals.
6. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.
7. Model PS1 PF, as manufactured by M.A. Industries, Inc.

## 2.03 PIPE CONNECTIONS AT MANHOLES

A. Openings in new manhole walls for incoming and outgoing sewers shall be precast. Coring is allowed only for connection to an existing manhole.

B. New Manholes:

1. Manufacturer/Products:
  - a. Z-Lok, A-Lok Products, Tullytown, PA.
  - b. A-Lok Premium, A-Lok Products, Tullytown, PA
  - c. Approved equal.

- C. Existing Manhole:
1. Openings into existing manholes for incoming and outgoing sewers shall be cored.
  2. Manufacturers/Products:
    - a. Inserta –Lok, A-Lok Products, Tullytown, PA.
    - b. G3, A-Lok Products, Tullytown, PA.
    - c. NPC, Kor-N-Seal, Series 106/406, Milford, NH
    - d. Approved equal
- D. Alternates may be approved by the Owner/Owner's Representative on a case by case basis.

## 2.04 MANHOLE FRAMES AND COVER

- A. General:
1. Made in the United States.
  2. Made of materials from the United States.
  3. Shall be "Heavy Duty" type, rated for a minimum of H-20 loading.
  4. Seating surfaces shall be machined flat to ensure contact between cover and frame along the full perimeter, in accordance with Federal Specification RR-F-621.
- B. Castings:
1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
  2. Cast Iron: ASTM A48/A48M Class 30B.
  3. Plane or grind bearing surfaces to ensure flat, true surfaces.
  4. Tolerances shall be plus or minus 1/16 inch, with an additional 1/16-inch per foot of dimension.
  5. Castings determined to be defective by the ESD shall be replaced prior to acceptance.
- C. Cover:
1. Owner's Standard.
  2. True and seat within ring at all points.
  3. With the most recent version of the emblem of Jefferson County. No substitute cover designs will be accepted.
  4. Cast with two (2) non-penetrating pick-holes of the Owner's standard dimensions.
  5. Shall not have vent holes.
  6. Cast with four (4) stacking lugs, each with 5/8-inch wide by 2 inches long, on the bottom of the lid.



D. Frames:

1. Shall have integrally cast, full perimeter mud rings.
2. Cast with four (4) 1-inch diameter holes in the flange for anchor bolts, located according to County standards.
3. For bolt-down type covers, frames shall be cast and machined to accept four (4) holes, 3/4-inch diameter, to accommodate the Owner's standard for anchor bolts.
  - a. Bolts shall be stainless steel, 5/8-inch – 11 by 2-inch hex-head cap screws, and shall be provided with all bolt-down covers.
  - b. Bolts shall include stainless steel washers and rubber sealing gaskets.
4. Gasket: Flat, 1/8-inch thick, black neoprene with a minimum tensile strength of 2,000 psi.
5. Secured to the seating surface of the frame with a non-degrading glue by the manufacturer.

E. Frame and cover manufacturers:

1. Approved models include:
  - a. East Jordan Ironworks/Vulcan Foundry #V-2480 (bolt-down cover).
  - b. East Jordan Ironworks/Vulcan Foundry #V-1480 (standard cover).

2.05 MANHOLE FRAME CONNECTION AND SEAL TO STRUCTURE

A. Butyl Sealant:

1. Conform to ASTM C1311, or AASHTO M198 and ASTM C990.
2. Trowelable or cartridge applied.
3. Manufacturers and Products:
  - a. Tremco Commercial Sealants and Waterproofing, Beachwood, OH; Tremco Butyl Sealant.
  - b. Bostik, Middleton, MA; Chem-Calk 300.
  - c. Press-Seal Gasket Company, Fort Wayne, IN; EZ-Stik #3.

B. External Wrap:

1. Meet requirements of ASTM C923.
2. Construct of high quality rubber that will provide flexible watertight seal around joint.
3. Thickness: Minimum 60 mils.
4. Consist of a top and bottom section and be sealed to structure, frame top, and bottom with mastic as applicable.
5. Length: Extend from manhole frame and extension ring to cone section.
6. Bands: If required, constructed of minimum 16-gauge sheet if channeled, or 5/16-inch diameter if round.

7. Manufacturers and Products:
  - a. Sealing Systems, Inc., Loretto, MN; Infi-Shield.
  - b. Trelleborg Engineered Systems, Milford, NH; NPC Flexrib Frame-Chimney Seals.
  - c. Cretex Specialty Products, Waukesha, WI; X-85 Seal.

C. Internal Wrap or Sealing Membrane:

1. Meet requirements of ASTM C923.
2. Minimum internal thickness of 3/16 inch or as recommended by manufacturer for installation climate.
3. Designed for application and have a demonstrated history of accommodating differential expansion between frame and concrete.
4. Width: Minimum 8 inches.
5. Expansive type wraps shall be fabricated of high quality rubber or urethane.
6. Bands: If required, constructed of minimum 16-gauge sheet if channeled, or 5/16-inch diameter if round.
7. Wrap shall not restrict access to manhole.
8. Manufacturers and Products:
  - a. Sealing Systems, Inc., Loretto, MN; Flex-Seal Utility Sealant.
  - b. Trelleborg Engineered Systems, Milford, NH; NPC Flexrib Frame-Chimney Seals.
  - c. Cretex Specialty Products, Waukesha, WI; Internal Manhole Chimney Seal.

2.06 BRICK

1. Bricks with holes through them will not be allowed.
2. Used to adjust manhole frame to grade.
3. Shall conform to ASTM C32 for grade SM.
4. Conform to the following, unless otherwise approved by Owner/Owner's Representative:
  - a. Shall be new and whole, of uniform standard size and with straight and parallel edges and square corners. Bricks shall be of compact textures, burned hard entirely through, tough and strong, free from injurious cracks and flaws and shall have a clear ring when struck together.
  - b. No soft or salmon brick shall be used.

2.07 MASONRY

- A. Conform to ASTM C90, Grade N, Type I or II, for hollow load bearing blocks.

## 2.08 MORTAR

- A. Prepared only in the quantities needed for immediate use.
- B. Any mortar mixed for more than 30 minutes or which has set or has been retempered shall not be used.
- C. Standard premixed in accordance with ASTM C387/C387M, or proportion one part Portland cement to two parts clean, well-graded sand that will pass a 1/8-inch screen.

## 2.09 PRECAST CONCRETE GRADE RING

- A. Minimum wall thickness of 1/12 of the internal diameter of the grade ring or 4-inches, whichever is greater.
- B. Minimum reinforcing steel area of 0.07 square inches per vertical foot but not less than 0.024 square inches in any ring.
- C. Minimum concrete cover of 1 inch over all steel.
- D. Keyed to help lock ring in place and seal ring.
- E. Minimum height shall be 4 inches.

## 2.10 MONOLITHIC LINING

- A. In accordance with Section 09 66 01, Monolithic Lining of Manholes and Pump Station Wet Wells.

# **PART 3 EXECUTION**

## 3.01 GENERAL

- A. Prior to installation inspect materials:
  - 1. Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
  - 2. Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
  - 3. Remove and replace structure that cannot be repaired.
- B. If needed, dewater excavation during construction and testing operations.

### 3.02 BEDDING AND BACKFILL

#### A. Bedding:

1. All precast concrete manhole base sections and drop manhole bases shall be set on a foundation of No. 57 compacted stone aggregate, 12 inch minimum thickness and covering the entire bottom of the excavation for the manhole. Aggregate size may be adjusted by the Owner/Owner's Representative based on field conditions.
2. Where soft soil is encountered or the structure is being placed in the field the services of a geotechnical engineer shall be used to confirm that the soil is compacted to 95 percent in accordance with ASTM D698. Geotechnical engineer shall specify modifications/improvements as required to prevent settlement.

#### B. Backfill:

1. Outside of Pavement: Backfill around structure with earth fill to lines and grades shown; allow for topsoil thickness where shown. Place in 8-inch thick maximum lifts. Compact each lift to 92 percent relative compaction as determined in accordance with ASTM D698.
2. Within Pavement: Backfill around structure with No. 57 stone aggregate. Place in 12-inch lifts and compact.

### 3.03 INSTALLATION OF PRECAST MANHOLES

#### A. Concrete Base:

1. Precast:
  - a. Place on compacted structural fill.
  - b. Properly locate, ensure firm bearing throughout, and plumb first section.

#### B. Sections:

1. Inspect precast manhole sections to be joined.
2. Clean ends of sections to be joined.
3. Do not use sections with chips or cracks in tongue.
4. Locate precast steps in line with each other to provide continuous vertical ladder.

#### C. Preformed Plastic Gaskets or Rubber O-Ring:

1. Use only pipe primer furnished by gasket manufacturer.
2. Install gasket material in accordance with manufacturer's instructions.
3. Completed Manhole: Rigid and watertight.

D. Mortar Joints:

1. Thoroughly wet joint with water prior to placing mortar.
2. Place mortar on groove of lower section prior to section installation.
3. Fill joint completely with mortar of proper consistency.
4. Trowel interior and exterior surfaces smooth on standard tongue-and-groove joint.
5. Prevent mortar from drying out and cure by applying approved curing compound or comparable approved method.
6. Do not use mortar mixed for longer than 30 minutes.
7. Chip out and replace cracked or defective mortar.
8. Completed Manhole: Rigid and watertight.

E. External Joint Wraps:

1. Required in all locations where manholes are installed within the 100 year flood plain.
2. Required where manholes / manhole joints will be submerged due to the groundwater elevation.
3. Install in accordance with manufacturer's instructions.

F. Extensions:

1. Grade Rings: Provide on manholes in streets or other locations to match final specified grade.
2. Frame: Set frames in three equally spaced beads of butyl sealant that run full circumference of frame.
3. Wrap: Install exterior manhole frame to structure seals in accordance with manufacturer's instructions. Seal shall cover grade rings.
4. Cover: Install in accordance with manufacturer's recommendations.
5. Concrete grade rings damaged during installation shall be replaced.

3.04 MANHOLE INVERT

- A. Construct with smooth transitions to ensure unobstructed flow through manhole. Remove sharp edges or rough sections that tend to obstruct flow.
- B. Where full section of pipe is laid through manhole, break out top section and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.

### 3.05 MANHOLE FRAMES AND COVERS

#### A. Grade Adjustment:

1. Install to height not exceeding 6 inches on new manholes.
2. Where adjustment to existing manhole is required height shall not exceed 15-inches. Where exceeds 15-inch riser section shall be installed or require manhole replacement when the existing material is brick.
3. Place brick using mortar a minimum of 2 wide to provide full support for manhole frame.

#### B. Set frames in three equally spaced beads of butyl sealant that run full circumference of frame.

#### C. Anchor frame to manhole with specified bolts.

#### D. Install interior or exterior manhole frame to structure seals as directed by the Engineer in accordance with manufacturer's instructions. Seal shall cover grade rings.

### 3.06 MANHOLE PIPING

#### A. Drop Assembly: See Drawings for detail of installation requirements.

#### B. Flexible Joints:

1. Provide in pipe not more than 1-1/2 feet from manhole walls.
2. Where last joint of pipe is between 1-1/2 feet and 6 feet from manhole wall, provide flexible joint in manhole wall.

#### C. Stubouts for Future Connections:

1. Provide same type and class of pipe as specified for use in service connection, lateral, main, or trunk sewer construction. Where there are two different classes of pipe at manhole use higher strength pipe.
2. Grout pipe in precast walls or manhole base to provide watertight seal or use flexible joints as specified herein.
3. Maximum Length: 5 feet outside manhole wall.
4. Test Plugs:
  - a. Install rubber-gasketed plugs in end of stubouts with gasket joints similar to sewer pipe being used.
  - b. Plugs shall withstand internal or external pressures without leakage.
  - c. Adequately brace plugs against hydrostatic or air test pressures.

- D. Permanent Plugs: Clean interior contact surfaces of pipes to be cut off or abandoned as shown, and construct plug as follows:
  - 1. Pipe 18 Inches or Less in Diameter: Concrete plug in end, minimum 2 feet long.
  - 2. Pipe 20 Inches and Larger: Concrete plug in end, minimum 4 feet long.
  - 3. Plugs shall be watertight and capable of withstanding internal and external pressures without leakage.

### 3.07 MANHOLES OVER EXISTING PIPING

- A. Maintain flow through existing pipelines at all times.
- B. Concrete Pipe: Apply bonding agent on surfaces in contact with concrete.
- C. Construct base under existing piping.
- D. Construct manhole as detailed in Drawings.
- E. Apply minimum of two complete wraps of hydrophilic waterstop centered on pipe in wall.
- F. Place a minimum of 24 inches of concrete around each pipe penetration outside manhole against undisturbed soil or compacted aggregate unless otherwise detailed.
- G. Grout channel through manhole.
- H. Saw cut out or demolish existing pipe within new manhole using method approved by Owner/Owner's Representative.
- I. Protect new concrete or grout for 7 days after placing concrete.

### 3.08 CONNECTIONS TO EXISTING MANHOLES

- A. Condition Assessment:
  - 1. To allow connection to an existing manhole it must be in good condition. Condition shall be confirmed with the Owner/Owner's Representative.
  - 2. Where determined that manhole is poor condition it shall be replaced. Coring and connection to a manhole in poor condition is not allowed.
- B. Replacement Manhole:
  - 1. Replacement manhole shall meet the requirements of this specification.
  - 2. Replacement of up to 10 feet of existing inflow and outflow pipe(s) shall be considered part of the manhole replacement.

C. Existing Manhole:

1. Core manhole bases and grouting as necessary.
2. Seal pipe in manhole using flexible connector.
3. Regrout to provide smooth flow into and through manholes.
4. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.09 MONOLITHIC LINING

- A. Install lining in accordance with Section 09 66 01, Monolithic Lining of Manholes and Pump Station Wet Wells. This shall be installed after completion of manhole testing to confirm the integrity of the structure.

3.10 TESTING AND INSPECTION

- A. All new manholes shall be tested and inspected. The following provides a summary of construction and inspection sequencing and requirements:
1. Prior to Inspection and Testing of manholes all utilities (gas, power, cable, fiber, telephone, etc.) that will cross the main sewer and/or be located within 8 feet of manholes shall be complete. Timely acceptance of the main sewer by the Owner/Owner's Representative in some situations due to scheduling/delays associated with other utilities, may require installation of casings where other utilities will be required to cross the main sewer or be located in close proximity to manholes. This will allow early, conditional acceptance of the sewer, upon completion of required CCTV Inspection and Leak Testing. Where utilities are installed that cross the main sewer or in close proximity to manholes by open cut or trenchless methods, after its inspection and testing, the contractor shall be required to repeat the Testing to confirm that the manhole was not damaged by the work. The specific testing methods shall be determined by the County on a case by case basis.
  2. Manhole Location:
    - a. Outside of Road or Area to Receive Asphalt or Concrete Pavement: Upon completion of installation of main sewer and manhole and backfilling to grade Contractor shall Manhole Test.
    - b. Within Road or Area to Receive Asphalt or Concrete Pavement:
      - 1) Upon completion of installation of main sewer and manhole and backfilling to grade Contractor shall perform Manhole Inspection.
      - 2) Upon completion of final paving repeat Manhole Test.
- B. Owner/Owner's Representative Inspections: Notify the Owner/Owner's Representative a minimum of 48-hours in advance of required inspection, CCTV and Leak Testing.



C. Manhole Testing:

1. Conduct negative air pressure (vacuum) test on all manholes in accordance with ASTM C1244, following the manufacturer's recommendations for proper and safe procedures. Conduct tests in presence of the Owner/Owner's Representative Inspector.
2. All pipe openings shall be sealed by installing suitable plugs that completely isolate the manhole structure. Any other openings such as lifting holes shall be permanently sealed.
3. Procedure:
  - a. A suitable vacuum pump shall be connected at the top access point of the manhole.
  - b. A vacuum of 10 inches of mercury (Hg) (5.0 psi) shall be drawn on the manhole.
  - c. The time shall be measured for the vacuum to drop to 9 inches of mercury (Hg) (4.5 psi).
  - d. Manholes will be considered to have failed if the time to drop 1 inch of mercury is less than what is shown in the following table:

<b>Vacuum Test Timetable</b>				
<b>Depth (ft)</b>	<b>Manhole Diameter</b>			
	<b>48-inch</b>	<b>60-inch</b>	<b>72-inch</b>	<b>96-inch</b>
4	10 sec	13 sec	16 sec	19 sec
8	20 sec	26 sec	32 sec	38 sec
12	30 sec	39 sec	48 sec	57 sec
16	40 sec	52 sec	64 sec	76 sec
20	50 sec	65 sec	80 sec	95 sec
+ Each 2'	+5.0 sec	+6.5 sec	+8.0 sec	+9.5 sec

- e. Manhole depths shall be rounded to the nearest foot.
  - f. Intermediate values shall be interpolated.
  - g. For depths above 20 feet, add appropriate values from table for each additional 2 feet of depth.
4. All manholes that fail the test or that have visible leakage in the manhole, even if passing the test, shall be repaired or replaced until the manhole passes the test, to the complete satisfaction of the Owner/Owner's Representative. Manholes with visible leaks will not be accepted under any circumstances.

**END OF SECTION**



**SECTION 40 05 15**  
**PIPING SUPPORT SYSTEMS**

**PART 1 GENERAL**

1.01 REFERENCES

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

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
3. ASTM International (ASTM):
  - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
  - c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. International Code Council (ICC):
  - a. International Building Code (IBC).
  - b. International Mechanical Code (IMC).
5. Manufacturers' Standardization Society (MSS):
  - a. SP 58, Pipe Hangers and Supports - Materials, Design and Manufacture.
  - b. SP 69, Pipe Hangers and Supports - Selection and Application.
  - c. SP 89, Pipe Hangers and Supports - Fabrication and Installation Practices.
  - d. SP 127, Bracing for piping Systems, Seismic-Wind-Dynamic Design, Selection and Application.

1.02 SUBMITTALS

A. Action Submittals:

1. Catalog information, design calculations, and Drawings of piping support system, locating each support, and anchor. Identify support, and anchor type by catalog number and Shop Drawing detail number.
2. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
3. Maintenance information on piping support system.

## 1.03 DESIGN REQUIREMENTS

### A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Supports are shown only where specific types and locations are required; additional pipe supports may be required. Designer may propose an alternate support to that shown for approval.
3. Meet requirements of MSS SP 58, MSS SP 69, MSS SP 89, and ASME B31.1 or as modified by this section.

B. Pipe Support Systems: Pipe support systems shall be designed for gravity and thrust loads imposed by weight of pipes or internal pressures, thermal expansion and wind loads including weight of fluid in pipes and insulation.

C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Special support and hanger details may be required for cases where standard catalog supports are inapplicable.

C. Materials: Supports shall be of all Type 304 stainless steel construction.

### D. Saddle Supports:

1. Pedestal Type: Schedule 40 pipe stanchion, saddle, and anchoring flange.
  - a. Nonadjustable Saddle: MSS SP 58 and MSS SP 69, Type 37 with U-bolt.
    - 1) Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 62C base.
    - 2) B-Line; Figure B3090, sizes 3/4 inches through 36 inches with B3088 base.
    - 3) Approved equal.
2. Elbow and Flange Supports:
  - a. Elbow with Nonadjustable Stanchion:
    - 1) Sizes 2-1/2 inches through 42 inches.
      - a) Anvil; Figure 63C base.
      - b) Approved equal.

- b. Flange Support with Adjustable Base:
  - 1) Sizes 2 inches through 24 inches.
    - a) B-Line; B3094, with Figure B3088T base.
    - b) Standon; Model S89.
    - c) Approved equal.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

#### **A. General:**

1. Install support systems in accordance as detailed by the manufacturer.
2. Support piping connections to equipment by pipe support and not by equipment.
3. Support all valves, fittings, and appurtenances independently of connected piping.
4. Support no pipe from pipe above it.
5. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
6. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
7. Repair mounting surfaces to original condition after attachments are made.

**END OF SECTION**



**SECTION 40 05 33**  
**PIPE HEAT TRACING**

**PART 1 GENERAL**

1.01 REFERENCES

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

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. Underwriters Laboratories, Inc. (UL).

**PART 2 PRODUCTS**

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

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

2.02 ELECTRICAL HEATING TAPE

- A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, stainless steel, and ductile iron pipe applications.
- B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.
- C. Maximum Maintenance Temperature: 70 degrees F.
- D. Maximum Intermittent Temperature: 70 degrees F.
- E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.

F. Manufacturers and Products:

1. Raychem; BTV-CR.
2. Thermon; BSX.
3. Nelson; CL1-J1 or L1-J1.

2.03 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.

C. Manufacturers and Products:

1. Power Connection Kit:
  - a. Raychem; JBS-100.
  - b. Thermon; PCA-1-SR or DP-L.
  - c. Nelson; PLT-BC.
2. Splice Kit:
  - a. Raychem; S-150.
  - b. Thermon; PCS-1-SR.
  - c. Nelson; PLT-BS.
3. Tee Kit:
  - a. Raychem; T-100.
  - b. Thermon; DS-S.
  - c. Nelson; PLT-BY.
4. End Seal Kit:
  - a. Raychem; E-150.
  - b. Thermon; DE-S.
  - c. Nelson; LT-ME.
5. Lighted End Seal Kit:
  - a. Raychem; E-100-L.
  - b. Thermon; DLS.
  - c. Nelson; LT-L.

2.04 SECURING TAPE

A. Plastic Piping Systems:

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



B. Metallic Piping Systems:

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

2.05 PIPE MOUNTED THERMOSTAT

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

2.06 AMBIENT THERMOSTAT

- A. Type: Adjustable setting (15 to 140 degrees F).
- B. Sensor: Fluid-filled probe.
- C. Enclosure: Epoxy-coated NEMA 250, Type 4X aluminum enclosure with exposed hardware of stainless steel.
- D. Switch: SP-DT, UL or FM listed, rated 22 amps, 125 to 250V ac.
- E. Manufacturers and Products:
  1. Raychem; DigiTrace Model AMC-1A.
  2. Thermon; B4X-15140.
  3. Raychem; DigiTrace Model AMC-1H for hazardous areas.
  4. Thermon; B7-15140 for hazardous areas.

## PART 3 EXECUTION

### 3.01 INSTALLATION

#### A. General:

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

#### B. Electrical Heating Tape:

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

<b>Service</b>	<b>Piping Material</b>	<b>Placement</b>	<b>Location</b>
FC	CPVC	Exposed	Ferric Chloride Feed System

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

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

- #### C. Heat Tracing Circuits:
- Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 50 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.

D. Thermostats:

1. Install in accordance with manufacturer's instructions and as approved by Engineer.
2. For each group of heat traced circuit, install one ambient thermostat.

3.02 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

**END OF SECTION**



**SECTION 40 27 00**  
**FORCE MAIN PIPING—GENERAL**

**PART 1 GENERAL**

1.01 DESIGN REQUIREMENTS

- A. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.

1.02 DELIVERY, STORAGE, AND HANDLING

- A. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
- B. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
- C. Linings and Coatings: Prevent excessive drying.
- D. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
- E. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

**PART 2 PRODUCTS**

2.01 PIPING

- A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.
- B. Installation Location Requirements:
  - 1. All suction piping and discharge piping within wet well (where applicable based upon the pump type, through valve vault, self-regulating automatic valve(s) vault and to the pump station property line unless otherwise approved by the ESD shall be Ductile Iron.
  - 2. Force main from the pump station to the discharge site shall be ductile iron or high-density polyethylene pipe (HDPE).
- C. Diameters Shown:
  - 1. Standardized Products: Nominal size.

## 2.02 DUCTILE IRON JOINTS

### A. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.

### B. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with break-off tightening bolts.
2. Thrust rated to 250 psi minimum.
3. Rated operating deflection not less than:
  - a. 3 degrees for sizes through 12 inches.
  - b. 2 degrees for sizes 14 inches through 16 inches.
  - c. 1.5 degrees for sizes 18 inches through 24 inches.
4. Manufacturer: Ebaa.

### C. Buried Service:

1. Restrained: Manufacturer's proprietary system. Locking gaskets shall for ductile iron shall only be used where approved by the Owner/Owner's Representative.
2. Unrestrained: Manufacturer's standard bell and gasket push on joint.

## 2.03 HDPE JOINTS

### A. Thermal butt –fusion of same rating as pipe.

### B. Thermally butt fused to end of pipe. Install with backup rings of Type 316 stainless steel.

## 2.04 GASKET LUBRICANT

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

## 2.05 FABRICATION

### A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer's identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

2.06 FINISHES

A. Factory prepare, prime, and finish coat in accordance with requirements of the drawings or where otherwise specified. .

**PART 3 EXECUTION**

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

3.02 PREPARATION

A. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

3.03 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.

9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer.

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

### 3.04 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

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

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

C. Connectors:

1. Dismantling Fittings: As specified in Section 40 27 10, Piping Specialties.

D. Flanges:

1. Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.
2. Where required and approved to allow field cutting of pipe, use Flange Adaptors as specified in Section 40 27 10, Piping Specialties.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment. Where required utilize Expansion Connector as specified in Section 40 27 10, Piping Specialties.

F. Heat trace and insulate all exposed piping in accordance with Sections 40 42 13, Process Piping Insulation and 40 05 33, Pipe Heat Tracing.



### 3.05 INSTALLATION—BURIED PIPE

#### A. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 31 23 23, Trench Backfill.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. After joint has been made, check pipe alignment and grade.
10. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
11. Prevent uplift and floating of pipe prior to backfilling.
12. Provide restrained joints where required.

#### B. Tolerances:

1. Deflection from Horizontal Line: Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 25 percent of manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

### 3.06 THRUST RESTRAINT

- #### A. Location: As detailed on the Drawings and approved by the Owner/Owner's Representative.

### 3.07 HDPE PIPE PLACEMENT

- #### A. Lay pipe snaking from one side of trench to other.
- #### B. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.
- #### C. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.

- D. Shield ends to be joined from direct sunlight prior to and during the laying operation.
- E. Install mid span restraints at transitions into structures and where it transitions to ductile iron to prevent the expansion/contraction forces from being transferred to the structure or transition fitting.

3.08 TOLERANCES

- A. Deflection from Horizontal Line [Except HDPE]: Maximum 2 inches.
- B. Deflection From Vertical Grade: Maximum 1/4 inch.
- C. Joint Deflection: Maximum of 75 percent of manufacturer’s recommendation.
- D. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
- E. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.09 FIELD FINISHING

- A. Notify the ESD at least 3 days prior to start of any surface preparation or coating application work.

3.10 FIELD QUALITY CONTROL

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

3.11 CLEANING

- A. Following assembly and testing, and prior to final acceptance, flush pipelines (except as stated below) with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

3.12 SUPPLEMENTS

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

- 1. Pipe Data Sheets.

<b>Number</b>	<b>Title</b>
40 27 01	Ductile Iron Pipe and Fittings
40 27 02	High Density Polyethylene Pipe and Fittings

**END OF SECTION**

**SECTION 40 27 01  
DUCTILE IRON PIPE AND FITTINGS**

<b>Item</b>	<b>Description</b>
Pipe	AWWA C150/A21.50, AWWA C151/A21.51
Minimum Pressure Rating	12-inch and smaller - 350 psi 14-inch and larger – 250 psi unless otherwise shown on Drawings or specified.
Exterior Coating	Exposed: Primed for final coating at site. Top coating shall be a high build epoxy rated for wastewater expose with top coat to provide protection where exposed to the sun Buried: Polywrapped where detailed or otherwise specified
Interior Lining	Permax CTF (White) or Approved Equal
Fittings	AWWA C110/A21.10. or ANSI/AWWA C153/A21.53
Joints	- Exposed: Flanged - Buried: Restrained Joint as Detailed using pipe manufacturer's proprietary joint restraint system
Field Cuts/Connection	EBAA Series 1100 or approved equal
Gaskets	Flanged: Toruseal or approved equal Buried: EPDM

**END OF SECTION**



**SECTION 40 27 02  
HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS  
(HDPE)**

<b>Item</b>	<b>Description</b>
Pipe and Fitting	ASTM F714
Resin	Meet requirements of ASTM D3350 for PE 4710 with cell classification of 445474C. Pressure rating based upon hydrostatic design stress of 1000 psi at 73.4 degrees F.
Minimum Pressure Rating	200 psi (unless otherwise detailed on the Drawings).
Minimum DR Rating	DR 11 (unless otherwise detailed on the Drawings).
Diameter	As Detailed on the Drawings.
Fittings	Thermal butt –fusion of same rating as pipe.
Installation	Install in accordance with AWWA M55, PPI TR-33, ASTM F2620 and pipe manufacturer’s recommendations.
Joining	Butt fuse. Provide data logger data if requested the ESD.
Flanges	Thermally butt fused to end of pipe. Install with backup rings of Type 316 stainless steel.
Transition Fittings	Where transitioning between materials and connecting to valves use HDPE MJ Adapter with metal insert, Metal Gland, Gasket, and attachment Bolts and Nuts.
Mid-Span Restraint/Wall Pipe	ISCO IPS Wall Anchor or approved equal
Gaskets	Material, size and thickness as recommended by flange manufacturer and in accordance with PPI Technical Note 38.

**END OF SECTION**



**SECTION 40 27 10  
PIPING SPECIALTIES**

**PART 1 GENERAL**

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
    - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings.
    - b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24.
    - c. American Water Works Association (AWWA):
    - d. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
    - e. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
    - f. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
    - g. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
    - h. Manual M11, Steel Pipe—A Guide for Design and Installation.
    - i. ASTM International (ASTM):
    - j. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
    - k. A276, Standard Specification for Stainless Steel Bars and Shapes.
  2. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

**PART 2 PRODUCTS**

2.01 GENERAL

- A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.
- B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.
1. Flange Adaptors.
    - a. Ebaa, Series 2100 Megaflange.

2.02 CONNECTORS

- A. Flexible Expansion:
1. Type: One Convolutions.

2. Materials of Construction.
    - a. Bellows: EPDM.
    - b. Flanges: Ductile Iron.
    - c. Reinforcing Rings: Stainless Steel.
    - d. Limiting Bolts: Type 304 stainless steel.
    - e. Pressure Rating: As Detailed.
  3. Manufacturer: Proco Products, Inc., or approved equal.
- B. Dismantling Fitting:
1. Material of Construction:
    - a. Spool: AWWA Class D Steel Ring Flange, compatible with ANSI Class 125 and 150 bolt circles.
    - b. Coating: Fusion bonded epoxy, NSF 61 certified.
    - c. Tie Rods: High tensile steel per ASTM A193 grade B7.
    - d. Pressure Rating: 350 psi working pressure.
  2. Manufacturer: Romak, DJ400 or approved equal.

### **PART 3 EXECUTION**

#### **3.01 GENERAL**

- A. Provide accessibility to piping specialties for control and maintenance.
- B. Provide dismantling fittings at all valves and pumps to facilitate removal.

#### **3.02 FLEXIBLE PIPE CONNECTIONS TO PUMPS**

- A. As detailed on Drawings.
- B. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

**END OF SECTION**



**SECTION 40 27 20**  
**VALVES AND OPERATORS**

**PART 1 GENERAL**

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
    - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
  2. American Water Works Association (AWWA):
    - a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
    - b. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
    - c. C509, Resilient-Seated Gate Valves for Water Supply Service.
    - d. C510, Double Check Valve Backflow Prevention Assembly.
    - e. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
    - f. C542, Electric Motor Actuators for Valves and Slide Gates.
    - g. C550, Protective Interior Coatings for Valves and Hydrants.
  3. ASTM International (ASTM):
    - a. A276, Standard Specification for Stainless Steel Bars and Shapes.
    - b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
    - c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
    - d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.

**PART 2 PRODUCTS**

2.01 GENERAL

- A. Valves to include operator, handwheel, extension stem, floor stand, operating nut, wrench, and accessories to allow a complete operation from the intended operating level.
- B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

- C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.
- D. Valve ends to suit adjacent piping.
- E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure.
- F. Size operators and actuators to operate valve for full range of pressures and velocities.
- G. Valve to open by turning counterclockwise, unless otherwise specified.
- H. Factory mount operator, actuator, and accessories.

## 2.02 FACTORY FINISHING

- A. General:
  - 1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
  - 2. Exterior coating for valves and hydrants shall be manufacturer recommended for corrosive environments and/or direct burial.

## 2.03 VALVES

- A. Type V100 Gate Valve 3 Inches and Smaller
  - 1. All-bronze, screwed bonnet, packed gland, single solid wedge gate, nonrising stem, Class 125 rated 200 psi CWP, complies with MSS SP-80 Type 1.
  - 2. Manufacturers and Products:
    - a. Crane; Figure 438, NPT threaded ends.
    - b. Stockham; Figure B103, NPT threaded ends.
    - c. Crane; Figure 1324, soldered ends.
- B. Type V134 Resilient Seated Ductile Iron Gate Valve 3 Inches to 12 Inches:
  - 1. Ductile iron body, resilient seat, bronze stem and stem nut, ASME B16.1 Class 125 flanged ends, nonrising stem, in accordance with AWWA C515, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550. NSF/ANSI 61 certified where required for the installation location.
  - 2. Manufacturers and Products:
    - a. American Flow Control; Series 2500.
    - b. M&H; Style 7000 and C515 Large RW Valves.

- C. Type V135 Resilient Seated Ductile Iron Gate Valve 3 Inches to 36 Inches:
  - 1. Ductile iron body, resilient seat, bronze stem and stem nut, mechanical joint ends, nonrising stem, in accordance with AWWA C515, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550. NSF/ANSI 61 certified where required for the installation location.
  - 2. Manufacturers and Products:
    - a. American Flow Control; Series 2500.
    - b. M&H; Style 7000 and C515 Large RW Valves.
  
- D. Type V301 Ball Valve 2 Inches and Smaller:
  - 1. Two-piece, full port, NPT threaded ends, bronze body and end piece, stainless steel ball and stem, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
  - 2. Manufacturers and Products:
    - a. Threaded:
      - 1) Conbraco Apollo; 77-100.
      - 2) Nibco; T-585-70.
  
- E. Plug Valves:
  - 1. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:
    - a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints
    - b. Buried service mechanical joint ends, exposed service flanged, unless otherwise shown.
    - c. Plug cast iron with round or rectangular port of no less than 100 percent (full port) of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
    - d. For buried service, provide external epoxy coating.
    - e. For exposed service provided primed for coating.
    - f. Operators:
      - 1) 3-Inch to 4-Inch Valves: Wrench lever manual.

- 2) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
- g. Manufacturers and Products:
  - 1) DeZurik; Style PEF.
  - 2) Milliken; Millcentric.

F. Check and Flap Valves:

- 1. Type V632 Ball Check Valve 3 Inches and Larger:
  - a. Cast iron body with epoxy coating or bronze body.
  - b. Suitable for wastewater service.
  - c. Threaded female x female connection.
  - d. Rated 150-pound working pressure.
  - e. Suitable for vertical up or horizontal flow.
  - f. Bolted or threaded access cover.
- 2. Manufacturers and Products
  - a. Flowmatic Corp, 508.
  - b. Golden Anderson, 240-T.
- 3. Type V705 Swing Check Valve 2 Inches to 12 Inches:
  - a. AWWA C508, 125-pound flanged ends, cast-iron body, bronze body seat, bronze mounted cast-iron clapper with rubber facing, stainless steel hinge shaft.
  - b. Valves, 2 inches through 12 inches rated 175-pound WWP and 14 inches through 24 inches rated 150-pound WWP. Valves to be fitted with adjustable outside lever and weight. Increasing-pattern body valve may be used where increased outlet piping size is shown.
  - c. Manufacturers and Products:
    - 1) M&H Valve; Style 59, 159, or 259.
    - 2) Mueller Co.; No. A-2600 Series.
    - 3) CCNE.

G. Self-Regulated Automatic Valves:

- 1. Type V750, Sewage Air and Vacuum Valve 2 Inches to 8 Inches (Combination Valve):
  - a. Suitable for sewage service; automatically exhausts air during system filling and allows air to re-enter during draining or when vacuum occurs.
  - b. Rated working pressure of 150 psi with operating pressure and orifice size as indicated on Drawings..
  - c. Materials: Cast or Ductile iron with fusion bonded epoxy coating or stainless steel.

- d. Sewage air and vacuum valve fitted with:
  - 1) Blowoff valve.
  - 2) Isolation valve, V134 or V301.
  - 3) Flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.
- e. Manufacturers and Products:
  - 1) ARI, D-023
  - 2) Val-Matic Valve; Series 301 to 306.
- 2. Type V752 Sewage Air Release Valve 2 Inches to 4 Inches:
  - a. Suitable for sewage service; automatically exhausts entrained air that accumulates in a system.
  - b. Rated working pressure of 150 psi, operating pressure and orifice size as indicated on Drawings.
  - c. Materials: Cast or Ductile iron with fusion bonded epoxy coating or stainless steel
  - d. Sewage air release valve fitted with:
    - 1) Blowoff valve.
    - 2) Isolation valve, V134 or V301.
    - 3) Flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.
  - e. Manufacturers and Products:
    - 1) ARI, D-020 or S-020
    - 2) Val-Matic Valve; Series 48 or 49.

## 2.04 ACCESSORIES

- A. Cast-Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 5-1/4-inch ID shaft.
  - 1. Box: Cast iron with minimum depth of 9 inches.
  - 2. Lid: Cast iron, minimum depth 3 inches, nonlocking type, marked SEWER.
  - 3. Extensions cast iron.
  - 4. Two-piece box and lid for valves 4 inches through 12 inches, three-piece box and lid for valves larger than 12 inches with base sized for valve.
  - 5. Valve extension stem for valves with operating nuts 3 feet or greater below finish grade.
  - 6. Manufacturers and Products:
    - a. East Jordan Iron Works; Cast-Iron Valve Boxes.
    - b. Bingham & Taylor; Cast-Iron Valve Boxes.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

#### **A. Flange Ends:**

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

#### **B. Screwed Ends:**

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

#### **C. Valve Installation and Orientation:**

##### **1. General:**

- a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
- b. Install valves in location for easy access for routine operation and maintenance.
- c. Install valves per manufacturer's recommendations.

##### **2. Eccentric Plug Valves:**

- a. Unless otherwise restricted or shown on Drawings, install valve as follows: Install valve in horizontal position with seat in highest portion of valve (seat up).

##### **3. Check Valves: Install swing check valve with shaft in horizontal position.**

##### **4. Self Regulated Automatic Valves:**

- a. Install on a tee. Installation on tap is not allowed.
- b. Install with isolation valve in accordance with detail.

#### **D. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.**

#### **E. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.**

### **3.02 TESTS AND INSPECTION**

#### **A. Valve may be either tested while testing pipelines, or as a separate step.**

#### **B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.**

- C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.
- D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.

**END OF SECTION**





**SECTION 40 42 13**  
**PROCESS PIPING INSULATION**

**PART 1      GENERAL**

1.01      REFERENCES

- A.      The following is a list of standards which may be referenced in this section:
1.      American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
  2.      ASTM International (ASTM):
    - a.      B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    - b.      C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
    - c.      C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
    - d.      C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
    - e.      C534/C534M, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
    - f.      C547, Standard Specification for Mineral Fiber Pipe Insulation.
    - g.      C552, Standard Specification for Cellular Glass Thermal Insulation.
    - h.      C585, Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
    - i.      C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
    - j.      C1729, Standard Specification for Aluminum Jacketing for Insulation.
    - k.      E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    - l.      E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
  3.      International Code Council (ICC): International Energy Conservation Code (IECC).
  4.      Underwriters Laboratories Inc. (UL).

## **PART 2 PRODUCTS**

### **2.01 PIPE AND FITTING INSULATION**

#### **A. Type 2—Fiberglass:**

1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
2. Insulation Temperature Rating: Zero to 850 degrees F.
3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in./hr-square foot degrees F at 75 degrees F.
4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96/E96M. Furnish with no jacket if field finish system specified.
5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
6. Flame Spread Rating: Less than 25 per ASTM E84.
7. Smoke Developed Index: Less than 50 per ASTM E84.
8. Manufacturers and Products:
  - a. Owens Corning Fiberglass; ASJ/SSL-11.
  - b. John Manville; Micro-Lok with Jacket.

### **2.02 INSULATION AT PIPE HANGERS AND SUPPORTS**

- A. Refer to Section 40 05 15, Piping Support Systems.
- B. Copper, Ductile Iron, and Nonmetallic Pipe: High-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield. Extend insert beyond shield.

### **2.03 INSULATION FINISH SYSTEMS**

#### **A. Type F1—PVC.**

#### **B. Type F3—Aluminum:**

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, in accordance with ASTM C1729, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, heat and pressure bonded to inner surface of aluminum jacketing.

3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
  - a. RPR Products; Insul-Mate.
  - b. ITW, Pabco-Childers.

## **PART 3 EXECUTION**

### **3.01 APPLICATION**

#### **A. General:**

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule in Section 40 27 00, Process Piping—General.

### **3.02 INSTALLATION**

#### **A. General:**

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.
3. Install over clean dry surfaces.
4. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
5. Do not allow insulation to cover nameplates or code inspection stamps.
6. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
7. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
8. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

**B. Connection to Existing Piping:** Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

**C. Cold Surfaces:** Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

- D. Placement.
- E. Insulate valves and fittings with sleeved or cut pieces of same material.
- F. Seal and tape joints.
- G. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.
- H. Vapor Barrier:
  - 1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
  - 2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
  - 3. Do not use staples and screws to secure vapor sealed system components.
- I. Aluminum Jacket:
  - 1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
  - 2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
  - 3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
  - 4. Do not use screws or rivets to fasten fitting covers.
  - 5. Install removable prefabricated aluminum covers on exterior flanges and unions.
  - 6. Caulk and seal exterior joints to make watertight.

### 3.03 FIELD FINISHING

- A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.
- B. Where pipe labels or banding are specified, apply to finished insulation, not to pipe.
- C. Painting Piping Insulation (Exposed to View): Aluminum or color coded PVC jacketing does not require painting.

### 3.04 SUPPLEMENTS

- A. The supplement listed below, following “End of Section,” is a part of this Specification:
  - 1. Service and Insulation Thickness Table.

**END OF SECTION**

Service and Insulation Thickness								
Service Type	Pipe Legend	Thickness	Fluid Temperature (degrees F)*	Insulation	Finish Systems			
					Concealed from View	Indoors Exposed	Outdoors	Buried
HT-Piping requiring heat tracing.	FC	Pipe Size: Insulation Thickness Inches:* 1/4-3: 1 3.5-10: 1.5	50 to 90	Type 2 Insulate and heat trace outside lines above grade.	None	F3	F3	N/A
<p>*Use these fluid temperatures unless otherwise noted in the Piping Schedule.            Inches*: Based upon insulation with glass fiber per ASTM C547, outdoors with 20 mph wind with 10 percent safety and no value assigned to cladding or air space at cladding. Matches the watts per foot in Section 40 05 33, Pipe Heat Tracing. 2012 IECC requires 1-inch minimum thickness.</p>								



**SECTION 40 80 01  
PIPING LEAKAGE TESTING**

**PART 1 GENERAL (NOT USED)**

**PART 2 PRODUCTS (NOT USED)**

**PART 3 EXECUTION**

3.01 PREPARATION

- A. Develop and review testing procedure with piping system manufacturer.
- B. Notify the ESD in writing 5 days in advance of testing. Perform testing in presence of the ESD.
- C. Pressure Piping:
  - 1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
  - 2. Wait 10 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
  - 3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
  - 4. Test Pressure: As Detailed on the Drawings.
- D. Test section may be filled with water and allowed to stand under low pressure prior to testing.

3.02 HYDROSTATIC TEST

- A. General:
  - 1. Testing of pipe shall be accomplished before grouting pipe in any casings.
  - 2. Test newly installed pipelines. Using water as test medium, pipes shall successfully pass a leakage test prior to acceptance.
  - 3. Furnish testing equipment and perform tests in manner satisfactory to Engineer. Testing equipment shall provide observable and accurate measurements of leakage under specified conditions.
  - 4. Supply temporary water for completion of test.
  - 5. Dispose of water used in testing in accordance with applicable regulations.

6. Procedure:
  - a. Maximum filling velocity shall not exceed 0.25 foot per second, calculated based on the full area of pipe.
  - b. Expel air from pipe system during filling. Expel air through air release valve or through corporation stop installed at high points and other strategic points.
  - c. Test pressure shall be 150 percent of the operating pressure as measured at the low point.
  - d. Test as pressure shall be for a minimum of 1 hour.
  - e. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
  - f. If measured leakage exceeds allowable leakage or if leaks are visible, repair defective pipe section and repeat hydrostatic test.
  - g. For high density polyethylene pipe, test procedure shall be in accordance with ASTM F2164.
    - 1) Initial Expansion Phase: Add water as required to maintain test pressure for 4 hours.
    - 2) Test Phase: Reduce pressure by 10 psi and start pressure test.
    - 3) Test is successful if pressure stays within 5 percent of initial value for 1 hour.
7. Allowable Leakage: Allowable leakage is zero.

### 3.03 FIELD QUALITY CONTROL

#### A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
  - a. Leaks (type, location).
  - b. Repair/replacement performed to remedy excessive leakage.

**END OF SECTION**



**SECTION 40 90 01**  
**INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS**

**PART 1      GENERAL**

1.01      REFERENCES

- A.    The following is a list of standards which may be referenced in this section:
1.    ASTM International (ASTM):
    - a.    A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
    - b.    A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
    - c.    A312, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
    - d.    B32, Standard Specification for Solder Metal.
    - e.    B88, Standard Specification for Seamless Copper Water Tube.
  2.    International Society of Automation (ISA):
    - a.    S5.1, Instrumentation Symbols and Identification (NRC ADOPTED).
    - b.    PR12.6, Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.
    - c.    S5.4, Standard Instrument Loop Diagrams.
    - d.    S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
    - e.    S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
  3.    National Electrical Manufacturers Association (NEMA):
    - a.    250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    - b.    ICS 1, General Standards for Industrial Control and Systems.
  4.    National Institute of Standards and Technology (NIST).
  5.    Underwriters Laboratory, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

1.02      SUMMARY

- A.    Work Includes:
1.    Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and Owner training for complete Process Instrumentation and Control (PIC).

2. All pump station shall include a Mission RTU-800 for remote monitoring.

### 1.03 DEFINITIONS

#### A. Abbreviations:

1. LCP: Local Control Panel.
2. PAT: Performance Acceptance Test.
3. PIC: Process Instrumentation and Control.
4. PLC: Programmable Logic Controller.

#### B. Rising/Falling: Terms used to define actions of discrete devices about their setpoints.

1. Rising: Contacts close when an increasing process variable rises through setpoint.
2. Falling: Contacts close when a decreasing process variable falls through setpoint.

#### C. Signal Types:

1. Analog Signals, Current Type:
  - a. 4 mA to 20 mA dc signals conforming to ISA S50.1.
  - b. Unless otherwise indicated for specific PIC Subsystem components, use the following ISA 50.1 options:
    - 1) Transmitter Type: Number 2, two-wire.
    - 2) Transmitter Load Resistance Capacity: Class L.
    - 3) Fully isolated transmitters and receivers.
2. Analog Signals, Voltage Type: 1 to 5 volts dc within panels where a common high precision dropping resistor is used.
3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.

#### D. Instrument Tag Numbers:

1. A shorthand tag number notation is used in the Loop Specifications. For example: AI-1-2(2)(3)[pH].

<u>Notation</u>	<u>Explanation</u>
AI	ISA designator for Analysis Indicator.
1	Unit process number.
2	Loop number.

<u>Notation</u>	<u>Explanation</u>
(2)	First unit number; number of same component types in a given loop; -1 and -2 in this example.
(3)	Second unit number; number of same component types with same first unit number in a given loop; -1, -2, and -3 in this example.
[pH]	Same notation shown at 2 o'clock position on ISA circle symbol on P&ID.

2. In this example, AI-1-12(2)(3)[pH] is shorthand for:

AI-1-12-1-1[pH], AI-1-12-1-2[pH], AI-1-12-1-3[pH]  
 AI-1-12-2-1[pH], AI-1-12-2-2[pH], AI-1-12-2-3[pH]

#### 1.04 QUALITY ASSURANCE

A. Calibration Instruments: Each instrument used for calibrating PIC equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Provide Site and warehouse storage facilities for PIC equipment.
- B. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.
- C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- D. Cover panels and other elements that are exposed to dusty construction environments.

#### 1.06 ENVIRONMENTAL REQUIREMENTS

- A. Standard Environmental Requirements: Unless otherwise noted, design equipment for continuous operation in these environments:
  - 1. Freestanding Panel and Consoles:
    - a. Inside, Air Conditioned: NEMA 1.
    - b. Inside: NEMA 12.
  - 2. Smaller Panels and Assemblies (that are not Freestanding):
    - a. All Other Locations: NEMA 4X.
  - 3. Field Elements: Outside.

B. Environmental Design Requirements: Following defines the types of environments referred to in the above.

1. Outside:

- a. Temperature: Minus 20 to 104 degrees F.
- b. Relative Humidity: 10 to 100 percent.
- c. NEC Classification: Nonhazardous.

2. Outside, Corrosive:

- a. Temperature: Minus 20 to 104 degrees F.
- b. Relative Humidity: 0 to 100 percent.
- c. Corrosive Environment: Hydrogen sulfide gas.
- d. NEC Classification: Nonhazardous.

## **PART 2 PRODUCTS**

### **2.01 GENERAL**

A. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to effect required system and loop performance.

B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment and materials.

- 1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with Article Submittals.
- 2. If using proposed item requires other changes, provide work and equipment to implement these changes. Changes that may be required include, but are not limited to: different installation, wiring, raceway, enclosures, connections, isolators, intrinsically safe barriers, software, and accessories.

C. Like Equipment Items:

- 1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
- 2. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

### **2.02 I&C COMPONENTS**

A. Components for Each Loop: Furnish all equipment that is necessary to achieve required loop performance.

B. Component Specifications: Generalized specifications for each type of component are located in Article Supplements.

## 2.03 NAMEPLATES AND TAGS

- A. Panel Nameplates: Enclosure identification located on the enclosure face.
  - 1. Location and Inscription: As shown.
  - 2. Materials: Laminated plastic attached to panel with stainless steel screws.
  - 3. Letters: 1/2-inch white on black background, unless otherwise noted.
  
- B. Component Nameplates—Panel Face: Component identification located on panel face under or near component.
  - 1. Location and Inscription: As shown.
  - 2. Materials: Laminated plastic attached to panel with stainless steel screws.
  - 3. Letters: 3/16-inch white on black background, unless otherwise noted.
  
- C. Component Nameplates—Back of Panel: Component identification located on or near component inside of enclosure.
  - 1. Inscription: Component tag number.
  - 2. Materials: Adhesive backed, laminated plastic.
  - 3. Letters: 3/16-inch white on black background, unless otherwise noted.
  
- D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.
  - 1. Inscription: Refer to:
    - a. Table under paragraph Standard Pushbutton Colors and Inscriptions.
    - b. Table under paragraph Standard Light Colors and Inscriptions.
    - c. P&IDs in Drawings.
  - 2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
  - 3. Letters: Black on gray or white background.
  
- E. Service Legends: Component identification nameplate located on face of component.
  - 1. Inscription: As shown.
  - 2. Materials: Adhesive backed, laminated plastic.
  - 3. Letters: 3/16-inch white on black background, unless otherwise noted.
  
- F. Nametags: Component identification for field devices.
  - 1. Inscription: Component tag number.
  - 2. Materials: 16-gauge, Type 304 stainless steel.

3. Letters: 3/16-inch imposed.
4. Mounting: Affix to component with 16- or 18-gauge stainless steel wire or stainless steel screws.

## 2.04 ELECTRICAL REQUIREMENTS

- A. In accordance with Division 26, Electrical.
- B. I&C and electrical components, terminals, wires, and enclosures: UL listed.
- C. Wires within Enclosures:
  1. ac Circuits:
    - a. Type: 600-volt, Type MTW stranded copper.
    - b. Size: For current to be carried, but not less than 18 AWG.
  2. Analog Signal Circuits:
    - a. Type: 600-volt stranded copper, twisted shielded pairs.
    - b. Size: 18 AWG, minimum.
  3. Other dc Circuits.
    - a. Type: 600-volt, Type MTW stranded copper.
    - b. Size: For current carried, but not less than 18 AWG.
  4. Special Signal Circuits: Use manufacturer's standard cables.
  5. Wire Identification: Numbered and tagged at each termination.
    - a. Wire Tags: Machine printed, heat shrink.
    - b. Manufacturers:
      - 1) Brady PermaSleeve.
      - 2) Tyco Electronics.
- D. Wires entering or leaving enclosures, terminate and identify as follows:
  1. Analog and discrete signal, terminate at numbered terminal blocks.
  2. Special signals, terminated using manufacturer's standard connectors.
- E. Terminal Blocks for Enclosures:
  1. Quantity:
    - a. One wire per terminal for field wires entering enclosures.
    - b. Maximum of two wires per terminal for 18-WG wire for internal enclosure wiring.
    - c. Spare Terminals: 20 percent of all connected terminals, but not less than 10 per terminal block.
  2. General:
    - a. Connection Type: Screw compression clamp.
    - b. Compression Clamp:
      - 1) Complies with DIN-VDE 0611.

- 2) Hardened steel clamp with transversal groves that penetrate wire strands providing a vibration-proof connection.
- 3) Guides strands of wire into terminal.
- c. Screws: Hardened steel, captive and self-locking.
- d. Current Bar: Copper or treated brass.
- e. Insulation:
  - 1) Thermoplastic rated for minus 55 to plus 110 degree C.
  - 2) Two funneled shaped inputs to facilitate wire entry.
- f. Mounting:
  - 1) Standard DIN rail.
  - 2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
  - 3) End Stops: Minimum of one at each end of rail.
- g. Wire preparation: Stripping only permitted.
- h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
- i. Marking System:
  - 1) Terminal number shown on both sides of terminal block.
  - 2) Allow use of preprinted and field marked tags.
  - 3) Terminal strip numbers shown on end stops.
  - 4) Mark terminal block and terminal strip numbers as shown on Panel Control Diagrams and Loop Diagrams.
  - 5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.
- j. Test Plugs: Soldered connections for 18 AWG wire.
  - 1) Pin Diameter: 0.079 inch.
  - 2) Manufacturer and Product: Entrelec; Type FC2.
- 3. Terminal Block, General-Purpose:
  - a. Rated Voltage: 600V ac.
  - b. Rated Current: 30 amp.
  - c. Wire Size: 22 AWG to 10 AWG.
  - d. Rated Wire Size: 10 AWG.
  - e. Color: Grey body.
  - f. Spacing: 0.25 inch, maximum.
  - g. Test Sockets: One screw test socket 0.079-inch diameter.
  - h. Manufacturer and Product: Entrelec; Type M4/6.T.
- 4. Terminal Block, Ground:
  - a. Wire Size: 22 AWG to 12 AWG.
  - b. Rated Wire Size: 12 AWG.
  - c. Color: Green and yellow body.
  - d. Spacing: 0.25 inch, maximum.
  - e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
  - f. Manufacturer and Product: Entrelec; Type M4/6.P.

5. Terminal Block, Blade Disconnect Switch:
  - a. Rated Voltage: 600V ac.
  - b. Rated Current: 10-amp.
  - c. Wire Size: 22 AWG to 12 AWG.
  - d. Rated Wire Size: 12 AWG.
  - e. Color: Grey body, orange switch.
  - f. Spacing: 0.25 inch, maximum.
  - g. Manufacturer and Product: Entrelec; Type M4/6.SN.T.
6. Terminal Block, Fused, 24V dc:
  - a. Rated Voltage: 600V dc.
  - b. Rated Current: 16-amp.
  - c. Wire Size: 22 AWG to 10 AWG.
  - d. Rated Wire Size: 10 AWG.
  - e. Color: Grey body.
  - f. Fuse: 0.25 inch by 1.25 inches.
  - g. Indication: LED diode 24V dc.
  - h. Spacing: 0.512 inch, maximum.
  - i. Manufacturer and Product: Entrelec; Type M10/13T.SFL.
7. Terminal Block, Fused, 120V ac:
  - a. Rated Voltage: 600V ac.
  - b. Rated Current: 16-amp.
  - c. Wire Size: 22 AWG to 10 AWG.
  - d. Rated Wire Size: 10 AWG.
  - e. Color: Grey body.
  - f. Fuse: 0.25 inch by 1.25 inches.
  - g. Indication: Neon Lamp 110V ac.
  - h. Leakage Current: 1.8 mA, maximum.
  - i. Spacing: 0.512 inch, maximum
  - j. Manufacturer and Product: Entrelec; Type M10/13T.SFL.
8. Terminal Block, Fused, 120V ac, High Current:
  - a. Rated Voltage: 600V ac.
  - b. Rated Current: 35 amps.
  - c. Wire Size: 18 AWG to 8 AWG.
  - d. Rated Wire Size: 8 AWG.
  - e. Color: Grey.
  - f. Fuse: 13/32 inch by 1.5 inches.
  - g. Spacing: 0.95 inch, maximum.
  - h. Manufacturer and Product: Entrelec; Type MB10/24.SF.

F. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections.
2. Ground bus grounded at a common signal ground point in accordance with National Electrical Code requirements.



3. Single Point Ground for Each Analog Loop:
    - a. Locate at dc power supply for loop.
    - b. Use to ground wire shields for loop.
  4. Ground terminal block rails to ground bus.
- G. Analog Signal Isolators: Furnish signal isolation for analog signals that are sent from one enclosure to another. Do not wire in series instruments on different panels, cabinets, or enclosures.
- H. Power Distribution within Panels:
1. Feeder Circuits:
    - a. Make provisions for feeder circuit conduit entry.
    - b. Furnish terminal board for termination of wires.
  2. Power Panel: Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
    - a. Locate to provide clear view of and access to breakers when door is open.
    - b. Breaker sizes: Coordinate such that fault in branch circuit will blow only branch breaker but not trip the main breaker.
    - c. Breaker Manufacturers and Products: Refer to Division 26, Electrical.
  3. Circuit Wiring: Use following rules for actual circuit wiring:
    - a. Devices on Single Circuit: 20, maximum.
    - b. Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
    - c. Branch Circuit Loading: 12 amperes continuous, maximum.
    - d. Panel Lighting and Service Outlets: Put on separate 15-amp, 120V ac branch circuit.
    - e. Provide 120V ac plugmold for panel components with line cords.
- I. Electrical Transient Protection:
1. Provide on incoming power to panel and all analog signals.
  2. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
  3. Implementation: Provide, install, coordinate, and inspect grounding of surge suppressors at:
    - a. Connection of ac power to PIC equipment including panels, consoles assembles, and field mounted analog transmitters and receivers.
    - b. At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.

4. Construction: First-stage high energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by series impedance. Includes grounding wire, stud, or terminal.
5. Response: 5 nanoseconds maximum.
6. Recovery: Automatic.
7. Temperature Range: Minus 20 degrees C to plus 85 degrees C.

J. Signal Distribution:

1. Within Panels: 4 mA to 20 mA dc signals may be distributed as 1 to 5V dc.
2. Outside Panels: Isolated 4 mA to 20 mA dc only.
3. All signal wiring twisted in shielded pairs.

K. Relays:

1. General:
  - a. Relay Mounting: Plug-in type socket.
  - b. Relay Enclosure: Furnish dust cover.
  - c. Socket Type: Screw terminal interface with wiring.
  - d. Socket Mounting: Rail.
  - e. Provide holddown clips.
2. Control Circuit Switching Relay, Nonlatching:
  - a. Type: Compact general-purpose plug-in.
  - b. Contact Arrangement: 3 Form C contacts.
  - c. Contact Rating: 10A at 28V dc or 240V ac.
  - d. Contact Material: Silver cadmium oxide alloy.
  - e. Coil Voltage: As noted or shown.
  - f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
  - g. Expected Mechanical Life: 10,000,000 operations.
  - h. Expected Electrical Life at Rated Load: 100,000 operations.
  - i. Indication Type: Neon or LED indicator lamp.
  - j. Push to test button.
  - k. Manufacturer and Product: Potter and Brumfield; Series KUP.
3. Control Circuit Switching Relay, Latching:
  - a. Type: Dual coil mechanical latching relay.
  - b. Contact Arrangement: 2 Form C contacts.
  - c. Contact Rating: 10A at 28V dc or 120V ac.
  - d. Contact Material: Silver cadmium oxide alloy.
  - e. Coil Voltage: As noted or shown.
  - f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
  - g. Expected Mechanical Life: 500,000 operations.
  - h. Expected Electrical Life at Rated Load: 50,000 operations.
  - i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.

4. Control Circuit Switching Relay, Time Delay:
  - a. Type: Adjustable time delay relay.
  - b. Contact Arrangement: 2 Form C contacts.
  - c. Contact Rating: 10A at 240V ac.
    - 1) Contact Material: Silver cadmium oxide alloy.
  - d. Coil Voltage: As noted or shown.
  - e. Operating Temperature: Minus 10 to 55 degrees C.
  - f. Repeatability: Plus or minus 2 percent.
  - g. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
  - h. Time Delay Setpoint: As noted or shown.
  - i. Mode of Operation: As noted or shown.
  - j. Adjustment Type: Integral potentiometer with knob external to dust cover.
  - k. Manufacturer and Products: Potter and Brumfield:
    - 1) Series CB for 0.1 second to 100 minute delay time ranges.
    - 2) Series CK for 0.1 to 120 second delay time ranges.

L. Power Supplies:

1. Furnish to power instruments requiring external dc power, including two-wire transmitters and dc relays.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
  - a. Protect instruments from damage due to power supply failure.
  - b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1 in accordance with NEMA 250.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
  - a. Type: Indicating.
  - b. Mount so fuses can be easily seen and replaced.

M. Internal Panel Lights for Freestanding Panels:

1. Type: Switched 100-watt incandescent back-of-panel lights.
2. Quantity: One light for every 4 feet of panel width.
3. Mounting: Inside and in the top of back-of-panel area.
4. Protective metal shield for lights.

N. Service Outlets for Freestanding Panels:

1. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
2. Quantity:
  - a. For panels 4 feet wide and smaller: One.
  - b. For panels wider than 4 feet: One for every 4 feet of panel width, two minimum per panel.
3. Mounting: Evenly spaced along back-of-panel area.

O. Internal Panel Lights and Service Outlets for Smaller Panels:

1. Internal Panel Light: Switched 100-watt incandescent light.
2. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle:

P. Standard Pushbutton Colors and Inscriptions: Use following color code and inscriptions for pushbuttons, unless otherwise noted.

<b>Tag Function</b>	<b>Inscription(s)</b>	<b>Color</b>
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

- a. Lettering Color:
  - 1) Black on white and yellow buttons.
  - 2) White on black, red, and green buttons.

- Q. Standard Light Colors and Inscriptions: Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted.

Tag Function	Inscription(s)	Color
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Green
FAIL	FAIL	Amber
HIGH	HIGH	Red
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow

1. Lettering Color:
  - a. Black on white and amber lenses.
  - b. White on red and green lenses.

## 2.05 REMOTE MONITORING

- A. Mission RTU-800. No equal or alternate.

## 2.06 TEST EQUIPMENT AND TOOLS

Item	Qty.	Options and Model
Digital Multimeter	2	Fluke Model 87V/E Industrial Electrician Combo Kit with test leads, removable test probes, long reach alligator clips, magnetic hanger, temperature probe, and carrying case.
Clamp-on Ammeter	1	3-1/2-digit display unit with protective case; TES Model 3040 or Fluke Model 337E.
DC Digital Process Signal Calibrator	2	Portable, two-channel, with test leads, rechargeable batteries, charger, and carrying case; Transmation Model 1045-01.

<b>Item</b>	<b>Qty.</b>	<b>Options and Model</b>
Recorder	1	Portable, two-channel, batteries, carrying case, Z-fold charts. Powered by internal rechargeable batteries and external 120V ac and 12V dc. Input ranges from 10mV to 50V dc. Chart speeds from 60 cm/min to 2cm/hr; Omega Model RD3057-22.
Pressure and Electrical Calibrator	1	Transmation Model 1091PLUS-LP with test leads, rechargeable batteries, ac charger, pressure transducer modules, and protective case. Transducer pressure ranges: Appropriate for pressure devices provided.
Pressure Pump Kit	1	Hand pump (0 to 300 psig), calibration labels, tubing, fittings, and carrying case. Transmation Pump Kit 22980P-300.
Small Tool Kit	1	Kit of instrument maintenance tools in soft, zipper case; Jensen Tools Model JTK-47CG Field Engineer's Kit.
Large Tool Kit	1	Kit of instrument maintenance tools in high-density polyethylene case; Jensen Tools Model JTK-17LST.
Screw Starters	1	Kits of slotted screw starters with magnetic retrievers; Jensen Tools Model 23B021 and 23B023.
Terminal Kit	1	Kit of solderless terminals and cable ties; Jensen Tools Model 23B210.

2.07 SPARE PARTS

<b>Description</b>	<b>Percent of Each Type and Size Used</b>	<b>No Less Than</b>
Annunciator light bulbs	20	10
Annunciator window module	10	[ 5
dc power supplies	20	2
Fuses	20	5
Indicating light bulb	20	10
Relays	20	3
Terminal Blocks	10	10
Hand Switches	10	5

## 2.08 FABRICATION

### A. General:

1. Panels with external dimensions and instruments arrangement as shown on Drawings.
2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code, state and local codes, NEMA, ANSI, UL, and ICECA.
3. Fabricate panels, install instruments, wire, and plumb, at the PIC factory.
4. Electrical Work: In accordance with Division 26, Electrical.

### B. Factory Assembly: Assemble panels at the manufacturer's factory. No fabrication other than correction of minor defects or minor transit damage shall be done on panels at Site.

### C. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.

### D. Wiring Within PIC Panels:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Abrasion protection for wire bundles which pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
  - a. Locking-fork-tongue or ring-tongue lugs.
  - b. Use manufacturer's recommended tool with required sized anvil to make crimp lug terminations.
  - c. Wires terminated in a crimp lug, maximum of one.
  - d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
  - a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
  - b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.

10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Ducts Fill: Do not exceed manufacturer's recommendation.

E. Temperature Control:

1. Freestanding Panels:
  - a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel or on panel.
  - b. Ventilated Panels:
    - 1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel or on panel.
    - 2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
    - 3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
    - 4) Louver Construction: Stamped sheet metal.
    - 5) Ventilation Fans:
      - a) Furnish where required to provide adequate cooling.
      - b) Create positive internal pressure within panel.
      - c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
    - 6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
  - c. Air Conditioned Panels: Where required for continuous operation of equipment. Design of system is subject to the approval of the ESD.
2. Space Heaters:
  - a. Thermostatically controlled to maintain internal panel temperatures above dew point.
  - b. Required for following panels:

F. Freestanding Panel Construction:

1. Materials: Sheet steel, unless otherwise shown on Drawings with minimum thickness of 10-gauge, unless otherwise noted.
2. Panel Fronts:
  - a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
  - b. No seams or bolt heads visible when viewed from front.
  - c. Panel Cutouts: Smoothly finished with rounded edges.
  - d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.



3. Internal Framework:
  - a. Structural steel for instrument support and panel bracing.
  - b. Permit panel lifting without racking or distortion.
4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
5. Adjacent Panels: Securely bolted together so front faces are parallel.
6. Doors: Full height, fully gasketed access doors where shown on Drawings.
  - a. Latches: Three-point, Southco Type 44.
  - b. Handles: "D" ring, foldable type.
  - c. Hinges: Full length, continuous, piano type, steel hinges with stainless steel pins.
  - d. Rear Access Doors: Extend no further than 24 inches beyond panel when opened to 90-degree position.
  - e. Front and Side Access Doors: As shown on Drawings.

G. Nonfreestanding Panel Construction:

1. Based on environmental design requirements required and referenced in Article Environmental Requirements, provide the following:
  - a. Enclosure Type: NEMA 4X in accordance with NEMA 250.
  - b. Materials: Type 316 stainless steel.
2. Metal Thickness: 14-gauge, minimum.
3. Doors:
  - a. Rubber-gasketed with continuous hinge.
  - b. Stainless steel lockable quick-release clamps.
4. Manufacturers:
  - a. Hoffman Engineering Co.
  - b. Rittal.

H. Factory Finishing:

1. Enclosures:
  - a. Stainless Steel: Not painted.

2.09 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:

1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering Co; Model A-HCI.

2.10 SOURCE QUALITY CONTROL

- A. Scope: Inspect and test entire PIC to ensure it is ready for shipment, installation, and operation.

- B. Location: Manufacturer's factory or Engineer approved staging Site.
- C. Test: Exercise and test all functions.
- D. Temporary PLC software configuring to allow PLC testing.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A. For equipment not provided by PIC, but that directly interfaces with the PIC, verify the following conditions:
  - 1. Proper installation.
  - 2. Calibration and adjustment of positioners and I/P transducers.
  - 3. Correct control action.
  - 4. Switch settings and dead bands.
  - 5. Opening and closing speeds and travel stops.
  - 6. Input and output signals.

#### **3.02 MISSION RTU-800.**

- A. Install in accordance with Manufacturer's instructions.
- B. Retain the service of a specialist to program unit and integrate into controls and the ESD system.

#### **3.03 INSTALLATION**

- A. Material and Equipment Installation: Retain a copy of manufacturers' instructions at Site, available for review at all times.
- B. Electrical Wiring: As specified in Division 26, Electrical.
- C. Removal or Relocation of Materials and Equipment:
  - 1. Remove from Site materials that were part of the existing facility but are no longer used, unless otherwise directed by Engineer to deliver to Owner.
  - 2. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

### 3.04 FIELD QUALITY CONTROL

#### A. Startup and Testing Team:

1. Thoroughly inspect installation, termination, and adjustment for components and systems.
2. Complete onsite tests.
3. Complete onsite training.
4. Provide startup assistance.

#### B. Operational Readiness Inspections and Calibrations: Prior to startup, inspect and test to ensure that entire PIC is ready for operation.

1. Loop/Component Inspections and Calibrations:
  - a. Check PIC for proper installation, calibration, and adjustment on a loop-by-loop and component-by-component basis.
  - b. Prepare component calibration sheet for each active component (except simple hand switches, lights, gauges, and similar items).
    - 1) Project name.
    - 2) Loop number.
    - 3) Component tag number.
    - 4) Component code number.
    - 5) Manufacturer for elements.
    - 6) Model number/serial number.
    - 7) Summary of functional requirements, for example:
      - a) Indicators and recorders, scale and chart ranges.
      - b) Transmitters/converters, input and output ranges.
      - c) Computing elements' function.
      - d) Controllers, action (direct/reverse) and control modes (PID).
      - e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
    - 8) Calibrations, for example:
      - a) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
      - b) Discrete Devices: Actual trip points and reset points.
      - c) Controllers: Mode settings (PID).
    - 9) Space for comments.
  - c. These inspections and calibrations will be spot checked by ESD.
2. Leak Test: In accordance with Section 33 05 01, Force Main and Pump Station Piping.

C. Performance Acceptance Tests (PAT):

1. General:
  - a. Test all PIC elements to demonstrate that PIC satisfies all requirements.
  - b. Test Format: Cause and effect.
    - 1) Person conducting test initiates an input (cause).
    - 2) Specific test requirement is satisfied if correct result (effect) occurs.
  - c. Procedures, Forms, and Checklists:
    - 1) Conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
    - 2) Describe each test item to be performed.
    - 3) Have space after each test item description for sign off by appropriate party after satisfactory completion.
  - d. Required Test Documentation: Test procedures, forms, and checklists. All signed by Engineer and Contractor.
  - e. Conducting Tests:
    - 1) Provide special testing materials, equipment, and software.
    - 2) Wherever possible, perform tests using actual process variables, equipment, and data.
    - 3) If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
    - 4) Define simulation techniques in test procedures.
  - f. Coordinate PIC testing with Owner and affected Subcontractors.
    - 1) Excessive Test Witnessing: Refer to Supplementary Conditions.
2. Test Requirements:
  - a. Once facility has been started up and is operating, perform a witnessed PAT on complete PIC to demonstrate that it is operating as required. Demonstrate each required function on a paragraph-by-paragraph and loop-by-loop basis.
  - b. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
  - c. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.

- d. Make updated versions of documentation required for PAT available to Engineer at Site, both before and during tests.
- e. Make one copy of O&M manuals available to Engineer at the Site both before and during testing.
- f. Refer to referenced examples of PAT procedures and forms in Article Supplements.

### 3.05 TRAINING

#### A. General:

1. Provide an integrated training program to meet specific needs of Owner's personnel.
2. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
3. Provide instruction on two working shift(s) as needed to accommodate the Owner's personnel schedule.
4. Owner reserves the right to make and reuse video tapes of training sessions.

#### B. Operations and Maintenance Training:

1. Include a review of O&M manuals and survey of spares, expendables, and test equipment.
2. Use equipment similar to that provided or currently owned by Owner.
3. Provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics or instrumentation.

#### C. Operations Training:

1. Training Session Duration: One 8-hour instructor days.
2. Number of Training Sessions: Two.
3. Location: Site.
4. Content: Conduct training on loop-by-loop basis.
  - a. Loop Functions: Understanding of loop functions, including interlocks for each loop.
  - b. Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
  - c. Interfaces with other control systems.

#### D. Maintenance Training:

1. Training Session Duration: One 8-hour instructor days.
2. Number of Training Sessions: Two.

3. Location: Project Site.
4. Content: Provide training for each type of component and function provided.
  - a. Loop Functions: Understanding details of each loop and how they function.
  - b. Component calibration.
  - c. Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
  - d. Troubleshooting and diagnosis for components.
  - e. Replacing lamps, chart paper, fuses.
  - f. Component removal and replacement.
  - g. Periodic maintenance.

### 3.06 CLEANING/ADJUSTING

- A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.
- B. Cleaning:
  1. Prior to closing system using tubing, clear tubing of interior moisture and debris.
  2. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

### 3.07 PROTECTION

- A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.
- B. Periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules just prior to Final Payment and Acceptance.

### 3.08 SUPPLEMENTS

- A. Supplements listed below, following "End of Section," are part of this Specification.
  1. Component Specifications.
  2. Instrument Calibration Sheet: Provides detailed information on each instrument (except simple hand switches, lights, and similar items).

3. Performance Acceptance Test Sheet: Describes the PAT for a given loop. The format is mostly free form.
  - a. Lists the requirements of the loop.
  - b. Briefly describes the test.
  - c. Cites expected results.
  - d. Provides space for check off by witness.

**END OF SECTION**





## COMPONENT SPECIFICATIONS

### A. L8 Level Switch, Float, Mercury:

1. General:
  - a. Function: Actuate contact at preset liquid level.
  - b. Type: Direct-acting float with enclosed mercury switch and integral cable.
2. Service (Liquid): Wastewater, unless otherwise noted.
3. Performance:
  - a. Setpoint: As required.
  - b. Differential: 2.5 inches, maximum.
  - c. Temperature: 0 degree F to 160 degrees F.
4. Features:
  - a. Entire Assembly: Watertight and impact-resistant.
  - b. Float Material and Size:
    - 1) Polypropylene body; 4.5-inch diameter and 6-inch length.
  - c. Cable:
    - 1) Combination support and signal.
    - 2) Length as noted or as necessary per mounting requirements.
    - 3) PVC cable jacket.
  - d. Mounting: Pipe, unless otherwise noted.
    - 1) Pipe Mounting:
      - a) Cable clamp, suitable for connection to 1-inch pipe.
      - b) Pipe-to-wall bracket, suitable for connection to 1-inch pipe.
    - 2) Suspended Mounting (internal weights): If noted.
      - a) Wall mounting bracket, unless otherwise noted.
    - 3) Anchor Mounting Kit: If noted.
      - a) Compatible with pipe-mounted floats.
      - b) 15-pound vinyl-coated cast iron anchor.
      - c) 1/8-inch, Type 316 stainless steel vinyl-coated wire rope.
      - d) Stainless steel cable clips.
5. Signal Interface:
  - a. Switch Type: Mercury tilt.
  - b. Switch Contacts:
    - 1) Isolated, rated 4.5A continuous at 120V ac.
    - 2) Form C contact (one NO, one NC), unless otherwise noted.
6. Accessories: As noted.
7. Manufacturers and Products:
  - a. Anchor Scientific; Roto-Float, Type P/Type S/Type W.
  - b. Siemens Water Technologies; Model LS Direct Acting Float Switch (B100).

- B. L52 Level Element/Transmitter, Submersible, Wastewater, Nonfouling:
1. General:
    - a. Function: Measure and transmit signal proportional to level.
    - b. Type:
      - 1) Totally submersible pressure sensor (loop powered).
      - 2) Nonfouling.
      - 3) Suitable for wastewater, slurries, and viscous fluids.
    - c. Parts: Sensor, interconnecting cable, other parts as noted.
  2. Service:
    - a. Fluid: Wastewater, unless otherwise noted.
  3. Performance:
    - a. Process Range:
      - 1) As required.
      - 2) Provide fixed factory range such that noted process range is between 40 percent and 80 percent of fixed factory range.
    - b. Accuracy: 0.25 percent of full scale.
    - c. Temperature, Operating: Minus 4 degrees F to plus 140 degrees F.
    - d. Overpressure:
      - 1) Proof: At least 1.5 times full scale.
      - 2) Burst: At least 2.0 times full scale.
  4. Features:
    - a. Sensor:
      - 1) Silicon pressure-sensing element.
      - 2) Type 316 stainless steel pressure module assembly.
      - 3) Other Wetted Materials: Teflon.
      - 4) NEMA 6/IP 68 rating (submersible).
      - 5) Temperature compensation.
      - 6) Sensing Area: 2.75-inch diameter.
      - 7) Integral diaphragm protector.
      - 8) Dimensions, Nominal:
        - a) Pressure-Sensing Assembly: 1-inch diameter.
        - b) Sensing Area Assembly: 4-inch diameter.
        - c) Length (without integral lightning protector): 8 inches.
      - 9) Nominal Weight: 3.5 pounds.
      - 10) Loop powered, 9-30V dc.
    - b. Interconnecting Cable:
      - 1) Length: As required.
      - 2) Polyurethane sheathed, unless otherwise noted.
      - 3) Kevlar strain relief cord.
      - 4) Integral vent tube.

- c. Sensor Termination Enclosure: Required, unless otherwise noted.
  - 1) Enclosure: NEMA 4X.
  - 2) Houses such noted items as desiccant vent, filter, microfilter, aneroid bellows.
- d. Accessories:
  - 1) Aneroid Bellows: If noted.
    - a) Bellows shall be suitable for application.
  - 2) Desiccant Module: Required, unless otherwise noted.
  - 3) Spare desiccant modules: If noted.
    - a) Quantity: As noted.
  - 4) Cable Hanger, Kellems Type Grip: Required, unless otherwise noted.
  - 5) Lightning Protection:
    - a) Internal (protects against water lightning strike): Required, unless otherwise noted.
    - b) External (protects 4 mA to 20 mA dc output): Required, unless otherwise noted.
- 5. Signal Interface: 4 mA to 20 mA dc output, for load impedance of 0 ohm to 750 ohms, minimum for 24V dc supply without load adjustment.
- 6. Electrical Connection: 1/2-inch, 14 NPT male conduit fitting with molded cable seal, unless otherwise noted.
- 7. Certification(s):
  - a. Class I, Div 1, Groups A, B, C, and D.
  - b. Class II, Div 1, Groups E, F, and G.
  - c. Class III, Div 1.
- 8. Manufacturer and Model: Esterline; KPSI Model 750.

**END OF COMPONENT SPECIFICATIONS**



## INSTRUMENT CALIBRATION SHEET

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COMPONENT			MANUFACTURER				PROJECT				
Code:			Name:				Number:				
Name:			Model:				Name:				
			Serial #:								
FUNCTIONS											
Indicate? Y / N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? Y / N			CONTROL? Y / N				
	Chart:			Describe:			Action? direct / reverse Modes? P / I / D				
Record? Y / N	Scale:						SWITCH? Y / N				
Transmit/ Convert? Y / N	Input:						Unit Range:				
	Output:						Differential: <span style="float: right;">fixed/adjustable</span> Reset? automatic / manual				
ANALOG CALIBRATIONS						DISCRETE CALIBRATIONS					Note No.
REQUIRED			AS CALIBRATED			REQUIRED			AS CALIBRATED		
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point (note rising or falling)	Reset Pt.	Trip Point (note rising or falling)	Reset Pt.
			Indicated	Output	Indicated	Output					
							1.				
							2.				
							3.				
							4.				
							5.				
							6.				
CONTROL MODE SETTINGS:			P:	I:	D:		7.				
#	NOTES:									<b>Component Calibrated and Ready for Startup</b>	
										By:	
										Date:	
										Tag No.:	

**INSTRUMENT CALIBRATION SHEET**  
**EXAMPLE - ANALYZER/TRANSMITTER**

Rev.06.05.92

COMPONENT			MANUFACTURER				PROJECT				
Code: A7			Name: Leeds & Northrup				Number: WDC30715.B2				
Name: pH Element & Analyzer/Transmitter			Model: 12429-3-2-1-7				Name: UOSA AWT PHASE 3				
			Serial #: 11553322								
FUNCTIONS											
Indicate? Y Record? N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N			CONTROL? N				
	Chart:			Describe:			Action? direct / reverse Modes? P / I / D				
Transmit/ Convert? Y	Scale:	1-14	pH units				SWITCH? N				
	Input:	1-14	pH units				Unit Range:				
	Output:	4-20	mA dc				Differential: fixed/adjustable				
							Reset? automatic / manual				
ANALOG CALIBRATIONS							DISCRETE CALIBRATIONS				Note No
REQUIRED			AS CALIBRATED				REQUIRED			AS CALIBRATED	
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.
			Indicated	Output	Indicated	Output					
1.0	1.0	4.0	1.0	4.0	1.0	3.9	1.	N.A.		N.A.	
2.3	2.3	5.6	2.2	5.5	2.3	5.6	2.				
7.5	7.5	12.0	7.5	11.9	7.5	12.0	3.				
12.7	12.7	18.4	12.7	18.3	12.6	18.3	4.				
14.0	14.0	20.0	14.0	20.0	14.0	20.0	5.				
							6.				
CONTROL MODE SETTINGS:			P: N.A.	I:	D:		7.				
#	<b>NOTES:</b>										<b>Component Calibrated and Ready for Startup</b>
	1. Need to recheck low pH calibration solutions.										
											By: J.D. Sewell
											Date: Jun-6-92
											Tag No.: AIT-12-6[pH]

## I&C VALVE ADJUSTMENT SHEET

Rev.06.05.92

<b>PARTS</b>	Project Name:		Project Number:		
<b>Body</b>	Type:		Mfr:		
	Size:		Model:		
	Line Connection:		Serial #:		
<b>Operator</b>	Type:		Mfr:		
	Action:		Model:		
	Travel:		Serial #:		
<b>Positioner</b>	Input Signal:		Mfr:		
	Action:		Model:		
	Cam:		Serial #:		
<b>Pilot Solenoid</b>	Action:		Mfr:		
	Rating:		Model:		
			Serial #:		
<b>I/P Converter</b>	Input:		Mfr:		
	Output:		Model:		
	Action:		Serial #:		
<b>Position Switch</b>	Settings:		Mfr:		
	Contacts:		Model:		
			Serial #:		
<b>Power Supply</b>	Type:		Air Set Mfr:		
	Potential:		Model:		
			Serial #:		
<b>ADJUSTMENTS</b>	Initial	Date	<b>VERIFICATION</b>	Initial	Date
Air Set			Valve Action		
Positioner			Installation		
Position Switches			Wire Connection		
I/P Converter			Tube Connection		
Actual Speed					
<b>REMARKS:</b>				<b>Valve Ready for Startup</b>	
				By:	
				Date:	
				Tag No.:	

PW/WBG/467807C  
NOVEMBER 11, 2015

INSTRUMENTATION AND CONTROL  
FOR PROCESS SYSTEMS  
40 90 01 SUPPLEMENT 2 - 1

**I&C VALVE ADJUSTMENT SHEET**  
**EXAMPLE**

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<b>PARTS</b>	Project Name: <i>SFO SEWPCP</i>		Project Number: <i>SFO10145.G2</i>		
<b>Body</b>	Type: <i>Vee-Ball</i>		Mfr: <i>Fisher Controls</i>		
	Size: <i>4-inch</i>		Model: <i>1049763-2</i>		
	Line Connection: <i>159 # ANSI Flanges</i>		Serial #: <i>1003220</i>		
<b>Operator</b>	Type: <i>Pneumatic Diaphragm</i>		Mfr: <i>Fisher Controls</i>		
	Action: <i>Linear - Modulated</i>		Model: <i>4060D</i>		
	Travel: <i>3-inch</i>		Serial #: <i>2007330</i>		
<b>Positioner</b>	Input Signal: <i>3-15 psi</i>		Mfr: <i>Fisher Controls</i>		
	Action: <i>Direct - air to open</i>		Model: <i>20472T</i>		
	Cam: <i>Equal percentage</i>		Serial #: <i>102010</i>		
<b>Pilot Solenoid</b>	Action:		Mfr:		
	Rating: <i>None</i>		Model:		
			Serial #:		
<b>I/P Converter</b>	Input: <i>4-20 mA dc</i>		Mfr: <i>Taylor</i>		
	Output: <i>3-15 psi</i>		Model: <i>10-T-576-3</i>		
	Action: <i>Direct</i>		Serial #: <i>1057-330</i>		
<b>Position Switch</b>	Settings: <i>Closed / Open 5 deg, rising</i>		Mfr: <i>National Switch</i>		
	Contacts: <i>Close / Close</i>		Model: <i>1049-67-3</i>		
			Serial #: <i>156 &amp; 157</i>		
<b>Power Supply</b>	Type: <i>Pneumatic</i>		Air Set Mfr: <i>Air Products</i>		
	Potential: <i>40 psi</i>		Model: <i>3210D</i>		
			Serial #: <i>1107063</i>		
<b>ADJUSTMENTS</b>	Initial	Date	<b>VERIFICATION</b>	Initial	Date
Air Set	<i>JDS</i>	<i>Jun-06-92</i>	Valve Action	<i>JDS</i>	<i>Jun-03-92</i>
Positioner	<i>JDS</i>	<i>Jun-06-92</i>	Installation	<i>JDS</i>	<i>Jun-03-92</i>
Position Switches	<i>JDS</i>	<i>Jun-06-92</i>	Wire Connection	<i>JDS</i>	<i>Jun-04-92</i>
I/P Converter	<i>JDS</i>	<i>Jun-07-92</i>	Tube Connection	<i>JDS</i>	<i>Jun-04-92</i>
Actual Speed	<i>JDS</i>	<i>Jun-07-92</i>			
<b>REMARKS:</b> <i>Valve was initially installed backwards.</i>				<b>Valve Ready for Startup</b>	
<i>Observed to be correctly installed May-25-92</i>				By: <i>J.D. Sewell</i>	
				Date: <i>Jun-07-92</i>	
				Tag No.: <i>FCV-10-2-1</i>	





**PERFORMANCE ACCEPTANCE TEST SHEET**  
**EXAMPLE**

Rev.06.05.92

Project Name: <i>SFO SEWPCP Plant Expansion</i>		Project No.: <i>SFO12345.CI</i>	
<b>Demonstration Test(s): For each functional requirement of the loop:</b>			
(a) List and number the requirement. (b) Briefly describe the demonstration test.			
(c) Cite the results that will verify the required performance. (d) Provide space for signoff.			
<i>1. MEASURE EFFLUENT FLOW</i>			
<i>1.a With no flow, water level over weir should be zero and</i>			
<i>FIT indicator should read zero.</i>			<i>Jun-20-92 BDG</i>
<i>2. FLOW INDICATION AND TRANSMISSION TO LP &amp; CCS</i>			
<i>With flow, water level and FIT indicator should be related by expression</i>			
<i><math>Q(\text{MGD}) = 429 * H^{**}(2/3)</math> (<i>H</i> = height in inches of water over weir).</i>			
<i>Vary H and observe that following.</i>			
<i>2.a Reading of FIT indicator.</i>			<i>Jun-6-92 BDG</i>
<i>2.b Reading is transmitted to FI on LP-521-1.</i>			<i>Jun-6-92 BDG</i>
<i>2.c Reading is transmitted and displayed to CCS.</i>			<i>Jun-6-92 BDG</i>
<i>H(measured)</i>	<i>0</i>	<i>5</i>	<i>10 15</i>
<i>Q(computed)</i>	<i>0</i>	<i>47.96</i>	<i>135.7 251.7</i>
<i>Q(FIT indicator)</i>	<i>0</i>	<i>48.1</i>	<i>137 253</i>
<i>Q(LI on LP-521-1)</i>	<i>0</i>	<i>48.2</i>	<i>138 254</i>
<i>Q(display by CCS)</i>	<i>0</i>	<i>48.1</i>	<i>136.2 252.4</i>
<b>Forms/Sheets Verified</b>			
By	Date		<b>Loop Accepted By Owner</b>
Loop Status Report	<i>J.D. Sewell</i>	<i>May-18-92</i>	By: <i>J.D. Smith</i>
Instrument Calibration Sheet	<i>J.D. Sewell</i>	<i>May-18-92</i>	Date: <i>Jun-6-92</i>
I&C Valve Calibration Sheet	<i>N.A.</i>		
<b>Performance Acceptance Test</b>			
By	Date		
Performed	<i>J. Blow MPSDC Co.</i>	<i>Jun-6-92</i>	
Witnessed	<i>B.deGlanville</i>	<i>Jun-6-92</i>	Loop No.: <i>30-12</i>

**SECTION 44 42 35**  
**SEWAGE GRINDER AND APPURTENANCES**

**PART 1      GENERAL**

1.01      SUMMARY

- A.    This section of the specification describes the sewage grinder(s) and controller(s). The equipment shall be installed as shown on the plans, as recommended by the supplier, and in compliance with all OSHA, local, state and federal codes and regulations.
- B.    The number of grinder(s) and controller(s) shall be one.
- C.    The grinder shall be capable of processing the peak sewage flow with a maximum head loss of 9-1/2 inches at a downstream water level at or below the invert of the inlet channel.
- D.    This specification is supplemented by the data and drawings provided of the installation site, conditions and performance requirements. Review drawings for normal and peak capacity requirements along with installation requirements/conditions.

1.02      REFERENCES

- A.    Grinder(s) shall, as applicable, meet the requirements of the following industry standards:
  - 1.    American Society for Testing and Materials (ASTM) A36: Standard Specification for Carbon Steel Plate.
  - 2.    American Society for Testing and Materials (ASTM) A536-84: Standard Specification for Ferritic Ductile Iron Castings.
  - 3.    American Iron and Steel Institute (AISI) 303 Stainless Steel.
  - 4.    American Iron and Steel Institute (AISI) 304 and 316 Stainless Steel.
  - 5.    American Iron and Steel Institute (AISI) 4130 Heat Treated Alloy Steel.
  - 6.    American Iron and Steel Institute (AISI) 4140 Heat Treated Hexagon Steel.
  - 7.    Rockwell C.
- B.    Controllers shall, as applicable, meet the requirements of the following Regulatory Agencies.
  - 1.    National Electrical Manufacturer's Association (NEMA) Standards.
  - 2.    National Electrical Code (NEC).
  - 3.    Underwriters Laboratory (UL and cUL).

### 1.03 QUALITY ASSURANCE

- A. Qualified suppliers shall have a minimum 15 years' experience at manufacturing, support systems, two (2)-shafted grinding equipment and controls with a minimum of 3,000 installations with similar equipment. Supplier shall provide a list of names and dates of installations for verification by the Engineer or Owner's Representative.
- B. Supplier shall provide the services of a factory-trained representative to check the installation and to start-up each grinder and controller. The factory representative shall have complete knowledge of proper installation, operation, and maintenance of equipment supplied. Representative shall inspect the final installation and supervise a start-up test of the equipment.
- C. Each grinder and controller shall be factory tested to ensure satisfactory operation.

### 1.04 DELIVERY, STORAGE AND HANDLING

- A. The equipment shall be packaged in containers constructed for normal shipping, handling and storage.
- B. The containers shall provide adequate protection for the equipment in a dry indoor environment between plus 40 degrees F (+4.5°C) and plus 100 degrees F (+37.8°C) until time for installation.

### 1.05 IDENTIFICATION

- A. Each unit of equipment shall be identified with a corrosion resistant nameplate, securely affixed in a conspicuous place. Nameplate information shall include equipment model number, serial number, supplier's name, and location.

## **PART 2 PRODUCTS**

### 2.01 MANUFACTURERS

- A. Grinder(s) and controller(s) shall be in compliance with these specifications and plans and shall be supplied by:
  - 1. JWC Environmental: Muffin Monster.
  - 2. Approved equal.
- B. Manufacturers requesting to be selected as an approved equal shall submit certified documentation showing compliance with these specifications a minimum of ten (10) days prior to bid opening. Selected equipment manufacturers shall be added to the list of approved manufacturers.

- C. The manufacturer must certify that the unit can be returned for maintenance to the factory or a local repair facility. The certification shall include a statement that there will be no charge for repair labor.

## 2.02 SUPPORT SYSTEM(S)

- A. The support frame and additional supports shall be of welded square tube, angle, and plate construction. The construction material shall be Type 316 stainless steel.
- B. The grinder shall have dual guide rails made of Type 316 stainless steel.

## 2.03 GRINDER(S)

### A. General:

1. Each grinder shall include cutters, spacers, shafts, bearings and seals, side rails, end housings, covers, reducer, and hydraulic drive unit.
2. The grinder shall be of two (2)-shaft design and be capable of continuous operation, processing wet or dry. Bar screens or single-shaft devices utilizing a single rotating cutter bar with stationary cutters shall not be acceptable. Grinders designed with cutter and spacer cartridges rather than individual cutters and spacers, shall not be acceptable.
3. Two (2)-shaft design shall consist of two (2) parallel shafts alternately stacked with individual intermeshing cutters and spacers positioned on the shaft to form a helical pattern. The two (2) shafts shall counter-rotate with the driven shaft operating at approximately two-thirds (2/3) the speed of the drive shaft. Cutter diameters on the drive and driven shafts shall be of equal diameter.

### B. Components:

1. Individual Cutters and Spacers:
  - a. The cutting chamber shall be a nominal height of 8 inches, minimum.
  - b. Individual cutters and spacers shall be 4130 or 4140 heat treated alloy steel, surface ground for uniformity and through-hardened to a minimum 45-50 Rockwell C.
  - c. The inside configuration of both the individual cutters and the individual spacers shall be hexagonal so as to fit the shafts with a total clearance not to exceed 0.015 inch (0.38 mm) across the flats to assure positive drive, minimize wear on the cutters.

- d. Cutter configuration shall consist of individual (min 7, max 11 tooth) cam cutters on both shafts. To maintain particle size, the height of the tooth shall not exceed 1/2 inch (13 mm) above the root diameter. Cutter to cutter root diameter overlap shall be not less than 1/16 inch (1.6 mm) or greater than 1/4 inch (6 mm) to maintain the best possible cutting efficiency while incurring the least amount of frictional losses. Clearing between overlapping cutters of opposing shafts shall be no greater than 0.015 inches (0.38 mm).
  - e. The cutters shall exert a minimum continuous force of 450 lbs/hp and 1,430 lbs/hp during momentary load peaks.
2. Shafts:
- a. Grinder drive and driven shafts shall be made of 4140 heat treated hexagon steel with a tensile strength rating of not less than 135,000 psi.
  - b. Each hexagonal shaft shall measure a nominal 2 inches (51 mm) across parallel surfaces.
3. Shaft Bearings and Seals:
- a. The radial and axial loads of the cutter shafts shall be borne by sealed, oversized, deep- groove ball bearings at each end.
  - b. The bearings shall be protected by a combination of a replaceable and independent tortuous path device and end face mechanical seals.
  - c. Face materials shall be tungsten carbide to tungsten carbide.
  - d. O-rings shall be made of Buna-N elastomers.
  - e. Products requiring continuous or occasional lubrication or flushing shall not be accepted.
  - f. The mechanical seal shall be rated at 90 psi (620 kPa) continuous duty by the seal supplier.
  - g. The bearings shall be housed in a replaceable cartridge that supports and aligns the bearings and seals, as well as protects the shafts and end housings. The seal elements shall be independent of the stack height; therefore cutter stack tightness shall not affect seal performance. The seal elements shall maintain their factory set preload independent of the cutter stack tightness.
  - h. Seals shall meet required pressure rating regardless of cutter stack fit. The seal cartridge shall provide seal protection against axial loading on shafts and bearings during shaft deflection.
  - i. Each seal element shall be positively locked to its corresponding rotating or static cartridge element. This positive lock on the seal elements is critical to long seal life in applications where grit or other abrasive materials are present.

4. Side Rails:
  - a. The inside profile of the cutter side rails shall be concave to follow the radial arc of the cutters.
  - b. Clearance between the major diameter of the cutters and the concave arc of the side rails shall not exceed 5/16 inch (7.9 mm).
  - c. The side rails shall have evenly slots that increase flow and decrease head loss. The slots shall only be built into the influent side of the side rail and the effluent side of the side rail shall be void of slots to allow for maximum flow of the processed effluent.
  - d. The grinder side rails shall be cast of A536-84 ductile iron.
5. End Housings and Covers:
  - a. Grinder end housings shall be of cast A536-84 ductile iron with a cast-in-place flow deflector, designed to protect the bushings while guiding particles directly into the cutting chamber.
  - b. Top covers shall be A536-84 ductile iron and bottom covers shall be A36 hot rolled plates.
6. Reducer:
  - a. The speed reducer shall be a grease-filled planetary-type of reducer with a 500 percent shock load capacity. The reduction ratio shall be 29:1.
  - b. The input shaft of the reducer shall be directly coupled to the drive unit. The output shaft of the reducer shall be directly coupled with the grinder using a two (2)-piece coupling.
7. Drive Unit:
  - a. Hydraulic Power Pack sized by the manufacturer.
  - b. Manufacturer shall provide sufficient hydraulic hose and associated components for the installation.
  - c. Electric/submersible motor driven units are not acceptable.

## 2.04 CONTROLLER

### A. General:

1. The controller shall provide independent control of the grinder.
2. Controller shall be the supplier's standard UL/cUL listed Model PC2200.

### B. Operation:

1. The controller shall be equipped with a GRINDER ON OFF/RESET-REMOTE three (3) position selector switch.
  - a. In the OFF/RESET position, the grinder shall not run.
  - b. In the ON position, the grinder shall run continuously.
  - c. In the REMOTE mode, the grinder shall start and stop as controlled by a remotely-located dry contact.
  - d. The grinder shall only be reset by switching the GRINDER ON-OFF/RESET-REMOTE switch to the OFF/RESET position.

C. Components:

1. Enclosure:
  - a. Enclosures shall be NEMA 4X, fabricated of fiberglass-reinforced polyester resins, and shall be suitable for wall mounting. Doors shall have hinges and corrosion-resistant latches.
  - b. Enclosure shall house the control devices, relays, terminal blocks and reversing starters.
2. Control Devices:
  - a. Pilot devices shall be mounted on the enclosure front panel door.
  - b. The controller shall have indicator lights for POWER ON, RUN, and FAIL.
  - c. Indicator lights shall be LED type pilot lights. Lights and the selector switches shall be heavy duty NEMA 4X type.
  - d. Control transformer shall be protected by two (2) primary fuses and one (1) secondary fuse. The 120-volt secondary shall have one (1) leg grounded.
  - e. Relay contacts shall be included for GRINDER run and FAIL signal outputs. The contacts shall be rated two (2) ampere, 240V ac, resistive load.
3. Hydraulic Power Pack:
  - a. Allow for forward and reverse operation with mechanical and electrical interlocks.
  - b. Overload relays (OL) shall be adjustable so that the range selected includes the FLA (full load amperes) rating and service factor.

D. Safety Features:

1. When a grinder jam condition occurs in the grinder ON or REMOTE mode the controller shall stop the grinder, and reverse grinder rotation to clear the obstruction. If the jam is cleared, the controller shall return the grinder to normal operation. Up to two (2) additional reversing cycles (3 times total) may occur within 30 seconds before the controller de-energizes the grinder and activates the grinder fail indicator and relay.
2. If a power failure occurs while a grinder is running, operation will resume when power is restored.
3. If a power failure occurs while the grinder is in a fail condition the fail indicator shall reactivate when power is restored.
4. The controller shall provide overload protection for the motor through an overload relay mounted directly on the grinder starter.
5. Short-circuit protection requires that a properly-sized circuit breaker or fuses be installed.
6. Controller reset shall be from the local panel controls only.



**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A. Grinder(s) and controller(s) shall be installed in accordance with the supplier's installation instructions, and in compliance with all OSHA, local, state, and federal codes and regulations.

**3.02 OPERATIONS MANUAL**

- A. Prior to start-up and training, provide the ESD three hard copies and one digital copy of an operating and maintenance manual for the grinder and all installed components.

**3.03 MANUFACTURER'S SERVICES**

- A. Manufacturer's Representative: Present at Site or classroom designated by ESD for minimum person-days listed below, travel time excluded:
  - 1. 1 person-days for installation assistance and inspection.
  - 2. 0.5 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
  - 3. 0.5 person-day for post-startup training of the ESD staff.
- B. Manufacture shall provide a certificate or proper installation grinder and control panel.

**END OF SECTION**



**SECTION 44 42 50**  
**SUBMERSIBLE PUMPS FOR SMALL**  
**WASTEWATER PUMP STATIONS (< 200 GPM)**

**PART 1      GENERAL**

1.01      SUMMARY

- A.    This Specification details the requirements for small residential and commercial wastewater pump stations. Small stations are defined as having a peak hour flow (PHF) capacity of less than 200 gpm.
- B.    This is not intended to be an all-inclusive specification for the construction of a submersible type station. Site and conditions may make it necessary to modify the requirements of this section.
- C.    All pump stations shall include a minimum of two pumps (duplex arrangement) sized to convey the PHF with one pump out of service.
- D.    All pump stations shall include a Mission unit for remote monitoring in accordance with Section 40 90 01, Instrumentation and Control for Process Systems.
- E.    Pump station shall be provided with a standby engine pump or generator. Standby engine driven pump or generator shall be natural gas fueled unless service is not available.
- F.    This specification is supplemented by the data and drawings provided of the installation site, conditions and performance requirements. Review drawings for:
  - 1.    Capacity (GPM).
  - 2.    Total Dynamic Head (FT).
  - 3.    Total Discharge Static Head (FT).
  - 4.    Minimum Submergence Depth (FT).

1.02      REFERENCES

- A.    The following is a list of standards that may be referenced in this section:
  - 1.    American Bearing Manufacturers Association (ABMA):
    - a.    9, Load Ratings and Fatigue Life for Ball Bearings.
    - b.    11, Load Rating and Fatigue Life for Roller Bearings.
  - 2.    American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 150.

3. ASTM International (ASTM):
  - a. A48, Standard Specification for Gray Iron Castings.
  - b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
4. Hydraulic Institute Standards (HIS):
  - a. 11.6, Submersible Pump Test.
  - b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA):
  - a. 70, National Electrical Code.
  - b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
7. Underwriters Laboratories Inc. (UL).

#### 1.03 DEFINITIONS

- A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

#### 1.04 EXTRA MATERIALS

- A. Furnish for this set of pumps:
  1. One set mechanical seals.
  2. One complete set of special tools required to dismantle pump.
  3. Impeller.

### **PART 2 PRODUCTS**

#### 2.01 GENERAL

- A. Submersible, vertical shaft, centrifugal nonclog type, for pumping wastewater.
- B. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.
- C. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.

- D. Where adjustable frequency drives are required or specified, furnish a coordinated operating system complete with pump, drive, and speed controller.
- E. Pumps and associated components to include the control panel to be provided by a single manufacturer.

## 2.02 MANUFACTURERS

- A. Acceptable manufacturers are:
  - 1. ABS.
  - 2. Flygt.
  - 3. No equal or alternate will be accepted.

## 2.03 COMPONENTS

- A. Equipment consists of pump complete with motor, control system, guide rail, anchoring brackets, base elbow, power cable, and pump lifting cable, access hatch(s) and control panel and level switches.
- B. Characteristics:
  - 1. Motor and rotating parts shall be removable from motor end of pump.
  - 2. Mating surfaces to be watertight and fitted with nitrile O-rings.
  - 3. Pumps fitted with dynamically balanced nonclog impellers designed to pass coarse solids and stringy materials.
- C. Lifting Arrangement:
  - 1. Type 316 stainless steel chain, 2 feet minimum, and one “grip-eye.”
  - 2. Attach chain permanently to pump and access platform with stainless steel wire rope.
  - 3. “Grip-eye” capable of being threaded over and engaging links of stainless steel chain so pump and motor may be lifted with “grip-eye” and independent hoist.
- D. Sliding Guide Bracket:
  - 1. Integral part of pump unit.
  - 2. Pump unit to be guided by no less than two guide bars of Type 316 stainless steel construction, and pressed tightly against discharge connection elbow with metal-to-metal contact or through use of profile-type gasket, provided gasket is attached to pump’s flange and can be easily accessed for inspection when pump is lifted out of wetwell.

3. Pump metal parts that come into contact with guide rail or cable system shall be made of nonsparking materials.
- E. Motor nameplate horsepower not to be exceeded at head-capacity point on pump curve.
  - F. Pump motor and sensor cables shall be suitable for submersible pump application and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.
  - G. Motor Protection Module: If required, provide pump with a motor protection module for remote mounting. Contract Drawings are based on first named submersible pump manufacturer and motor protection module. If pump and motor protection module other than first named manufacturer is provided, provide revised wiring for the motor protection module.
  - H. Cable Entry System:
    1. Junction chamber and motor separated by stator lead sealing gland or terminal board that prevents foreign material entering through pump top.
    2. Utilize cable with factory-installed sealing gland with nonshrink epoxy seal system.
    3. O-ring compression seal between sealing gland and cable entry point shall also be acceptable.

#### 2.04 CONTROL PANEL

- A. Type 304 stainless steel, NEMA 4X enclosure, for outdoor duty.
- B. Refer to Section 40 90 01, Instrumentation and Control for Process Systems, for panel requirements.
- C. Free standing, post mounted.
- D. Features:
  1. Main circuit breaker disconnect interlocked with panel door.
  2. Combination circuit breaker type, NEMA rated motor starters.
  3. Fused control power transformer, 120V ac.
  4. Alternator and pump lead-lag controls.
  5. ON/OFF/AUTO switches.
  6. Running lights.
  7. High level indication.

8. Normally closed, dry, 5 amps at 120V ac contacts for remote indication of:
    - a. High level alarm.
    - b. Pump failure (temperature or moisture alarm).
  9. Terminal strip for interfacing with external wiring.
  10. High temperature indication.
  11. Moisture alarm indication.
  12. Alarm (high temperature, moisture, or high level) beacon located on top of panel.
  13. Lightning protection.
  14. Intrinsically safe relays as required for UL validation.
  15. Alarm silence button.
  16. Phase failure relay.
  17. Document pocket located inside panel with pump and panel operation and maintenance manual, and separate laminated pump curve.
  18. 110-volt, duplex GFI outlet, weather-protected, and accessible from outside of panel.
  19. Run hour meter.
  20. 100 watts minimum, condensation heater with thermostat.
  21. UL listing mark.
- E. Prewired and factory tested.
- F. Air conditioned where required for proper operation of controls and adjustable/variable frequency drive.
- G. Mount control switches, indicating lights, and switches on hinged front panel.
- H. Single Feed: 480 volts, three-phase.

## 2.05 ACCESSORIES

- A. Level Switches: In accordance with Section 40 90 01, Instrumentation and Control for Process Systems, component L8 and for:
  1. Low Low Level: Pumps off.
  2. High High Level: Alarm.
- B. Level Transmitter: In accordance with Section 40 90 01, Instrumentation and Control for Process Systems, Component L52.
- C. Variable/Adjustable frequency drive where specified and required by the ESD.

- D. Equipment Identification Plate: 16-gauge Type 316 stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
- E. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.
- F. Sidewalk Door: Sized by equipment manufacturer with the following additional requirements:
  - 1. Gasketed and odor tight.
  - 2. Channel drain is not required.
  - 3. Aluminum.

## 2.06 ADJUSTABLE/VARIABLE FREQUENCY DRIVE

### A. General:

- 1. Design and provide drive system consisting of adjustable frequency controller, drive motor, certain auxiliary items, and components necessary for complete operating system.
- 2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
- 3. Furnish VFDs rated on basis of actual motor full load nameplate current rating.
- 4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using the pulse-width-modulation (PWM) technique to produce the adjustable frequency output.
- 5. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for the drive system.
- 6. Incoming Line Reactor: Design to minimize harmonic distortion on the incoming power feeder.
- 7. Operator Interface with the following functions:
  - a. Start (when in local mode).
  - b. Stop (when in local mode).
  - c. Speed increase (when in local mode).
  - d. Speed decrease (when in local mode).
  - e. Parameter mode selection (recall programmed parameters).
  - f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 to 20 mA analog signal).
  - g. Fault reset, manual for all faults (except loss of ac voltage which is automatic upon return).



- h. RUN/preset speed.
- i. Parameter lock (password or key switch lockout of changes to parameters).
- j. Start disable (key switch or programmed code).

B. Service Conditions:

- 1. Ambient Operating Temperature: 32 to 104 degrees F.
- 2. Storage Temperature: Minus 40 to 158 degrees F.
- 3. Humidity: 0 to 95 percent relative (noncondensing).
- 4. Altitude: 0 to 3,300 feet. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

C. Manufacturer:

- 1. ABB.
- 2. Eaton.
- 3. Approved equal.

2.07 PIPING

- A. Piping shall be ductile iron in accordance with Section 40 27 00, Force Main Piping-General. Transition to high density polyethylene pipe is permitted at property line of the pump station or as approved by the ESD after the valve vault and self-regulated automatic valve(s).
- B. Heat trace and insulate all exposed piping in accordance with Sections 40 42 13, Process Piping Insulation and 40 05 33, Pipe Heat Tracing.

2.08 FACTORY FINISHING AND TESTING

- A. Manufacturer's standard finish for outside installation in a corrosive environment.
- B. Functional Test: Perform manufacturer's standard test on equipment.
- C. Performance Test:
  - 1. In accordance with Hydraulic Institute Standards.
  - 2. Adjust, realign, or modify units and retest accordance with Hydraulic Institute Standards if necessary.
- D. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

## 2.09 SOURCE QUALITY CONTROL

### A. Control Panel:

1. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

## **PART 3 EXECUTION**

### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's printed instructions.
- B. Mount the discharge elbow to the floor of the wetwell floor with stainless steel bolts.
- C. Connect piping without imposing strain to flanges.
- D. No portion of pump shall bear directly on floor of sump.

### 3.02 FIELD QUALITY CONTROL

- A. Functional Test: With the ESD Electrician and the Engineer present conduct on each pump.
  1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
  2. Flow Output: Measured by calibrated temporary flow measurement device.
  3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
  4. Test for continuous 3-hour period.

### 3.03 OPERATIONS MANUAL

- A. Prior to start-up of station and training, provide the ESD three hard copies and one digital copy of an operating and maintenance manual for the overall pump station and all installed components.

### 3.04 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: Present at Site or classroom designated by ESD for minimum person-days listed below, travel time excluded:
  1. 1 person-days for installation assistance and inspection.
  2. 0.5 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
  3. 0.5 person-day for post-startup training of the ESD staff.

- B. Manufacture shall provide a certificate or proper installation for the pumps and control panel.

**END OF SECTION**



**SECTION 44 42 55**  
**STANDBY ENGINE DRIVEN PUMP**

**PART 1 GENERAL**

1.01 DESCRIPTION

- A. This section includes the Work necessary to provide one permanent skid-mounted, engine driven, self-priming centrifugal pump, complete with sound-attenuating enclosure, automatic priming system, instrumentation and control system, and all other appurtenances as specified herein.
- B. It is the preference of the ESD that the pump engine be natural gas fueled.

1.02 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
  - 1. American Bearing Manufacturers Association (ABMA):
    - a. 9, Load Ratings and Fatigue Life for Ball Bearings.
    - b. 11, Load Rating and Fatigue Life for Roller Bearings.
  - 2. American National Standards Institute (ANSI): B16.1, Standard for Cast Iron Pipe Flanges and Flanged Fittings.
  - 3. Hydraulic Institute Standards (HIS).
  - 4. Underwriters Laboratories Inc. (UL).

1.03 WARRANTY

- A. The manufacturer shall warrant to the Owner the equipment against defects in material and workmanship for a period of 18 months from the date of acceptance. This warranty shall cover the cost of labor and materials required to correct any warrantable defect.

1.04 EXTRA MATERIALS

- A. Furnish for each pump provided, packaged and labeled in box for storage:
  - 1. One set of pump bearings.
  - 2. One set of gaskets for each pump joint.
  - 3. One complete pump mechanical seal.
  - 4. One pump casing wear ring.
  - 5. Two engine air filters.
  - 6. Two engine oil filters.
  - 7. Two engine fuel filters.
  - 8. One complete set of special tools required to dismantle pump.
- B. Diesel (as applicable for pump motor type): Full diesel tank, after final startup, testing and acceptance.

## 1.05 DELIVERY AND STORAGE

- A. Pump shall not be delivered to the project site no more than 90 days prior to facility startup.
- B. The Contractor shall exercise the pump regularly as recommended by manufacturer.
- C. Failure to maintain pump in like-new condition prior to startup and acceptance will be cause for rejection of the pumps.

## **PART 2 PRODUCTS**

### 2.01 MANUFACTURERS

- A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.
- B. The pump shall be one of the following listed manufacturers and standard model numbers, furnished as modified to conform to the performance, functions, features, and materials of construction as specified herein:
  - 1. Godwin.
  - 2. Cornell Pump Company.
  - 3. Or approved equal.

### 2.02 GENERAL

- A. Provide pumping unit of the end suction, single-stage centrifugal type, each driven by a natural gas or diesel engine. Design the pumping units to prevent undue wear and clogging.
- B. The pump and accessories shall be supplied by the pump manufacturer.
- C. The pump shall be fitted with a fully automatic priming system incorporating either of the following:
  - 1. Air compressor, air ejector assembly, and an air/water separation tank. The air ejector shall operate on the discharge side of the compressor, eliminating the possibility of water being drawn into the air source
  - 2. Venture type prime system.
  - 3. Vacuum pump.
- D. No water shall be required in the pump to achieve a prime.

- E. Priming systems that require manual water additions to facilitate pump priming are not acceptable. A demonstration of the pump's ability to repeatedly cycle from dry suction/pump/snore/repriming/pump shall be required. This will necessitate the draining of all residual water from the pump case to initiate a dry suction starting condition.
- F. Pump to be fully automatic, needing no form of adjustment on priming system. The pump shall be capable of static suction lifts to 28 feet, vertical, at sea level. It shall also be capable of operation using extended suction lines.
- G. Equipment acceptance shall be contingent upon its ability to run in a completely dry condition for periods up to 24 continuous hours at full speed. This requires the draining of all residual water to initiate a dry suction starting condition. A demonstration may be required by the ESD.
- H. The pump offered shall be a manufacturer's standard production model. It shall have been in continuous use by municipal and industrial owners for a minimum of 5 years. A list of five user contacts including contact names and telephone numbers may be requested by ESD should a pump manufacturer other than that listed in the section above be proposed. Failure to supply a verifiable users list may be cause for rejection of the pump.

## 2.03 CONSTRUCTION

- A. Pump casings shall be cast iron. Pump design shall incorporate a direct suction flow path that is in axial alignment with the impeller eye. There shall be no turns, chambers, or valves between the suction flange and the impeller eye.
- B. The pump impeller shall be of non-clog type. The impeller shall be two-bladed, of hardened cast chromium steel construction or cast iron.
- C. Pumps shall either have wear plates or wear rings.
  - 1. Wear plates shall be fully adjustable and replaceable, fabricated of cast iron. Wear plate clearances shall have no relationship to the ability of the pump to achieve a prime. The pump wear plates shall be of a diameter equal to or greater than the impeller diameter to ensure maximum protection to the pump casing.
  - 2. Wear rings shall be easily replaceable.
- D. Pump shall be fitted with a bearing bracket that contains the shaft and heavy duty ball or tapered roller bearings of adequate size to withstand imposed loads. Minimum I.S.O. L-10 bearing life to be 100,000 hours at design condition. Impeller shaft shall be of 1-1/2 percent chromium alloy and have a minimum diameter of 60 mm at the pump seal.

- E. Seals shall be high pressure, mechanical self-adjusting type capable of withstanding suction pressures to 100 psi. The mechanical seal shall be cooled and lubricated in an oil bath reservoir, requiring no maintenance or adjustment. Pump shall be capable of running dry, with no damage, for periods up to 24 hours. All metal parts shall be of stainless steel.
- F. Pump suction and discharge flanges shall be cast iron ANSI B16.1, Class 125, raised faced. The casing shall have tapped and plugged holes for draining.
- G. Pump gaskets shall be compressed fiber and/or Teflon.
- H. Pump O-rings shall be Viton.
- I. Pump shall be supplied with an integral check valve mounted on the discharge flange of the pump, allowing unrestricted flow into the impeller. The check valve shall prevent in-line return of flow when the pump is shut off.
- J. Drive Unit: Natural gas (or where approved Diesel) engine shall be water-cooled. Engine shall drive pump by use of direct connected intermediate drive plate. Starter shall be 12-volt electric. Safety shut-down switches for low oil pressure and high temperature shall be integral to the pump control panel. A tachometer and an hourmeter shall be integral to the pump control panel. Battery shall have 180 amp-hour rating.
- K. Governor shall be electronic type. Engine speed shall be adjustable to operate the pump between maximum and minimum design operation speeds.
- L. Exhaust system shall include a hospital grade muffler housed in a separate chamber within the enclosure. All exhaust piping and manifolds shall be encased in fitted acoustic blankets. They shall be constructed of high-density fiberglass material with waterproof jacketing.
- M. Sound-Attenuating Enclosure: The engine and pump shall be completely enclosed with sheet metal panels backed with 1-inch and 2-inch layers of polydamp acoustical sound-deadening material. The acoustical enclosure shall reduce pump and engine noise to 68 dBA or less at a distance of 30 feet. The enclosure shall be removable for easy access to the engine/pump for maintenance and repair. The enclosure doors shall all be equipped with latches that are keyed alike. For maintenance and service needs, the enclosure sides shall have hinged doors for quick access to the engine oil fill, fuel fill port, oil dipstick, and filters.



N. Diesel Fueled Pump:

1. The tank design shall be a closed-top dike pump base tank. It shall be of double-wall construction having a primary tank to contain the diesel fuel, held within another tank which is intended to collect and contain any accidental leakage from the primary fuel tank. The completed base tank assembly is to incorporate pump mounting locations and must be able to support four times the rated load.
2. Tank shall be sized to provide a run time of 72 hours under full engine load.
3. Primary tank shall be designed to withstand normal and emergency internal pressures and external loads. It shall be capable of withstanding internal air pressures of 3 to 5 psig without showing signs of excessive or permanent distortion and 25 psig hydrostatic pressure without evidence of rupture or leakage.
4. The primary and secondary tanks or dike shall have venting provisions to prevent the development of vacuum or pressure capable of distorting them as a result of the atmospheric temperature changes or while emptying or filling. The vent shall also permit the relief of internal pressures caused by exposure to fires. The vent size shall be determined by using the calculated wetted surface area in square feet (the top is excluded) in conjunction with venting capacity table 10.1 of UL 142. The tank's vent shall also be equipped with a coupling device and shall be located to facilitate connection to a vent piping system. The dike's vent may be an opening for venting directly to the atmosphere and protection from the entrance of natural elements or debris shall be provided.
5. The primary tank is to be constructed of 7-gauge ASTM A569 or ASTM A36 hot-rolled steel. Internal baffles or reinforcement plates shall be located on a maximum of 24-inch centers in tanks up to 60-inch width and on a maximum of 19.5-inch centers in tanks over 60-inch width. At least one baffle shall separate the fuel suction pipe from the fuel return line.
6. The outer tank is to be constructed in a manner to be able to support four times the wet load of the pump and housing. All of the load is to be carried by the outer tank so no load or vibration stress is placed on the primary tank. If the pump base tank is wider than the pump set to be supported, structural rails are to be incorporated to span the width of the base tank so that the load is transferred to the side rails of the tank. Vertical reinforcements shall be welded to the outer sides of the secondary tank or dike at a maximum of 45-inch centers on tanks up to 30 inches high and on 24-inch centers on tanks greater than 30 inches high. At least one vertical reinforcement shall be positioned adjacent to each mounting hole location.

7. Both primary and secondary tanks shall be fitted with the proper welded pipe fittings to accommodate the requirements for the fill port, and normal and emergency venting requirements.
8. Manufacturing and testing of this system shall be performed within the scope of Underwriters Laboratories, Inc. "Standard for Safety UL 142." A UL label shall be permanently attached to the tank system showing the following information:
  - a. The registered UL mark and the name: Underwriters Laboratories, Inc.
  - b. A control number and the word "listed".
  - c. The product's name as identified by Underwriters Laboratories Inc.
  - d. The serial number assigned by Underwriters Laboratories, Inc.
  - e. Other manufacturer's information may also be included.

#### 2.04 AUTOMATIC STARTING CONTROL SYSTEM

- A. The engine shall be equipped with a factory-installed microprocessor-based control panel and designed to start/stop the engine at a signal supplied by high and low level floats.
- B. The control panel shall be weatherproof enclosed, and contain an external weatherproof 12-position keypad accessible without the need to remove or open any protective cover or enclosure. It shall be designed to start/stop the engine at a signal supplied by high and low level floats. The controller shall provide the following functions without modification, factory recalibration, or change of chips or boards, by simply accessing the keypad.
  1. The keypad shall be a capacitive touch sensing system. No mechanical switches will be acceptable. The keypad shall operate in extreme temperatures, with gloves, through ice, snow, mud, grease, etc. and maintain complete weather-tight sealing of the panel.
  2. In automatic mode, the unit shall conserve energy and "go to sleep."
  3. The control panel shall function from float switches as well as manual start/stop by selection at the keypad. No other equipment or hardware changes are required.
  4. The control panel shall be capable of varying the engine speed to maintain a constant level in a process without a change to the panel other than via the keypad.
  5. The start function can be programmed to provide three separate functions each day for 7 days (i.e., a start, warm-up, exercise cycle on 2 separate days at different times and for a varying length of time, all via the keypad).
  6. Manual-Automatic Button:
    - a. In Manual Mode, Manual "Start" button starts engine and runs until "Stop" button is depressed or an emergency shutdown occurs.

- b. In Automatic Mode, start/stop sequencing is initiated by one-normally open and one-normally closed narrow angler float switches.
- 7. The control panel shall integrate the engine safety shut-off for low-oil temperature, high-temperature, and provide over-speed protection.
- 8. The control panel shall include standard field adjustable parameters for engine cycle crank timer, shutdown time delay, warm-up time delay, and cool-down time delay.
- 9. The control panel shall have only one circuit board with 8 built-in relays. Each relay can be named to provide any function all via the key play without changing relays, chips, printed circuits or any hardware or software.
- 10. Standard components shall consist of (24) digital inputs, (7) analog inputs, (1) magnetic pick-up input, (8) 20-amp form "C" relays, (1) RS232 port, (1) RS485 port, (1) RS232/RS485 port, (1) J1939 port, and (1) 64X128 pixel full graphic LCD display with backlight.

## 2.05 ACCESSORIES

- A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
- B. Lifting Bail: Equipment weight over 100 pounds.
- C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.
- D. The unit shall include a duplex GFCI outlet (junction box) for a single point 115V ac, 30-amp electrical connection circuit to power the engine coolant heater.
- E. The unit shall include a fully automatic trickle charger powered by 6 amps, 115V ac.
- F. The drive unit shall be supplied with an integral thermostatically controlled engine block heater (15-amp, 115V ac required).
- G. The unit shall include a single switch operated 12V dc light within the enclosure.
- H. The unit shall be supplied with two float switches, which shall integrate with the engine control panel to start and stop the pump.
- I. Heat trace and insulate all exposed piping in accordance with Sections 40 42 13, Process Piping Insulation and 40 05 33, Pipe Heat Tracing.

## 2.06 FACTORY FINISHING

- A. Prepare, prime, and finish coat with manufacturer's standard system.

## 2.07 SOURCE QUALITY CONTROL

- A. Shop Tests: Perform a certified shop test on the pumping unit in accordance with the test code of the Hydraulic Institute, except as specified herein. Drive pump by its own drive unit during the shop test.
  - 1. Test at rated speed to determine the curves of head, brake horsepower, and efficiency as a function of capacity. Take a minimum of six points including shutoff. Take at least one point as near as possible to each specified condition of head and capacity. Express capacity in gallons per minute and express head in feet of water. Furnish certified copies of the curves, raw test data, calculated results and sufficient information for computation and plotting of the curves.
  - 2. Subject each pump in the shop to a hydrostatic test. Use a test pressure of not less than 1-1/2 times the shutoff head of the pump as shown by the characteristic curve. Under this test pressure, ensure no part shows undue deflection or leakage or other defects. Provide certification of hydrostatic tests.

## PART 3 EXECUTION

### 3.01 INSTALLATION

- A. Install in accordance with manufacturer's printed instructions.
- B. Anchor Bolts: Accurately place using equipment templates. Sized by the manufacturer and constructed of Type 316 stainless steel.
- C. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide level bearing surface for pump base. Accomplish wedging so that there is no change of level or springing of baseplate when anchor bolts are tightened.
- D. After pump skid has been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with poured, nonshrink grout of the proper category. Remove wedges after grout is set and pack voids with grout.
- E. Connect suction and discharge piping without imposing strain to pump flanges.
- F. Install the float switches in accordance with the manufacturer's printed instructions.

### 3.02 FIELD QUALITY CONTROL

- A. Functional Test: After installation of the pumping unit and all appurtenances, subject each unit to a field running test under actual operating conditions.

### 3.03 MANUFACTURER'S SERVICES

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

**END OF SECTION**



**SECTION 44 42 60**  
**HORIZONTAL, SELF PRIMING, SUCTION LIFT PUMPS FOR**  
**WASTEWATER PUMP STATIONS (200 TO 600 GPM)**

**PART 1 GENERAL**

1.01 SUMMARY

- A. This specification details the requirements for residential and commercial wastewater pump stations having a peak hour flow (PHF) capacity of 200 to 600 gpm.
- B. This is not intended to be an all-inclusive specification for the construction of a submersible type station. Site and conditions may make it necessary to modify the requirements of this section.
- C. All pump stations shall include a minimum of two pumps (duplex arrangement) sized to convey the PHF with one pump out of service.
- D. All pump stations shall include a Mission unit for remote monitoring in accordance with Section 40 90 01, Instrumentation and Control for Process Systems.
- E. Pump station shall be provided with a standby diesel driven engine pump or generator.
- F. This Specification is supplemented by the data and drawings provided of the installation site, conditions and performance requirements. Review drawings for:
  - 1. Capacity (GPM).
  - 2. Total Dynamic Head (FT).
  - 3. Total Dynamic Suction Lift (FT).
  - 4. Maximum Repriming Lift (FT).
  - 5. Maximum Static Suction Lift (FT).
  - 6. Total Discharge Static Head (FT).
  - 7. Minimum Submergence Depth (FT).

1.02 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
  - 1. American National Std. Institute (ANSI) / American Water Works Assoc. (AWWA):
    - a. ANSI B16.1 Cast iron pipe flanges and flanged fittings.

- b. ANSI/AWWA C115/A21.51 Cast/ductile iron pipe with threaded flanges.
  - c. ANSI 253.1 Safety Color Code for Marking Physical Hazards.
  - d. ANSI B40.1 Gages, Pressure and Vacuum.
  - e. AWWA C508 Single Swing Check Valves.
2. American Society for Testing and Materials (ASTM):
- a. ASTM A48 Gray Iron Castings.
  - b. ASTM A126 Valves, Flanges, and Pipe Fittings.
  - c. ASTM A307 Carbon Steel Bolts and Studs.
  - d. ASTM A36 Structural Steel.
3. Institute of Electrical and Electronics Engineers (IEEE):
- a. ANSI/IEEE Std 100 Standard Dictionary of Electrical Terms.
  - b. ANSI/IEEE Std 112 Test Procedure for Polyphase Induction Motors.
  - c. IEEE Std 242 Protection of Industrial and Control Power Systems.
4. National Electric Code (NEC) / National Electrical Manufacturers Assoc. (NEMA):
- a. NEC National Electric Code.
  - b. NEC 701 National Electric Code article 701.
  - c. NEMA Std MG1 Motors and Generators.
5. Miscellaneous References:
- a. Ten-State Standards Recommended Standards for Sewage Works.
  - b. Hydraulic Institute Std for Centrifugal, Rotary and Reciprocating Pumps.
  - c. NMTBA and JIC Std. National Machine Tool Builders Association and Joint Industrial Council Standards

### 1.03 DEFINITIONS

- A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

### 1.04 EXTRA MATERIALS

- A. Furnish for this set of pumps:
  - 1. Complete set packing.
  - 2. Complete set bearings.
  - 3. Complete set gaskets and O-ring seals.
  - 4. Complete set of shaft sleeves.
  - 5. Complete set keys, dowels, pins, etc.
  - 6. Complete mechanical seal.
  - 7. Impeller.
  - 8. Impeller shaft.



9. Impeller wear ring.
10. Head shaft.
11. One complete set of special tools required to dismantle pump.

## **PART 2 PRODUCTS**

### 2.01 GENERAL

- A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.
- B. Self-priming, suction lift centrifugal nonlog type, for pumping wastewater.
- C. Designed for continuous operation.
- D. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.
- E. Where adjustable frequency drives are required or specified, furnish a coordinated operating system complete with pump, drive, and speed controller.
- F. Pumps and associated equipment to include the control panel to be provided by a single manufacturer.

### 2.02 MANUFACTURERS

- A. Acceptable manufacturers are:
  1. Gorman Rupp, Super T or Ultra V as detailed in the Drawings.
  2. No equal or alternate will be accepted.

### 2.03 CONTROL PANEL

- A. Type 304 stainless steel, NEMA 4X enclosure, for outdoor duty.
- B. Refer to Section 40 90 01, Instrumentation and Control for Process Systems, for panel requirements.
- C. Free standing, post mounted.
- D. Features:
  1. Main circuit breaker disconnect interlocked with panel door.
  2. Combination circuit breaker type, NEMA rated motor starters.
  3. Fused control power transformer, 120V ac.
  4. Alternator and pump lead-lag controls.
  5. ON/OFF/AUTO switches.

6. Running lights.
  7. High level indication.
  8. Normally closed, dry, 5 amps at 120V ac contacts for remote indication of:
    - a. High level alarm.
    - b. Pump failure (temperature or moisture alarm).
  9. Terminal strip for interfacing with external wiring.
  10. High temperature indication.
  11. Alarm beacon located on top of panel.
  12. Lightning protection.
  13. Intrinsically safe relays as required for UL validation.
  14. Alarm silence button.
  15. Document pocket located inside panel with pump and panel operation and maintenance manual, and separate laminated pump curve.
  16. 110-volt, duplex GFI outlet, weather-protected, and accessible from outside of panel.
  17. Phase failure relay.
  18. Run hour meter.
  19. 100 watts minimum, condensation heater with thermostat.
  20. UL listing mark.
- E. Prewired and factory tested.
- F. Air conditioned where required for proper operation of controls and adjustable/variable frequency drive.
- G. Mount control switches, indicating lights, and switches on hinged front panel.
- H. Single Feed: 480 volts, three-phase.

#### 2.04 ACCESSORIES

- A. Level Switches: In accordance with Section 40 90 01, Instrumentation and Control for Process Systems, component L8 and for:
1. Low Low Level: Pumps off.
  2. High High Level: Alarm.
- B. Level Transmitter: In accordance with Section 40 90 01, Instrumentation and Control for Process Systems, Component L52.
- C. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

- D. Variable/Adjustable frequency drive where specified and required by the ESD.
- E. Lifting Lugs: Equipment weighing over 100 pounds.
- F. OSHA-approved coupling guard for direct coupled or belt driven pumps.
- G. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

## 2.05 ADJUSTABLE/VARIABLE FREQUENCY DRIVE

### A. General:

1. Design and provide drive system consisting of adjustable frequency controller, drive motor, certain auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish VFDs rated on basis of actual motor full load nameplate current rating.
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using the pulse-width-modulation (PWM) technique to produce the adjustable frequency output.
5. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for the drive system.
6. Incoming Line Reactor: Design to minimize harmonic distortion on the incoming power feeder.
7. Operator Interface with the following functions:
  - a. Start (when in local mode).
  - b. Stop (when in local mode).
  - c. Speed increase (when in local mode).
  - d. Speed decrease (when in local mode).
  - e. Parameter mode selection (recall programmed parameters).
  - f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 to 20 mA analog signal).
  - g. Fault reset, manual for all faults (except loss of ac voltage which is automatic upon return).
  - h. RUN/preset speed.
  - i. Parameter lock (password or key switch lockout of changes to parameters).
  - j. Start disable (key switch or programmed code).

B. Service Conditions:

1. Ambient Operating Temperature: 32 to 104 degrees F.
2. Storage Temperature: Minus 40 to 158 degrees F.
3. Humidity: 0 to 95 percent relative (noncondensing).
4. Altitude: 0 to 3,300 feet.
5. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

A. Manufacturer:

1. ABB.
2. Eaton.
3. Approved equal.

2.06 PIPING

- A. Suction and discharge piping shall be ductile iron in accordance with Section 40 27 01, Ductile Iron Pipe and Fittings. Transition to high density polyethylene pipe is permitted at property line of the pump station or as approved by the ESD after the valve vault and self-regulated automatic valve(s).
- B. Heat trace and insulate all exposed piping in accordance with Sections 40 42 13, Process Piping Insulation and 40 05 33, Pipe Heat Tracing.

2.07 FACTORY FINISHING AND TESTING

- A. Manufacturer's standard finish for outside installation in a corrosive environment.
- B. Functional Test: Perform manufacturer's standard test on equipment.
- C. Performance Test:
1. In accordance with Hydraulic Institute Standards.
  2. Adjust, realign, or modify units and retest accordance with Hydraulic Institute Standards if necessary.
- D. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

2.08 SOURCE QUALITY CONTROL

- A. Control Panel:
1. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A. Install in accordance with manufacturer's printed instructions.
- B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.
- C. Adjust pump assemblies such that the driving units are properly aligned, plumb, and level with the driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.
- D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout the space between the bottom of the baseplate and the concrete foundation with a poured, nonshrinking, non-metallic grout recommended by the pump manufacturer. Remove wedges after grout is set and pack void with grout.
- E. Connect suction and discharge piping without imposing strain to pump flanges.

### **3.02 FIELD QUALITY CONTROL**

- A. Functional Test: With the ESD Electrician and the Engineer present conduct on each pump.
  - 1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
  - 2. Flow Output: Measured by calibrated temporary flow measurement device.
  - 3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
  - 4. Test for continuous 3-hour period.

### **3.03 OPERATIONS MANUAL**

- A. Prior to start-up of station and training, provide ESD three hard copies and one digital copy of an operating and maintenance manual for the overall pump station and all installed components.

### 3.04 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: Present at Site or classroom designated by ESD for minimum person-days listed below, travel time excluded:
  - 1. 1 person-day for installation assistance and inspection.
  - 2. 0.5 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
  - 3. 0.5 person-day for post-startup training of the ESD staff.
- B. Manufacture shall provide a certificate or proper installation for the pumps and control panel.

**END OF SECTION**

**SECTION 44 42 65**  
**FACTORY-BUILT BASE MOUNTED PUMP STATION**  
**WITH DUPLEX/SIMPLEX SELF-PRIMING PUMPS, STANDBY ENGINE**  
**PLC-BASED CONTROL AND FIBERGLASS ENCLOSURE**

**PART 1 GENERAL**

1.01 SUMMARY

- A. Contractor shall furnish and install one factory built, automatic pump station. The station shall be complete with all equipment specified herein, factory assembled on a common steel baseplate. Equipment shall include but not be limited to:
1. Two self-priming, horizontal, centrifugal, v-belt motor driven sewage pumps.
  2. One water cooled standby engine.
  3. Valves, and piping.
  4. A PLC based pump motor control panel with thermal-magnetic circuit breakers, magnetic motor starters, automatic liquid level control systems for normal and standby operation, and internal wiring.
- B. This Specification is supplemented by the data and drawings provided of the installation site, conditions and performance requirements. Review Drawings for:
1. Capacity (GPM).
  2. Total Dynamic Head (FT).
  3. Total Dynamic Suction Lift (FT).
  4. Maximum Repriming Lift (FT).
  5. Maximum Static Suction Lift (FT).
  6. Total Discharge Static Head (FT).
  7. Minimum Submergence Depth (FT).
  8. Fault current provided at the pump station control panel.

1.02 REFERENCES

- A. Publications listed below form part of this specification to extent referenced in the text by basic designation only. Consult latest edition of publication unless otherwise noted.
1. American National Std. Institute (ANSI) / American Water Works Assoc. (AWWA):
    - a. ANSI B16.1 Cast iron pipe flanges and flanged fittings.
    - b. ANSI/AWWA C115/A21.51 Cast/ductile iron pipe with threaded flanges.

- c. ANSI 253.1 Safety Color Code for Marking Physical Hazards.
- d. ANSI B40.1 Gages, Pressure and Vacuum.
- e. AWWA C508 Single Swing Check Valves.
- 2. American Society for Testing and Materials (ASTM):
  - a. ASTM A48 Gray Iron Castings.
  - b. ASTM A126 Valves, Flanges, and Pipe Fittings.
  - c. ASTM A307 Carbon Steel Bolts and Studs.
  - d. ASTM A36 Structural Steel.
- 3. Institute of Electrical and Electronics Engineers (IEEE):
  - a. ANSI/IEEE Std 100 Standard Dictionary of Electrical Terms.
  - b. ANSI/IEEE Std 112 Test Procedure for Polyphase Induction Motors.
  - c. IEEE Std 242 Protection of Industrial and Control Power Systems.
- 4. National Electric Code (NEC) / National Electrical Manufacturers Assoc. (NEMA):
  - a. NEC National Electric Code.
  - b. NEC 701 National Electric Code article 701.
  - c. NEMA Std MG1 Motors and Generators.
- 5. Miscellaneous References:
  - a. Ten-State Standards Recommended Standards for Sewage Works.
  - b. Hydraulic Institute Std for Centrifugal, Rotary and Reciprocating Pumps.
  - c. NMTBA and JIC Std. National Machine Tool Builders Association and Joint Industrial Council Standards
  - d. ISO 9001 International Organization for Standardization.

### 1.03 DEFINITIONS

- A. The term “pump manufacturer” or “pump station manufacturer” shall be defined as the entity which designs, machines, assembles, hydraulically tests and warranties the final product.

### 1.04 SUBMITTALS

- A. Product Data:
  - 1. If requested by the ESD, prior to fabrication, pump station manufacturer shall submit 5 copies of submittal data for review and approval. Submittal shall include:
    - a. Electrical ladder logic drawings. The electrical ladder logic drawings shall illustrate motor branch and liquid level control circuits to extent necessary to validate function and integration of circuits to form a complete working system.



- b. Catalog cuts sheets reflecting characteristics for major items of equipment, materials of construction, major dimensions, motor and v-belt drive data, pump characteristic curves showing the design duty point capacity (GPM), head (FT), net positive suction head required (NPSHr), and hydraulic brake horsepower (BHP). Electrical components used in the motor branch and liquid level control shall be fully described.
- c. Shop drawings detailing layout of mechanical equipment and anchor bolt locations for equipment baseplate.
- d. Installation manual. Comprehensive instructions shall enable personnel to properly install, operate and maintain all equipment supplied. Content and instructions shall assume operating personnel are familiar with pumps, motors, piping and valves, but lack experience on exact equipment supplied.
- e. Operations, control and maintenance manual.
- f. Documentation shall be specific to the pump station supplied and collated in functional sections. Each section shall combine to form a complete system manual covering all aspects of equipment supplied by the station manufacturer. Support data for any equipment supplied by others, even if mounted or included in overall station design, shall be included in the manual to detail the overall pumping system/station. Operations, control and maintenance manual shall include the following as a minimum:
  - 1) Functional description of each major component, complete with operating instructions.
  - 2) Instructions for operating pumps, engine and pump controls in all modes of operation.
  - 3) Calibration and adjustment of equipment for initial start-up, replacement of level control components, or as required for routine maintenance.
  - 4) Support data for all components not produced by the station manufacturer, but supplied in accordance with the Specifications. Data shall be supported by literature from the prime manufacturer and incorporated as appendices.
  - 5) Electrical schematic diagram of the pump station circuits shall be in accordance with NFPA70. Schematics shall illustrate, to the extent of authorized repair, pump motor branch, control and alarm system circuits including interconnections. Wire numbers and legend symbols shall be shown. Schematic diagrams for individual components, not normally repairable by the station operator, need not be included. Details for such parts shall not be substituted for an overall system schematic. Partial schematics, block diagrams, and simplified schematics shall not be provided in lieu of an overall system diagram.

- 6) Mechanical layout drawing of the pump station and components, prepared in AutoCAD that detail all dimensions and location of all pumps, motors, engine, valves, piping and appurtenances.
- 7) Operation and maintenance instructions which rely on vendor cut-sheets and literature and that include general configurations, or require operating personnel to selectively read portions of the manual shall not be acceptable.

#### 1.05 QUALITY ASSURANCE

- A. The pumps and pump station manufacturer must be ISO 9001 certified, with scope of registration including design control and service after sales activities.
- B. Upon request from the ESD and the Engineer, the pump station manufacturer shall prove financial stability and ability to produce the station within the specified delivery schedules. Evidence of facilities, equipment and expertise shall demonstrate the manufacturer's commitment to long term customer service and product support.
- C. Manufacturer must show proof of original product design and testing. Products violating intellectual property regulations shall not be allowed, as they may violate international law and expose the ESD or Engineer to unintended liabilities. "Reverse-engineered" products fabricated to substantially duplicate the design of original product shall not be allowed, as they may contain substantial differences in tolerances and material applications addressed in the original design, which may contribute to product failure.

#### 1.06 PERFORMANCE CRITERIA

- A. Pumps must be designed to handle raw, unscreened, domestic sanitary sewage. All internal passages, impeller vanes, and recirculation ports shall pass a 3-inch spherical solid. Smaller internal passages that create a maintenance nuisance or interfere with priming and pump performance shall not be permitted. Upon request from the ESD or Engineer, manufacturer's certified drawings showing size and location of the recirculation port(s) shall be submitted for approval.
- B. Each pump shall be selected to perform to the operating conditions detailed on the Drawings.

C. Reprime Performance:

1. Consideration shall be given to the sanitary sewage service anticipated, in which debris is expected to lodge between the suction check valve and its seat, resulting in the loss of the pump suction leg, and siphoning of liquid from the pump casing to the approximate center line of the impeller. Such occurrence shall be considered normal, and the pump must be capable of automatic, unattended operation with an air release line installed.
2. During unattended operation, the pump shall retain adequate liquid in the casing to insure automatic repriming while operating at its rated speed in a completely open system. The need for a suction check valve or external priming device shall not be required.
3. Pump must reprime the height/vertical feet detailed on the Drawings at the specified speed and impeller diameter. Reprime lift is defined as the static height of the pump suction above the liquid, while operating with only one-half of the liquid remaining in the pump casing. The pump must reprime and deliver full capacity within five minutes after the pump is energized in the reprime condition.
4. Reprime performance must be confirmed and upon request from the ESD or Engineer, certified performance test results, prepared by the manufacturer, and certified by a registered professional engineer, shall be submitted for approval prior to shipment. Test setup and operating requirements include:
  - a. A check valve to be installed downstream from the pump discharge flange. The check valve size shall be equal (or greater than) the pump discharge diameter.
  - b. A length of air release pipe shall be installed between pump and the discharge check valve. This line shall be open to atmosphere at all times duplicating the air displacement rate anticipated at a typical pump station fitted with an air release valve.
  - c. The pump suction check valve shall be removed. No restrictions in the pump or suction piping will prevent the siphon drop of the suction leg. Suction pipe configuration for reprime test shall incorporate a 2 feet minimum horizontal run, a 90 degree elbow and vertical run at the specified lift. Pipe size shall be equal to the pump suction diameter.
  - d. Impeller clearances shall be set as recommended in the pump service manual.
  - e. Repeatability of performance shall be demonstrated by testing five consecutive reprime cycles. Full pump capacity (flow) shall be achieved within five minutes during each cycle.
  - f. Liquid to be used for reprime test shall be water.

## 1.07 EXTRA MATERIALS

- A. One spare pump mechanical seal (complete), and with it all gaskets, seals, sleeves, O-rings, and packing required to be replaced during replacement of the seal.
- B. One set of impeller clearance adjustment shims.
- C. One set cover plate O-ring.
- D. One rotating assembly O-ring.

## 1.08 SPECIAL MANUFACTURER'S WARRANTY

- A. The pump station manufacturer shall warrant all equipment to be of quality construction, free of defects in material and workmanship.
- B. A written warranty shall include specific details described below.
  - 1. In addition to defects in material and workmanship, fiberglass reinforced polyester station enclosures (where applicable) are warranted for sixty (60) months to be resistant to rust, corrosion, corrosive soils, effects of airborne contamination or physical failures occurring in normal service for the period of the pump station warranty.
  - 2. All other equipment, apparatus, and parts furnished shall be warranted for sixty (60) months, except those items that are normally consumed in service, such as light bulbs, oils, grease, packing, gaskets, O-rings, etc.
- C. The pump station manufacturer shall be solely responsible for warranty of the station and all components.
- D. Components failing to perform or as proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer.

## **PART 2 PRODUCT**

### 2.01 MANUFACTURER'S UNITARY RESPONSIBILITY

- A. In order to unify responsibility for proper operation of the complete pumping station, it is the intent of these Specifications that all system components be furnished by a single supplier (unitary source). The pumping station must be of standard catalog design, totally warranted by the manufacturer.
- B. A system consisting of parts compiled and assembled by a manufacturer's representative or distributor shall not be accepted.

## 2.02 MANUFACTURERS AND PRODUCTS

- A. Acceptable manufacturers are: Gorman Rupp, Super T, Ultra V Series or Ultramate.

## 2.03 PUMP COMPONENTS AND MATERIALS OF CONTRUCTION

### A. Pump:

1. Pump casing: Casing shall be cast iron Class 30 with integral volute scroll and include the following features:
  - a. Mounting feet sized to prevent tipping or binding when pump is completely disassembled for maintenance.
  - b. Fill port coverplate, 3 1/2-inch diameter, shall be opened after loosening a hand nut/clamp bar assembly.
  - c. Hand nut threads to allow slow release of pressure.
  - d. The clamp bar shall be retained by detent lugs.
  - e. A Teflon gasket shall prevent adhesion of the fill port cover to the casing.
  - f. Casing drain plug shall be at least 1 1/4-inch NPT to insure complete and rapid draining.
2. Coverplate: Coverplate shall be cast iron Class 30 and shall include the following features:
  - a. Retained by hand nuts for complete access to pump interior.
  - b. Provide ample clearance for removal of stoppages, and allow service to the impeller, seal, wearplate or check valve without removing suction or discharge piping.
  - c. A replaceable wearplate secured to the coverplate by weld studs and nuts shall be AISI 1015 HRS.
  - d. A pressure relief valve in the coverplate. Relief valve shall open at 75-200 psi.
  - e. Two O-rings of Buna-N material shall seal coverplate to pump casing.
  - f. Pusher bolt capability to assist in removal of coverplate. Pusher bolt threaded holes shall be sized to accept same retaining capscrews as used in rotating assembly.
  - g. Easy-grip handle mounted to face of coverplate.

3. Rotating Assembly: A rotating assembly, which includes impeller, shaft, mechanical shaft seal, lip seals, bearings, sealplate and bearing housing, shall be removable as a single unit without disturbing the pump casing or piping. Rotating assembly shall include the following features:
  - a. Sealplate and bearing housing shall be cast iron Class 30. Separate oil filled cavities, vented to atmosphere, shall be provided for shaft seal and bearings. Cavities must be cooled by the liquid pumped. Lip shall prevent leakage of oil. Additional features and requirements include:
    - 1) The bearing cavity shall have an oil level sight gauge and fill plug check valve. A clear sight gauge shall provide easy monitoring of the bearing cavity oil level and condition of oil without removal of the fill plug check valve. The check valve shall vent the cavity but prevent introduction of moist air to the bearings.
    - 2) The seal cavity shall have an oil level sight gauge and fill/vent plug. A clear sight gauge shall provide easy monitoring of the seal cavity oil level and condition of oil without removal of the fill/vent plug.
    - 3) Double lip seal shall provide an atmospheric path providing positive protection of bearings, with capability for external drainage monitoring.
  - b. Impeller shall be ductile iron, two-vane, semi-open, non-clog, with integral pump out vanes on the back shroud. Impeller shall thread onto the pump shaft and be secured with a lock screw and conical washer.
  - c. Shaft shall be AISI 17-4 pH stainless steel.
  - d. Bearings shall be anti-friction ball type of proper size and design to withstand all radial and thrust loads expected during normal operation.
    - 1) Bearings shall be oil lubricated from a dedicated reservoir.
    - 2) Pump designs which use the same oil to lubricate the bearings and shaft seal shall not be acceptable.
  - e. Shaft seal shall be oil lubricated mechanical type. The stationary and rotating seal faces shall be tungsten titanium carbide alloy.
    - 1) Each mating surface shall be lapped to within three light bands flatness (35 millionths of an inch), as measured by an optical flat under monochromatic light.
    - 2) The stationary seal seat shall be double floating by virtue of a dual O-ring design; an external O-ring secures the stationary seat to the sealplate, and an internal O-ring holds the faces in alignment during periods of mechanical or hydraulic shock (loads which cause shaft deflection, vibration, and axial/radial movement).
    - 3) Elastomers shall be viton.

- 4) Cage and spring to be stainless steel.
  - 5) Seal shall be oil lubricated from a dedicated reservoir.
  - 6) The same oil shall not lubricate both shaft seal and shaft bearings.
- f. Pusher bolt capability to assist in removal of rotating assembly. Pusher bolt threaded holes shall be sized to accept same capscrews as used for coverplate.
4. Adjustment of the impeller face clearance (distance between impeller and wearplate) shall be accomplished by external means.
- a. Clearances shall be maintained by a four point external shimless coverplate adjustment system, utilizing a four collar and four adjusting screw design allowing for incremental adjustment of clearances by hand as required. Each of the four points shall be lockable to prevent inadvertent clearance increases or decreases due to equipment vibration or accidental operator contact. The four point system also allows for equal clearance gaps at all points between the impeller and wear plate. Requirement of realignment of belts, couplings, etc., shall not be acceptable. Coverplate shall be capable of being removed without disturbing clearance settings. Clearance adjustment systems that utilize less than four points will not be considered.
  - b. Provisions shall be provided for additional clearance adjustment in the event that adjustment tolerances have been depleted from the coverplate side of the pump. The removal of stainless steel shims from the rotating assembly side of the pump shall allow for further adjustment as described above.
  - c. Clearance adjustment which requires movement of the shaft only, thereby adversely affecting seal working length or impeller back clearance, shall not be acceptable.
5. An externally removable suction check valve shall be molded Neoprene with integral steel and nylon reinforcement. A blow-out center shall protect pump casing from hydraulic shock or excessive pressure. Removal or installation of the check valve must be accomplished from the top of pump without disturbing the suction piping or completely draining the casing. Sole function of check valve shall be to save energy by eliminating need to reprime after each pumping cycle. Pumps requiring a suction check valve to assist reprime will not be acceptable.

B. Unit Base:

1. The unit base shall be comprised of structural steel with a perimeter flange and reinforcements.
2. Perimeter flange and reinforcements shall be designed to prevent flexing or warping under operating conditions.

3. Perimeter flange shall be drilled for hardware used to secure unit base to concrete pad as shown on the Contract Drawings.
4. Unit base shall contain provisions for lifting the complete pump unit during shipping and installation.

C. Pump Drain Kit:

1. The pump drain kit shall consist of a 10' length of plastic hose with a quick connect female Kamlock fitting on one end of hose and two sets of fittings for pump drains. Each set of fittings for pump drain includes a stainless steel pipe nipple, stainless steel bushing, stainless steel ball valve and an aluminum quick connect male Kamlock fitting.

D. Volute Casing Heaters:

1. Where installed in an unheated area/enclosure or where required by the ESD or Engineer, pump shall be provided with a thermostat mounted to the exterior of the volute casing, and 115 volt electric heater inserted into the interior of the volute by means of a dedicated port. The heater shall be energized at 40 degrees F and sized to prevent freezing to 0 degrees F to provide heat to the casing and eliminate the possibility of freezing.
2. Heater probes that must be installed through a pump drain port is not be acceptable.
3. Heater probes that must be installed through a pump drain port is not be acceptable.

E. Isolation, Check and Self-Regulated Automatic Valves:

1. All pumps shall be include discharge isolation valve, check valve and self-regulated automatic valve (also referenced as air release/air vacuum valves).
2. See Section 40 27 20, Valves and Operators.

F. Piping: All piping shall be ductile iron in accordance with Sections 40 27 00, Force Main Piping and 40 27 01, Ductile Iron Pipe and Fittings.

G. Pipe and Valve Support:

1. Valves and pipes shall be supported in accordance with Section 40 27 10, Piping Specialties.



- H. Dismantling:
  - 1. To allow removal of pumps and valves provide dismantling fittings on suction and discharge side of pumps in accordance with Section 40 27 10, Piping Specialties.
- I. Heat Trace and Insulation:
  - 1. Heat trace and insulate all exposed piping in accordance with Sections 40 42 13, Process Piping Insulation and 40 05 33, Pipe Heat Tracing.
- J. Gauge Kit:
  - 1. Each pump shall be equipped with a glycerin-filled compound gauge to monitor suction pressures, and a glycerin-filled pressure gauge to monitor discharge pressures. Gauges shall be a minimum of 4 inches in diameter, and shall be graduated in feet water column. Rated accuracy shall be 1 percent of full scale reading. Compound gauges shall be graduated minus 34 feet to plus 34 feet water column minimum. Pressure gauges shall be graduated 0 to 140 feet water column minimum.
  - 2. Gauges shall be mounted on a resilient panel and frame assembly which shall be firmly secured to pumps or piping. Gauge installations shall be complete with all hoses and stainless steel fittings, and shall include a shutoff valve installed in each gauge inlet at the point of connection to suction and discharge pipes.

#### 2.04 ELECTRIC MOTOR

- A. Pump motors shall be horizontal ODP, 1800 RPM, NEMA design B with cast iron frame with copper windings, induction type, with class F insulation and 1.15 SF for normal starting torque and low starting current characteristics, suitable for continuous service. The motors shall not overload at the design condition or at any head in the operating range as specified.
- B. Motors shall be tested in accordance with provisions of ANSI/IEEE Std 112.
- C. Motor with engine shall be of a double shaft configuration.

## 2.05 STANDBY (LPG/NATURAL GAS) ENGINE

- A. Standby engine shall be a four (4) cylinder or six (6) cylinder, EPA Certified Dual Fuel (LPG/natural gas), water cooled type, and shall have continuous duty power rating suitable for the horsepower requirements of the pump. Engine shall be supplied with connections for both LPG and natural gas fuels. Engine shall be cooled by an integral water cooling system capable of maintaining safe engine operating temperature under expected operating loads, and subject to the expected maximum ambient temperatures in the pump station enclosure.
- B. The engine shall be equipped with all controls and components required for manual and automatic operation when used with the engine controls and DC level control system described in these specifications. Such components shall include, but not be limited to, the following:
  - 1. 12 Volt dc electrical system including starter and alternator.
  - 2. Storage battery, 84 ampere-hour capacity minimum.
  - 3. Elapsed running time meter.
  - 4. Sensors for engine temperature, oil pressure, and overspeed.
  - 5. Critical grade exhaust silencer to limit engine exhaust noise.
  - 6. Switch for manual operation of the cranking motor, mounted on or near the engine.
  - 7. Voltmeter.
  - 8. Solenoid fuel lock-off valve suitable for use with natural gas or LPG service.
  - 9. Lube oil pressure gauge.
  - 10. Jacket water temperature gauge.
  - 11. Tachometer.
  - 12. J1939 trouble codes.
- C. Engine electrical equipment shall be wired to a terminal board on the engine and pre-wired to the base secured control panel.
- D. The following minimum performance standards shall be used for engine selection:
  - 1. Engine speed shall be controlled by an electronic, governor-controlled throttle which shall maintain the preset speed over the range of expected pumping loads. This speed shall not be less than 1,800 rpm to insure adequate cooling, nor more than 3,000 rpm so that internal engine wear is held to a minimum. This governed speed shall not be acceptable if it is greater than that speed at which the engine torque and horsepower curves intersect. Engine manufacturer's published performance curves shall be submitted for review to support engine selection.

2. The engine shall develop approximately 95 percent of manufacturer's published performance after a reasonable run-in period.
  3. For selection of engine size, engine performance shall be derated according to manufacturer's specifications to allow for decreased performance if installed at elevations more than 1,000 feet above sea level.
  4. For selection of engine size, engine performance shall be derated according to manufacturer's specifications to allow for decreased performance in an ambient temperature of 100 degrees F, which can reasonably be expected in the pump station.
  5. Engine rating shall be further reduced to conform to engine manufacturer's recommendations for continuous service applications.
- E. Brake horsepower requirements of pump shall not exceed calculated engine horsepower after derating for power available after run-in, temperature compensation, and altitude compensation.

## 2.06 DRIVE TRANSMISSION

- A. Power shall be transmitted from engine to pump by a v-belt drive assembly through a centrifugal clutch mounted on a jackshaft, which shall be coupled or otherwise interfaced with a shaft extension on the pump motor. Jackshaft shall be constructed of steel, not less than 1 1/2 inches in diameter, and shall be mounted in two pillow blocks furnished with anti-friction roller bearings.
1. Each drive assembly shall have a minimum of two v-belts or one synchronized belt system. Each v-belt drive assembly shall be selected on the basis that adequate power will be transmitted from driver to pump based on the data developed in accordance with drive calculations.
  2. Precise alignment tolerances of the drive assemblies shall be achieved by means of a belt/sheave laser alignment system resulting in the reduction of vibration, accelerated wear, and premature failure.
  3. Centrifugal clutch shall be designed to remain disengaged until engine has reached some speed greater than idle speed to reduce starting loads. Once engaged, clutch shall be rated to transmit power continuously until engine speed has been reduced below disengagement speed. Clutch shall disengage completely while engine is not operating.
  4. Belt guards:
    - a. Pump drive transmissions shall be enclosed on all sides in a guard constructed of any one or combination of materials consisting of expanded, perforated, or solid sheet metal, except that maximum perforated or expanded openings shall not exceed 1/2 inch.

- b. Guards shall be manufactured to permit complete removal from the pump unit without interference with any unit component, and shall be securely fastened to the unit base.
- c. All metal shall be free of burrs and sharp edges. Structural joints shall be continuously welded. Panels may be riveted to frames with not more than five-inch spacing. Tack welds shall not exceed four-inch spacing.
- d. The guard shall be coated in accordance with section 3, Color Definitions of ANSI 253.1; Safety Color Code for Marking Physical Hazards.

## 2.07 FINISH

- A. Pumps, piping, motors and exposed steel framework shall be coated with a high build epoxy system rated for use in a highly corrosive environment as recommended by Tnemec, Sherwin Williams, Porter or an equal manufacturer. Coating system(s) shall be applied to a prepared surface in accordance with the manufacturer's recommendations. Prepared and coated in accordance with the painting manufacturer's directions with a high build epoxy. The finish shall allow for over-coating and touch up after final installation.

## 2.08 ELECTRICAL CONTROL COMPONENTS

- A. The pump station control panel will be tested as an integral unit by the pump station manufacturer. The control panel shall also be tested with the pump station as a complete working system at the pump station manufacturer's facility.
- B. The electrical control components shall be provided by the pump station supplier and conform to the requirements of Section 26 05 01, Electrical, Section 40 90 01, Instrumentation and Control for Process Systems along with the following additional requirements.
- C. Panel enclosure:
  - 1. Enclosure shall be constructed in conformance with applicable section of National Electrical Manufacturers Association (NEMA) standards for type 1 electrical enclosures. Enclosure shall be fabricated of Type 304 stainless steel of not less than 12 gauge.
  - 2. Enclosure shall be equipped with a door mounted on a continuous steel hinge, and sealed around its perimeter. Door shall be held closed with clamps that are quick and easy to operate. The door shall accommodate the mounting of switches and indicators.

3. Enclosure shall be furnished with a removable back panel, fabricated of Type 304 steel having a thickness of not less than 0.106 inch (12-gauge), which shall be secured to the enclosure with collar studs. Such panel shall be of adequate size to accommodate all basic components.
4. All control components shall be securely fastened to a removable back panel with screws and lock washers. Switches, indicators and instruments shall be mounted through the control panel door. All control devices and instruments shall be secured to the sub-plate with machine screws and lockwashers. Mounting holes shall be drilled and tapped; Self-tapping screws shall not be used to mount any components. All connections from the back panel to door mounted or remote devices shall be made through terminal blocks. All control devices shall be clearly labeled to indicate function.

D. Motor Branch Components:

1. Main connections:
  - a. A main terminal block and ground lug shall be furnished for field connection of the electrical supply. The connections shall be designed to accept copper conductors of sufficient size to serve the pump station loads. The main terminal block shall be mounted to allow incoming wire bending space in accordance with article 373 of the National Electric Code (NEC). A separate terminal strip shall be provided for 115 volt, single phase control power and shall be segregated from the main terminal block. Ten percent of the control terminals shall be furnished as spares.
  - b. All motor branch and power circuit components shall be of highest industrial quality. The short circuit current rating of all power circuit devices shall be a tested combination or evaluated per the National Electrical Code Article 409. The lowest rated power circuit component shall be the overall control panel short circuit rating and shall not be less than the fault current available. The minimum control panel rating shall not be less than 10 kA, rms symmetrical. Control assemblies operating at 120 volts nominal or less may be provided with transformers which limit the fault current and may be rated less than the minimum required short circuit rating.
2. Circuit breakers and operating mechanisms:
  - a. A properly sized heavy duty air circuit breaker shall be furnished for each pump motor. All circuit breakers shall be sealed by the manufacturer after calibration to prevent tampering.

- b. A padlocking operating mechanism shall be installed on each motor circuit breaker. Operator handles for the mechanisms shall be located on the exterior of the control compartment door, with interlocks which permit the door to be opened only when circuit breakers are in the "off" position. An additional mechanism(s) shall be provided on the circuit breaker permitting the breaker to be operated and/or locked with the control panel door in the open position.
3. Auxiliary Power Transformer:
- a. The lift station shall be equipped with a 5 KVA step-down transformer to supply 115 volt, AC, single phase for the control and auxiliary equipment.
  - b. The primary and secondary side of the transformer to be protected by a thermal magnetic circuit breaker, sized to meet the power requirements of the transformer.
  - c. An operating mechanism shall penetrate the control panel door and a padlockable operator handle shall be secured on the exterior surface.
  - d. Interlocks must prevent opening the door until circuit breakers are in "OFF" position.
  - e. An additional mechanism(s) shall be provided on the circuit breaker permitting the breaker to be operated and/or locked with the control panel door in the open position.
4. Motor Starter:
- a. A reduced voltage, solid state motor starter shall be furnished for each pump motor. The starter construction shall be modular with separately replaceable power and control sections. The power section shall consist of six back-to-back SCR's rated 208 to 480 volts, 50/60 hertz. The SCR's shall have a minimum repetitive peak inverse voltage rating of 1,400 volts at 480 volts. The enclosed operating temperature range shall be 0 to 40 degrees C at altitudes up to 2000 meters without derating.
  - b. Starting Modes: Starting modes shall be selectable soft start, current limit, or full voltage. Soft starting the pump shall include an adjustable initial torque value of 0 to 90 percent. The acceleration ramp shall be adjustable from 0 to 30 seconds. The starter shall include a selectable kick start providing a current pulse at start. Kick start level shall be adjustable from 0 to 90 percent of locked rotor torque. Kick start time shall be adjustable from 0 to 2 seconds. Current limit mode shall provide means for limiting the starting current to a programmable value between 50 and 600 percent of full load current. Full voltage start shall provide across the line starting with a ramp time of less than 0.25 seconds.

- c. Pump Control Mode: Ramp time will be dependent on pump torque requirements. The starter shall provide smooth acceleration and deceleration, which approximates the flow rate of a centrifugal pump. The starter's microcomputer shall analyze motor variables and generate control commands, which will minimize surges in the system. Pump stop time shall be adjustable from 0 to 120 seconds. Pump control provides reduced hydraulic shock.
- d. Bypass: When the start ramp time is complete, the starter shall energize an integral bypass contactor. When in the bypass mode, the bypass contactor shall carry the motor load to minimize internal heating in the electrical enclosure.
- e. Protection: The starter shall include protective features:
  - Communication fault, control temperature, excess starts/hour, stall, jam, line fault, open gate, overload, overvoltage, phase reversal, power loss, underload, undervoltage, shorted SCR, open bypass and voltage unbalance.
  - 1) An integral electronic overload relay equipped with thermal memory shall be included and shall utilize three phase current sensing. Adjustments shall include trip current, service factor and 10, 15, 20 or 30 trip class.
  - 2) Jam trip shall be adjustable 0-1,000 percent of the nominal motor current with a delay time adjustment of 0-99 seconds.
  - 3) Stall protection senses that the motor is not up-to-speed at end of ramp and will shut down after a user-selected delay time has elapsed. Stall delay shall be adjustable from 0-10 seconds.
  - 4) Fault diagnostics shall be displayed on the starter and shall include temperature fault, line fault, open gate and power loss.
- f. Door Mounted Display: Each starter shall be furnished with a display and keypad mounted to the door of the control panel. The door mounted display will duplicate the functions of the starter display and allow the operator to monitor or change parameters without opening the control panel door.

E. Transient Voltage Surge Suppressor:

- 1. The control panel shall be equipped with a transient voltage surge suppressor to minimize damage to the pump motors and control from transient voltage surges. The suppressor shall utilize thermally protected silicon-oxide varistors encapsulated in a non-conductive housing. Mechanical indicators shall be provided on each phase to indicate protection has been lost. The suppressor shall have a surge current rating of 100,000 Amps per phase and a 100kA interrupting rating.

F. Voltage Alert Indication:

1. The control panel shall include a voltage alert indicator to reduce the risk of electrical arc flash by pre-verifying the electrical isolation from outside of the control panel. Hardwired to the main incoming point of termination, the indicator shall be powered by the same voltage that it indicates utilizing redundant circuitry, thereby flashing whenever voltage is present. An eight detector display shall visually alert the presence of dangerous ac or dc potentials occurring between any combination of the monitored input lines.

G. Three Phase Voltage Monitor: The control panel shall be equipped to monitor the incoming power and shut down the pump motors when required to protect the motor(s) from damage caused by phase reversal, phase loss, high voltage, low voltage, and voltage unbalance. An adjustable time delay shall be provided to minimize nuisance trips. The motor(s) shall automatically restart, following an adjustable time delay, when power conditions return to normal.

H. Other Control Components:

1. The control circuit shall be fused, and shall be provided with a disconnect switch connected in such a manner as to allow control power to be disconnected from all control circuits.
2. Pump mode selector switches shall be connected to permit manual start and manual stop of each pump motor individually. Manual operation shall override shutdown systems supplied with the level control system except motor overload.
3. Pump alternation shall be integral to the PLC (Programmable Logic Controller). Provisions for automatic alternation or manual selection shall also be integral to the PLC (Programmable Logic Controller).
4. A selector switch shall provide manual alternation of the air pumps in the bubbler system. The switch shall be connected in such a manner that either pump may be selected to operate continuously.
5. A pushbutton shall be provided on the operator interface to silence the alarm circuits while corrective actions are underway. Depressing the alarm reset pushbutton shall also cause any alarm circuit to reset when the condition has been corrected.
6. High pump temperature shutdown circuit:
  - a. The control panel shall be equipped with circuitry to override the level control system and shut down the pump motor(s) when required to protect the pump from damage caused by excessive temperature.



- b. A thermostat shall be mounted on each pump to detect its temperature. If the pump temperature should rise to a level which could cause pump damage, the thermostat shall cause the shutdown circuit to drop out the motor starter. An indicator, visible on the operator interface shall indicate that the pump motor has been stopped because of a high temperature condition. The pump shall remain locked out until the pump has cooled and the circuit has been manually reset. Automatic reset of such a circuit shall not be acceptable.
7. Six digit elapsed time meters (non-reset type) shall be connected to each pump motor starter to indicate the total running time of each pump in "hours" and "tenths of hours".
8. A duplex ground fault indicating utility receptacle providing 115V ac, 60 hertz, single phase current shall be mounted on the side of the control enclosure. Receptacle circuit shall be protected by a 15 ampere thermal-magnetic circuit breaker.
9. Indicating lights shall be oil tight type and equipped with integral step-down transformers for long lamp life. Lamps shall be incandescent type rated 14 volts or less. Lamps shall be replaceable from the front without opening the control panel door and without the use of tools. Indicating lights will be provided for the following functions:
  - a. Alarm condition.
  - b. Pump #1 run.
  - c. Pump #2 run.
  - d. 115 volt power available.

I. Wiring:

1. The pump station components, as furnished by the manufacturer, shall be completely pre-wired.
2. All wiring, workmanship, and schematic wiring diagrams shall be in compliance with applicable standards and specifications for industrial controls set forth by the Joint Industrial Council (JIC), National Machine Tool Builders Association (NMTBA), and the National Electric Code (NEC).
3. All user serviceable wiring shall be type MTW or THW, 600 volts, and shall be color coded as follows:
  - a. Line and load circuits, AC or DC power: Black.
  - b. AC control circuit less than line voltage: Red.
  - c. DC control circuit: Blue.
  - d. Interlock control circuit, from external source: Yellow.
  - e. Equipment grounding conductor: Green.
  - f. Current carrying ground: White.
  - g. Hot with circuit breaker open: Orange.

4. Wire identification and sizing:
  - a. Control circuit wiring inside the panel, with the exception of internal wiring of individual components, shall be 16-gauge minimum, type MTW or THW, 600 volts. Wiring in conduit shall be 14-gauge minimum. Motor branch wiring shall be 10-gauge minimum.
  - b. Motor branch conductors and other power conductors shall not be loaded above the temperature rating of the connected termination. Wires shall be clearly numbered at each end in conformance with applicable standards. All wire connectors in the control panel shall be of the ring tongue type with nylon insulated shanks. All wires on the sub-plate shall be bundled and tied. All wires extending from components mounted on door shall be terminated on a terminal block mounted on the back panel. All wiring outside the panel shall be installed in conduit.
5. Control conductors connecting components mounted on the enclosure door shall be bundled and tied in accordance with good commercial practice. Bundles shall be made flexible at the hinged side of the enclosure. Adequate length and flex shall be allowed so that the door can swing to its full open position without undue mechanical stress or abrasion on the conductors or insulation. Bundles shall be clamped and held in place with mechanical fastening devices on each side of the hinge.

J. Conduit requirements are as follows:

1. All conduit and fittings shall be UL listed and in accordance with Section 26 05 01, Electrical.
2. Conduit shall be supported in accordance with articles 346, 347, and 350 of the National Electric Code.
3. Conduit shall be sized according to the National Electric Code.

K. Grounding:

1. The pump station manufacturer shall ground all electrical equipment to the enclosure back panel. The mounting surface of all ground connections shall have any paint removed before making final connections.
2. The contractor shall provide an earth driven ground connection to the control panel at the main ground lug in accordance with the National Electric Code (NEC).
3. Equipment Marking:
  - a. Permanent corrosion resistant name plate(s) shall be attached to the control and include following information:
    - 1) Equipment serial number.

- 2) Control panel short circuit rating.
  - 3) Supply voltage, phase and frequency.
  - 4) Current rating of the minimum main conductor.
  - 5) Electrical wiring diagram number.
  - 6) Motor horsepower and full load current.
  - 7) Motor overload heater element.
  - 8) Motor circuit breaker trip current rating.
  - 9) Name and location of equipment manufacturer.
- b. Control components shall be permanently marked using the same identification keys shown on the electrical diagram. Labels shall be mounted adjacent to device being identified.
  - c. Switches, indicators, and instruments mounted through the control panel door shall be labeled to indicate function, position, etc. Labels shall be mounted adjacent to, or above the device.

## 2.09 LIQUID LEVEL CONTROL SYSTEM

- A. Pump station shall operate on utility power while such power is available, except for exercise periods as specified herein. When operating on utility power, operation of pumps and motors shall be controlled by the level control system as specified herein. During a failure of utility power and during exercise periods, operation of the pump with the standby engine shall be controlled by the level control system and engine control system specified herein. Transfer from normal (utility power) control and to engine control shall occur as follows.
  1. PLC based controls shall be provided to accomplish the following functions:
    - a. All operator adjustable settings shall be accessible via the operator interface without opening control panel door.
    - b. Time delay after failure of utility power before transfer from normal control to engine control. Delay shall be manually adjustable from 0 to 600 seconds.
    - c. Time delay after restoration of utility power before transfer from engine control to normal control. Delay shall be manually adjustable from 2 to 1800 seconds.
    - d. Automatic override of time delay after power restoration, upon occurrence of: engine or engine control failure as specified under engine control system.
    - e. Manual override of time delay on restoration of normal power. Momentary pushbutton or similar device shall be acceptable.

- f. Time delay after transfer from engine control to normal control before application of AC power to motor of pump with standby engine. Such relay shall be preset at approximately 5 seconds to permit engine to stop completely before motor is started.
      - g. Indicate the presence of utility (normal) power. Such indicator shall be the press-to-test type to permit the operator to verify failure of utility power.
    2. These functions and interlocks shall be applicable only to the motor of the pump furnished with the standby engine. No hindrance shall be included for the motor starter and motor branch circuit for the pump which does not have the standby engine. Immediately upon restoration of utility power after power interruption, and during exercise periods, the pump which does not have the standby engine shall be permitted to run if operation of that pump is required by the level control system.
- B. Controls shall be provided to cause regular use of the engine control system and standby engine. Such exercise of standby components shall occur to maintain these components in a ready condition, and to discover malfunctions before emergency conditions arise.
  1. Exercise periods shall be established by an operator adjustable exercise timer. Timer shall provide a 7-day timing cycle, and shall permit the selection of one to four exercise periods of 0-1440 minute duration, which shall repeat every 7 days.
  2. During exercise periods, timer shall simulate a loss of utility power to transfer circuits described herein. After transfer from normal control to engine control, the engine control system shall operate the pump with the standby engine through the engine control system as described in these Specifications.
  3. If the standby engine is operating at the end of the exercise period, it shall continue to operate until one of the following conditions occurs:
    - a. The standby control system stops the engine through the engine control system, or,
    - b. The delay on restoration of utility power relay times out.
  4. Upon occurrence of either of these conditions, operation of the engine shall cease and revert to control by the normal control system.
  5. During exercise periods, utility power shall remain available to the motor of the pump which does not have the standby engine.
- C. Liquid Level Control:
  1. The integral PLC level control system shall start and stop the pump motors/engine in response to changes in wet well level, as set forth herein.

2. The integral level control system shall start and stop the standby engine through the engine control system and in response to changes in the wet well liquid level during a failure of utility power and during exercise periods.
3. The level control system shall be capable of operating as either an air bubbler type level control system, submersible transducer type system, or ultrasonic transmitter type system.
4. The level control system shall be designed to accomplish the following tasks:
  - a. Continuously monitor the level of liquid in the wet well.
  - b. Start and stop pump motors/engine as required by the level of liquid in the wet well.
  - c. Select the sequence of pump operation upon operator command for automatic alternation.
  - d. Provide alarm indications upon occurrence of predetermined malfunctions.
  - e. Upon restoration of utility power after a power outage, the system shall delay the application of power to the engine driven pump, by a length of time that has been preselected by the operator.
5. The level control system shall utilize alternation to select first one pump, then the second pump, to run as lead pump for a pumping cycle. Alternation shall occur at the end of a pumping cycle, or in the event of excessive run time.
6. EPS Analog Output circuit will be furnished with transient voltage surge suppression to protect related equipment from induced voltage spike from lightning.

D. Submersible Transducer System:

1. In accordance with Section 40 90 01, Instrumentation and Control for Process Systems.
2. An intrinsically safe repeater shall be supplied in the control enclosure. Repeater must be recognized and listed as intrinsically safe by a nationally recognized testing laboratory. Station manufacturer shall make all connections from repeater to feeder lines and motor controls. Installing contractor shall make connections from repeater to transducer.
3. Submersible transducer will be furnished with transient voltage surge suppression to protect related equipment from an induced voltage spike from lightning.

E. Engine Control System (PLC Based):

1. The engine control system shall be designed to accomplish the following tasks:
  - a. Permit the operator to select mode of engine operation, providing manual start and stop of the engine to override the level control system and cranking circuit if required.
  - b. Crank the engine upon start command from the level control system, and stop the engine upon a stop command.
  - c. Stop the cranking sequence if the engine fails to start after a reasonable number of attempts, and provide an alarm indication of failure to start.
  - d. While the engine is operating, continuously monitor engine speed, temperature and oil pressure.
  - e. Stop the engine for excessive speed, excessive engine water temperature, or insufficient oil pressure, and provide an alarm indication of shutdown and its cause, and shall
  - f. Maintain the charge on the engine storage battery.
  - g. Shutdown features shall be wired to the terminal strip to provide a general alarm indication.
2. Upon operator selection of automatic operation, when the standby level control system provides a start command, the engine control system shall start the engine cranking motor for a short period of time. If the engine does not start, the system shall stop the cranking motor for a short period of time, then resume cranking. Typically, 5 10-second cranking periods, each followed by a 10-second rest period, should be considered a reasonable effort to start the engine. When the engine starts, a sensor on the engine or elsewhere in the system shall stop the cranking cycle and reset the cranking circuit for the next start.
3. If the engine does not start within the preset number of attempts, the cranking circuit shall be de-energized, a failure to start indicator on the O/I (operator interface) shall be illuminated, and an external alarm device shall be energized. Control of the pump with the standby engine shall be returned to utility power.
4. Once the engine has started normally, the engine control system shall monitor engine speed, cylinder head temperature, and oil pressure. Upon engine failure from any cause, system shall provide an alarm indication, illuminate an indicator on the O/I, and energize and external alarm device as specified below.
5. During periods when the DC control system is fully operative, a battery charger shall continuously charge the engine storage battery.

6. Mode of engine operation:
  - a. Switches or other devices shall be provided and connected to perform as follows:
    - 1) When automatic operation is selected, engine shall start and stop under control of the engine control system.
    - 2) When manual operation is selected, engine cranking motor shall be controlled by a manual pushbutton or other device on the engine. Once started, engine shall run until off is selected.
    - 3) Operator can stop engine if it is running, and prevent it from starting during maintenance or repair.
  - b. Engine failure circuits shall stop the engine, illuminate an indicator on the O/I, and energize an external alarm device for each of the following conditions:
    - 1) Engine speed exceeds maximum overspeed setting.
    - 2) Engine temperature exceeds safe operating temperature as specified by the engine manufacturer.
    - 3) Engine oil pressure falls below engine manufacturer's specified recommendations. System must override or bypass this function during cranking and several seconds after starting to permit engine to build up oil pressure.
7. Engine control system shall be furnished with one battery charger, designed and connected to operate on 115 volts, ac 60 hertz to maintain the charge on the 12 volt dc storage battery supplied with the engine. Battery charger shall incorporate the following design features:
  - a. Automatic charge sensing and charging rate adjustment circuit.
  - b. Integral current limit circuit to limit charging rate.
  - c. Charging rate ammeter.
  - d. Fuse for protection of charging circuit.
8. Operating power for the engine control system, except the battery charger, shall be provided by the storage battery furnished with the standby engine during periods of utility power outage.

## 2.10 PLC CONTROL SYSTEM

### A. Programmable Logic Controller:

1. The PLC shall be an Allen-Bradley Micrologix 1500 system. The PLC shall be equipped with a Model LRP CPU with 14K memory, and a configurable port which is reserved for future customer use.
2. The PLC shall operate on 24V dc power and be equipped with the communication devices, digital and analog I/O necessary to accomplish the specified operation. A minimum of 10 percent spare of the I/O used shall be supplied.

3. The program logic shall be stored in battery backed random access memory, as well as on a programmable, read only memory module. The memory module shall auto load and run when installed in the programmable control processor and is included to facilitate field repair or replacement of the programmable control hardware without the use of programming terminals or personal computers.
4. The power supply to the programmable control shall be industrial grade design with integral power factor correction, dc "OK" signal indicator, and adjustable voltage. Operating range shall be minus 10 degrees C to plus 60 degrees C. Power supply shall have infinite short circuit, overvoltage and overtemperature protection. Each motor starter or contactor shall be equipped with a surge suppressor.
5. An Allen-Bradley Panelview 600 color electronic operator interface shall be provided for data entry and display. The operator interface shall be mounted on the front of the control panel with other operator controls. The operator interface shall be a TFT touch-screen terminal. A memory module shall be included.
6. Electromechanical relays and timers, when used shall be equipped with 120V ac coils and contacts rated NEMA A-300 minimum.
7. All user adjustable timer settings shall be PLC based. Time delay adjustment to be accessible via the operator interface without opening control panel door.

B. Control Logic:

1. Control logic shall be accomplished using programmable controllers. Electromechanical relays may be used when necessary. However, the primary control logic shall be performed by the PLC.
2. The O&M manual shall be provided with complete ladder logic program documentation including English names, rung comments, and coil/contact cross-references.
3. The control shall be pre-programmed or wired to provide the following routines:
  - a. Pump alternation at lead stop.
  - b. Excessive pump run time alternation.
  - c. Jump to next pump on lead failure.
  - d. Start/stop pumps at normal level settings.
  - e. Pump start delays when called simultaneously.
  - f. General alarm pilot light activation: Quick flashing alarm/slow flashing acknowledge/ steady on reset/off when clear.
  - g. Station trouble alarm (115V ac and normally open dry contact).
  - h. High and low level alarms.
  - i. Pump start/stop level control.
  - j. Engine start/stop level control.
  - k. Pump high temperature shutdown.



- l. Transfer to engine control.
- m. Phase failure relay.
- n. Automatic engine exerciser.
- 4. The operator interface shall be equipped with the following displays and functions:
  - a. Main Menu.
  - b. Wet Well Level.
  - c. Wet Well Level Simulation.
  - d. Low Water Alarm Status.
  - e. High Water Alarm Status.
  - f. Pump High Temperature Status #1, #2.
  - g. Engine alarm(s) status (overspeed, high temp, low oil pressure, overcrank, low battery).
  - h. Pump Sequence Selection.
  - i. Alarm Silence.
  - j. Alarm Reset.
  - k. Alarm History.
  - l. General Alarm Lamp Test.
  - m. Lead Level Start/Stop Setpoints.
  - n. Lag Level Start/Stop Setpoints.
  - o. Low Water Alarm Setpoints.
  - p. High Water Alarm Setpoints.
  - q. Engine Battery Monitor.
  - r. Idle Function selection for Exercise and/or Power Fail.
  - s. Power-up Delay Setpoint.
  - t. Alarm Delay Setpoint.
  - u. Pump Start Delay Setpoint.
  - v. Alternation Time Interval Setpoint.
  - w. Level Transmitter Calibration.
  - x. Exercise Period Setpoints (4).

#### 2.11 REMOTE MONITORING

- A. Pump station shall include a Mission unit for remote monitoring in accordance with Section 40 90 01, Instrumentation and Control for Process Systems.

#### 2.12 FIBERGLASS ENCLOSURE

- A. Pumping system shall be housed inside of a durable fiberglass enclosure sized by the pump station manufacturer.

- B. System: Design, furnish, and install complete fiberglass enclosure using manufacturer's standard components. The entire structure and the components of the structure including doors, louvers, etc. is to meet the Local Building Code regarding impact high velocity wind zones and calculated positive and negative required wind resistance and impact.
1. Structure: Fabricated fiberglass environmental enclosure designed to be moved and installed as a single unit.
  2. Design: Coordinate enclosure design with equipment to be enclosed. Design shall allow access to pumps, valves and piping and removal of the components without having to remove the structure.
  3. Components:
    - a. Shell:
      - 1) Fiberglass with yacht type finish.
      - 2) Provide weathertight structure that has straight, plumb walls with square or round corners.
    - b. Insulation to provide a minimum R value of 8.
    - c. Heated to protect to protect from freezing down to 10 degrees F.
    - d. Pump enclosures shall include vents / louvers and exhaust fan as sized and recommended by the Pump Manufacturer.
    - e. Louvers and fan must be on opposite side of the enclosure to allow air to be pulled across the structure to prevent the buildup of heat inside and to cool the pumps.
    - f. Louvers be constructed of aluminum and be manually closeable to allow the heater to protect the equipment from freezing in the winter.
    - g. Fan shall be rated for installation in a wet, corrosive environment.
    - h. Fan shall be thermostatically controlled to operate any time the temperature inside the enclosure exceeds 75 degrees.
    - i. Anchor Bolts: Type 316 stainless steel sized by manufacturer.

## **PART 3 EXECUTION**

### **3.01 EXAMINATION**

- A. Contractor shall off-load equipment at installation site using equipment of sufficient size and design to prevent injury or damage.
- B. Handle in accordance with the manufacturer written instructions

### **3.02 INSTALLATION**

- A. Install, level, align, and lubricate pump station as indicated on project drawings. Installation must be in accordance with written instructions supplied by the manufacturer at time of delivery.

- B. Suction pipe connections are vacuum tight. Fasteners at all pipe connections must be tight. Install pipe with supports and thrust blocks to prevent strain and vibration on pump station piping. Install and secure all service lines (level control, air release valve or pump drain lines) as required in wet well.
- C. Check motor and control data plates for compatibility to site voltage. Install and test the station ground prior to connecting line voltage to station control panel.
- D. Prior to applying electrical power to any motors or control equipment, check all wiring for tight connection. Verify that protective devices (fuses and circuit breakers) conform to project design documents. Manually operate circuit breakers and switches to ensure operation without binding. Open all circuit breakers and disconnects before connecting utility power. Verify line voltage, phase sequence and ground before actual start-up.

### 3.03 FACTORY TESTING

#### A. Certified Pump Performance Test:

1. Tests shall be conducted in accordance with Hydraulic Institute Standards 14.6.3.4 Acceptance Grade 2B at the specified head, capacity, rated speed and horsepower. The performance tests will validate the correct performance of the equipment at the design head, capacity and speed.
2. For pumps utilizing up to (13 hp) motors; but larger than (1.3 hp), tests shall be conducted in accordance with Hydraulic Institute Standards 14.6.3.4.1, as the specified head, capacity, rated speed and horsepower.

#### B. Factory System Test:

1. All components including the pumps, motors, engine, valves, piping and controls will be tested as a complete working system at the manufacturer's facility. Tests shall be conducted in accordance with Hydraulic Institute Standards at the specified head, capacity, rated speed and horsepower. Factory operational test shall duplicate actual performance anticipated for the complete station.
2. Upon request from the ESD or Engineer, the operational test may be witnessed by the ESD or Engineer, and/or representatives of his choice, at the manufacturer's facility.

### 3.04 FIELD QUALITY CONTROL

- A. Functional Test: With the ESD Electrician and the Engineer present conduct on each pump.
  - 1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
  - 2. Flow Output: Measured by calibrated temporary flow measurement device.
  - 3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
  - 4. Test for continuous 3-hour period.

### 3.05 OPERATIONS MANUAL

- A. Prior to start-up of station and training, provide the ESD three hard copies and one digital copy of an operating and maintenance manual for the overall pump station and all installed components.

### 3.06 MANUFACTURER'S SERVICES

- A. Manufacturer's Representative: Present at Site or classroom designated by ESD for minimum person-days listed below, travel time excluded:
  - 1. 1 person-day for installation assistance and inspection.
  - 2. 0.5 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
  - 3. 0.5 person-day for post-startup training of the ESD staff.
- B. Manufacture shall provide a certificate of proper installation for the pumps and control panel.

### 3.07 CLEANING

- A. Prior to acceptance, inspect interior and exterior of pump station for dirt, splashed material or damaged paint. Clean or repair accordingly. Remove from the jobsite all tools, surplus materials, scrap and debris.

### 3.08 PROTECTION

- A. The pump station should be placed into service immediately. If operation is delayed. Station is to be stored and maintained per manufacturer's written instructions.

**END OF SECTION**