LOS OSOS COMMUNITY SERVICES DISTRICT

CONSTRUCTION OF
LOS OSOS WASTEWATER PROJECT
AREA A, AREA B, AREA C, & AREA D

STATE REVOLVING FUND LOAN PROGRAM
PROJECT NO. C – 06 – 4014 - 110

VOLUME IIB:

TECHNICAL SPECIFICATIONS

DIVISION 11 THROUGH DIVISION 17

MWH
MONTGOMERY WATSON HARZA

Bids will be received at the office of the Los Osos Community Services District located at 2122 9th Street, Los Osos, CA 93402 on April 14, 2004.

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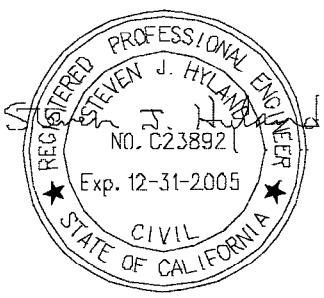

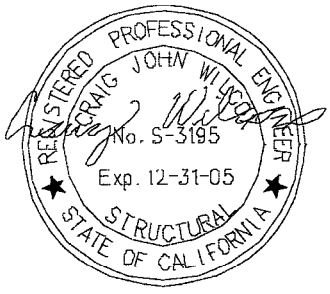

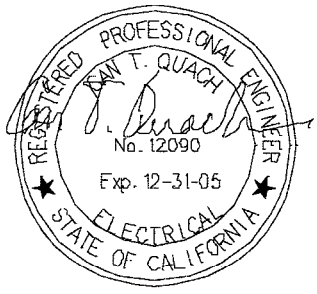

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SECTION 11000 - EQUIPMENT GENERAL PROVISIONS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide all tools, supplies, materials, equipment, and all labor necessary for the furnishing, construction, installation, testing, and operation of all equipment and appurtenant work, complete and operable, all in accordance with the requirements of the Contract Documents.

B. The provisions of this Section shall apply to all equipment except where otherwise indicated.

C. **Equipment Arrangement:** Unless specifically indicated otherwise, the arrangement of equipment shown on the Drawings is based upon information available at the time of design and is not intended to show exact dimensions particular to a specific manufacturer in all cases. Some aspects of the Drawings are diagrammatic and some features of the illustrated equipment arrangement may require revision to meet the actual equipment requirements. Structural supports, foundations, piping and valve connections, and electrical and instrumentation connections indicated may have to be altered to accommodate the equipment provided. No additional payment will be made for such revisions and alterations. Substantiating calculations and drawings shall be submitted prior to beginning the installation of equipment.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Equipment shall be in accordance with the following standards, as applicable and as indicated in each equipment specification:

1. American Society for Testing and Materials (ASTM).
2. American National Standards Institute (ANSI).
3. American Society of Mechanical Engineers (ASME).
4. American Water Works Association (AWWA).
5. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
6. American Welding Society (AWS).
7. National Fire Protection Association (NFPA).
8. Federal Specifications (FS).
9. National Electrical Manufacturers Association (NEMA).
10. Manufacturer's published recommendations and specifications.
11. General Industry Safety Orders (OSHA).

B. The following standards are referenced in this Section:

ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
ANSI B16.5	Pipe Flanges and Flanged Fittings, Steel, Nickel Alloy and other Special Alloys
ANSI B46.1	Surface Texture
ANSI S12.6	Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors
ASME B1.20.1	General Purpose Pipe Threads (Inch)
ASME B31.1	Power Piping
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm through 3,600 mm)
AWWA D100	Welded Steel Tanks for Water Storage
ASTM A 48	Gray Iron Castings
ASTM A 108	Steel Bars, Carbon, Cold-Finished, Standard Quality

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. **Shop Drawings:** Furnish complete drawings and technical information for equipment, piping, valves, and controls. Where indicated or required by the ENGINEER, Shop Drawings shall include clear, concise calculations showing equipment anchorage forces and the capacities of the anchorage elements proposed by the CONTRACTOR.

C. **Spare Parts List:** The CONTRACTOR shall obtain and submit from the manufacturer a list of suggested spare parts for each piece of equipment. CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment.

D. Torsion and Vibration Analyses

1. The CONTRACTOR shall arrange for and submit torsional and lateral vibration analyses for the following equipment types:

   a. Engine drives except engine generators.

   b. Pumps, blowers, and compressors with constant speed drives of 500 horsepower and greater.

   c. Pumps, blowers and compressors with variable speed drives of 100 horsepower and greater.

   d. Vertical pumps with universal joints and extended shafts.

e. Other equipment as indicated.

2. An experienced specialist from the equipment manufacturer shall perform a complete torsional and lateral vibration analysis of each distinct equipment, motor, and variable speed drive. These analyses shall identify the dry and wet lateral critical speeds plus the torsional critical speeds of the system. Appropriate lateral and critical speed maps shall be produced and submitted.

3. No active critical speed shall be allowed within 25 percent of the operating speed range. No fabrication of the equipment shall be started until the analyses have been approved by the ENGINEER.

E. **Seismic Analysis:** The CONTRACTOR shall submit a full set of UBC seismic design criteria and certification by a registered engineer that the design and installation of equipment was designed to that criteria to resist the seismic forces characteristic of the site, as provided herein.

F. **Support Requirements:** The CONTRACTOR shall also submit complete calculations, for all equipment weighing more than 400 pounds, showing the forces, and distribution of forces, imposed on the supporting structure resulting from normal operation, normal operation plus seismic loadings, and normal operation plus wind loadings. The size, type, capacity, location, and other placement requirements of all anchorage elements shall also be provided by the CONTRACTOR.

1.4 QUALITY ASSURANCE

A. **Costs:** The CONTRACTOR shall be responsible for performing and paying the costs of inspection, startup, testing, adjustment, and instruction services performed by factory representatives. The OWNER will pay for costs of power and water. If available, the OWNER's operating personnel will provide assistance in the field testing.

B. **Inspection:** The CONTRACTOR shall inform the local authorities, such as building and plumbing inspectors, fire marshal, OSHA inspectors, and others, to witness required tests for piping, plumbing, fire protection systems, pressure vessels, safety systems, and related items to obtain required permits and certificates, and shall pay inspection fees.

C. **Quality and Tolerances:** Tolerances and clearances shall be as shown on the Shop Drawings and shall be closely adhered to.

1. Machine work shall be of high-grade workmanship and finish, with due consideration to the special nature or function of the parts. Members without milled ends and which are to be framed to other steel parts of the structure may have a variation in the detailed length of not greater than 1/16-inch for members 30-feet or less in length, and not greater than 1/8-inch for members over 30-feet in length.

2. Castings shall be homogeneous and free from non-metallic inclusions and defects. Surfaces of castings which are not machined shall be cleaned to remove foundry irregularities. Casting defects not exceeding 12.5 percent of the total thickness and where defects will not affect the strength and serviceability of the casting may be repaired by approved welding procedures. The ENGINEER shall be notified of larger defects. No repair welding of such defects shall be carried out without the ENGINEER'S written approval. If the removal of metal for repair reduces the stress resisting cross-section of the casting by more than 25 percent or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by

more than 25 percent, then the casting may be rejected. Costs of casting new material shall be the CONTRACTOR'S responsibility as part of the WORK.

3. Materials shall meet the physical and mechanical properties in accordance with the reference standards.

D. **Machine Finish:** The type of finish shall be the most suitable for the application and shall be shown in micro-inches in accordance with ANSI B46.1. The following finishes shall be used:

1. Surface roughness not greater than 63 micro-inches shall be required for surfaces in sliding contact.

2. Surface roughness not greater than 250 micro-inches shall be required for surfaces in contact where a tight joint is not required.

3. Rough finish not greater than 500 micro-inches shall be required for other machined surfaces.

4. Contact surfaces of shafts and stems which pass through stuffing boxes and contact surfaces of bearings shall be finished to not greater than 32 micro-inches.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. **Noise Level:** When in operation, no single piece of equipment shall exceed the OSHA noise level requirement of 105 dBA for one hour exposure per day.

B. **High Noise Level Location:** The CONTRACTOR shall provide one personal hearing protection station at each high noise level location. Each hearing protection station shall shall include two pairs of high attenuation hearing protectors in the original unopened packaging plus 200 pairs of disposable foam ear plugs in individual packages. The ear protectors shall be capable of meeting the requirements of ANSI S12.6 and shall produce a noise level reduction of 25 dBA at a frequency of 500 Hz. The hearing protectors shall have fluid filled ear cushions and an adjustable, padded headband. The protectors shall be stored in a weatherproof, labeled, steel cabinet, provided at an approved location near the noise producing equipment. Locations are defined as follows:

1. Outdoor Location: Any single equipment item or any group of equipment items that produce noise exceeding OSHA noise level requirements for a 2-hour exposure. Where such equipment is separated by a distance of more than 20-feet, measured between edges of footings, each group of equipment shall be provided with a separate hearing protection station.

2. Indoor Location

a. Any single equipment item or any group of equipment items located within a single room not normally occupied, that produces noise exceeding OSHA noise level requirements for a 2-hour exposure.

b. Any single equipment item or any group of equipment items located within a single room normally occupied by workers, that produces noise exceeding OSHA noise level requirements for an 8-hour exposure.

C. **Personal Hearing Protection:** In addition to the equipment provided in the hearing protection stations required above, the CONTRACTOR shall furnish 3 pairs of high attenuation hearing protectors in the original unopened packaging. The ear protectors shall be capable of meeting the requirements of ANSI S12.6 and shall produce a noise level reduction of 25 dBA at a frequency of 500 Hz. The hearing protectors shall have fluid filled ear cushions and an adjustable, padded headband.

D. **Drive Trains and Service Factors:** Service factors shall be applied in the selection or design of mechanical power transmission components. All components of drive train assemblies between the prime mover and the driven equipment shall be designed and rated to deliver the maximum peak or starting torque, speed, and horsepower. All of the applicable service factors shall be considered, such as mechanical (type of prime mover), load class, start frequency, ventilation, ambient temperature, and fan factors. Drive train components include couplings, shafts, gears and gear drives, drive chains, sprockets, and V-belt drives. Unless otherwise indicated, the following load classifications shall apply in determining service factors:

Type of Equipment	Service Factor	Load Classification
Blowers		
centrifugal or vane	1.0	Uniform
lobe	1.25	Moderate Shock
Centrifugal Fans	1.0	Uniform
Reciprocating Air Compressors		
multi-cylinder	2.0	Heavy Shock
single-cylinder	2.0	Heavy Shock
Pumps		
centrifugal or rotary	1.0	Uniform
reciprocating	1.8	Moderate Shock
progressing cavity	1.0	Uniform
Mixers		
constant density	1.0	Uniform
variable density	1.25	Moderate Shock
rapid mixer	1.25	Moderate Shock
flocculator	1.25	Moderate Shock
sludge mixer	2.5	Moderate Shock
surface aerator	2.5	Heavy Shock
Clarifiers	1.0	Uniform
Sludge Thickeners	1.25	Moderate Shock
Vacuum Filters	1.25	Moderate Shock

Dewatering Screws	1.25	Moderate Shock
Grit Handling Equipment	1.25	Moderate Shock
Mechanical Bar Screens	1.0	Uniform
Scum Breakers	1.25	Moderate Shock
Cranes or Hoists	1.25	Moderate Shock

E. Mechanical Service Factors

	Mechanical Service Factors	
	Electric Motor	**Internal Combustion Engine**
Uniform	1.25	1.50
Moderate Shock	1.50	1.75
Heavy Shock	2.00	2.25

F. For thermal rating adjustments such as start frequency, ambient temperature, and hourly duty cycle factor, ventilation factor, and fan factor, refer to gear manufacturer sizing information.

G. For service factors of electric motors, see Section 16460 - Electric Motors.

H. Where load classifications are not indicated, service factors based on AGMA 514.02 shall be used for standard load classifications and for flexible couplings.

I. **Welding:** Unless otherwise indicated, welding shall conform to the following:

1. Latest revision of ANSI/AWWA D100.

2. Latest revision of AWWA C206.

3. Composite fabricated steel assemblies that are to be erected or installed inside a hydraulic structure, including any fixed or movable structural components of mechanical equipment, shall have continuous seal welds to prevent entrance of air or moisture.

4. Welding shall be by the metal-arc method or gas-shielded arc method as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards.

5. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the AWS code. Upon completion of welding,

weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance, with uniform weld contours and dimensions. Sharp corners of material that is to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.

J. **Protective Coating:** Equipment shall be painted or coated in accordance with Section 09800 – Protective Coating, unless otherwise indicated. Non-ferrous metal and corrosion-resisting steel surfaces shall be coated with grease or lubricating oil. Coated surfaces shall be protected from abrasion or other damage during handling, testing, storing, assembly, and shipping.

K. **Protection of Equipment:** Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry at all times. Pumps, motors, drives, electrical equipment, and other equipment having anti-friction or sleeve bearings shall be stored in weathertight storage facilities prior to installation. For extended storage periods, plastic equipment wrappers should be avoided, to prevent accumulation of condensate in gears and bearings. In addition, motor space heaters shall be energized and shafts shall be rotated. Equipment delivered to the Site with rust or corroded parts shall be rejected. If equipment develops defects during storage, it shall be disassembled, cleaned, and recoated to restore it to original condition.

L. **Identification of Equipment Items:**

1. At the time of shipping, each item of equipment shall have a legible identifying mark corresponding to the equipment number in the Contract Documents for the particular item.

2. After installation, each item of equipment shall be given permanent identification.

   a. Pumps, compressors, and blowers smaller than 100 horsepower shall receive acrylic plastic nametags in accordance with Section 10400 – Identifying Devices.

   b. Pumps, compressors, and blowers larger than 150 horsepower shall receive stainless steel platenametags in accordance with Section 10400.

M. **Vibration Isolators:** Air compressors, blowers, engines, inline fans shall be provided with restrained spring-type vibration isolators or pads per manufacturer's written recommendations. Vibration isolations shall be provided with seismic restraint.

N. **Shop Fabrication:** Shop fabrication shall be performed in accordance with the Contract Documents and the Shop Drawings.

O. **Controls:** Equipment and system controls shall be in accordance with Division 17 - Instrumentation.

2.2 EQUIPMENT SUPPORTS AND FOUNDATIONS

A. **Equipment Supports:** Unless otherwise indicated, equipment supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads. The design horizontal seismic force shall be the greater of: that noted in the general structural notes or as required by the governing building code. Design calculations

submitted for equipment supports shall bear the signature and seal of an engineer registered in the State wherein the project is to be built, unless otherwise indicated.

B. **Seismic Requirements:** All equipment shall be designed and anchored in place by methods which meet the requirements of the Uniform Building Code for seismic loading conditions. The following parameters shall be used:

Seismic Zone: 4

Importance Factor: I = 1.25, Ip = 1.50

Soil Profile: S_D

Na = 1.3, Nv = 1.6

Ca = 0.44 Na, Cv = 0.64 Nv

C. **Anchors:** Anchor bolts shall be in accordance with Section 05500 - Miscellaneous Metalwork. Anchoring methods and leveling criteria shall be per the written recommendations of the equipment manufacturer. Such recommendations shall be submitted as required for Shop Drawings in Section 01300, "Contractor Submittals."

D. **Equipment Foundations:** Equipment foundations shall be as per manufacturer's written recommendations. Mechanical equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on minimum 3.5-inch high concrete bases, unless otherwise indicated. Equipment foundations are indicated on Drawings. The CONTRACTOR through the equipment manufacturer shall verify the size and weight of equipment foundation to insure compatibility with equipment.

2.3 COUPLINGS

A. Mechanical couplings shall be provided between the driver and the driven equipment. Flexible couplings shall be provided between the driver and the driven equipment to accommodate slight angular misalignment, parallel misalignment, end float, and to cushion shock loads. Unless otherwise indicated or recommended by the equipment manufacturer, coupling type shall be furnished with the respective equipment as follows:

Equipment Type	Coupling Type
Horizontal and end suction pumps	Gear or flexible spring
Vertical turbine pumps	3 piece spacer for solid shaft or double nut for hollow shaft
Vertical nonclog pumps, close coupled	Flexible disc pack
Screw pumps	Flexible spring, gear coupling, fluid coupling
Vertical nonclog pumps with extended shaft	Flexible disc pack or Universal joint with carbon fiber composite shaft and steady bearing support(s)

Belt conveyors	Gear coupling for fractional to 7.5 horsepower, Silicone filled fluid coupling for 10 hp and larger
Sludge collector	Gear coupling or jaw clutch
Engine driven pumps	Universal joint type or elastomeric flexible type
Single stage centrifugal blowers	Flexible disc pack
Air compressors	Gear or flexible disc pack

B. Each coupling size shall be determined based on the rated horsepower of the motor, speed of the shaft, and the load classification service factor. The CONTRACTOR shall have the equipment manufacturer select or recommend the size and type of coupling required to suit each specific application.

C. **Differential Settlement:** Where differential settlement between the driver and the driven equipment may occur, 2 sets of universal type couplings shall be provided.

D. **Taper-Lock** or equal bushings may be used to provide for easy installation and removal of shafts of various diameters.

2.4 SHAFTING

A. **General:** Shafting shall be continuous between bearings and shall be sized to transmit the power required. Keyways shall be accurately cut in line. Shafting shall not be turned down at the ends to accommodate bearings or sprockets whose bore is less than the diameter of the shaft. Shafts shall rotate in the end bearings and shall be turned and polished, straight, and true.

B. **Design Criteria**: All shafts shall be designed to carry the steady state and transient loads suitable for unlimited number of load applications, in accordance with ASME B106.1M - Design of Transmission Shafting. Where shafts are subjected to fatigue stresses, such as frequent start and stop cycles, the mean stress shall be determined by using the modified Goodman Diagram. The maximum torsional stress shall not exceed the endurance limit of the shaft after application of the factor of safety of 2 in the endurance limit and the stress concentration factor of the fillets in the shaft and keyway. Stress concentration factor shall be in accordance with ASME Standard B17.1 - Keys and Keyseats.

C. **Materials:** Shafting materials shall be appropriate for the type of service and torque transmitted. Environmental elements such as corrosive gases, moisture, and fluids shall be taken into consideration. Materials shall be as indicated unless furnished as part of an equipment assembly.

1. Low carbon cold-rolled steel shafting shall conform to ASTM A 108, Grade 1018.

2. Medium carbon cold-rolled shafting shall conform to ASTM A 108, Grade 1045.

3. Other grades of carbon steel alloys shall be suitable for service and load.

4. Corrosion-resistant shafting shall be stainless steel or Monel, whichever is most suitable for the intended service.

D. **Differential Settlement:** Where differential settlement between the driver and the driven equipment may occur, a shaft of sufficient length with 2 sets of universal type couplings shall be provided.

2.5 GEARS AND GEAR DRIVES

A. Unless otherwise indicated, gears shall be of the spur, helical, or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a service factor suitable for load class, mechanical service and thermal rating adjustment, a minimum L-10 bearing life of 60,000 hours, and a minimum efficiency of 94 percent. Peak torque, starting torque, and shaft overhung load shall be checked when selecting the gear reducer. Worm gears shall not be used unless specifically approved by the ENGINEER.

B. Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided, located for easy reading.

C. Gears and gear drives that are part of an equipment assembly shall be shipped fully assembled for field installation.

D. Material selections shall be left to the discretion of the manufacturer, provided the above AGMA values are met. Input and output shafts shall be adequately designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shaft shall have 2 positive seals to prevent oil leakage.

E. Oil level and drain locations shall be easily accessible. Oil coolers or heat exchangers with all required appurtenances shall be provided when necessary.

F. Where gear drive input or output shafts from one manufacturer connect to couplings or sprockets from a different manufacturer, the CONTRACTOR shall have the gear drive manufacturer furnish a matching key taped to the shaft for shipment.

2.6 DRIVE CHAINS

A. Power drive chains shall be commercial type roller chains meeting ANSI Standards.

B. A chain take-up or tightener shall be provided in every chain drive arrangement to provide easy adjustment.

C. A minimum of one connecting or coupler link shall be provided in each length of roller chain.

D. Chain and attachments shall be of the manufacturer's best standard material and be suitable for the process fluid.

2.7 SPROCKETS

A. **General:** Sprockets shall be used in conjunction with chain drives and chain-type material handling equipment.

B. **Materials:** Unless otherwise indicated, materials shall be as follows:

1. Sprockets with 25 teeth or less, normally used as a driver, shall be made of medium carbon steel in the 0.40 to 0.45 percent carbon range.

2. Type A and B sprockets with 26 teeth or more, normally used as driven sprockets, shall be made of minimum 0.20 percent carbon steel.

3. Large diameter sprockets with Type C hub shall be made of cast iron conforming to ASTM A 48, Class 30.

C. Sprockets shall be accurately machined to ANSI Standards. Sprockets shall have deep hardness penetration in tooth sections.

D. Finish bored sprockets shall be furnished complete with keyseat and set screws.

E. To facilitate installation and disassembly, sprockets shall be of the split type or shall be furnished with **Taper-Lock** bushings as required.

F. Idler sprockets shall be provided with brass or Babbitt bushings, complete with oil hole and axial or circumferential grooving with stainless steel tubing and grease fitting extended to an accessible location. Steel collars with set screws may be provided in both sides of the hub.

2.8 V-BELT DRIVES

A. V-belts and sheaves shall be of the best commercial grade and shall conform to ANSI, MPTA, and RMA Standards.

B. Unless otherwise indicated, sheaves shall be machined from the finest quality gray cast iron.

C. Sheaves shall be statically balanced. In some applications where vibration is a problem, sheaves shall be dynamically balanced. Sheaves operating at belt speeds exceeding 6,500 fpm may be required to be of special materials and construction.

D. To facilitate installation and disassembly, sheaves shall be provided complete with **Taper-Lock** or **QD** bushings as required.

E. Finish bored sheaves shall be complete with keyseat and set screws.

F. Sliding motor bases shall be provided to adjust the tension of V-belts.

2.9 DRIVE GUARDS

A. Power transmission trains, prime movers, machines, shaft extensions, and moving machine parts shall be guarded to conform with the Division of Industrial Safety General Industrial Safety Orders latest edition The guards shall be constructed of minimum 10 gauge expanded, flattened steel with smooth edges and corners, galvanized after fabrication, and securely fastened. Where required for lubrication or maintenance, guards shall have hinged and latched access doors.

2.10 BEARINGS

A. **General:** Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

B. To assure satisfactory bearing application, fitting practice, mounting, lubrication, sealing, static rating, housing strength, and lubrication shall be considered in bearing selection.

C. Re-lubricatable type bearings shall be equipped with a hydraulic grease fitting in an accessible location and shall have sufficient grease capacity in the bearing chamber.

D. Lubricated-for-life bearings shall be factory-lubricated with the manufacturer's recommended grease to insure maximum bearing life and best performance.

E. **Anti-Friction Type Bearing Life:** Except where otherwise indicated, bearings shall have a minimum L-10 life expectancy of 5 years or 20,000 hours, whichever occurs first. Where so indicated, bearings shall have a minimum rated L-10 life expectancy corresponding to the type of service, as follows:

Type of Service	Design Life, years	L-10 Design Life, hours
	(whichever comes first)	
8-hour shift	10	20,000
16-hour shift	10	40,000
Continuous	10	60,000

F. Bearing housings shall be of cast iron or steel and bearing mounting arrangement shall be as indicated or as recommended in the published standards of the manufacturer. Split-type housings may be used to facilitate installation, inspection, and disassembly.

G. **Sleeve Type Bearings**: Sleeve-type bearings shall have a cast iron or ductile iron housing and Babbitt or bronze liner. Bearing housing shall be bolted and doweled to the lower casing half. These housings shall be provided with cast iron caps bolted in place and the bearing end caps shall be bored to receive the bearing shells. Sleeve bearings shall be designed on the basis of the maximum allowable load permitted by the bearing manufacturer. If the sleeve bearing is connected to an equipment shaft with a coupling, the coupling transmitted thrust will be assumed to be the maximum motor or equipment thrust. Lubricant, lubrication system, and cooling system shall be as recommended by the bearing manufacturer.

H. **Plate Thrust Bearings**: Thrust bearings shall be the **Kingsbury** Type, designed and manufactured to maintain the shaft in the fixed axial position without undue heating or the necessity of adjustment or attention. Bearings shall be oil lubricated to suit the manufacturer's standard method of lubrication for the specific bearing. If bearing cooling is required, manufacturer shall provide necessary piping, filters, and valves.

2.11 PIPING CONNECTIONS

A. **Pipe Hangers, Supports, and Guides:** Pipe connections to equipment shall be supported, anchored, and guided to avoid stresses and loads on equipment flanges and equipment. Supports and hangers shall be in accordance with Section 15006 - Pipe Supports.

B. **Flanges and Pipe Threads:** Flanges on equipment and appurtenances shall conform to ANSI B16.1, Class 125, or B16.5, Class 150, unless otherwise indicated. Pipe threads shall be in accordance with ANSI/ASME B1.20.1 and Section 15000 - Piping, General.

C. **Flexible Connectors:** Flexible connectors shall be installed in all piping connections to engines, blowers, compressors, and other vibrating equipment and in piping systems in accordance with the requirements of Section 15000. Flexible connectors shall be harnessed or otherwise anchored to prevent separation of the pipe where required by the installation.

D. **Insulating Connections:** Insulating bushings, unions, couplings, or flanges, as appropriate, shall be used in accordance with the requirements of the Section 15000.

2.12 GASKETS AND PACKINGS

A. Gaskets shall be in accordance with Section 15000.

B. Packing around valve stems and reciprocating shafts shall be of compressible material, compatible with the fluid being used. Chevron-type "V" packing shall be **Garlock No. 432, John Crane "Everseal,"** or equal.

C. Packing around rotating shafts (other than valve stems) shall be "O"-rings, stuffing boxes, or mechanical seals, as recommended by the manufacturer and approved by the ENGINEER, in accordance with Section 11100 - Pumps, General.

2.13 NAMEPLATES

A. Equipment nameplates of stainless steel shall be engraved or stamped and fastened to the equipment in an accessible location with No. 4 or larger oval head stainless steel screws or drive pins. Nameplates shall contain the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the machine performance ratings.

2.14 TOOLS AND SPARE PARTS

A. **Tools:** The CONTRACTOR shall furnish one complete set of special wrenches and other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality hardened steel forgings with bright finish. Wrench heads shall have work faces dressed to fit nuts. Tools shall be suitable for professional work and manufactured by **Snap On, Crescent, Stanley,** or equal. The set of tools shall be neatly mounted in a labeled toolbox of suitable design provided with a hinged cover.

B. Spare parts shall be furnished as indicated in the individual equipment sections. All spare parts shall be suitably packaged in a metal box and labeled with equipment numbers by means of stainless steel or solid plastic nametags attached to the box.

2.15 EQUIPMENT LUBRICANTS

A. The CONTRACTOR shall install lubricants for all equipment during storage and prior to initial testing of the equipment. After successful initial testing, final testing, and satisfactory completion startup testing as specified in Section 01660 - Equipment Testing and Plant Startup, the CONTRACTOR shall conduct one complete lubricant change on all equipment. In addition, the CONTRACTOR shall be responsible for the proper disposal of all used lubricants. The OWNER will then be responsible for subsequent lubricant changes

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment**: Where required by individual sections, an authorized, experienced, and competent service representative of the manufacturer shall visit the Site for the number of days indicated in those sections to witness or perform the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.

1. Installation of equipment

2. Inspection, checking, and adjusting the equipment and approving its installation

3. Startup and field testing for proper operation, efficiency, and capacity

4. Performing field adjustments during the test period to ensure that the equipment installation and operation comply with requirements

B. Instruction of the Owner's Personnel

1. Where required by the individual equipment sections, an authorized training representative of the manufacturer shall visit the Site for the number of days indicated in those sections to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.

2. The representative shall have at least 2 years experience in training. A resume of the representative shall be submitted.

3. Training shall be scheduled 3 weeks in advance of the scheduled session.

4. Proposed training material and a detailed outline of each lesson shall be submitted for review. Review comments from the ENGINEER shall be incorporated into the material.

5. The training materials shall remain with the trainees after the session.

6. The OWNER may videotape the training for later use by the OWNER's personnel.

C. **Vibration Monitoring**: For the equipment types listed in paragraph 1.3D, the CONTRACTOR shall arrange for at least two Site visits by the manufacturer's specialist

during testing of the equipment covered by torsional and vibration analysis submittals to measure the amount of vibration and prepare written recommendations for keeping the vibration within acceptance limits. If vibration readings exceed the specified or the applicable referenced standard vibration limits for the type of equipment, the CONTRACTOR shall make necessary corrections for the equipment to meet the acceptance criteria.

3.2 INSTALLATION

A. **General:** Equipment shall be installed in accordance with the manufacturers written recommendations.

B. **Alignment**: Equipment shall be field tested to verify proper alignment.

3.3 PACKAGED EQUIPMENT

A. When any system is furnished as pre-packaged equipment, the CONTRACTOR shall coordinate all necessary space and structural requirements, clearances, utility connections, signals, and outputs with subcontractors to avoid later change orders.

B. If the packaged system has any additional features (as safety interlocks, etc.) other than required by the Contract Documents, the CONTRACTOR shall coordinate such features with the ENGINEER and provide all material and labor necessary for a complete installation as required by the manufacturer.

3.4 FIELD ASSEMBLY

A. Studs, cap screws, bolt and nuts used in field assembly shall be coated with **"Never Seize"** compound or equal.

3.5 WELDING

A. Welds shall be cleaned of weld-slag, splatter, etc. to provide a smooth surface.

3.6 FIELD TESTS

A. Where indicated by the individual equipment sections, equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or no overheating of bearings or motor.

B. The following field testing shall be conducted:

1. Start equipment, check, and operate the equipment over its entire operating range. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable Standards..

2. Obtain concurrent readings of motor voltage, amperage, capacity, vibration and bearing temperatures.

3. Operate equipment indicated in Section 01660.

C. The ENGINEER shall witness field-testing. The CONTRACTOR shall notify the ENGINEER of the test schedule three days in advance.

D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and resettled until it satisfies the requirement.

- END OF SECTION -

SECTION 11100 - PUMPS, GENERAL

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide all pumps and pumping appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all pumps and pumping equipment except where otherwise indicated in the Contract Documents.

C. The requirements of Section 11000 – Equipment General Provisions apply to this Section.

D. **Unit Responsibility:** The pump manufacturer shall be made responsible for furnishing the WORK and for coordination of design, assembly, testing, and installation of the WORK of each pump Section; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each pump Section.

E. **Single Manufacturer:** Where two or more pump systems of the same type or size are required, the pumps shall all be produced by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01300 – Contractor Submittals.

B. **Shop Drawings:** Shop Drawings shall contain the following information:

1. Pump name, identification number, and specification Section number.

2. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump. The equipment manufacturer shall indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions and the maximum and minimum flow conditions. Performance curves at intervals of 100 rpm from minimum speed to maximum speed shall be furnished for each centrifugal pump equipped with a variable speed drive.

3. The CONTRACTOR shall require the manufacturer to indicate the limits on the performance curves recommended for stable operation without surge, cavitation, or excessive vibration. The stable operating range shall be as wide as possible based on actual hydraulic and mechanical tests.

4. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.

5. Data, in accordance with Section 16460 – Electric Motors, for the electric motor proposed for each pump.

6. Elevation of proposed local control panel showing panel-mounted devices, details of enclosure type, single line diagram of power distribution, and current draw of panel, and list of all terminals required to receive inputs or to transmit outputs from the local control panel.

7. Wiring diagram of field connections with identification of terminations between local control panels, junction terminal boxes, and equipment items.

8. Complete electrical schematic diagram.

C. **Technical Manual:** The Technical Manual shall contain the required information for each pump Section.

D. **Spare Parts List:** A spare parts list shall contain the required information for each pump Section.

E. **Factory Test Data:** Signed, dated, and certified factory test data for each pump system which requires factory testing, submitted before shipment of equipment.

F. **Certifications:**

1. Manufacturer's certification of proper installation.

2. CONTRACTOR's certification of satisfactory field testing.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Compliance with the requirements of the individual pump Sections may necessitate modifications to the manufacturer's standard equipment.

B. **Performance Curves:** All centrifugal pumps shall have a continuously rising curve or the system operating range shall not cross the pump curve at two different capacities or "dip region." Unless indicated otherwise, the required pump shaft horsepower at any point on the performance curve shall not exceed the rated horsepower of the motor or engine or encroach on the service factor.

C. All components of each pump system provided under the pump Sections shall be entirely compatible. Each unit of pumping equipment shall incorporate all basic mechanisms, couplings, electric motors or engine drives, variable speed controls, necessary mountings, and appurtenances.

2.2 MATERIALS

A. All materials shall be suitable for the intended application; materials not indicated shall be high-grade, standard commercial quality, free from all defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements:

1. Cast iron pump casings and bowls shall be of close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or equal.

2. Bronze pump impellers shall conform to ASTM B 62 - Composition Bronze or Ounce Metal Castings, or B 584 - Copper Alloy Sand Castings for General Applications, where dezincification does not occur.

3. Stainless steel pump shafts shall be Type 416 or 316. Miscellaneous stainless steel parts shall be Type 316.

4. Anchor bolts, washers, and nuts in Standard Service (Non-Corrosive Application) shall be galvanized steel in accordance with the requirements of Section 05500 - Miscellaneous Metalwork. Anchor bolts, washers, and nuts in Corrosive Service as defined in Section 05500 shall be stainless steel in accordance with that Section – Miscellaneous Metalwork.

2.3 PUMP COMPONENTS - GENERAL

A. **Flanges and Bolts:** Suction and discharge flanges shall conform to ANSI/ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 or ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings dimensions. Bolts shall be in accordance with Section 05500 – Miscellaneous Metalwork.

B. **Lubrication:** Vertical pump shafts of clean water pumps shall be product water-lubricated, unless otherwise indicated. Deep-well pumps and pumps with dry barrels shall have water- or oil-lubricated bearings and seals and enclosed line shafts. Pumps for sewage, sludge, and other process fluids shall be lubricated as indicated.

C. **Handholes:** Handholes on pump casings shall be shaped to follow the contours of the casing to avoid any obstructions in the water passage.

D. **Drains:** All gland seals, air valves, cooling water drains, and drains from variable speed drive equipment shall be piped to the nearest floor sink or drain, with galvanized steel pipe or copper tube, properly supported with brackets.

E. **Grease Lubrication:** For all vertical propeller, mixed-flow, and turbine pumps, other than deep well pumps, of bowl sizes 10 inches and larger, the CONTRACTOR shall provide a stainless steel tube attached to the column for grease lubrication of the bottom bearing.

F. **Stuffing Boxes:** Where stuffing boxes are indicated for the pump seal, they shall be of the best quality, using the manufacturer's suggested materials best suited for the specific application. For sewage, sludge, drainage, and liquids containing sediments, the seals shall be fresh-water flushed, using lantern rings. If fresh water is not available, the seal shall be flushed with product water cleaned by a solids separator as manufactured by John Crane Co., Lakos (Claude Laval Corp.), or equal.

1. Conventional Packing Gland Type Seal: Unless otherwise indicated, the packing material shall be interlaced Teflon braiding, containing 50 percent ultrafine graphite impregnation to satisfy the following. Acceptable ring materials are asbestos-free die-molded packing rings of braided graphite material free of PTFE, Chesterton 1400R, or equal for non-potable water service and braided PTFE material, Chesterton 1725 or equal that is listed under NSF Standard 61 for potable water service.

Shaft speeds	up to 2500 fpm

Temperature	up to 500 degrees F
pH range	0-14

2. Mechanical Seals (Conventional Non-Split Type): Mechanical seals shall be fresh water-flushed unless indicated otherwise; in which case product water cleaned by a solids separator as above shall be used. Mechanical seals shall be as manufactured by the following, or equal:

Sewage, Sludge, or Wastewater Pumps	Double seals	John Crane Type 88, Flowserve Type ISCPP, Chesterton Type GDS or 255

3. Mechanical Seals (Split Type): Split type mechanical seals shall be fresh water flushed unless indicated otherwise; in which case product water cleaned by a solids separator as above shall be used. Mechanical seals shall be as manufactured by the following or equal

Sewage, Sludge, or Wastewater Pumps	Double seals	John Crane Type 3710, Flowserve Type PSS2, Chesterton Type 442

G. Where indicated, a buffer fluid must be circulated a minimum 20 psi above discharge pressure, or as required by the manufacturer, in order to maintain reliable seal performance.

H. Mechanical seals for all services shall be equipped with nonclogging, flexible–mounted seats with elastomer secondary seals. Wetted metal parts shall be Type 316 stainless steel, Alloy 20, or Hastelloy B or C, whichever has the best corrosion resistance to the pumped fluid. Dual cartridge seals shall be double balanced to allow for seal integrity in case of flush water pressure reversal. All single and double seals shall have springs in the non-wetted end of the seal.

I. Fresh water shall be delivered to the seals through appropriate size piping with plug valves, strainers, pressure regulators, electrically operated solenoid valves, and rotameters. Wiring shall comply with Division 16 – Electrical and solenoid control shall comply with Division 17 – Instrumentation.

2.4 PUMP APPURTENANCES

A. **Nameplates:** Each pump shall be equipped with a stainless steel nameplate indicating serial numbers, rated head and flow, impeller size, pump speed, and manufacturer's name and model number.

B. **Solenoid Valves:** The pump manufacturer shall provide solenoid valves on the water or oil lubrication lines and on all cooling water lines. Solenoid valve electrical ratings shall be compatible with the motor control voltage.

C. Gauges

1. All pumps (except sample pumps, sump pumps, and hot water circulating pumps) shall be equipped with pressure gauges installed at pump discharge lines. Pump suction lines shall be provided with compound gauges. Gauges shall be located in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings.

2. Where subject to shock or vibrations, the gauges shall be wall-mounted or attached to galvanized channel floor stands and connected by means of flexible connectors.

3. Pressure and compound gauges shall be provided in accordance with Section 17108 - Pressure Measuring Systems.

2.5 FACTORY TESTING

A. The following tests shall be conducted on each indicated pump system:

1. Motors: Electric motors shall be tested in accordance with Section 16460 – Electrical Motors. Test results shall be furnished to the pump manufacturer prior to the pump test.

2. Pump Systems: All centrifugal pump systems with drives 10 hp up to and including 125 hp shall be tested at the pump factory in accordance with the American National Standard for Centrifugal Pump Tests (ANSI/HI 1.6) acceptance Level "A" or the American National Standard for Vertical Pump Tests (ANSI/HI 2.6) as approved by ANSI and published by the Hydraulic Institute. For sump pumps, acceptance shall be in accordance with Level "B" of ANSI/HI 1.6 unless indicated otherwise. Tests shall be performed using the complete pump system to be furnished, including the project motor and variable speed drive if equipped with variable speed drive. For pumps with motors smaller than 100 hp, the manufacturer's certified test motor shall be acceptable. Testing of prototype models will not be acceptable. The following minimum test results shall be submitted:

   a. Hydrostatic test results

   b. At maximum speed, a minimum of five hydraulic test readings between shutoff head and 25 percent beyond the maximum indicated capacity, recorded on data sheets as defined by the Hydraulic Institute. For variable speed driven pumps, each pump shall be tested between maximum and minimum speed at 100 rpm increments.

   c. Pump curves showing head, flow, bhp, and efficiency requirements.

   d. NPSH required test curve if required by the pump specification. Otherwise, a calculated NPSH required curve may be submitted.

   e. Certification that the pump shaft horsepower demand did not exceed the rated motor horsepower of 1.0 service rating at any point on the curve.

3. Factory Witnessed Tests: All pumps, variable speed drives, and motors, 150 hp and larger shall be factory-tested as complete assembled systems and may be witnessed by the OWNER and ENGINEER. The CONTRACTOR shall give the ENGINEER a minimum of 2 weeks notification prior to the test. All costs for

OWNER and ENGINEER shall be borne by the CONTRACTOR and shall be included in the bid price. Such costs shall include travel and subsistence for two people excluding salaries. Test results shall be submitted to the ENGINEER. No equipment shall be shipped until the test data have been approved by the ENGINEER.

4. Acceptance: In the event of failure of any pump to meet any of the requirements, the CONTRACTOR shall make all necessary modifications, repairs, or replacements to conform to the requirements of the Contract Documents and the pump shall be re-tested until found satisfactory.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment:** Where required by the individual pump Sections, an authorized service representative of the manufacturer shall visit the Site for the number of days indicated in those sections to witness the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.

1. Installation of the equipment

2. Inspection, checking, and adjusting the equipment

3. Startup and field testing for proper operation

4. Performing field adjustments to ensure that the equipment installation and operation comply with requirements

B. Instruction of the OWNER's Personnel

1. Where required by the individual pump Sections, an authorized training representative of the manufacturer shall visit the Site for 40 hours per piece of equipment to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.

2. The representative shall have at least 2 years experience in training. A resume for the representative shall be submitted.

3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.

4. Proposed training material and a detailed outline of each lesson shall be submitted for review. Comments shall be incorporated into the material.

5. The training materials shall remain with the trainees.

6. The OWNER may videotape the training for later use with the OWNER'S personnel.

3.2 INSTALLATION

A. **General:** Pumping equipment shall be installed in accordance with the manufacturer's written recommendations.

B. **Alignment:** All equipment shall be field tested to verify proper alignment and freedom from binding, scraping, shaft runout, or other defects. Pump drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing. Equipment shall be secure in position and neat in appearance.

C. **Lubricants:** The CONTRACTOR shall provide the necessary oil and grease for initial operation.

3.3 PROTECTIVE COATING

A. Materials and equipment shall be coated as required in Section 09800 - Protective Coating.

3.4 FIELD TESTS

A. Each pump system shall be field tested after installation to demonstrate:

1. Satisfactory operation without excessive noise and vibration.

2. No material loss caused by cavitation.

3. No overheating of bearings.

4. Indicated head, flow, and efficiency at design point.

B. The following field testing shall be conducted:

1. Startup, check, and operate the pump system over its entire speed range. If the pump is driven by a variable speed drive, the pump and motor shall be tested at 100 RPM increments. If the pump is driven at constant speed, the pump and motor shall be tested at max RPM. Unless otherwise indicated, vibration shall be within the amplitude limits recommended by the Hydraulic Institute Standards at a minimum of four pumping conditions defined by the ENGINEER.

2. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least 4 pumping conditions at each pump rotational speed if variable speed at 100 RPM increment or at max RPM if constant speed. Check each power lead to the motor for proper current balance.

3. Determine bearing temperatures by contact type thermometer. A run time until bearing temperatures have stabilized shall precede this test, unless insufficient liquid volume is available.

4. Electrical and instrumentation tests shall conform to the requirements of the sections under which that equipment is specified.

C. Field testing will be witnessed by the ENGINEER. The CONTRACTOR shall furnish 3 days advance notice of field testing.

D. In the event any pumping system fails to meet the indicated requirements, the pump shall be modified or replaced and re-tested as above until it satisfies the requirements.

E. After each pumping system has satisfied the requirements, the CONTRACTOR shall certify in writing that it has been satisfactorily tested and that all final adjustments have been made. Certification shall include the date of the field tests, a listing of all persons present during the tests, and the test data.

F. The CONTRACTOR shall be responsible for all costs of field tests, including related services of the manufacturer's representative, except for power and water, which the OWNER will bear. If available, the OWNER'S operating personnel will provide assistance in field testing.

- END OF SECTION -

SECTION 11102 – SUBMERSIBLE WELL PUMPS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide a submersible well pump, electric motor, and appurtenant work, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11000 - Equipment General Provisions and Section 11100 - Pumps, General apply to the WORK of this Section.

C. The Supplier shall examine the site conditions, intended application, and operation of the pump system and recommend the pump which will satisfy the indicated requirements.

PART 2 – PRODUCTS

2.1 SUBMERSIBLE WELL PUMPS

A. Identification:

AREA B: Loma Harvest Well

AREA B: Palisades Harvest Well

AREA C: East Paso Harvest Well

B. **Operating Conditions:** The WORK of this Section shall be suitable for long term operation under the following conditions:

1.	Duty	-	Intermittent
2.	Drive	-	Constant speed
3.	Fluid service	-	Untreated Groundwater
4.	Fluid specific gravity	-	1.0
5.	Project site elevation	-	As noted on Drawings
6.	Power Supply	-	230 VAC, 1-phase 60 Hz (Loma) 480 VAC, 3-phase 60 Hz (Palisades & East Paso)

C. **Performance Requirements:**

1. See Harvest Well Drawings for performance requirements.

D. **Pump Dimensions:**

1. See Harvest Well Drawings for dimensional requirements

2.2 PUMP REQUIREMENTS

A. **Pump Design:** Pump shall include an integral check valve designed into the discharge of the pump. Pump shall include an integral carbon graphite bearing to handle momentary upthrust loads. An upthrust bumper bolt in the discharge of the pump will not be acceptable. Pump downthrust shall be absorbed by the motor thrust bearing. Each impeller shall be fitted with a seal ring around its eye or skirt to prevent hydraulic loss. A filter screen shall be included as part of the suction inlet assembly. All metallic components of the pump shall be stainless steel. All elastomeric components shall be Nitrite Rubber.

B. **Motor Design:** The motor shall be a squirrel cage induction motor designed for continuous underwater operation in conformance with NEMA standards. A Kingsbury type thrust bearing shall be used to carry the pump downthrust load. The bearing shall be rated for a minimum of 130% of the maximum pump downthrust load. Motor shall be filled with a water and propylene glycol solution for cooling and lubrication. No oils or grease lubrication shall be used. A flexible diaphragm shall be provided to permit expansion of internal motor fluid. The shaft seal shall be a Nitrile Rubber lip seal or a Nitrile, Carbon, Carbide and/or Ceramic face seal. A mercury type shaft seal will not be acceptable. The nameplate horse power shall not be exceeded at any point on the pump curve.

C. **Electrical Cable:** The motor lead to electrical cable splice shall conform to IEEE and NEC standards. The electrical wire shall be annealed bare 19 stranded copper conductors insulated with PVC. All power conductors plus a ground conductor shall be jacketed in a flat heavy duty PVC jacketing. All cable shall be UL listed per UL83 Type TW Construction A, as Deep Well Submersible Cable. Power conductors shall be sized to allow no more than 5% of voltage loss in the entire length. Grounding conductor shall be sized per Table 24.3 of UL83. The electrical cable shall be strapped to the discharge column with stainless steel bands.

D. **Discharge Column:** The discharge column shall be of a black steel pipe conforming to ASTM A 53 Grade A for sizes 6-inch or smaller. Thread shall be a .75-inch taper National Pipe thread.

E. **Discharge Head:** A fabricated steel discharge head shall be provided. Discharge head shall be constructed to support 150% of the weight of all items in the well. Tapping for electrical wire, instrumentation, sounder tube and venting shall be provided. A screened vent cap shall be included. The discharge head shall have lifting eyes. The discharge head shall rest on a sole plate welded to the well casing. A .25-inch neoprene gasket and cadmium plated bolts with nuts shall seal the discharge head to the sole plate. If the well casing below the discharge head is to be encased in concrete the sole plate shall have tapped bolt holes. The discharge outlet shall be as shown in the drawings.

2.3 MANUFACTURER , OR EQUAL

A. **Grundfos Pump 150S75-4 (140 GPM, 160 TDH)**

B. **Grundfos Pump 85S50-4 (87 GPM, 160 TDH)**

C. **Grundfos Pump 75S50-8 (69 GPM, 185 TDH)**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The installation shall be in accordance with manufacturers written recommendations. The installation shall be as shown in the drawings.

B. Prior to OWNER acceptance and formal pump station start-up, all equipment shall be inspected for proper alignment, quiet operation, proper connection, and satisfactory performance by means of a function test. A start-up report showing function testing, motor voltages, running amperages and well water levels shall be provided to the ENGINEER after pump station start-up.

- END OF SECTION -

SECTION 11148 - SUBMERSIBLE NON-CLOG PUMPS

PART 1 -- PRODUCTS

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide submersible non-clog pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The Area A and Area D construction CONTRACTOR will be responsible for furnishing the submersible non-clog pumps and appurtenances to both the Area B and Area C construction CONTRACTOR and the Waste Water Treatment Plant CONTRACTOR to insure commonality of equipment into all pump station installations. The Area B & Area C CONTRACTOR will require the submersible pumps at the Lupine Pump Station and the Sunny Oaks Pump Station. The Waste-Water Treatment Plant CONTRACTOR will require the submersible pumps for installation into the Influent Pump Station and Plant Drain Pump Station at the Waste-Water Treatment Plant site. The requirements of Section 11100 - Pumps, General apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump which will best satisfy the indicated requirements.

1.2 EXTENDED PERIOD FOR CORRECTION OF DEFECTS

A. The CONTRACTOR shall correct defects in the pumping system upon notification from the OWNER within 1 year from the date of Substantial Completion. Corrections shall be completed within 5 days after notification.

PART 2 -- GENERAL

2.1 GENERAL DESCRIPTION

A. **Identification**

Pump Name	Submersible Pumps
Equipment numbers	As indicated in Drawings
Quantity	As indicated in Drawings
Location	<u>Area A</u> West Paso (WP) Pump Station Baywood (BW) Pump Station East Ysabel (EY) Pump Station East Paso (EP) Pump Station <u>Area B</u> Lupine (LU) Pump Station

	Area C Sunny Oaks (SO) Pump Station Area D Mountain View (MV) Pump Station

B. **Operating Conditions:** The WORK of this Section shall be suitable for long term operation under the following conditions:

Project Site Elevation	As noted in Drawings
Ambient temperature, degrees F	40 to 90
Ambient relative humidity, percent	0 to 100
Fluid service	Raw wastewater (a)
Fluid temperature, degrees F	50 to 80
Fluid pH range	5.0 to 9.0
Fluid specific gravity	1.01
Fluid viscosity, absolute, centipoise at 60 deg F	1.0
Sump classification in accordance with National Electrical Code	Class I, Division 1, Groups C and D
Duty	Intermittent or continuous
Drive	West Paso and Lupine are variable speed. All others are constant speed
Power supply	480-volt 3-phase 60 Hz

(a) Raw wastewater will contain paper products, rags, plastics, and other coarse materials typical of raw sewage from residential communities.

C. **Performance Requirements**

1. See Pump Station Drawings for performance requirements.

D. **Pump Parameters**

Size of discharge flange, inch diameter	As noted in Drawings
Flange rating, ANSI, psi	150

Maximum size spheres to pass, inch diameter	3
Pump removal method	Rails

2.2 PUMP REQUIREMENTS

A. **General**

1. Each pump shall be capable of continuous and intermittent operation, from minimum speed to maximum speed, at full load with a water level of 36-inches above the invert of the wet well, without cavitation or overheating of the motor.

2. Each pump, with its cable and appurtenances, shall be able to withstand continuous submergence to a minimum depth of 65 feet, whether running or off, without leakage.

3. Each pump shall be able to operate for short periods at zero static suction head without causing any damage to any part of the unit. Each motor shall be capable of operation with the wet well level below the motor without the use of spray or other external cooling methods.

4. Each pump shall be designed to be non-overloading at any point on the pump performance curve.

B. **Pump Construction:** Construction of submersible non-clog pumps shall conform to the following requirements:

Connections	Machined metal-to-metal quick disconnect type, for withdrawal of unit from above without disconnecting pipe. When lowered into place, the pump shall automatically connect and lock into the discharge pipe, allowing for zero leakage at all anticipated pump heads.
Pump Design	Single stage, centrifugal type, close-coupled submersible electric motor, for operation in dry or wet pit, without external cooling.
Impeller	Maximum 2-vane, semi-open, back-swept, non-clog type with replaceable wear rings on impeller and in casing, to handle raw unscreened sewage, solids, and fibrous materials. The impeller vanes shall be self-cleaning on each rotation. Flygt N-Impeller, ABS Contra Block, or equal.
Bearings	Permanently-lubricated, heavy-duty axial and radial ball or roller bearings top and bottom, with a minimum L-10 life of 50,000 hours, at continuous, maximum load and speed, supported by detailed calculations, to

	be submitted with the Shop Drawings.
Seals	The motor to pump interface shall be sealed by two bi-directional, independent, mechanical seal sets. Each shall be lubricated by an oil bath between the lower and upper seals. Each seal face shall be solid tungsten carbide such that they may be re-lapped to extend their service life. The seal springs shall be independent and of 316 SS material. Other types of seal systems that are not bi-directional or rely on tension with the impeller are not acceptable.
Oil Chamber	To supply oil for lubrication and cooling of the shaft seals.
Support	Cast duckfoot bend or discharge base elbow with machined face, anchored to sump floor.
Cables	Include necessary cables for power connection, moisture detection, and overload protection; sheathed, coded, and suitable for submersible pumps; and of sufficient length for direct connection to the terminal boxes indicated. Cables shall be connected to the pumps and tested at the factory.
Lifting Devices	Type 304 stainless steel guide rails with brackets and stainless steel lifting system of sufficient operating length rated at least 5 times the weight of the pump and motor.

C. **Materials**

Pump, volute, oil casing, sliding bracket, motor frame	Cast iron
Impeller	Cast iron, statically and dynamically balanced
Pump shaft	Type 420 stainless steel, or 1045 carbon steel with Type 420 stainless steel sleeve
Exposed bolts, nuts, washers	Type 304 stainless steel
Mechanical seals	Independently operating tandem tungsten-carbide or silicon carbide and carbon rings with stainless steel springs
Wear rings	Type 304 or 416 stainless steel and nitrile rubber with steel insert, with a Brinnell

	hardness of 300 on impeller and 350 on case

2.3 MOTOR

A. **Approval:** The pumping system, including the motor and wiring, shall be approved by a nationally approved testing agency for explosion-proof service. The system shall be rated Class I, Division 1, Group C and D service as determined by the National Electric Code and approved by a nationally recognized testing agency (UL or FM) at the time of opening Bids.

B. **Variable Speed Operation:** The motor shall be suitable for continuous and intermittent operation with variable frequency drives as specified in Section 16455 – Variable Frequency Drive Units.

C. **Insulation:** The pump motors shall be designed for continuous duty and variable speed in hazardous locations. The stator and stator leads shall be moisture-resistant, triple varnished and insulated according to Class H, capable of withstanding a temperature rise of up to 155 degrees C. The allowable temperature rise of the motor at full load condition shall not exceed 80 degrees C.

D. **Motor Stator:** The motor stator shall be mounted in an air-filled, watertight casing and shall not be fixed in place by externally-mounted screws which may cause leakage in the motor.

E. **Motor Rating:** Motors shall have service factor of 1.10 or greater. For motors driven by variable frequency drives, motor horsepower shall be the greater of:

1. Non-overloading conditions throughout the pump curve.

2. 1.15 times the horsepower required by the pump at maximum indicated flow.

F. **Junction Box:** The motor shall have a junction box capable of being sealed completely from the motor stator casing to prevent leakage through the junction box into the stator housing should a motor cable be damaged or have some other means to prevent leakage into the junction box under any condition. Each component of the motor cable entry shall be field replaceable.

G. **Cable Entry:** The cable entry water seal design shall be such that it precludes specific torque requirements to ensure a watertight and submersible seal. The seal shall permit no entry of water into any high voltage area even if the cable is severed below the water level.

H. **Cooling System:** Each pump shall be provided with an adequately designed cooling system using a wastewater jacket and thermal radiator integrally cast with the stator casing. Cooling medium channels and ports shall be non-clogging by virtue of their dimensions. Wastewater jackets are not required for motors that are designed to operate continuously at full load with ambient cooling.

I. **Motor Protection:** Integral thermal sensors in the motors, one for each phase, shall be provided to monitor stator temperatures. These sensors shall be used in conjunction with and supplemented by external motor over-current protection located at the control panel. Each motor shall include a water leakage detector in the stator housing. A relay shall be provided and installed in the motor control panel. The relay shall receive the

leakage detector signal and motor thermal overload signal and provide separate alarm indications. The circuit shall be intrinsically safe and operate on 24 V.

J. **Appurtenances:** One pump in each station shall include a valve mounted on the volute to stir the station contents at the start cycle. The valve shall not require electrical signals or pneumatic devices in order to perform its function. At the pump start cycle the valve will admit pumped liquid into the station to re-suspend settled solids and incorporate floating material. The valve shall shut automatically by virtue of a venturi effect raising a ball into place.

K. **Wet Well Hatch Covers:** The pump supplier shall provide and coordinate the wet well access covers. The covers shall be aluminum diamond plate at least ¼" thick rated for HS-20- loads. The access doors shall be flush with the sump top and include a hold open arm, slam lock, and safety grating system for fall protection. The grating shall have openings at least 5" x 5" to facilitate viewing the sump. The grating shall be hinged to lock in place at 90 degrees to form a personnel barrier. The grating shall allow pumps to be set on them for wash down.

2.4 PUMP CONTROLS

A. Pumps shall be controlled in accordance with Section 17300 - Control Strategies.

2.5 SPARE PARTS

A. **General:** The pumps shall be backed by supplies of spare parts from stock and after-sales service from a factory trained and authorized maintenance facility located within 500 miles from the Site.

B. Parts to be Furnished

1. One set of mechanical shaft seals for each pump.

2. One set of wear rings for each pump.

3. One set of bearings for each pump and motor.

4. Three sets of O-rings and gaskets for each pump.

5. One submersible cable of required length, with termination kit, for each pump.

2.6 FACTORY TESTING

A. In addition to the factory testing specified in Section 11100 – Pumps, General the following procedures shall be included with the factory test prior to shipment:

1. Verification of the pump characteristic curves by testing at 1/4, 1/2, 3/4, and full flow and recording the measured head and motor current for each flow.

2. Verification of cavitation-free service and absence of motor overheating during conditions simulating the actual operating conditions after installation, whether submerged, semi-submerged, or dry.

3. Pump seals shall be designed for complete water tightness at 65-feet submergence for 30 minutes and data on factory testing and quality control shall be submitted with the Shop Drawings.

2.7 PROTECTION AND SHIPMENT

A. Parts shall be properly lubricated and protected so that no damage or deterioration will occur even during a prolonged delay from the time of shipment until installation is completed and the pumps are ready for operation.

B. Finished ferrous surfaces not painted shall be properly protected to prevent rust and corrosion.

C. The finished surfaces of exposed flanges shall be protected by strong wooden blind flanges.

D. Each pump shall be properly crated to protect against damage during shipment.

2.8 MANUFACTURERS, OR EQUAL

A. **Flygt Corporation;**

B. **ABS Pumps;**

C. **Pumpex.**

PART 3 – EXECUTION

3.1 INSTALLATION

A. In addition to the requirements of Section 11100 – Pumps, General, the CONTRACTOR shall ensure that anchor bolts are set only after the discharge piping has been properly installed, to ensure exact fit with embedded piping components.

3.2 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment:** The service representative of the manufacturer shall be present at the Site for a minimum of two work days to furnish the services required by Section 11100 – Pumps, General for the pump stations located in Area A and Area B (first phase construction) and a minimum of one work day for the pump stations located in Area C and Area D (second phase construction).

B. **Instruction of OWNER's Personnel:** The training representative of the manufacturer shall be present at the Site for a minimum of two work days to furnish the training services required by Section 11100 – Pumps, General.

C. For the purposes of this paragraph, a work day is defined as an 8 hour period at the Site, excluding travel time.

D. The ENGINEER may require that the services for inspection, startup, and field adjustment and instruction of OWNER's personnel specified above be furnished in up to four separate trips.

- END OF SECTION -

SECTION 11149 - SUBMERSIBLE GRINDER PUMPS

PART 1 -- PRODUCTS

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide submersible grinder pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11100 - Pumps, General apply to this Section.

C. The Supplier shall examine the Site conditions, intended application, and operation of the pump system and recommend the pump which will best satisfy the indicated requirements.

1.2 EXTENDED PERIOD FOR CORRECTION OF DEFECTS

A. The CONTRACTOR shall correct defects in the pumping system upon notification from the OWNER within 5 years from the date of Substantial Completion. Corrections shall be completed within 5 days after notification.

PART 2 -- GENERAL

2.1 GENERAL DESCRIPTION

A. **Identification**

Pump Name	Submersible Grinder Pumps
Equipment numbers	As indicated in Drawings
Quantity	26 installed (refer to Drawings), 5 spares
Location	<u>Area A</u> 04A Pocket Pump Station 07A Pocket Pump Station 08A Pocket Pump Station 09A Pocket Pump Station 10A Pocket Pump Station 11A Pocket Pump Station 12A Pocket Pump Station 13A Pocket Pump Station <u>Area B</u> None <u>Area C</u> None

	Area D 09B Pocket Pump Station 09C Pocket Pump Station 13B Pocket Pump Station 15B Pocket Pump Station

B. **Operating Conditions:** Each pump shall be suitable for long term operation under the following conditions:

Project Site Elevation	As noted in Drawings
Ambient temperature, degrees F	40 to 90
Ambient relative humidity, percent	0 to 100
Fluid service	Raw wastewater (a)
Fluid temperature, degrees F	50 to 80
Fluid pH range	5.0 to 9.0
Fluid specific gravity	1.01
Fluid viscosity, absolute, centipoise at 60 deg F	1.0
Sump classification in accordance with National Electrical Code	Class I, Division 1, Groups C and D
Duty	Intermittent
Drive	Constant speed
Power supply	240-volt, 1-phase, 60 Hz

(a) Raw wastewater will contain paper products, rags, plastics, and other coarse materials typical of raw sewage from residential communities.

C. **Performance Requirements:** Each pump shall be designed to meet the following performance requirements:

Design flow, gpm	11
Design head, feet	92
Maximum flow, gpm	15
Maximum flow head, feet	0

Minimum flow, gpm	9
Minimum flow, feet	138
Maximum pump speed, rpm	1800
Maximum motor speed, rpm	1800
Minimum motor size, hp	1.0

D. **Pump Parameters:** Each pump shall be designed to meet the following pump parameters:

Size of discharge, inch diameter	1.25
Pump removal method	Rails

2.2 PUMP REQUIREMENTS

A. **General**

1. Each pump shall be capable of continuous and intermittent operation at full load with a water level of 36-inches above the invert of the wet well, without cavitation or overheating of the motor.

2. Each pump, with its cable and appurtenances, shall be able to withstand continuous submergence to a minimum depth of 65 feet, whether running or off, without leakage.

3. Each pump shall be designed to be non-overloading at any point on the pump performance curve.

4. Each pump shall be removable from the wet well without personnel entry into the wet well. The pumps shall include rail slide systems such that the pumps stand on their feet on the sump bottom and can be raised and lowered with out entering the wet well. The slide rail system shall be 316ss and consist of 2" square tubing mounted on brackets. The bottom bracket shall allow for sloping of the sump bottom. Each pump shall include an independent discharge hose suitable for the service with a slide face located at the exit piping of the station.

B. **Pump Construction:** Construction of submersible grinder pumps shall conform to the following requirements:

Pump Design	Semi-positive displacement pump with integral grinder unit close-coupled to sealed or submersible electric motor, for operation in dry or wet pit, without external cooling. Rotating assembly shall be dynamically balanced.

Pump unit	Vertical, stainless steel rotor with elastomeric stator to handle raw unscreened sewage, solids, and fibrous materials. Minimum 5-inch diameter inlet shroud and stainless steel support stand.
Grinder unit	Direct driven, rotating grinder assembly with minimum two stainless steel cutter bars and stationary stainless steel shredding ring.
Bearings	Permanently-lubricated, heavy-duty axial and radial ball or roller bearings top and bottom, with a minimum L-10 life of 50,000 hours, at continuous, maximum load and speed.
Seals	Mechanical shaft seal with stationary ceramic seat and rotating carbon surface.
Check valve / Anti-siphon valve	Each pump unit shall be equipped with an integral full-port, flapper-type, check valve and an anti-siphon valve at the pump discharge.
Discharge connection	Flexible, reinforced discharge hose from pump unit to slide-face quick disconnect connection mounted at the top of the wet well.
Cables	Include necessary cables for power connection, level detection, and overload protection; sheathed, coded, and suitable for submersible pumps. Each pump shall be provided with identical length cables, suitable for the longest run to the terminal boxes indicated, for interchangeability of all pumps at all pump stations. Cables shall be connected to the pumps and tested at the factory.
Lifting Devices	Type 316 stainless steel guide rails with brackets and stainless steel lifting cable rated at least 5 times the weight of the pump and motor. Each pump shall be equipped with identical length lifting cable for the maximum depth pump station wet well for interchangeability of all pumps at all pump stations.

2.3 MOTOR

A. **Approval:** The pumping system, including the motor and wiring, shall be approved by a nationally approved testing agency for explosion-proof service. The system shall be rated Class I, Division 1, Group C and D service as determined by the National Electric Code and approved by a nationally recognized testing agency (UL or FM) at the time of opening Bids.

B. **Motors:** The pump motors shall be designed for continuous and intermittent duty in hazardous locations. Each motor shall be squirrel cage induction with ball bearings

C. **Motor Stator:** The motor stator shall be mounted in an air-filled, watertight casing and shall not be fixed in place by externally mounted screws, which may cause leakage in the motor.

D. **Motor Rating:** Motors shall have service factor of 1.10 or greater.

E. **Junction Box:** The motor shall have a junction box capable of being sealed completely from the motor stator casing to prevent leakage through the junction box into the stator housing should a motor cable be damaged or have some other means to prevent leakage into the junction box under any condition.

F. **Cable Entry:** The cable entry water seal design shall be such that it precludes specific torque requirements to ensure a watertight and submersible seal. The seal shall permit no entry of water into any high voltage area even if the cable is severed below the water level.

G. **Motor Protection:** Each motor shall be provided with an integral thermal overload protector.

2.4 PUMP CONTROLS

A. Pumps shall be controlled in accordance with Section 17300 - Control Strategies.

B. Each pump shall be equipped with a level-sensing bell to provide low level shutoff function.

2.5 SPARE PARTS

A. **General:** The pumps shall be backed by supplies of spare parts from stock and after-sales service from a factory trained and authorized maintenance facility located within 250 miles from the Site.

B. Parts to be furnished:

1. Five complete submersible grinder pump units with grinder, pump, motor, check valve, cables, and appurtenances to serve as replacement units for installed submersible grinder pumps.

2. Five sets of mechanical shaft seals.

3. Five sets of wear rings.

4. Five sets of pump and motor bearings.

5. Five sets of O-rings and gaskets.

6. Three submersible cables of required length, with termination kit, for each pump.

2.6 APPURENTANCES

1. The Pump supplier shall provide aluminum wet well access covers. The covers shall be aluminum diamond plate at least ¼" thick. They shall be flush with the sump top and include a slam lock. Each cover shall incorporate safety grating for fall protection. The grating shall be hinged for 90 degree openings and to form a barrier. The grating shall have a 5" X 5" openings and allow pumps to be set on it for wash down.

2.7 FACTORY TESTING

A. In addition to the factory testing specified in Section 11100 – Pumps, General the following procedures shall be included with the factory test prior to shipment:

1. Verification of the pump characteristic curves by testing at 1/4, 1/2, 3/4, and full flow and recording the measured head and motor current for each flow.

2. Verification of cavitation-free service and absence of motor overheating during conditions simulating the actual operating conditions after installation, whether submerged or semi-submerged.

3. Pump seals shall be designed for complete water tightness at 65-feet submergence for 30 minutes and data on factory testing and quality control shall be submitted with the Shop Drawings.

2.8 PROTECTION AND SHIPMENT

A. Parts shall be properly lubricated and protected so that no damage or deterioration will occur even during a prolonged delay from the time of shipment until installation is completed and the pumps are ready for operation.

B. Finished ferrous surfaces not painted shall be properly protected to prevent rust and corrosion.

C. The finished surfaces of exposed flanges shall be protected by strong wooden blind flanges.

D. Each pump shall be properly crated to protect against damage during shipment.

2.9 MANUFACTURERS OR EQUAL

A. Eone AMGP

PART 3 -- EXECUTION

3.1 INSTALLATION

A. In addition to the requirements of Section 11100 – Pumps, General, the CONTRACTOR shall ensure that anchor bolts are set only after the discharge piping has been properly installed, to ensure exact fit with embedded piping components.

3.2 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment:** The service representative of the manufacturer shall be present at the Site for a minimum of two work days to furnish the services required by Section 11100 – Pumps, General for the pump stations located in Area A (first phase construction) and a minimum of one work day for the pump stations located in Area D (second phase construction).

B. **Instruction of OWNER's Personnel:** The training representative of the manufacturer shall be present at the Site for a minimum of one work day to furnish the training services required by Section 11100 – Pumps, General.

C. For the purposes of this paragraph, a work day is defined as an 8 hour period at the Site, excluding travel time.

D. The ENGINEER may require that the services for inspection, startup, and field adjustment and instruction of OWNER's personnel specified above be furnished in up to three separate trips.

- END OF SECTION -

SECTION 11258 - CHEMICAL FEEDING EQUIPMENT, GENERAL

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide chemical feeding equipment, complete and operable, in accordance with the Contract Documents.

B. Equipment shall be from manufacturers with minimum 5 years of experience in the manufacture and assembly of similar products, with a record of successful installations. Such manufacturers shall maintain a well established, authorized, local service agency with sufficient spare parts and personnel to respond within 48 hours to any service calls.

C. The requirements of Section 11000 - Equipment General Provisions apply to the WORK of this Section.

D. Unless indicated otherwise, the requirements of this Section apply to all chemical feeding equipment in the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the requirements of Section 01300 – Contractor Submittals.

B. Shop Drawings: Complete fabrication, assembly, foundation, and installation drawings, together with detailed specifications and data covering materials used, power drive assemblies, parts, devices, pumps, tanks, mixers, supports, panels, and other accessories forming a part of the equipment, plus schematics, diagrams, and panel layouts.

C. Certification: The CONTRACTOR shall obtain written certification from the manufacturer, addressed to the OWNER, stating that the equipment will efficiently and thoroughly perform the required functions in accordance with these Specifications and the Drawings, that the materials are best suited for the chemicals handled, and that the manufacturer accepts joint responsibility with the CONTRACTOR for coordination of equipment, including motors, variable speed drives, controls, and services required for proper installation and operation of the completely assembled and installed unit.

D. Technical Manuals: Furnish complete operations and maintenance manuals prior to start-up.

E. Spare Parts List: The CONTRACTOR shall obtain from the manufacturer a list of suggested spare parts for each piece of equipment subject to wear, such as seals, packing, gaskets, nuts, bolts, washers, wear rings, etc.

F. Maintenance: Printed instructions relating to proper maintenance, including lubrication, and parts lists indicating the various parts by name, number, and diagram where necessary, shall be furnished in duplicate with each unit or set of identical units.

G. Field Procedures: Instructions for field procedures for erection, adjustments, inspection, and testing shall be furnished prior to installation of the equipment.

H. Calibration Graphs: The manufacturer's representative shall prepare a calibration graph from field tests for each chemical feed unit which does not have a rate set device. Graphs shall read in pounds per hour for dry feeders or in gallons per hour for liquid feeders. The graph shall show the rate setter graduation conversion to pounds per hour or gallons per hour throughout the range of the feed unit. Each graph shall be furnished on hard paper and be sealed in clear plastic.

1.3 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Erection and Startup Assistance: Service and instruction assistance by the manufacturer's engineering representative for each equipment unit shall be furnished by the CONTRACTOR during the following period:

1. One day during erection, unless indicated otherwise in the feed equipment section.

2. One day during startup, unless indicated otherwise in the feed equipment section.

B. Instruction of OWNER'S Personnel: The CONTRACTOR shall furnish the services of a factory service representative to instruct the OWNER'S personnel in the operation and maintenance of the equipment. This service shall consist of a minimum one day's visit to the plant for each type of similar equipment.

1.4 GUARANTEES, WARRANTIES

A. After completion, the CONTRACTOR shall furnish to the OWNER the manufacturer's written guarantees that the equipment will operate with the published efficiencies, heads, criteria, and flow ranges and meet these specifications. The CONTRACTOR shall also furnish the manufacturer's warranties as published in its literature.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Wherever it is required that a single manufacturer shall be responsible for the compatible and successful operation of the various components of any equipment unit, it shall be understood to mean that the CONTRACTOR shall provide only such equipment as the designated manufacturer will certify is suitable for use with its equipment and with the further understanding that this in no way constitutes a waiver of any indicated requirements.

B. Manufactured items provided under this Section shall be new, of current manufacture, and shall be the products of reputable manufacturers specializing in the manufacture of such products.

C. Where 2 or more units of the same type or size of equipment are required, such units shall be produced by the same manufacturer.

2.2 MATERIALS

A. General: Materials employed in the equipment shall be suitable for the intended application; materials not specifically called for shall be high-grade, standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended.

B. Corrosion Resistance: Materials used in the construction of chemical feeding equipment, shall be resistant to corrosive attacks from the chemicals.

2.3 APPURTENANCES

A. Nameplate: Each piece of equipment shall be provided with a stainless steel nameplate, indicating equipment characteristics, capacity, motor horsepower, speed, electrical characteristics, manufacturer, model number, and serial number.

B. Solenoid Valves: The equipment manufacturer shall provide solenoid valves which are part of the chemical feeding unit. The solenoid valve electrical rating shall be compatible with the equipment voltage and valves shall be complete with the necessary conduit and wiring from the control panel to the solenoids. The valve material shall be suitable for the intended service in accordance with the Section 15230 -Miscellaneous Valves.

C. Pressure Gauges: Where indicated, chemical transfer and metering pumps and other equipment shall be equipped with pressure gauges with diaphragm seals in accordance with Section 17100 – Process Control Instrumentation Systems, except that the size of gauges on small metering pumps may be smaller than indicated in that section.

D. Equipment Supports: Chemical feeding equipment and piping shall be firmly supported on concrete equipment pads and anchored down. Fabricated metal supports exposed to chemical spills shall be of Type 316 stainless steel or enameled steel. Anchor bolts, nuts, and washers of such supports shall be of Type 316 stainless steel, with an antiseize compound on the threads.

E. Controls: Controls shall be housed in enclosures with NEMA ratings which comply with the area designations of Section 16050 - Electrical Work, General.

F. Safety Equipment: Where required by Code, chemical unloading, storage, and feeding equipment shall be provided with the necessary safety devices and warning signs, clearly visible.

2.4 TOOLS AND SPARE PARTS

A. Tools: Special tools necessary for maintenance and repair of the equipment and one pressure grease gun for each type of grease required for the equipment shall be furnished as a part of the WORK; such tools shall be suitably stored in metal tool boxes, and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

B. Spare Parts: Furnish spare seals, packing, gaskets, wear rings, and bearings as required by the feed equipment sections.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General: Chemical feeding equipment shall be installed in accordance with governing safety standards, the Shop Drawings, and as indicated.

B. Alignment: Equipment shall be field tested to verify proper alignment, operation as indicated, and freedom from binding, scraping, vibration, shaft runout, leaks, or other defects. Drive shafts shall be measured just prior to assembly to ensure correct

alignment without forcing. Equipment shall be secure in position and neat in appearance.

C. Lubricants: The WORK shall include furnishing the necessary oil and grease for initial lubrication and testing of all equipment.

- END OF SECTION-

SECTION 11259 - METERING PUMPS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide chemical metering pumps and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11000 - Equipment General Provisions apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The pumps shall be of corrosion-resistant construction, and diaphragm and seals shall be a suitable material for the chemicals indicated at maximum temperature of 125 degrees F. Each pump shall be complete with pump base, drive, diaphragm, check valves, back-pressure valve, internal relief valve, pulsation dampener, coupling guard and electric motor. Size and characteristics of the pumps shall be as indicated.

2.2 CONSTRUCTION

A. **Type and Range**: The pumps shall be of hydraulically actuated diaphragm type, suitable for metering service, with an adjustable stroke (dosage) control range of 10:1 with accuracy of 1.0 percent of the full-scale range. Pumps requiring variable speed drives shall have a set speed range of 10:1 which, in conjunction with the stroke control, shall provide a total feeding range of 100:1, minimum.

B. **Materials**: Wetted parts of metering pumps shall be selected by the manufacturer to ensure optimum, corrosion-free, and erosion-free operation for the chemicals involved. Pumps for polymer service shall be suitable for feeding cationic, nonionic, or anionic polymer solutions having a maximum viscosity of 3,000 centipoise. Pump bases shall be steel, coated in accordance with Section 09800 – Protective Coating. Plastic bases are not acceptable.

C. **Alternative Type**: At the option of the CONTRACTOR and after approval by the ENGINEER, a progressive cavity type pump of suitable construction and materials may be furnished in lieu of a hydraulic diaphragm pump. The pump must be capable of continuous operation with the chemical solution listed, and the variable speed drive must be capable of covering the entire feed range with an accuracy of one percent of the full scale range. The progressive cavity pump shall be as manufactured by Robbins and Meyers (Moyno), Allweiler Pump, Inc., or equal.

2.3 CONTROL

A. The dosage of each metering pump shall be set at each metering pump control station. The length of stroke and drive speed of each metering pump shall be adjusted manually in order to maintain pre-set dosage.

2.4 SCHEDULE OF METERING PUMPS

I D No.	Chemical	Feed Range (gpd)	Min Head (psi)	Min Motor (hp)	Type of Drive
EP-001	Orthophosphate	500	300@3GPD		Variable Speed
EP-002	Soduim-hyphoclorite	500	300@3GPD		Variable Speed

2.5 PUMP ACCESSORIES

A. Mounting and Connections: Unless otherwise indicated, metering pumps shall be mounted on concrete pedestals of approximately 2 feet in height and shall be provided with corrosion-resistant pulsation dampeners, sample valves, pressure gages with diaphragm seals, shut-off valves, check valves, relief valves, valved and graduated calibration tanks in pump suction. Pipe connections to pumps shall be firmly supported from a floor-mounted, galvanized, structural steel frame, to avoid any stress on the pump or on the piping system.

2.6 SPARE PARTS

A. A complete set of extra diaphragms and seals shall be furnished with each pump. Where applicable, one set of spare bearings shall be furnished with each piece of equipment.

2.7 MANUFACTURER

A. Manufacturer's Experience: The pumps shall be the product of a manufacturer who has designed and manufactured similar equipment and has a record of at least 5 years of successful operation of this type of process. The CONTRACTOR may be required to submit evidence to this effect together with a representative list of installations. The pump manufacturer shall maintain a permanent, local service department and a spare parts department.

B. Manufacturers, or Equal

1. **Milton Roy Company (Sunstrand);**

2. **Pulsafeeder (Chemwest);**

3. **U.S. Filter/Wallace and Tiernan.**

C. Unit Responsibility: The CONTRACTOR shall assign to a single manufacturer full responsibility for the furnishing and functional operation of the chemical feeder system along with all related tanks, mixers, pumps, piping, valves and controls. The designated single manufacturer, however, need not manufacture more than one part of the system but shall coordinate the design, assembly, testing, and erection of the system as indicated. The manufacturer of the metering pump shall also manufacture the dry chemical feeders.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Pumping equipment shall be installed in accordance with the Shop Drawings and as indicated.

B. General installation requirements shall be in accordance with Section 11100 - Pumps, General.

- END OF SECTION -

SECTION 14600 – HOISTS AND CRANES, GENERAL

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the hoisting equipment, ancillary steel, and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of this Section apply to all hoists and cranes unless indicated otherwise.

1.2 REFERENCE SPECIFICATIONS CODES, AND STANDARDS

A. Commercial Standards

AISC	Specifications for the Design, Fabrication, and Erection of Structural Steel for Building
AGMA	American Gear Manufacturer's Association
ANSI B30.11	Overhead and Gantry Cranes
ANSI MH 27.1	Underhung Crane and Monorail Systems
ASTM A 36	Carbon Structural Steel
CMA	Crane Manufacturer's Association of America
NEMA	National Electrical Manufacturer's Association

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. Shop Drawings shall include all electrical requirements, weights, wheel loads, dimensions, and clearances required.

C. **Technical Manuals:** Include complete operating and maintenance instructions of the hoist and crane systems.

1.4 QUALITY ASSURANCE

A. **Inspection and Testing Requirements:** After erection, the CONTRACTOR shall inspect and test all hoists and crane systems in the presence of the manufacturer's service representative, for proper operation and conformance to the Specifications.

B. **Acceptance Criteria and Tolerances:** The ENGINEER reserves the right to reject any equipment not conforming to the tolerances, deflections, and lateral stiffness indicated.

1.5 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall have the hoist or crane manufacturer furnish the services of a trained, qualified representative for at least one day after the units are installed, for the purpose of inspecting the installation and instructing the OWNER's operating personnel.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Equipment of similar design shall be from the same manufacturer.

B. The capacity of each hoist and trolley shall be permanently marked in a conspicuous manner on the equipment. The wire rope reeving shall be of the 2-part double, cross mounted or similar appropriate type, to provide a true, vertical lift without drift, unless otherwise indicated.

C. All hooks shall be safety type with latch.

D. **Motors:** Motors shall comply with the requirements of Section 16460 - Electric Motors.

E. The CONTRACTOR shall verify all dimensions and clearances in the field prior to erection and shall be responsible for the proper fitting and operation of the equipment.

F. Manufacturers, or Equal

1. **ACCO Babcock, Inc.**

2. **American Monorail**

3. **Cleveland Tramrail**

4. **Thern, Inc.**

2.2 BASIC MATERIALS

A. Materials used must be new and of the best commercial grade. Where materials are not indicated, the CONTRACTOR shall have the manufacturer use the most suitable selection for the given application and environment.

2.3 PLANT FABRICATED ITEMS

A. Fabrication, assembly, and welding shall be carried out by factory-trained specialists and certified welders.

2.4 TOOLS AND SPARE PARTS

A. **Tools:** The CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment. All tools shall be of best quality and furnished in labeled tool boxes of suitable design.

B. **Spare Parts:** Furnish spare parts as required by the hoist or crane section. Parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Hoist and crane equipment shall be installed in strict accordance with the manufacturer's printed instructions.

B. Workmanship shall be in accordance with the referenced standards and codes.

C. Care shall be taken that the structural integrity of beams, columns, walls, floors, and roofs will be maintained at all times.

3.2 FIELD TESTING

A. After completion of the WORK, the CONTRACTOR shall test all hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify in writing that the equipment meets applicable standards and specifications.

- END OF SECTION -

SECTION 15000 - PIPING, GENERAL

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide all piping systems indicated, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all piping sections in Divisions 2 and 15.

C. The mechanical drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type. The mechanical drawings are **not** pipe construction or fabrication drawings. Where pipe supports and spacings are indicated on the Drawings and referenced to a Standard Detail, the CONTRACTOR shall use that Detail. Where pipe supports are not indicated on the Drawings, it is the CONTRACTOR's responsibility to develop the details necessary to design and construct all mechanical piping systems, to accommodate the specific equipment provided, and to provide all spacers, adapters, and connectors for a complete and functional system.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be furnished in accordance with Item SP-12 of the Special Provisions.

B. **Shop Drawings:** Shop Drawings shall contain the following information:

1. Drawings: Layout drawings including all necessary dimensions, details, pipe joints, fittings, specials, bolts and nuts, gaskets, valves, appurtenances, anchors, guides, and material lists. Fabrication drawings shall indicate all spacers, adapters, connectors, fittings, and pipe supports to accommodate the equipment and valves in a complete and functional system.

2. Thermoplastic Pipe Joints: Submit solvent cement manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

3. Gasket Material: Submit gasket manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.

C. **Samples:** Performing and paying for sampling and testing as necessary for certifications are the CONTRACTOR'S responsibility.

D. Certifications

1. All necessary certificates, test reports, and affidavits of compliance shall be obtained by the CONTRACTOR.

2. A certification from the pipe fabricator that all pipes will be manufactured subject to the fabricator's or a recognized Quality Control Program. An outline of the program shall be submitted to the ENGINEER for review prior to the manufacture of any pipe.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Extent of Work:** Pipes, fittings, and appurtenances shall be provided in accordance with the requirements of the applicable Sections of Divisions 2 and 15 and as indicated. Materials in contact with potable water shall be listed as compliant with NSF Standard 61.

B. **Pipe Supports:** Pipes shall be adequately supported, restrained, and anchored in accordance with Section 15006 - Pipe Supports, and as indicated. Supports shall resist stresses created by a seismic loads.

C. **Lining:** Application, thickness, and curing of pipe lining shall be in accordance with the applicable Sections of Division 2 unless otherwise indicated.

D. **Coating:** Application, thickness, and curing of pipe coating shall be in accordance with the applicable Sections of Division 2, unless otherwise indicated. Pipes above ground or in structures shall be field-coated in accordance with Section 09800 - Protective Coating.

E. **Pressure Rating:** Piping systems shall be designed for the maximum expected pressure as defined in Section 01656 - Pressure Pipe Testing and Disinfection, or as indicated on the Piping Schedule.

F. **Inspection:** Pipe shall be subject to inspection at the place of manufacture. During the manufacture of the pipe, the ENGINEER shall be given access to all areas where manufacturing is in progress and shall be permitted to make all inspections necessary to confirm compliance with requirements.

G. **Tests:** Except where otherwise indicated, materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards. Welds shall be tested as indicated. The CONTRACTOR shall be responsible for performing material tests.

H. **Welding Requirements:** Qualification of welding procedures used to fabricate pipe shall be in accordance with the provisions of ANSI/AWS D1.1 - Structural Welding Code. Welding procedures shall be submitted for the ENGINEER'S review.

I. **Welder Qualifications:** Welding shall be done by skilled welders and welding operators who have adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9, by an independent local, approved testing agency not more than 6 months prior to commencing work on the pipeline. Machines and electrodes similar to those used in the WORK shall be used in qualification tests. Qualification testing of welders and materials used during testing are part of the WORK.

2.2 PIPE FLANGES

A. **General:** Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise indicated. Attachment of the flanges to the pipe shall conform to the applicable requirements of ANSI/AWWA C207. Flange faces shall be perpendicular to the axis of the adjoining pipe. Flanges for miscellaneous small pipes shall be in accordance with the standards indicated for these pipes.

B. Pressure Ratings

1. 150 psi or less: Flanges shall conform to either ANSI/AWWA C207 - Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings, 150 lb class.

2. 150 psi to 275 psi: Flanges shall conform to either ANSI/AWWA C207 Class E or Class F, or ANSI/ASME B16.5 150 lb class.

3. 275 psi to 700 psi: Flanges shall conform to ANSI/ASME B16.5, 300 lb class.

4. Selection based on test pressure: AWWA flanges shall not be exposed to test pressures greater than 125 percent of rated capacity. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected.

C. **Blind Flanges:** Blind flanges shall be in accordance with ANSI/AWWA C207, or as indicated for miscellaneous small pipes. Blind flanges for pipe sizes 12 inches and greater shall be provided with lifting eyes in the form of welded or screwed eye bolts.

D. **Flange Coating:** Machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

E. **Flange Bolts:** Bolts and nuts shall conform to Section 05500 - Miscellaneous Metalwork. Studs and bolts shall extend through the nuts a minimum of 1/4-inch. All-thread studs shall be used on all valve flange connections, where space restrictions preclude the use of regular bolts.

F. **Insulating Flanges:** Insulated flanges shall have bolt holes 1/4-inch diameter greater than the bolt diameter.

G. **Insulating Flange Sets:** Insulating flange sets shall be provided where indicated. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2-inch or smaller and shall be made of acetal resin. For bolt diameters larger than 1-1/2-inch, insulating sleeves and washers shall be 2 piece and shall be made of polyethylene or phenolic material. Steel washers shall be in accordance with ASTM A 325 - Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength. Insulating gaskets shall be full-face.

H. Insulating Flange Manufacturers, or equal

1. **JM Red Devil, Type E;**

2. **Maloney Pipeline Products Co., Houston;**

3. **PSI Products, Inc., (Frost Engineering Service Co., Costa Mesa, California.).**

I. Flange Gaskets

1. Gaskets for flanged joints used in general water and wastewater service shall be full-faced type, with material and thickness in accordance with ANSI/AWWA C207, suitable for temperatures to 700 degrees F, a pH of one to eleven, and pressures to 1000 psig. Blind flanges shall have gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be

permitted, unless otherwise indicated. Flange gaskets shall be as manufactured by **John Crane, Style 2160, Garlock, Style 3000,** or equal.

2. Gaskets for flanged joints used in chemicals, air, solvents, hydrocarbons, steam, chlorine and other fluids shall be made of materials compatible with the service, pressure, and temperature.

2.3 THREADED INSULATING CONNECTIONS

A. **General:** Threaded insulating bushings, unions, or couplings, as appropriate, shall be used for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. **Materials:** Threaded insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene, or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

A. **General:** Cast mechanical-type couplings shall be provided where indicated. The couplings shall conform to the requirements of ANSI/AWWA C606 - Grooved and Shouldered Joints. Bolts and nuts shall conform to the requirements of Section 05500 - Miscellaneous Metalwork. Gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of grooved piping shall conform with the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid stress on equipment, equipment connections with mechanical-type couplings shall have rigid-grooved couplings or flexible type coupling with harness in sizes where rigid couplings are not available, unless thrust restraint is provided by other means. Mechanical-type couplings shall be bonded. The CONTRACTOR shall have the coupling manufacturer's service representative verify the correct choice and application of couplings and gaskets, and the workmanship, to assure a correct installation. To assure uniform and compatible piping components, all grooved fittings, couplings, and valves shall be from the same manufacturer.

B. Manufacturers of Couplings for Steel Pipe, or equal

1. **Gustin-Bacon (Aeroquip Corp.) (banded or grooved);**

2. **Victaulic Style 41 or 44 (banded, flexible);**

3. **Victaulic Style 77 (grooved, flexible);**

4. **Victaulic Style 07 or HP-70 (grooved, rigid).**

C. Manufacturers of Ductile Iron Pipe Couplings, or equal

1. **Gustin-Bacon, (Aeroquip Corp.);**

2. **Victaulic Style 31 (flexible or rigid grooving).**

Note: Ductile iron pipe couplings shall be furnished with flush seal gaskets.

D. Manufacturers of Couplings for PVC Pipe, or equal

1. **Gustin-Bacon, (Aeroquip Corp);**

2. **Victaulic Style 775.**

Note: Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends.

2.5 SLEEVE-TYPE COUPLINGS

A. **Construction:** Sleeve-type couplings shall be provided where indicated, in accordance with ANSI/AWWA C219 - Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe. Couplings shall be steel with steel bolts, without pipe stop. Couplings shall be of sizes to fit the pipe and fittings indicated. The middle ring shall be not less than 1/4-inch thick or at least the same wall thickness as the pipe to which the coupling is connected. If the strength of the middle ring material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe. The coupling shall be either 5 or 7 inches long for sizes up to and including 30 inches and 10 inches long for sizes greater than 30 inches, for standard steel couplings, and 16 inches long for long-sleeve couplings. The followers shall be single-piece contoured mill sections welded and cold-expanded as required for the middle rings, and of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Bolts and nuts shall conform to the requirements of Section 05500. Buried sleeve-type couplings shall be epoxy-coated at the factory as indicated.

B. **Pipe Preparation:** Where indicated, the ends of the pipe shall be prepared for flexible steel couplings. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the ends of the pipe, with outside diameter not more than 1/64-inch smaller than the nominal outside diameter of the pipe. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.

C. **Gaskets**

1. Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," Grade 60, or equivalent suitable elastomer. The rubber in the gasket shall meet the following specifications:

a. Color - Jet Black

b. Surface - Non-blooming

c. Durometer Hardness - 74 plus and minus 5

d. Tensile Strength - 1000 psi Minimum

e. Elongation - 175 percent Minimum

2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. All gaskets shall meet the requirements of ASTM D 2000 - Classification System for Rubber Products in Automotive Applications, AA709Z, meeting Suffix B13 Grade 3, except as noted above. Where sleeve couplings are used in water containing chloramine or other fluids which attack rubber materials, gasket material shall be compatible with the piping service and fluid utilized.

3. Gasket materials used in water with chloramines shall be **Gylon Style 3500** by **Garlock,** or equal.

D. **Insulating Sleeve Couplings:** Where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a sleeve of an insulating compound material compatible with the fluid service in order to obtain insulation of all coupling metal parts from the pipe.

E. **Restrained Joints:** Sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be designed by the pipe manufacturer in accordance with Manual M11, or as indicated. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation to prevent misalignment of the pump imparted by the thrust within the piping system.

F. Manufacturers, or equal

1. **Dresser, Style 38;**

2. **Ford Meter Box Co., Inc., Style FC1 or FC3;**

3. **Smith-Blair, Style 411.**

2.6 FLEXIBLE CONNECTORS

A. **Low Temperatures:** Flexible connectors shall be installed in all piping connections to engines, blowers, compressors, and other vibrating equipment, and where indicated. Flexible connectors for service temperatures up to 180 degrees F shall be flanged, reinforced Neoprene or Butyl spools, rated for a working pressure of 40 to 150 psi, or reinforced, flanged duck and rubber, as best suited for the application. Flexible connectors for service temperatures above 180 degrees F shall be flanged, braided stainless steel spools with inner, annular, corrugated stainless steel hose, rated for minimum 150 psi working pressure, unless otherwise indicated. The connectors shall be a minimum of 9 inches long, face-to-face flanges, unless otherwise indicated. The final material selection shall be approved by the manufacturer. The CONTRACTOR shall submit manufacturer's shop drawings and calculations.

B. **High Temperature:** Flexible connectors shall be installed in engine exhaust piping and where indicated. Connectors shall be sufficient to compensate for thermal expansion and contraction and also to isolate vibration between the engine and the exhaust piping system. Connectors shall be stainless steel bellows type, flanged, and rated for minimum 150 psi, 2000 degrees F.

2.7 EXPANSION JOINTS

A. Piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement without exertion of undue forces to equipment or

structures. This may be accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints. Expansion joints shall be flanged end, stainless steel, Monel, rubber, or other materials best suited for each individual service. The CONTRACTOR shall submit detailed calculations and manufacturer's Shop Drawings of all proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature and pressure ratings.

2.8 PIPE THREADS

A. Pipe threads shall be in accordance with ANSI/ASME B1.20.1 - Pipe Threads, General Purpose (inch), and be made up with Teflon tape unless otherwise indicated.

2.9 PIPE INSULATION

A. Hot and cold liquid piping, flues, and engine exhaust piping shall be insulated as indicated, in accordance with the requirements of Section 15145 - Pipe and Equipment Insulation. No unprotected hot piping shall be within reach of operating personnel or other persons.

B. Preinsulated pipe for underground service shall be in accordance with Section 02550 - Preinsulated Pipe.

2.10 HEAT TRACING

A. Pipes subject to freezing shall be protected by heat tracing in accordance with Section 16850 - Electric Heat Tracing.

2.11 CATHODIC PROTECTION

A. Where so indicated, buried piping shall be cathodically protected in accordance with Section 16644 - Buried Galvanic Cathodic Protection System.

2.12 AIR AND GAS TRAPS

A. Air and gas pipes shall slope to low points and be provided with drip legs, shut-off valves, strainers, and traps. The traps shall be piped to the nearest drain. Air and gas traps shall be not less than 150 lb iron body float type with copper or stainless steel float. Bracket, lever, and pins shall be of stainless steel. Drain traps shall have threaded connections.

B. Manufacturers, or equal

1. **Armstrong International, Inc.;**

2. **Spirax Sarco, Inc.**

2.13 STEAM TRAPS

A. Steam traps shall be installed in all low points of steam piping, at minimum 300-foot intervals in mains, at steam appliances, heat exchangers, heaters, and control valves, and where indicated. Steam traps shall be preceded by drip legs, gate valves, and strainers, and shall be connected to the condensate system. Steam traps shall be of the float and thermostatic type, the bucket type, or the disc type, as best suited for the service, with cast iron or steel body, stainless steel or monel trim, and screwed connections, with minimum rating of 150 psig.

B. Manufacturers, or equal

1. **Armstrong International, Inc.;**

2. **Dunham-Bush;**

3. **ITT Fluid Handling;**

4. **Spirax Sarco, Inc.**

2.14 GLASS LINING

A. **General:** Ductile iron or steel pipe and fittings shall be glass-lined where indicated. The glass lining shall be suitable for handling sewage, primary sludge, digested sludge, and scum. It shall be smooth, continuous, and suitable for prevention of grease and foam build-up. The glass lining shall be capable of withstanding thermal shock of 350 degrees F (430 degrees to 80 degrees) without crazing, blistering, or spalling.

B. **Criteria:** The glass lining shall consist of a vitreous material to meet or exceed the following criteria:

1. Unaffected by scraping with a sharp knife, simulating the effects of rodding.

2. Unaffected by the continuous application of live steam from a steam generator, immediately followed by a cold water quench.

3. Unaffected by an 8 percent sulfuric acid solution at 148 degrees F for a ten-minute period.

4. Minimum thickness: 10 mils by micro test.

5. Spark tested: Must be free of pinholes.

6. Hardness: 5-6 Mohs.

7. Density: 2.5-3.0 g/cu cm, measured by ASTM D 792 - Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.

C. **Application:** Cast or ductile iron pipes and fittings shall be bored or machined smooth to remove voids or protrusions. Steel pipe shall be seamless pipe, with all internal fitting welds ground smooth, slag holes ground out, re-welded, and ground smooth. Interior surfaces shall be grit blasted to white metal and lining shall be fused on to chemically clean metal at above 1400 degrees F. Welded flanges shall be factory-installed before lining. Screwed flanges or cast and ductile iron pipes shall be installed after lining. All pieces shall be sealed and tested prior to shipment. Finish shall be subject to the ENGINEER'S approval.

D. Manufacturers, or equal

1. **The Pfaudler Co, Inc., Rochester, New York;**

2. **A.O. Smith Corp., Florence, Kentucky;**

3. **Waterworks, Mfg. Co., Marysville, California.**

PART 3 – EXECUTION

3.1 MATERIAL DELIVERY, STORAGE, AND PROTECTION

A. Piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground for protection against oxidation caused by ground contact. Defective or damaged materials shall be replaced with new materials.

3.2 GENERAL

A. Piping, fittings, and appurtenances shall be installed in accordance with the requirements of applicable Sections of Division 2 and Division 15. Care shall be taken to insure that piping flanges, mechanical-type couplings, sleeve-type couplings, flexible connectors, and expansion joints are properly installed as follows:

1. Gasket surfaces shall be carefully cleaned and inspected prior to making up the connection. Each gasket shall be centered properly on the contact surfaces.

2. Connections shall be installed to prevent inducing stress to the piping system or the equipment to which the piping is connected. Contact surfaces for flanges, couplings, and piping ends shall be aligned parallel, concentric, and square to each axis at the piping connections.

3. Bolts shall be initially hand-tightened with the piping connections properly aligned. Bolts shall be tightened with a torque wrench in a staggered sequence to the AISC recommended torque for the bolt material.

4. After installation, joints shall meet the indicated leakage rate. Flanges shall not be deformed nor cracked.

B. **Lined Piping Systems:** The lining manufacturer shall take full responsibility for the complete, final product and its application. Pipe ends and joints of lined pipes at screwed flanges shall be epoxy-coated to assure continuous protection.

C. **Core Drilling:** Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction to avoid damage to embedded raceways and reinforcing bars.

D. **Cleanup:** After completion of the WORK, cuttings, joining and wrapping materials, and other scattered debris shall be removed from the Site. The entire piping system shall be handed over in a clean and functional condition.

- END OF SECTION -

SECTION 15005 - PIPING IDENTIFICATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide identification for exposed piping and valves, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI A13.1 Scheme for the Identification of Piping Systems

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Item SP-12 of the Special Provisions.

B. Shop Drawings: A list of suggested wording for each valve tag, prior to fabrication.

C. Samples

1. One sample of each type of identification device.

2. Sample of each proposed color required by the pipe color schedule.

PART 2 -- PRODUCTS

2.1 IDENTIFICATION OF PIPING

A. Except as indicated below for very short pipe lengths, identify exposed piping larger than 2 inches nominal size for the pipe contents and direction of flow.

1. Marker Type

a. Stencil: Lettering painted directly on surface of pipe inside color coded marker area.

2. Marker Area: Sized per pipe size according to ANSI A13.1; color from the table below.

3. Lettering: Sized per pipe size according to ANSI A13.1; color from the table below.

4. Arrows: at least 2 arrows at each marker area, showing direction of flow.

B. Pipe 2 inches and smaller shall be identified by plastic plates made from laminated 3-layer plastic with engraved black letters on white background.

C. Pipe identification shall be as manufactured by **Brady, Seton,** or equal.

2.2 EXISTING IDENTIFICATION SYSTEMS

A. In installations where existing piping identification systems have been established, the CONTRACTOR shall follow the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the indicated system.

2.3 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

A. Identifying devices for valves and the sections of pipe that are too short to be identified with markers and arrows shall be identified with metal or plastic tags.

B. Metal tags shall be stainless steel with embossed lettering. Plastic tags shall be solid black plastic laminate with white embossed letters. Tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to such valves or short pipes.

C. Wording on the valve tags shall describe the exact function of each valve, e.g., "HWR-BALANCING," "CLS THROTTLING", "RAS-PUMP SHUT-OFF," etc.

PART 3 -- EXECUTION

3.1 GENERAL

A. Markers and identification tags shall be installed in accordance with the manufacturer's printed instructions, and shall be neat and uniform in appearance. Tags and markers shall be readily visible from all normal working locations.

3.2 VALVE TAGS

A. Valve tags shall be permanently attached to the valve or structure by means of 2 stainless steel bolts or screws.

3.3 MARKER LOCATIONS

A. Each pipe shall be marked at:

1. Intervals of 20-feet in straight runs.

2. At least once in every room.

3. Within 2-feet of turns, elbows, and valves.

4. On the upstream side of tees, branches, and other distribution points.

5. On both sides of walls and floors through which the piping passes.

3.4 IDENTIFICATION COLORS

A. Conform to the following color codes.

Color Schedule				
Pipe Contents		Pipe Color	Marker Color	Letter Color
Abbreviation	Identification			
A	Air		blue	white
FOR	Fuel oil return		yellow	black
FOS	Fuel oil supply		yellow	black
FSP	Fire protection sprinkler system		red	white
IA	Instrument air		blue	white
LSP	Landscape sprinkler system		green	white
NG	Natural gas		yellow	black
OF	Overflow		green	white
PW	Potable water		green	white
RWL	Rain water leader		green	white
SA	Sample lines		yellow	black
SD	Sanitary drains and vents		yellow	black
SDR	Storm drain		green	white
SPD	Sump pump discharge		green	white
SS	Sanitary sewer		yellow	black
SUC	Structure underdrain collector		green	white

- END OF SECTION -

SECTION 15006 - PIPE SUPPORTS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide pipe supports, hangers, guides, and anchors, complete and in place, in accordance with the Contract Documents.

B. Where pipe support systems are not indicated on the Drawings, the CONTRACTOR shall design and provide the supports in accordance with this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. **Shop Drawings:** Shop Drawings shall include the following information:

1. Drawings of pipe supports, hangers, anchors, and guides

2. Seismic analysis calculations

3. Calculations for special supports and anchors.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. **Code Compliance:** Piping systems and pipe connections to equipment shall be properly anchored and supported to prevent undue deflection, vibration, dislocation due to seismic events, line pressures, thermal changes, and stresses on piping, equipment, and structures. See Section 11000, EQUIPMENT GENERAL PROVISIONS for seismic design criteria. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping, except as supplemented or modified below. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

All pipe supports and restraints shall be designed to support their respective pipes under the maximum combination of peak loading conditions, including pipe weight, liquid movement, pressure forces, thermal expansion and contraction, vibrations, and all probable externally supplied forces, including seismic forces, wind forces, and forces applied during construction.

The CONTRACTOR shall note that the pipe support details in the Contract Drawings are not designed to resist all seismic and wind forces. The CONTRACTOR shall design and install additional supports as needed to resist seismic and wind forces given in Section 11000, EQUIPMENT GENERAL PROVISIONS. Design calculations shall be submitted to the ENGINEER in accordance with Section 01300, CONTRACTOR SUBMITTALS.

B. **Structural Members:** Wherever possible, pipes shall be supported from structural members. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided by the CONTRACTOR. Supplementary members shall be in accordance with the requirements of the building

code and the American Institute of Steel Construction and shall be acceptable to the ENGINEER.

C. **Pipe Hangers:** Pipe hangers shall be capable of supporting the pipe in all conditions of operation, allowing free expansion and contraction of the piping and preventing excessive stress on equipment. Hangers shall have a means of vertical adjustment after erection. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves shall include hydraulic shock suppressors. Hanger rods shall be subject to tensile loading only.

D. **Hangers Subject to Horizontal Movements:** At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement. Where horizontal pipe movement is greater than 1/2-inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold to the hot position of the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

E. **Spring-Type Hangers:** Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate the compression of the spring. Supports shall be capable of accommodating at least 4 times the maximum travel due to thermal expansion.

F. **Thermal Expansion:** Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or expansion joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely away from the anchored points. Components shall be structurally suitable to withstand loads imposed.

G. **Heat Transmission:** Supports, hangers, anchors, and guides shall be so designed and insulated that excessive heat will not be transmitted to the structure or to other equipment.

H. **Riser Supports:** Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

I. **Freestanding Piping:** Free-standing pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure. Exterior, free-standing overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, or with horizontal, welded steel angles, and U-bolts or clamps securing the pipes.

J. Materials of Construction

1. **General**: Pipe support assemblies, including framing, hardware, and anchors, shall be steel construction, galvanized after fabrication, unless otherwise indicated.

2. Submerged Supports: Submerged supports, as well as piping, conduits, and equipment in hydraulic structures within 24-inches of the water level, shall be

supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel, unless otherwise indicated.

3. Enclosed Hydraulic Structures: All supports, as well as piping, conduits, and equipment in hydraulic structures enclosed with covers, shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel, unless otherwise indicated.

4. Corrosive: Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel or FRP, unless otherwise indicated.

K. **Point Loads:** Any meters, valves, heavy equipment, and other point loads on PVC, FRP, and other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations to avoid undue pipe stresses and failures. To avoid point loads, supports on PVC, FRP, and other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

L. **Concrete Anchors:** Unless otherwise indicated, concrete anchors for pipe supports shall be according to the following table. Consult the ENGINEER for any anchor applications not on the table. Anchor embedment shall comply with Section 05500.

Pipe Support Application	Type of Concrete Anchor
New Concrete	Use embedded concrete insert anchors on a grid pattern. Use **Grinnell (Anvil International), Tolco**, or equal.
Existing Concrete	Use non-shrink grouted anchors, metallic type expansion anchors, or epoxy anchors. Exceptions: Metallic type expansion anchors and epoxy anchors are not permitted for pipe supports subject to vibrating loads. Epoxy anchors are not permitted where the concrete temperature is in excess of 100 degrees F or higher than the limiting temperature recommended by the manufacturer. Epoxy anchors are not accepted where anchors are subject to vibration or fire.
Vibratory Loads and High Temperature Conditions	Use non-shrink grouted anchors

M. **Noise Reduction:** To reduce transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar, suitable material at each pipe support, bracket, clip, or hanger.

2.2 SUPPORT SPACING

A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads. Pipe support spacing shall not exceed the maximum spans in the tables below. For temperatures other than ambient temperatures or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of loading effects.

B. Where support spacing is not indicated on the Drawings, the CONTRACTOR shall use the spacing below.

1. Support Spacing for Schedule 10 and Schedule 40 Stainless Steel and Schedule 40 and Schedule 80 Steel Pipe

Nominal Pipe Diameter, in	Maximum Span, ft
1/2	6
3/4 and 1	8
1-1/4 and Larger	10

2. Not Used

3. Support Spacing for Ductile-Iron Pipe

Nominal Pipe Diameter, in	Maximum Span, ft
All Diameters	Two supports per pipe length or 10-feet (one of the 2 supports located at joint)

4. Support Spacing for Copper Tubing

Nominal Pipe Diameter, in	Maximum Span, ft
1/2 to 1-1/2	6
2 to 4	10
6 and greater	12

5. Support Spacing for Schedule 80 PVC Pipe

Nominal Pipe Diameter, in	Maximum Span At 100 degrees F, ft
1/2	4
3/4	4.5
1	5
1-1/4	5.5
1-1/2	5.75
2	6.25
3	7.5
4	8.25

6	10
8	11
10	12.25
12	13.25

6. Support Spacing for Schedule 80 Polypropylene Pipe

Nominal Pipe Diameter, in	Maximum Span at 100 degrees F, ft
1/2	3
3/4	3.5
1	3.75
1-1/4	4
1-1/2	4.25
2	4.5
3	5.5
4	6
6	7.25
8	8
10	8.75
12	9.5

7. Support Spacing for Fiberglass Reinforced Plastic (FRP) Pipe

Nominal Pipe Diameter, in	Maximum Span at 100 degrees F, ft
2	8.8
3	10
4	11
6	12.7
8	13.4

10	14
12	15.4
14	16.2
16	17.3
18 and greater	18

2.3 MANUFACTURED SUPPORTS

A. **Stock Parts:** Where not specifically indicated, designs that are generally accepted as exemplifying good engineering practice and using stock or production parts shall be utilized wherever possible. Such parts shall be locally available, new, of best commercial quality, designed and be rated for the intended purpose.

B. Manufacturers, or Equal

1. **Basic Engineers Inc.**, Pittsburgh, PA
2. **Bergen-Paterson Pipesupport Corp.**, Woburn, MA
3. **Grinnell Corp. (Anvil International)**, Cranston, RI
4. **NPS Products, Inc.**, Westborough, MA
5. **Power Piping Company**, Pittsburgh, PA
6. **Tolco Incorporated**, Corona, CA

2.4 COATING

A. **Galvanizing:** Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. **Other Coatings:** Other than stainless steel or non-ferrous supports, supports shall receive protective coatings in accordance with the requirements of Section 09800 - Protective Coating.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** Pipe supports, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 - Power Piping. Concrete inserts for pipe hangers and supports shall be coordinated with the formwork.

B. **Appearance:** Pipe supports and hangers shall be positioned to produce an orderly, neat piping system. Hanger rods shall be vertical, without offsets. Hangers shall be

adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, without interference with other WORK.

3.2 FABRICATION

A. **Quality Control:** Pipe hangers and supports shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available. Fabricated supports shall be neat in appearance without sharp corners, burrs, and edges.

- END OF SECTION

SECTION 15025 - STEEL PIPE
(ASTM A 53 / A 106, MODIFIED)

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 15000 - Piping, General apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. **Water, Air, Fuel Gas, Oil, Steam, and Waste Service:** Unless otherwise indicated, galvanized and black steel pipe shall conform to ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless or ASTM A 106 - Seamless Carbon Steel Pipe for High Temperature Service, Grade B, and shall be Schedule 40 or 80, as indicated in the Piping Schedule. Galvanized steel pipe shall not be cement mortar lined unless so indicated.

B. **Chlorine and Sulfur Dioxide Pressure Service:** Black steel pipe shall conform to Chlorine Institute Pamphlet 6, ASTM A 106, Grade A or B, and shall be Schedule 80.

2.2 PIPE JOINTS

A. Black steel pipe for general service shall have screwed ends with NPT threads, welded joints, or flanged joints. Screwed joints shall be made up with Teflon tape and welded joints may have butt-weld fittings, socket-weld fittings, or flanges. Where indicated, black steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

B. Black steel pipe for chlorine or sulfur dioxide pressure service shall be socket-welded except where required to match mating fittings of vacuum regulator-check units, gas filters, valves, diaphragm units, gauges, and switches.

C. Galvanized steel pipe shall have screwed ends with NPT threads made up with Teflon tape. Where indicated, galvanized steel pipe shall have grooved ends for shouldered couplings or plain ends for sleeve-type couplings.

D. Where pressure conditions permit, black and galvanized steel pipe may have push-on joints for compression type fittings. For high pressure service these joints shall be harnessed.

2.3 FITTINGS

A. **Common Use:** The following fittings shall be provided for galvanized or black steel pipe, as indicated in the Piping Schedule:

1. Threaded malleable iron fittings conforming to ANSI/ASME B 16.3 - Malleable-Iron Threaded Fittings, Classes 150 and 300.

2. Threaded cast iron fittings conforming to ANSI/ASME B 16.4 - Cast Iron Threaded Fittings, Class 125 and 250.

3. Forged steel socket welded fittings conforming to ANSI/ASME B 16.11 - Forged Fittings, Socket - Welding and Threaded.

4. Butt welding fittings conforming to ANSI/ASME B 16.9 - Factory-Made Wrought Steel Butt Welding Fittings, Schedule 40 or 80, as indicated.

5. Threaded cast iron drainage fittings conforming to ANSI/ASME 16.12 - Cast Iron Threaded Drainage Fittings.

6. Flanged cast iron fittings conforming to ANSI/ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.

7. Flanged steel fittings conforming to ANSI/ASME B 16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.

8. Grooved ductile iron fittings with grooving dimensions conforming to ANSI/AWWA C 606 - Joints, Grooved and Shouldered Type.

9. Compression-type steel fittings with armored Buna S gaskets for plain end pipe.

B. Special Applications

1. Fittings for chlorine and sulfur dioxide under pressure shall be 3,000 lb. forged steel socket welded fittings conforming to ASTM A 105, Grade 2 - Forgings, Carbon Steel, for Piping Components, and 300 lb. forged steel fittings conforming to ANSI/ASME B 16.11, as indicated in the Piping Schedule.

2. Flanges for chlorine and sulfur dioxide pressure service shall conform to ASTM A 105, ANSI/ASME B 16.5, Class 300, with 1/16-inch raised face, with 1/16-inch high temperature, compressed, self-centering ring type gaskets to ANSI/ASME B 16.21 - Nonmetallic Flat Gaskets for Pipe Flanges. Unions shall be four bolt tongue and groove, ammonia type, suitable for chlorine and sulfur dioxide service, with female threads and lead gaskets.

3. High tensile alloy steel corrosion-resistant bolts and nuts shall be used with each set of flanged unions. Unions shall be rated for 500-lb. CWP service pressure, reducing-type, straight-type or blind-type, as required for the installation. Blind unions shall be provided as cleanouts where indicated, and straight unions shall be provided adjacent to each threaded valve or piece of equipment. Unions shall be as manufactured by **Henry Valve Company; Vogt Valve Co.;** or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** All steel pipes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the site, to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipes shall afford maximum headroom and access to equipment, and where necessary, all piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. All installations shall be acceptable to the ENGINEER.

B. **Supports and Anchors:** All piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 15006 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipes shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences.

C. **Valves and Unions:** Water, steam, condensate, gas, vacuum, and air supply piping to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Low points in water systems and driplegs in steam, gas, and air systems shall have drainage valves. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

D. **Branch Connections:** Branch connections in horizontal runs of air and gas piping shall be made from the top of the pipe, to avoid drainage of condensate into the equipment.

3.2 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true. Ends of threaded pipes shall be reamed and filed smooth. All pipefittings shall be equally cleaned before assemblage.

3.3 PIPE JOINTS

A. **Threaded Joints:** Pipe threads shall conform to ANSI/ASME B 1.20.1 - Pipe Threads, General Purpose (inch), and shall be full and cleanly cut with sharp dies. Not more than three threads shall remain exposed after installation.

B. **Welded Joints:** Welded joints shall conform to the specifications and recommendations of ANSI/ASME B 31.1 - Power Piping. All welding shall be done by skilled and qualified welders per Section 15000 - Piping, General.

C. **Grooved Joints:** Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the Manufacturer's recommendations and conform to ANSI/AWWA C 606. All grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.

D. **Push On Joints:** Push on joints and gasket installation shall be in accordance with the Manufacturer's recommendations and lubricants. Pipe ends shall be beveled to facilitate assembly. Lubricants shall be suitable for potable water service and shall be kept clean in closed containers.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** All finished installations shall be carefully inspected for proper supports, anchoring, interferences, and damage to pipe, fittings, and coating. Any damage shall be repaired to the satisfaction of the ENGINEER.

B. **Field Testing:** Prior to enclosure or burying, all piping systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour, without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish all test equipment, labor, materials, and devices at no extra cost to the OWNER. For additional testing requirements, refer to Section 01656 - Pressure Pipe Testing and Disinfection.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. All fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.

2. After completion of the pressure tests, all chlorine gas piping shall be tested for leakage using chlorine gas under operating pressures. Piping shall be thoroughly clean and dry before admitting chlorine gas into the system. Chlorine shall be slowly admitted to the piping system. Leakage shall be checked with a swab soaked in aqua ammonia solution and waved in the vicinity of each fitting. Ammonia solution shall not be applied to the fittings. Formation of white fumes will be evidence of leaks. All chlorine gas shall be purged from the line before leaks are repaired.

3. Leaks shall be repaired to the satisfaction of the ENGINEER, and the system shall be re-tested until no leaks are found.

- END OF SECTION -

SECTION 15037 - COPPER WATER TUBE
(ASTM B 88, MODIFIED)

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide copper tube for water, gas, and vacuum service, complete and in place, in accordance with the Contract Documents

B. The requirements of Section 15000 - Piping, General apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. Copper water tube shall conform to the requirements of ASTM B 88 - Seamless Copper Water Tube, and shall be soft temper tube in rolls for buried locations, or hard drawn lengths for all other applications. Unless otherwise indicated, all copper water tube shall be of Type K wall thickness.

2.2 JOINTS

A. Copper water tube shall have either soldered joints, flared ends and fittings, or compression type joints. Soldered joints shall be made with 95 - 5 percent tin-antimony solder or with silver solder. Buried piping shall have flared or compression type joints. No soft-soldered joints will be allowed on buried piping. No solders containing more than 0.2 percent of lead shall be used.

2.3 FITTINGS

A. **Soldered Fittings:** Soldered fittings shall conform to ANSI B 16.18 - Cast Copper Alloy Solder Joint Pressure Fittings, or to ANSI/ASME B 16.22 - Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings. The soldering flux shall be the Manufacturer's approved type for the fitting and solder used.

B. **Flared Fittings:** Flared fittings shall conform to ANSI/ASME B 16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.

C. **Compression Fittings**: Compression type fittings shall be brass fittings as manufactured by **Crawford Company - SWAGELOK, Parker-Hannifin - CPI**, or equal.

D. **Flanged Fittings:** Cast copper alloy flanges and flanged fittings shall be in accordance with ANSI/ASME B 16.24 - Cast Copper Alloy Pipe Flanges and Flanged Fittings, and ASTM B 62 - Standard Specification for Composition Bronze or Ounce Metal Castings, with 150 lb. ratings, or as indicated.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** All copper tubes shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the site, to avoid interferences with

structural members, architectural features, openings, and equipment. Exposed tubing shall afford maximum headroom and access to equipment, and where necessary all tubing shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. All installations shall be acceptable to the ENGINEER.

B. **Supports and Anchors:** All tubing shall be firmly supported with fabricated or commercial hangers, brackets, or supports in accordance with Section 15006 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the tubes shall be anchored or harnessed. Expansion joints and guides shall compensate for expansion due to temperature differences.

C. **Valves and Unions:** Unless otherwise indicated, tubing to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Low points in water systems and driplegs in steam, gas, and air systems shall have drainage valves. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.

D. **Branch Connections:** Branch connections in horizontal runs of air and gas tubing shall be made from the top of the main to avoid drainage of condensate into the equipment.

E. **Tapping:** The City shall perform the tapping of the existing water main. The Contractor shall contact the water district six (6) weeks in advance to schedule the tapping. The contractor shall excavate and expose the water main for the City and provide support. Upon completion of the tap, the Contractor shall make the necessary pipe connections as directed by the City, then backfill and restore the area.

The Contractor shall pay all fees to the City for the tapping services.

Contact Information: LOCSD

3.2 PREPARATION

A. Prior to installation, each tube length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Ends of tubes shall be reamed and filed smooth. All fittings shall be equally cleaned before assembly.

3.3 JOINTS

A. **Brazed and Soldered Joints:** Brazed and soldered joints shall conform to the manufacturer's recommendations and to the specifications and recommendations of ANSI/ASME B 31.1 - Power Piping. All brazing shall be done by skilled and qualified welders per Section 15000 - Piping, General. Prior to the application of flux, the end of all tubes shall be thoroughly dried and cleaned.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** All finished installations shall be carefully inspected for proper joints and supports, anchoring, interferences, and damage to tubing, fittings, and coating. Damage shall be repaired to the satisfaction of the ENGINEER.

B. **Field Testing:** Prior to enclosure or burying, all tubing systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour, without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the tubes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish all test equipment, labor, materials, and devices at no extra

cost to the OWNER. For additional testing requirements refer to Section 01656 - Pressure Pipe Testing and Disinfection.

1. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. All fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines be plugged or capped as required during the testing procedures.

2. Leaks shall be repaired to the satisfaction of the ENGINEER, and the system shall be re-tested until no leaks are found.

- END OF SECTION -

SECTION 15046 - CORROSION RESISTANT CAST IRON SOIL PIPE (ASTM A 861, MODIFIED)

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide corrosion resistant cast iron soil pipe, complete and in place, in accordance with the Contract Documents

B. The requirements of Section 15000 - Piping, General apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. Unless otherwise indicated, cast iron chemical waste and vent piping shall be service weight corrosion resistant cast iron soil pipe with hub and spigot ends or hubless pipe in accordance with ASTM A 518 - Corrosion-Resistant High-Silicon Iron Castings and ASTM A 861 - High-Silicon Iron Pipe and Fittings.

B. Cast iron drains and vents indicated for non-chemical service shall be in accordance with Section 15045 - Cast Iron Soil Pipe.

2.2 PIPE JOINTS

A. Hub and spigot pipe shall have joints caulked with acid-proof rope packing and lead per Cast Iron Soil Pipe Institute standards.

B. Hubless pipe shall have joints made up with Teflon and Neoprene sleeves and Type 304 or 316 stainless steel clamps with stainless steel bolts per Standard 301 - Hubless Cast Iron Sanitary System of the Cast Iron Soil Pipe Institute.

2.3 FITTINGS

A. Corrosion-resistant cast iron soil pipe shall have service weight, drainage pattern, hub and spigot, or hub and hub fittings per ASTM A 861, or hubless fittings per Standard 301 of the Cast Iron Soil Pipe Institute, respectively. Fittings shall be made of corrosion resistant cast iron per ASTM A 518.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** Corrosion resistant cast iron soil pipe shall be installed in a neat and workmanlike manner, in accordance with the prevailing plumbing and building codes. Pipes shall have the required grades for proper drainage. Pipes inside buildings shall be coordinated with the work from all other trades to avoid interferences and to provide sufficient headroom. Installations shall be acceptable to the ENGINEER and to the local plumbing inspector.

B. **Supports:** Pipes shall be firmly supported with fabricated or commercial hangers and supports in accordance with Section 15006 - Pipe Supports. Horizontal runs shall have at least one support for each length of pipe.

3.2 COATING

A. Exposed pipes shall be coated in accordance with Section 09800 - Protective Coating.

3.3 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper joints and supports, interferences, and damage to pipe, fittings, and coating. Temporary plugs and covers shall be removed from openings and floor drains. Damage shall be repaired to the satisfaction of the ENGINEER and the plumbing inspector.

B. **Field Testing:** Prior to enclosure or burying, drains and vents shall be tested in the presence of the local plumbing inspector and the ENGINEER as required in the Piping Schedule, for a period of not less than one hour, or as requested by the plumbing inspector. The CONTRACTOR shall furnish all test equipment, labor, material, and devices at no extra cost to the OWNER. Leaks shall be repaired to the satisfaction of the ENGINEER and the plumbing inspector, and the system shall be re-tested until no leaks are found.

- END OF SECTION -

SECTION 15060 - PVC PRESSURE PIPE (ASTM D 1785, MODIFIED)

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide polyvinyl chloride (PVC) pressure pipe, complete and in place, in accordance with the Contract Documents.

B. The requirements of Section 15000 - Piping, General, apply to the WORK of this Section.

C. This Section includes PVC pressure pipe with solvent-welded, flanged, or screwed joints. PVC pipe with bell and spigot joints is included in Section 02597 - PVC Pressure Pipe, Rubber Joints.

PART 2 -- PRODUCTS

2.1 PIPE MATERIAL

A. PVC pipe shall be made from all new rigid unplasticized polyvinyl chloride and shall be normal impact Type 1, Grade 1, class 12454, Schedule 80, listed as compliant with NSF Standard 61, unless otherwise indicated, in accordance with ASTM D 1785-Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

2.2 PIPE JOINTS

A. Pipe joints shall be solvent-welded type with solvent cement and primer as recommended by the pipe manufacturer for the chemical in the pipe.

B. Screwed joints that are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape.

C. Flanged joints shall be made with solvent-welded PVC flanges, drilled to ANSI/ASME B 16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated. Gaskets shall be ANSI 150 lb. full face, 1/8-inch thick Neoprene for water or wastewater service. Gasket material for chemicals shall be suitable for the chemical service.

2.3 FITTINGS

A. **Solvent Welded and Threaded Fittings:** Solvent-welded and threaded fittings shall be Schedule 80 PVC fittings in accordance with ASTM D 2467 - Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

B. **Flanged Fittings:** Flanged fittings shall be Schedule 80 fabricated PVC fittings with 150 lb. flanges to ANSI/ASME B 16.5.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** PVC pipe shall be installed in a neat and workmanlike manner, properly aligned, and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipe

shall afford maximum headroom and access to equipment, and where necessary, piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points. It is recommended that the CONTRACTOR obtain the assistance of the pipe manufacturer's field representative to instruct the pipefitters in the correct installation and support of PVC piping.

B. **Supports and Anchors:** Piping shall be firmly supported with fabricated or commercial hangers or supports in accordance with Section 15006 - Pipe Supports. Where necessary to avoid stress on equipment or structural members, the pipe shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature changes.

C. **Valves and Unions:** Unless otherwise indicated, connections to fixtures, groups of fixtures, and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection. Valves and flanges attached to PVC pipe shall be provided with adequate supports.

3.2 PIPE PREPARATION

A. Prior to installation, each pipe length shall be carefully inspected, flushed clean of any debris or dust, and be straightened, if not true. Ends of threaded pipes shall be reamed and filed smooth. Pipe fittings shall be equally cleaned before assembly.

3.3 PIPE JOINTS

A. **Threaded Joints:** Pipe threads shall conform to ASTM F 1498 - Taper Pipe Threads 60 Degrees for Thermoplastic Pipe and Fittings, and shall be full and cleanly cut with sharp dies or molded. Joints shall be made with Teflon tape or thread sealant.

B. **Solvent-Welded Joints:** Solvent-welded joints shall be made with fresh primer and solvent cement on clean, dry pipe ends. The primer and cement cans shall be kept closed at all times and the joints shall be made up at the recommended ambient temperatures, to the pipe or cement manufacturer's written recommendations. Pipe ends shall be inserted to the full depth of the socket.

C. **Flange Joints:** Flanged joints shall be made with gaskets and Type 316 stainless steel bolts and nuts. Care shall be taken not to over-torque the bolts, in accordance with the manufacturer's written recommendations.

3.4 INSPECTION AND FIELD TESTING

A. **Inspection:** Finished installations shall be carefully inspected for proper joints and sufficient supports, anchoring, interferences, and damage to pipe, fittings, and coating. Damage shall be repaired to the satisfaction of the ENGINEER.

B. **Field Testing:** The CONTRACTOR shall allow adequate time for the solvent cement joints to cure. Curing time shall be per the solvent cement manufacturer's recommendation. Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule, for a period of not less than one hour, without exceeding the tolerances listed in the Piping Schedule. Caution - Do not use air or gas for testing PVC pipe. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The CONTRACTOR shall furnish all test equipment, labor, materials, and devices.

C. Leakage shall be determined by loss of pressure. Fixtures, devices, or other accessories that would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines shall be plugged or capped as appropriate during the testing procedures.

D. Leaks shall be repaired to the satisfaction of the ENGINEER, and the system shall be re-tested until no leaks are found.

- END OF SECTION -

SECTION 15145 - PIPE AND EQUIPMENT INSULATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide pipe and equipment insulation, complete and in place, in accordance with the Contract Documents. In addition to the insulation indicated, the CONTRACTOR shall insulate any cold or hot piping and exhausts that could be hazardous to the OWNER's personnel upon contact.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Federal Specifications

HH-1-558B	Insulation Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type)

B. Commercial Standards

ASTM C 547	Mineral Fiber Pipe Insulation
ASTM E 84	Test Method for Surface Burning Characteristics of Building Materials

1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit complete Shop Drawings of all thermal insulation, with manufacturer's data on materials, covering, jackets, and finish, in accordance with Section 01300 - Contractor Submittals.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Components of the insulation, including covering, mastics, and adhesives, shall have a flame-spread rating of not over 25 and a smoke development rating of not over 50. Ratings shall be as established by tests in accordance with ASTM E 84 and Federal Specification standards. The integrated insulation assemblies shall also conform to the above specifications. Insulation shall be applied in strict accordance with the manufacturer's instructions.

2.2 BASIC MATERIALS

A. **Standard Temperature Insulation:** This type of insulation shall be employed for process, cold and hot water, steam, and condensate piping and equipment with surface temperatures up to 850 degrees F. Pipe insulation and jacketing shall be applied to piping where indicated, including associated fittings, flanges, and valves. Pipe insulation shall be molded-type pipe covering, made of fibrous glass with a minimum k-factor of 0.23 at 75 degrees F mean temperature.

B. The insulation shall be oversized for installation over electric heating cable. Insulation shall have a factory-applied white fire-retardant vapor-barrier jacket of kraft paper and aluminum foil laminated together and reinforced with fiberglass yarn. Fittings and valves

shall be covered with the same material as the pipe, cut in segments to fit snugly without open spaces, held in place with copper wire or cement, and then be covered with the same jacketing material as the pipe. Insulated fittings adjacent to vapor-barrier insulation shall be sealed with acceptable vapor-barrier cement before installation of the finish jacket. Pipe insulation and vapor-barrier shall be continuous through hangers and supports. Insulation shall be coordinated with the pipe hangers and supports and where insulation protection shields are provided the top half section of pipe insulation at support locations shall be of the same density, and the bottom half insulation segments provided between the pipe and the insulation protection shields shall have a density of not less than 6 lb/cu ft. Insulation shall be covered with smooth aluminum weatherproof metal or plastic preformed jacketing with a factory-attached moisture barrier. Jackets for fittings shall consist of precision-formed smooth-sided sections and shall be sized to cover and protect the insulated fitting. Each section shall be manufactured from aluminum or PVC, and joints shall be sealed with silicone mastic or solvent welding to provide a continuous air and weathertight joint. Strapping shall be 1/2-inch wide, Type 3003 aluminum or stainless steel.

C. **High Temperature Insulation:** This type of insulation shall be employed for engine exhaust pipes, flues, and similar pipes and equipment with surface temperatures up to 1200 degrees F. The high temperature insulation shall consist of 4-inch thick calcium silicate or similar pre-molded blocks in two layers of 2-inch thickness, each with staggered joints, all applied over a 3/4-inch high metal rib lath. The inner layer shall be suitable for 1200 degrees F, and the second layer for 1000 degrees F. Bends, voids, joints, fittings and other parts of the piping system shall be filled with insulating cement. Aluminum lagging with preformed aluminum fittings shall be banded to the insulation in a similar fashion as required for standard insulation. Allowance shall be made for thermal expansion.

D. Manufacturers, or Equal

1. **Armstrong Contracting and Supply Corp.;**

2. **Certain-Teed Corporation;**

3. **Manville;**

4. **Owens-Corning Fiber Glass Corp.;**

5. **P.P.G. Industries, Inc.**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Insulation shall be installed by a qualified insulation contractor in strict accordance with the manufacturer's recommendations.

- END OF SECTION -

SECTION 15200 - VALVES, GENERAL

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide all valves, actuators, and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11000 - Equipment General Provisions, apply to the WORK of this Section.

C. The provisions of this Section shall apply to all valves and valve actuators except where otherwise indicated. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls indicated in other Sections of the Specifications.

D. Where a valve is to be supported by means other than the piping to which it is attached, the CONTRACTOR shall obtain from the valve manufacturer a design for support and foundation that satisfies the criteria in Section 11000. The design, including drawings and calculations sealed by an engineer, shall be submitted with the Shop Drawings. When the design is approved, the support shall be provided.

E. **Unit Responsibility:** A single manufacturer shall be made responsible for coordination of design, assembly, testing, and furnishing of each valve; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each valve section. Unless indicated otherwise, the responsible manufacturer shall be the manufacturer of the valve.

F. **Single Manufacturer:** Where two or more valves of the same type and size are required, the valves shall be furnished by the same manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be furnished in accordance with Item SP-12 of the Special Provisions.

B. **Shop Drawings:** Shop Drawings shall contain the following information:

1. Valve name, size, Cv factor, pressure rating, identification number (if any), and specification section number.

2. Complete information on valve actuator, including size, manufacturer, model number, limit switches, and mounting.

3. Cavitation limits for all control valves.

4. Assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, handwheels, position indicators, limit switches, integral control systems, needle valves, and control systems.

5. Data in accordance with Section 16460 - Electric Motors for all electric motor-actuated valves.

6. Complete wiring diagrams and control system schematics.

7. Valve Labeling: A schedule of valves to be furnished with stainless steel tags, indicating in each case the valve location and the proposed wording for the label.

C. **Technical Manual:** The Technical Manual shall contain the required information for each valve.

D. **Spare Parts List:** A Spare Parts List shall contain the required information for each valve assembly, where indicated.

E. **Factory Test Data:** Where indicated, signed, dated, and certified factory test data for each valve requiring certification shall be submitted before shipment of the valve. The data shall also include certification of quality and test results for factory-applied coatings.

PART 2 -- PRODUCTS

2.1 PRODUCTS

A. **General:** Valves and gates shall be new and of current manufacture. Shut-off valves 6 inches and larger shall have actuators with position indicators. Buried valves shall be provided with valve boxes and covers containing position indicators and valve extensions. Manual shut-off valves mounted higher than 7-feet above working level shall be provided with chain actuators.

B. **Valve Actuators:** Unless otherwise indicated, valve actuators shall be in accordance with Section 15201 - Valve and Gate Actuators.

C. **Protective Coating:** The exterior surfaces of all valves and the wet interior surfaces of ferrous valves of sizes 4 inches and larger shall be coated in accordance with Section 09800 - Protective Coating. The valve manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with these Specifications. Flange faces of valves shall not be epoxy coated.

D. **Valve Labeling:** Except when such requirement is waived by the ENGINEER in writing, a label shall be provided on all shut-off valves and control valves except for hose bibbs and chlorine cylinder valves. The label shall be of 1/16-inch plastic or stainless steel, minimum 2 inches by 4 inches in size, as indicated in Section 15005 - Piping Identification Systems, and shall by permanently attached to the valve or on the wall adjacent to the valve as directed by the ENGINEER.

E. **Valve Testing:** As a minimum, unless otherwise indicated or recommended by the reference Standards, valves 3 inches in diameter and smaller shall be tested in accordance with manufacturer's standard and 4 inches in diameter and larger shall be factory tested as follows:

1. **Hydrostatic Testing:** Valve bodies shall be subjected to internal hydrostatic pressure equivalent to twice the water rated pressure of the valve. Metallic valves rating pressures shall be at 100 degrees F and plastic valves shall be 73 degrees, or at higher temperature according to type of material. During the hydrostatic test, there shall be no leakage through the valve body, end joints, or shaft seals, nor shall any part of the valve be permanently deformed. The duration shall be sufficient time to allow visual examination for leakage. Test duration shall be at least 10 minutes.

2. **Seat Testing:** Valves shall be tested for leaks in the closed position with the pressure differential across the seat equal to the water rated pressure of the valve. The duration of test shall be sufficient time to allow visual examination for leakage. Test duration shall be at least 10 minutes. Leakage past the closed valve shall not exceed 1 fluid ounce per hour per inch diameter for metal seated valves and drop-tight for resilient seated valves.

3. **Performance Testing:** Valves shall be shop operated from fully closed to fully open position and reverse under no-flow conditions in order to demonstrate the valve assembly operates properly.

F. **Certification:** Prior to shipment, the CONTRACTOR shall submit for valves over 12 inches in size, certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, or ASTM.

G. **Valve Marking:** Valve bodies shall be permanently marked in accordance with MSS SP25 - Standard Marking Systems for Valves, Fittings, Flanges, and Unions.

2.2 MATERIALS

A. **General:** Materials shall be suitable for the intended application. Materials in contact with potable water shall be listed as compliant with NSF Standard 61. Materials not indicated shall be high-grade standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended. Unless otherwise indicated, valve and actuator bodies shall conform to the following requirements:

1. **Cast Iron:** Close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

2. **Ductile Iron:** ASTM A 536 - Ductile Iron Castings, or to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

3. **Steel:** ASTM A 216 - Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, or to ASTM A 515 - Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service.

4. **Bronze:** ASTM B 62 - Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Copper Alloy Sand Castings for General Applications.

5. **Stainless Steel:** Stainless steel valve and operator bodies and trim shall conform to ASTM A 351 - Steel Castings, Austenitic, for High-Temperature Service, Grade CF8M, or shall be Type 316 stainless steel.

6. **PVC:** Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 12454.

7. **CPVC:** Chlorinated Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 23447.

8. **NSF Standard 14:** Materials shall be listed for use in contact with potable water.

2.3 VALVE CONSTRUCTION

A. **Bodies:** Valve bodies shall be cast, molded (in the case of plastic valves), forged, or welded of the materials indicated, with smooth interior passages. Wall thicknesses shall be uniform in agreement with the applicable standards for each type of valve, without casting defects, pinholes, or other defects that could weaken the body. Welds on welded bodies shall be done by certified welders and shall be ground smooth. Valve ends shall be as indicated, and be rated for the maximum temperature and pressure to which the valve will be subjected.

B. **Valve End Connections:** Unless otherwise indicated, valves 2-1/2 inches diameter and smaller may be provided with threaded end connections. Valves 3 inches and larger shall have flanged end connections.

C. **Bonnets:** Valve bonnets shall be clamped, screwed, or flanged to the body and shall be of the same material, temperature, and pressure rating as the body. The bonnets shall have provision for the stem seal with the necessary glands, packing nuts, or yokes.

D. **Stems:** Valve stems shall be of the materials indicated, or, if not indicated, of the best commercial material for the specific service, with adjustable stem packing, O-rings, Chevron V-type packing, or other suitable seal. Where subject to dezincification, bronze valve stems shall conform to ASTM B 62, containing not more than 5 percent of zinc or more than 2 percent of aluminum, with a minimum tensile strength of 30,000 psi, a minimum yield strength of 14,000 psi, and an elongation of at least 10 percent in 2 inches. Where dezincification is not a problem, bronze conforming to ASTM B 584 may be used, except that zinc content shall not exceed 16 percent.

E. **Stem Guides:** Stem guides shall be provided, spaced 10-feet on centers unless the manufacturer can demonstrate by calculation that a different spacing is acceptable. Submerged stem guides shall be 304 stainless steel.

F. **Internal Parts:** Internal parts and valve trim shall be as indicated for each individual valve. Where not indicated, valve trim shall be of Type 316 stainless steel or other best suited material.

G. **Nuts and Bolts:** Nuts and bolts on valve flanges and supports shall be in accordance with Section 05500 - Miscellaneous Metalwork.

2.4 VALVE ACCESSORIES

A. Valves shall be furnished complete with the accessories required to provide a functional system.

2.5 SPARE PARTS

A. The CONTRACTOR shall furnish the required spare parts suitably packaged and labeled with the valve name, location, and identification number. The CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve. Spare parts are intended for use by the OWNER, after expiration of the correction of defects period.

2.6 MANUFACTURERS

A. **Manufacturer's Qualifications:** Valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the valves indicated.

PART 3 -- EXECUTION

3.1 VALVE INSTALLATION

A. **General:** Valves, actuating units, stem extensions, valve boxes, and accessories shall be installed in accordance with the manufacturer's written instructions and as indicated. Gates shall be adequately braced to prevent warpage and bending under the intended use. Valves shall be firmly supported to avoid undue stresses on the pipe.

B. **Access:** Valves shall be installed with easy access for actuation, removal, and maintenance and to avoid interference between valve actuators and structural members, handrails, or other equipment.

C. **Valve Accessories:** Where combinations of valves, sensors, switches, and controls are indicated, the CONTRACTOR shall properly assemble and install such items so that systems are compatible and operating properly. The relationship between interrelated items shall be clearly noted on Shop Drawing submittals.

- END OF SECTION -

SECTION 15201 - VALVE AND GATE ACTUATORS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide valve and gate actuators and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all valves and gates, except where otherwise indicated in the Contract Documents.

C. **Unit Responsibility:** The valve or gate manufacturer shall be made responsible for coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the CONTRACTOR shall be responsible to the OWNER for compliance of the valves, gates, and actuators with the Contract Documents.

D. **Single Manufacturer:** Where 2 or more valve or gate actuators of the same types or sizes are required, the actuators shall be produced by the same manufacturer.

E. The requirements of Section 16485 - Local Control Stations and Miscellaneous Electrical Devices apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Item SP-12 of the Special Provisions and Section 15200 - Valves, General.

B. **Shop Drawings:** Shop Drawing information for all actuators shall be submitted together with the valve and gate submittals as a complete package.

C. **Calculations:** Selection calculations showing dynamic seating and unseating torques versus output torque of actuator.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, shut-off and throttling valves and externally actuated valves and gates shall be provided with manual or power actuators. The CONTRACTOR shall furnish actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, handwheels, levers, chains, and extensions, as applicable. Actuators shall have the torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and shall be capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering. Actuator torque ratings for butterfly valves shall be determined in accordance with AWWA C504 - Rubber-Seated Butterfly Valves. All wires of motor-driven actuators shall be identified by unique numbers.

B. **Manufacturers:** Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer. Where actuators are furnished by different manufacturers, the CONTRACTOR shall coordinate selection to have the fewest number of manufacturers possible.

C. **Materials:** Actuators shall be current models of the best commercial quality materials and be liberally-sized for the required torque. Materials shall be suitable for the environment in which the valve or gate is to be installed.

D. **Actuator Mounting and Position Indicators:** Actuators shall be securely mounted by means of brackets or hardware specially designed and sized for this purpose and be of ample strength. The word "open" shall be cast on each valve or actuator with an arrow indicating the direction to open in the counter-clockwise direction. Gear and power actuators shall be equipped with position indicators. Where possible, manual actuators shall be located between 48- and 60 inches above the floor or the permanent working platform.

E. **Standard:** Unless otherwise indicated and where applicable, actuators shall be in accordance with AWWA C 540 - Power-Actuating Devices for Valves and Sluice Gates.

F. **Functionality:** Electric, pneumatic, and hydraulic actuators shall be coordinated with the power requirements of Division 16 and instrumentation equipment indicated in Section 17100 - Process Control and Instrumentation Systems.

G. Fasteners shall be in accordance with Section 05500 - Miscellaneous Metalwork.

H. Protective coatings shall be in accordance with Section 09800 - Protective Coatings.

2.2 MANUAL ACTUATORS

A. **General:** Unless otherwise indicated, valves and gates shall be furnished with manual actuators. Valves in sizes up to and including 4 inches shall have direct acting lever or handwheel actuators of the manufacturer's best standard design. Larger valves and gates shall have gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the handwheel. Buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psi, valves 30 inches in diameter and larger, and where so indicated, shall have worm gear actuators, hermetically-sealed water-tight and grease-packed. All other valves 6 inches to 24 inches in diameter may have traveling-nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. **Buried Valves:** Unless otherwise indicated, buried valves shall have extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys. Where so indicated, buried valves shall be in cast-iron, concrete, or similar valve boxes with covers of ample size to allow operation of the valve actuators. Covers of valve boxes shall be permanently labeled as required by the local Utility Company or the ENGINEER. Wrench-nuts shall comply with AWWA C 500 - Metal - Seated Gate Valves for Water Supply Service.

C. **Chain Actuator:** Manually-activated valves with the stem located more than 7-feet above the floor or operating level shall be provided with chain drives consisting of sprocket-rim chain wheels, chain guides, and operating chains provided by the valve manufacturer. The wheel and guide shall be of ductile iron, cast iron, or steel, and the chain shall be hot-dip galvanized steel or stainless steel, extending to 5-feet 6 inches above the operating floor level. The valve stem of chain-actuated valves shall be extra strong to allow for the extra weight and chain pull. Hooks shall be provided for chain storage where chains interfere with pedestrian traffic.

D. **Floor Boxes:** Hot-dip galvanized cast iron or steel floor boxes and covers to fit the slab thickness shall be provided for operating nuts in or below concrete slabs. For operating nuts in the concrete slab, the cover shall be bronze-bushed.

E. **Tee Wrenches:** Buried valves with floor boxes shall be furnished with 2 operating keys or 1 key per 10 valves, whichever is greater. Tee wrenches, sized so that the tee handle will be 2 to 4 feet above ground, shall fit the operating nuts.

F. **Manual Worm Gear Actuator:** The actuator shall consist of a single or double reduction gear unit contained in a weather-proof cast iron or steel body with cover and minimum 12-inch diameter handwheel. The actuator shall be capable of 90-degree rotation and shall be equipped with travel stops capable of limiting the valve opening and closing. The actuator shall consist of spur or helical gears or worm gearing. The gear ratio shall be self-locking to prevent "back-driving." The spur or helical gears shall be of hardened alloy steel and the worm gear shall be alloy bronze. The worm gear shaft and the handwheel shaft shall be of 17-4 PH or similar stainless steel. All gearing shall be accurately cut with hobbing machines. Ball or roller bearings shall be used throughout. Output shaft end shall be provided with spline to allow adjustable alignment. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator. All gearing shall be designed for a 100 percent overload. The entire gear assembly shall be sealed weatherproof.

2.3 ELECTRIC MOTOR ACTUATORS

A. General

1. Equipment Requirements: Where electric motor actuators are indicated, an electric motor-actuated valve control unit shall be attached to the actuating mechanism housing by means of a flanged motor adapter piece.

2. Gearing: The motor actuator shall include the motor, reduction gearing, reversing starter, torque switches, and limit switches in a weather-proof NEMA 6 assembly. The actuator shall be a single or double reduction unit consisting of spur or helical gears and worm gearing. The spur or helical gears shall be of hardened alloy steel and the worm gear shall be alloy bronze. All gearing shall be accurately cut with hobbing machines. All power gearing shall be grease- or oil-lubricated in a sealed housing. Ball or roller bearings shall be used throughout. Actuator output speed changes shall be mechanically possible by simply removing the motor and changing the exposed or helical gearset ratio without further disassembly of the actuator.

3. Starting Device: Except for modulating valves, the unit shall be so designed that a hammer blow is imparted to the stem nut when opening a closed valve or closing an open valve. The device should allow free movement at the stem nut before imparting the hammer blow. The actuator motor must attain full speed before stem load is encountered.

4. Switches

a. Electronic Type Switches: Limit switches or valve position shall be sensed by a 15 bit, optical, absolute position encoder. The open and closed positions shall be stored in a permanent, non-volatile memory. The encoder shall measure valve position at all times, including both motor and hand wheel operation, with or without use of battery. An electronic torque sensor shall be furnished. The torque limit may be adjusted from 40 to 100 percent of rating in 1 percent

increments. The motor shall be de-energized if the torque limit is exceeded. A boost function shall be included to prevent torque trip during initial valve unseating, and a "jammed valve" protection feature with automatic retry sequence shall be incorporated to de-energize the motor if no movement occurs. Valve actuators with electronic type switches shall be as manufactured by **Limitorque, Rotork** or **Auma Actuators, Inc.**

b. The actuator shall be wired in accordance with the schematic diagram. All wiring for external connections shall be connected to marked terminals. One 1-inch and one 1-1/4-inch conduit connection shall be provided in the enclosing case. A calibration tag shall be mounted near each switch correlating the dial setting to the unit output torque. Switches shall not be subject to breakage or slippages due to over-travel. Traveling-nuts, cams, or micro switch tripping mechanisms shall not be used. Limit switches shall be of the heavy-duty open contact type with rotary wiping action.

5. Handwheel Operation: A permanently attached handwheel shall be provided for emergency manual operation. The handwheel shall not rotate during electrical operation. The maximum torque required on the handwheel under the most adverse conditions shall not exceed 60-lb.ft, and the maximum force required on the rim of the handwheel shall not exceed 60-lb. An arrow and either the word "open" or "close" shall be cast or permanently affixed on the handwheel to indicate the appropriate direction to turn the handwheel. A clutch lever shall be provided to put actuator into handwheel operation. All valves with electric motor activators with stems located more than 7-feet above the floor shall be provided with chain activator handwheels. The clutch lever shall be provided with a cable secured to the chain to allow disengagement for manual operation.

6. Motor: The motor shall be of the totally enclosed, non-ventilated, high-starting torque, low-starting current type for full voltage starting. It shall be suitable for operation on 480-volt, 3-phase, 60-Hz current, and have Class F insulation and a motor frame with all dimensions in accordance with the latest revised NEMA MG Standards. The observed temperature rise by thermometer shall not exceed 55 degrees C above an ambient temperature of 40 degrees C when operating continuously for 15 minutes under full rated load. With a line voltage ranging between 10 percent above to 10 percent below the rated voltage, the motor shall develop full rated torque continuously for 15 minutes without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop-out. Bearings shall be of the ball type and thrust bearings shall be provided where necessary. All bearings shall be provided with suitable seals to confine the lubricant and prevent the entrance of dirt and dust. Motor conduit connections shall be watertight. Motor construction shall incorporate the use of stator and rotor as independent components from the valve operation such that the failure of either item shall not require actuator disassembly or gearing replacement. . Two Class B thermal contacts or solid state thermistors imbedded within the motor windings shall be provided to protect against over-temperature damage. The motor shall be provided with a space heater suitable for operation on 120-volt, single-phase, 60-Hz circuit unless the entire actuator is a hermetically sealed, non-breathing design with a separately sealed terminal compartment which prevents moisture intrusion. Each electric motor actuator shall be provided with a local disconnect switch or circuit breaker to isolate power from the motor and controller during maintenance activities.

7. Control of designated actuators shall be accomplished through the use of a microprocessor based 2 wire control system. The control system shall consist of field units located at each actuator which are linked by shielded twisted pair. The Modbus RS-485 signals shall be used over the twisted pair to communicate the digital data. Data shall be transferred to and from the field units by a PLC indicated in Division 17. The communications protocol between the PLC and the valves shall be RS-485 Modbus only. Proprietary network protocols shall not be permitted. The hardware and software required to interface the valve network with the PLC shall be provided by the CONTRACTOR per the respective actuator manufacturer's requirements. Refer to Sheet GI-4 for the number of networks required and for valve assignment.

   a. Communications Network: The field units shall be controlled by a 2 wire network that connects all of the actuators in a loop fashion through the use of RS-485 signals. Modbus protocol shall be utilized. The network shall be tolerant of cable faults. A single cable fault (break, open, or short circuit) shall not cause communication loss to any field unit. All network connections shall be protected by high level surge protectors including gas discharge tubes and surge suppression diodes. Surge suppression shall be in compliance with ITU-T and IEC 801.5. Loss of power shall not compromise the redundancy feature of the network. Include surge immunity to IEC 1000-4-5, magnetic field immunity to IEC 1000-4-8, conducted emissions to EN55011, radiated, ESD, and EFT immunity to EN50082-2. Loss of power to any field device shall not compromise the integrity of the network loop

   b. Polling System: The PLC shall be able to control, configure, and monitor the motor operated valve field units. The hardware shall provide the RS-485 network ports for communication with the actuator based field units. Wiring shall be looped between these ports to provide continuous communications path to every field unit. The system shall continuously poll every field unit via the communications path and immediately produce an alarm upon the failure of any single access path. All functions of each field unit shall be programmable and verifiable.

   c. Field Unit: A field unit shall be enclosed in each actuator. The field unit receives commands and requests for information over the network for the following capabilities:

      1) Commands - OPEN valve, CLOSE valve, STOP valve, and LOCKOUT (inhibit local and remote electrical operation). Modulating control valves shall receive a positioning control command (0 -100 percent open).

      2) Status - valve OPEN, valve CLOSED, selector switch in REMOTE, and selector switch in LOCAL. Some of the designated valves shall also have valve position (0 -100 percent) indication.

      3) Alarms - field unit "fuse blown", "motor overload tripped", "torque switches tripped", and "communications failure".

      4) Additional features: Local push buttons shall be wired directly to the motor contactor circuit and shall not depend on a microprocessor for proper operation. Malfunction or removal of the microprocessor circuit board shall not affect electrical operation.

5) Status lights shall be red for "open" and green for "closed."

8. Open/Close Operating Speed: Unless otherwise indicated, electric actuators shall provide a full close to full open or full open to full close operating time range from 30 seconds. Open/close speed of motor/power-actuated valves shall be indicated in the table below.

9. Valves with electric motor actuators where the valve centerline is located at a height greater than 6-feet above the floor shall provide a remote actuator control station at a location no higher than 4-feet above the floor. The CONTRACTOR shall provide conduit and wiring between the actuator controls and the valve actuator for these applications. The actuator controls shall be wall mounted beneath the valve at a location approved by the ENGINEER.

B. Electric Motor Actuators (AC Reversing Control Type)

1. General: Where indicated, electric motor actuators shall be the AC reversing type complete with local control station with open/close and local/ auto selector switches.

2. Actuator Appurtenances: The actuator for each valve shall be supplied with open and close status lights; open, close and lockout/stop push buttons; and other devices indicated.

3. Starter: The starter shall be a suitably sized amperage rated reversing starter with its coils rated for operation on 480-volt, 3-phase, 60-Hz current. A control power transformer shall be included to provide a 120-volt source, unless otherwise indicated. The starter shall be equipped with 3 overload relays of the automatic reset type. Its control circuit shall be wired as indicated. The integral weatherproof compartment shall contain a suitably sized 120-volt ac, single-phase, 60-Hz space heater to prevent moisture condensation on electrical components. A local power disconnect switch shall be provided with each actuator. A close-coupled, padlockable switch shall be provided with each actuator.

4. Local Control Station: Each actuator shall be provided with a local control station with the valve actuator assembly. The station shall include open, close, and stop push buttons and a local/remote selector switch. Where indicated on the Instrumentation Drawings, provide a two-wire control system as indicated above. This system shall allow communications to the PLC via a Modbus RS-485 protocol over a twisted shielded pair cable to monitor and control the valve as indicated above and in Section 17300 - Control Strategies. The local control station and local power disconnect may be provided as an integral part of the actuator or as otherwise indicated or required to permit operation by a person at floor elevation and within sight of the valve actuator.

5. Manufacturers, or equal

a. **EIM;**

b. **Auma Actuators, Inc.;**

c. **Limitorque Corp;**

d. **Rotork.**

C. Electric Motor Actuators (AC Modulating Control Type)

1. General: Where indicated, modulating electric motor actuators shall be the ac modulating type complete with a local control station with power disconnect switch or circuit breaker, Local/Remote switch, non-latching open/close pushbuttons, and open/close status lights

2. Actuator Appurtenances: The actuator for each valve shall be provided with a padlockable disconnect switch; open and closed status lights; open, close and lockout stop pushbuttons; local/remote selector switch; and other devices indicated.

3. Control Module: The control module shall be of the electronic solid-state ac type with control outputs for positioning the valve via 4 - 20 ma input signals.

4. Starter: The actuator shall control a solid-state reversing starter designed for minimum susceptibility to power line surges and spikes. The solid-state starter and control module shall be rated for continuous modulating applications. Power supply shall be 480-volt, 3-phase, 60-Hz. A disconnect switch shall be included with each actuator.

5. Construction: The control unit shall be microprocessor-based and shall contain an analog/digital converter, separate input-output switches, non-volatile random access memory for storage of calibration parameters and push-button calibration elements for field-setup. Potentiometer adjustments shall contain a PID control function internally. In addition, the controller shall contain as standard feature a loss of command signal protection selectable to lock in last or lock in pre-set valve position and a valve position output signal in 4-20 ma. As an alternative to the construction requirement, the motor shall be capable of modulating at a rate of [200][600] starts per hour at the 50 percent to 85 percent travel range of the valve. This system shall allow communications to the RTU via a Modbus RS-485 protocol over twisted shielded pair cable to monitor and control the valve as indicated. The system shall also allow control of the open, close, or percent open function when the local/remote switch is in the remote position. Each actuator shall have a Frequency Shut Down system which when pre-programmed, shall function as directed upon receipt of an ESD signal.

6. Manufacturers, or equal

   a. EIM;

   b. Limitorque;

   c. Rotork;

   d. Auma Actuators, Inc.

D. Electric Motor Actuators (DC Modulating Control Type)

1. Equipment Requirements: Where indicated, electric motor actuators shall be of the dc modulating control type and shall be attached to the actuating mechanism housing.

2. Actuator Assembly: The assembly shall include a dc motor, reduction gearing, a control unit, limit-switches, and required accessories in one enclosure.

3. Control Unit: The electric motor-operated control unit shall be suited for input power supply of 90 to 140 volts, 60-Hz ac and shall operate satisfactorily when input power is within those limits. Power will be supplied at 120 volts, single-phase, 60-Hz ac.

4. Input Signal: The control unit shall be suited to receive an input set-point signal from an external source of 4 to 20 ma dc with properly selected calibrating resistor.

5. Control Panel: Each actuator shall be provided with a separate, local control panel for attachment to the valve actuator assembly. The panel shall include an open/close/auto/hold selector switch and shall be suitable for indoor or outdoor installation, as required.

6. Manufacturers, or equal

   a. **EIM "Futronic-III";**

   b. **Limitorque Corp. "Modutronic-10".**

E. 120V Quarter-Turn and Multiturn Electric Valve Operators 6 Inches and Smaller

1. Provide 120V, single-phase motor operated valve operator suitable for use with quarter-turn ball valves, multiturn diaphragm valves, and multiturn globe valves. Operator shall have the following characteristics and features:

   a. Reversing capacitor-start motor rated for operation on 120V ac, 60 Hz, single phase. Output torque as required for valve application and pressure differential.

   b. Integral motor overload protection, with auto-reset

   c. Permanently-lubricated gear train

   d. For open/close control, provide four single-pole, double-throw cam actuated limit switches (2 OPEN, 2 CLOSED). One set of limit switches shall be used for both motor control and local indication. The other set shall be available for connection to remote monitoring. Limit switch contacts shall be adjustable and shall be rated for not less than 5 amps at 120V ac.

   e. Local Control Station: Open/Close: Corrosion-resistant, NEMA 4X, for mounting near valve actuator. Provide two-position selector switch for LOCAL-REMOTE selection and two pushbuttons, OPEN and CLOSE. In addition, provide OPEN and CLOSE indicating lights operating at 120V ac for connection to valve control limit switches.

   f. For modulating control, provide an electronic positioner and feedback potentiometer. The positioner shall utilize a 4 - 20 ma signal to adjust the valve opening. Feedback potentiometer shall be 0 -1000 ohms.

   g. Local Control Station Modulating: Corrosion resistant, NEMA 4X, for mounting near valve actuator. Provide two-position selector switch for LOCAL-REMOTE selection, one OPEN and one CLOSE push buttons, a resistance to current converter with 4 - 20 ma output and a 0 to 100 percent electronic valve position indicator.

h. Local power disconnect switch (NEMA 4X) for disconnecting 120V ac power to valve. Disconnect shall be installed in the field within sight of the valve actuator, in accordance with the requirements of NPFA 70.

2. See Drawings for control diagram wiring interface.

3. Two-wire control systems are not required for this actuator.

4. Operators shall be **RCS, Asahi/America Quarter Master** or equal.

2.4 PNEUMATIC ACTUATORS

A. General

1. Controls

a. Pneumatic cylinder actuators shall be provided complete with all necessary pneumatic or electro-pneumatic controls for the intended actuation of the valve or gate.

b. Manufacturers, or equal

1) **G.H. Bettis/Shafer;**

2) **Fisher Controls;**

3) **Miller Fluid Power;**

4) **Neles-Jamesbury, Inc.;**

5) **Rexroth Corporation.**

2. Filters, Regulators, and Lubricators: Where required by the service and type of actuator, filters, regulators, and oil-lubricators shall be provided in the air supply to the actuator, according to the manufacturer's instructions.

3. Air Supply

a. All pneumatic actuators shall be sized for the available air pressure as indicated and shall be provided with isolating valves, adjustable filter-regulators, pressure gauges, and condensate drains. The filter elements shall be replaceable 40-micron units.

b. Manufacturers, or equal

1) **Fisher Controls;**

2) **Miller Fluid Power.**

B. Diaphragm Actuators

1. Construction: The actuator shall consist of a ductile-iron, aluminum, or carbon steel diaphragm housing and stainless steel or carbon steel stem; a ductile-iron or cast-iron yoke and spring barrel with carbon steel spring, and Nitrile-covered fabric diaphragm of sufficient strength for the maximum expected torque or force.

2. Manual Override: Each actuator shall be provided with a manual handwheel override, top-mounted for linear actuation, and worm gear mounted with declutchable handwheel for rotary actuation. The worm gear construction shall be as indicated for manual actuators.

3. Manufacturers, or equal

   a. **Fisher Corporation;**

   b. **ITT Engineered Valves;**

   c. **Neles-Jamesbury, Inc.**

C. Double-Piston Actuators

1. Construction: The actuators shall be of the double-acting cylinder type with provision for later field conversion to spring-return action. A rack-and-pinion drive shall provide a 90 degree rotation of the output shaft, which shall be extended to receive a manual override. The actuator shall be totally enclosed in a hard-anodized aluminum, ductile-iron, cast-iron, or steel housing. The cylinders and pistons shall be of hard anodized aluminum or ductile-iron or steel, honed, and nickel or chrome-plated, or coated with a permanent dry-film lubricant and corrosion inhibitor. The rack, pinion, end caps, and tie-rods shall be of hardened carbon steel. The seals and O-rings shall be Buna N.

2. Manual Override: Each actuator shall be provided with a manual worm-gear override with declutchable handwheel. The worm-gear construction shall be as indicated for manual actuators.

3. Manufacturers, or equal

   a. **G.H. Bettis/Shafer;**

   b. **Neles-Jamesbury.**

D. Scotch-Yoke Piston Actuators

1. Construction: The actuator shall be of the double-acting cylinder type with provision for later field conversion to spring-return action. The actuator may be of the single- or double-cylinder design. A scotch-yoke drive shall provide a 90-degree rotation of the output shaft, which shall be extended to receive a manual override. The unit shall be totally enclosed in a hard-anodized aluminum, ductile-iron, cast-iron, or steel housing. The cylinders and pistons shall be of hard-anodized aluminum, cast iron, ductile iron, or steel, honed and nickel- or chrome-plated, or coated with a permanent dry film lubricant and corrosion inhibitor. The piston rod shall be of hard chrome- or nickel-plated steel. The tie-rods shall be of hardened carbon steel, and the seals and O-rings of Buna N.

2. Manual Override: Each actuator shall be provided with a manual worm gear actuator override with declutchable handwheel. The worm gear construction shall be as indicated for manual actuators.

3. Manufacturers, or equal

   a. **G.H. Bettis/Shafer;**

b. **Neles-Jamesbury;**

c. **Rotork Controls, Inc.**

2.5 AIR-OVER-OIL CYLINDER ACTUATORS

A. **Equipment Requirements:** The valve manufacturer for the pump control valves shall furnish air-over-oil cylinder actuators of the tandem cylinder type. The valve actuator shall be designed to unseat, open or close, and seat the valve under the most adverse operating condition to which the valve will be subjected. The valve actuator shall be capable of closing the valve starting from wide open with the extreme closing flow indicated and ending with a differential equal to the indicated shutoff pressure. Actuator construction shall be completed in accordance with the requirements of AWWA C540 Section 4.3 (Hydraulic) and 4.5 (Pneumatic).

B. **Air-Over-Oil Cylinder Construction:** Each cylinder unit shall consist of an air cylinder driving an oil hydraulic cylinder of the same diameter, mounted as a single assembly. Cylinders shall be of tie-rod or bolted flange construction. The air cylinder shall operate the valve, and the oil cylinder shall regulate the opening and closing speed. Each unit shall be provided with an oil reservoir and two flow control valves on the oil cylinder, and a 4-way solenoid valve and hand control valve on the air cylinder. The cylinder shall operate the valve satisfactorily with 100 psi pneumatic air pressure available upstream of the pressure regulator valve from the compressed air system. Tandem cylinders shall be designed to prevent the leakage of air from the air cylinder into the oil cylinder. Leakage of air into the oil cylinder shall be cause for rejection of both cylinders. Rejected cylinders shall be replaced with new cylinders of acceptable design. The valve actuator mechanism shall be coupled to the cylinders and shall be totally enclosed. The cylinders shall be rigidly secured to the mechanism housing and shall not pivot, rotate, or swing during operation. The cylinder piston rods shall be enclosed in the mechanism housing and shall not be exposed to view.

C. **Air System:** A pneumatic pressure prefilter, pneumatic pressure filter of the coalescing type, and pneumatic pressure regulator shall be provided on the air supply line directly upstream of each actuator as indicated. The pneumatic pressure prefilters shall be of the general purpose, non-coalescing type with an automatic drain and 40 micron element, with standard bowl and guard and 1/2-inch NPT inlet and outlet ports, as manufactured by **Numatics, Norgren,** or equal. The pneumatic pressure filters shall be of the coalescing (oil removed) type with an automatic drain and 0.3 micron element, with standard bowl and guard and 1/2-inch NPT inlet and outlet ports, as manufactured by **Numatics, Norgren,** or equal. The pressure regulator shall have a zinc body, aluminum bonnet, a brass valve, a valve seat, and shall be of the self relieving type, with 1/2-inch NPT inlet and outlet ports, as manufactured by **Numatics** or equal.

1. Lubricator: An air lubricator shall be provided in the air supply to the actuator in accordance with the manufacturer's instructions.

2. Setup: The air supply pressure upstream of the pressure-regulating valve is 100 psi. The valve actuator supplier shall set the pressure-regulating valve as needed for the air and oil cylinders.

D. **Solenoid Control Valves:** A 4-way solenoid valve shall be provided to control the operation of each air-oil cylinder actuated valve. Each solenoid valve shall be heavy-duty, single solenoid, 2-position type rated for a differential operating air pressure of 125 psig. Each valve shall be designed and constructed for exceptionally long life with

forged brass body; poppet type seats and discs; continuous duty, molded, Class F coil; NEMA Type 4 solenoid enclosure; and 1/2-inch threaded conduit connection. Solenoid valves shall be rated for use with 120 volt, 60 Hz, 1 phase power supply and shall be **ASCO "Bulletin 8344 High Flow 4 Way Solenoid Valves"** as manufactured by **Automatic Switch Co.** or equal. The actuator shall be provided with two, 2-way emergency close solenoid valves of similar quality of construction to the main solenoid control valve. The emergency closure feature shall have a flow control valve activated by power failure, adjustable to the closure rates indicated.

E. **Speed Control:** Each oil connection on each oil cylinder shall be equipped with an adjustable speed flow control valve. The flow control valves and connecting oil piping shall be arranged to permit control of the rate of flow of exhaust oil from the cylinder and to permit the independent adjustment and control of valve normal opening and closing speeds, and emergency closing speed. Control valves shall be sized so that the time required for the air cylinder piston to complete its stroke can be adjusted as follows:

Normal Open Times:	60 seconds minimum 300 seconds maximum
Normal Close Times:	60 seconds minimum 300 seconds maximum
Emergency Close Times:	10 seconds minimum 30 seconds maximum

F. **Speed Control Valves:** Control valves shall be manufactured from brass or stainless steel and shall be **Parker Hannifin "Colorflow F Series" or Mead "Dyla-Trol"** or equal. An oil reservoir shall be provided in the oil piping connecting the 2 control valves. A hand control valve shall permit local manual operation of each air-over-oil cylinder operated valve.

G. **Connections:** The control system shall be fully piped and wired and be contained within a non-metallic NEMA 6 cabinet with a hinged access door. All fittings and tubing shall be brass and copper. Electrical wiring shall terminate in a separate NEMA 6 non-metallic junction box within the control cabinet.

H. **Limit Switches:** The pump control valve should be provided with 3 limit switches, one each for the full open and full close positions, and the third switch shall provide momentary interruption of the [pump motor control to initiate pump shutdown prior to 100 percent valve closure to minimize hydraulic surge.

I. Manufacturers, or equal

1. **Cunningham Manufacturing Co.**;
2. **Miller Fluid Power;**
3. **Milwaukee Cylinder Co.**

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **Field Adjustments:** Field representatives of manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators shall adjust actuator controls and limit-switches in the field for the required function.

3.2 INSTALLATION

A. Valve and gate actuators and accessories shall be installed in accordance with Section 15200 - Valves, General. Actuators shall be located to be readily accessible for operation and maintenance, without obstructing walkways. Actuators shall not be mounted where shock or vibrations will impair their operation, nor shall the support systems be attached to handrails, process piping, or mechanical equipment.

3.3 HYDRAULIC (OIL) POWER SYSTEM INSTALLATION

A. **Cleaning:** After installation, the piping shall be thoroughly inspected and cleaned to remove machining burrs and foreign materials, including mill scale, dirt, rust, oil, grease, weld spatter, and cutting chips. Cleaning may be accomplished by hot oil flush or other approved method. Cleaning shall be done in strict accordance with the manufacturer's written instructions.

B. **Inspection, Startup, and Field Adjustment:** An authorized representative of the manufacturer shall visit the Site and witness the following:

1. Installation of the equipment for not less than 2 days.

2. Inspection, checking, and adjusting the equipment for not less than 1day.

3. Startup and field-testing for proper operation for not less than 1 day.

C. **Instruction of OWNER's Personnel:** The authorized service representative shall visit the Site for not less than 2 days to instruct the OWNER'S personnel in the operation and maintenance of the equipment including step-by-step troubleshooting procedures with necessary test equipment.

- END OF SECTION -

SECTION 15203 – CHECK VALVES

PART 1 -- PART 1 -- PRODUCTS

1.1 SWING CHECK VALVES (3-INCH AND LARGER)

A. General: Swing check valves for wastewater and general service shall be of the outside lever and spring or weight type, in accordance with ANSI/AWWA C 508 - Swing-Check Valves for Waterworks Service, 2 in. through 24 in. NPS, unless otherwise indicated, with full-opening passages, designed for a water-working pressure of 150 psi. They shall have a flanged cover piece to provide access to the disc.

B. Body: The valve body and cover shall be of cast iron conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with flanged ends conforming to ANSI/ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, or mechanical joint ends, as indicated.

C. Disc: The valve disc shall be of cast iron or ductile iron.

D. Seat and Rings: The valve seat and rings shall be of bronze to conforming ASTM B 62 or B 148 - Aluminum-Bronze Castings, or of Buna-N.

E. Hinge Pin: The hinge pin shall be of bronze or Type 316 stainless steel.

F. Manufacturers, or Equal

1. American Flow Control (Darling);
2. APCO (Valve and Primer Corp.);
3. Kennedy Valve;
4. Mueller Company (Grinnell Corporation);
5. Stockham Valves and Fittings.

1.2 INTERNAL SPRING-LOADED CHECK VALVES (GLOBE STYLE)

A. General: Internal spring-loaded check valves for water pumps, compressors, gas, air, and steam shall be of the full-flow internal spring-loaded poppet type. The valves shall be designed for a water-working pressure of not less than 150 psi unless otherwise indicated. Valves 09-CV-1, 09-CV-2, 09-CV-3 and 09-CV-4 shall be Class 250.

B. Body: The bodies of all valves in sizes 3-inch and larger shall be of cast iron conforming to ASTM A 126 with 125-lb flanged ends conforming to ANSI/ASME B 16.1 unless otherwise indicated. Valves 09-CV-1, 09-CV-2, 09-CV-3 and 09-CV-4 shall have 250-lb flanged ends. Where necessary, there shall be a positive, watertight seal between the removable seat and the valve body. The stem guide shall be integrally cast with the body or screwed into the body.

C. Valves smaller than 3 inches shall have bronze bodies with screwed ends conforming to ANSI/ASME B 1.201, suitable for a minimum working pressure of 200 psi, and a

temperature of 250 degrees F, unless otherwise indicated. The type of bronze shall be suitable for the intended service.

D. Disc and Stem: The disc and stem of all valves in sizes 3-inch and larger shall be of bronze conforming to ASTM B 584 - Copper Alloy Sand Castings for General Applications or stainless steel. The stem shall have 2-point bearings. The downstream bearing shall have a bronze or other suitable bushing, to provide a smooth operation.

E. Valves smaller than 3 inches shall have discs and retaining rings of Teflon, nylon, or other suitable material, and stems of bronze, brass, or stainless steel, suitable for the intended service.

F. Stem Guide: The stem guide shall be either firmly fixed in the valve body to prevent it from sliding into the adjacent pipe and damaging the pipe lining, or the valve manufacturer shall furnish each valve with one matching flange compatible with the adjacent pipe and its lining to prevent damage to the lining. The compatible flange shall be part of the Shop Drawing submittal.

G. Seat: Valves for general service at temperatures up to 250 degrees F shall have bubble-tight shut-off with resilient seats of Buna-N, Teflon, or other suitable material. Valves for steam service and temperatures over 250 degrees F shall have metal-to-metal seating of bronze or stainless steel, as recommended by the manufacturer for the specific service condition. Resilient seats shall be firmly attached to the seating ring by compression-molding or other acceptable method.

H. Spring: Valves in sizes 3-inch and larger shall have Type 316 stainless steel springs, and valves smaller than 3-inch shall have stainless steel or beryllium copper springs, as suitable for the service. The spring tension of the valves shall be designed for the individual pressure condition of each valve.

I. Manufacturers, or Equal

1. **APCO (Valve and Primer Corp.);**

2. **CPV (Combination Pump Valve Company);**

3. **Miller Valve Co., Inc.;**

4. **VAL-MATIC (Valve and Manufacturing Corporation);**

1.3 DOUBLE-LEAF CHECK VALVES

A. General: Double-leaf check valves for air and gas service and where indicated, shall be of the wafer-type designed to fit between ANSI B16.1 flanges for 125-lb rating. The check valve leaves shall be spring-loaded. Flow from one direction shall cause the valve to open, and upon valve shutoff, the spring shall shut the valve leaves before reverse flow starts, acting at a point of zero velocity, for non-slam closure. The spring-tension of each valve shall be designed for the individual operating condition.

B. Body: The valve body shall be of cast iron conforming to ASTM A 126 with integrally-cast seat, rated for minimum 150-lb working pressure at up to 250 degrees F.

C. Leaves: The leaves shall be of bronze, aluminum bronze, or ductile iron, revolving on stainless steel or monel hinge pins with retainers.

D. Seat: The valves shall have resilient seats for bubble-tight shut-off, suitable for temperatures up to 250 degrees F without sticking. The seats shall be Buna-N, Viton, or other suitable material for the intended purpose. The seat rings shall be firmly attached a shoulder cast in the body or to the disc by compression-molding or similar acceptable method.

E. Springs: The springs shall be of Type 316 stainless steel or Inconel, as best suited for the service condition.

F. Manufacturers, or Equal

1. APCO (Valve and Primer Corporation);

2. Proquip International;

3. VAL-MATIC (Valve and Manufacturing Corporation).

1.4 SLANTING DISC CHECK VALVES

A. General: Slanting disc check valves for water service shall have a seating angle of approximately 55 degrees. Valves shall have replaceable seat rings and disc rings. The water passage cross-sectional area shall be equal to the full pipe area. Valves shall have sufficient clearance around the pivot pins to permit free seating of the disc without binding and shall be guaranteed not to stick in the closed position. All slanting disc check valves shall have position indicators and two flanged connections for attachment of dashpots or hydraulic snubbers. The valves shall be designed for a water working pressure of 150 psi, unless otherwise indicated.

B. Body: The valve body shall be of cast iron conforming to ASTM A 48-Gray Iron Castings for Valves, Flanges, and Pipe Fittings or A 126, Class B, with flanged ends conforming to ANSI/ASME B 16.1, Class 125, unless otherwise indicated.

C. Disc: The valve disc shall be designed with an "aerofoil" configuration of cast iron or ductile iron, with bronze seating face, except for valves 10 inches or smaller, which may have solid bronze or aluminum bronze discs. The disc shall be partially balanced with a short travel, to resist slamming.

D. Seat Ring: The seat ring shall be of centrifugally cast bronze, aluminum bronze, or stainless steel, with beveled edges, firmly clamped or screwed into the valve body.

E. Pins: The pivot pins and bushings shall be of stainless steel, bronze, or aluminum bronze, to allow free movement of the disc without binding.

F. Manufacturers, or Equal

1. APCO (Valve and Primer Corporation);

2. Crane Company (Without Dashpot, Only);

3. VAL-MATIC (Valve and Manufacturing Corporation).

1.5 RUBBER FLAPPER SWING CHECK VALVES

A. General: Rubber flapper swing check valves for water, sewage, sludge, and abrasives shall have full pipe size flow areas, one moving part only, and body seats at 45 degrees,

to permit horizontal and vertical up-flow. Valves shall be designed for a minimum water-working pressure of 150 psi, with a flanged cover plate holding down the rubber flapper. The valves shall be of the non-clog design.

B. Body: The valve body and cover shall be of cast iron conforming to ASTM A 126 with flanged ends conforming to ANSI/ASME B 16.1. There shall be a threaded tapping in the bottom of the body for insertion of a back-flow device, and provision for mounting of a signal switch.

C. Disc: The valve disc or flapper shall be of Buna-N or other best-suited elastomer one-piece construction, precision molded, with integral O-ring type sealing surface, steel and nylon or fabric reinforced, with non-slam closing action through a 35-degree disc stroke, for bubble-tight shut off at high and low pressures.

D. Manufacturers, or Equal

1. APCO (Valve and Primer Corporation);

2. VAL-MATIC (Valve and Manufacturing Corporation).

1.6 PLASTIC BALL CHECK VALVES

A. General: Plastic ball check valves for corrosive fluids, in sizes up to 4-inch, shall be used for vertical up-flow conditions only, unless the valves are provided with spring actions.

B. Construction: The valve bodies and balls shall be of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polyvinylidene fluoride (PVDF), or polypropylene (PP) construction, as best suited for each individual service condition. They shall have unions with socket connections, or flanged ends conforming to ANSI/ASME B16.5 - Pipe Flanges and Flanged Fittings, class 150. Seals shall have Viton O-rings, and valve design shall minimize possibility of the balls sticking or chattering. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F.

C. Manufacturers, or Equal

1. ASAHI-AMERICA;

2. George Fischer, Inc.;

3. NIBCO Inc. (Chemtrol Division);

4. Spears Mfg. Co. (PVC, CPVC, AND PP only).

1.7 PLASTIC SWING OR WYE-CHECK VALVES

A. General: Plastic swing or wye-check valves for corrosive fluids, in sizes up to 8 inches or as available, may be used for horizontal or vertical up-flow conditions.

B. Construction: The valve bodies and discs or piston shall be of PVC, PP, or PVDF construction, as best suited for each individual service condition. They shall have flanged ends conforming to ANSI/ASME B16.5 Class 150, and flanged top access covers, and they shall shut positively at no-flow conditions. The seats and seals shall be of EPDM, Teflon, or Viton. The PVC valves shall be rated for a maximum non-shock

working pressure of 150 psi at 73 degrees F for sizes 3-inch and smaller. For larger sizes and other materials and temperatures the pressure rating may be lower.

C. Manufacturers, or Equal

1. ASAHI-AMERICA;

2. George Fischer, Inc.;

3. Spears Mfg. Co. (Plastic Swing Check only).

- END OF SECTION -

SECTION 15204 - BALL VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide ball valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 15200 - Valves, General apply to this Section.

C. The requirements of Section 15201 - Valve and Gate Actuators apply to this Section.

D. The requirements of Section 11258 - Chemical Feeding Equipment, General apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 15200 - Valves, General.

PART 2 -- PRODUCTS

2.1 BALL VALVES (6-INCH AND LARGER)

A. **Construction:** Unless otherwise indicated, ball valves shall be in accordance with AWWA C 507 - Standard for Ball Valves 6-in. through 48-in (resilient seated), API 6D - Specification for Pipeline Valves (resilient seated), or API 607 - Fire Test for Soft-Seated Valves (resilient seated), with cast iron, ductile iron, or cast steel bodies, flanged ends, suitable for velocities up to 35 fps, temperatures up to 125 degrees F, and design pressures to 150 psi. The balls shall be of cast iron, ductile iron, or cast steel, shaft- or trunnion-mounted, with tight shut-off, single or double seat, and full bore. The valves shall be rubber-, soft- (nylon, teflon, polymer, or similar), or metal-seated, with stainless steel, forged steel, or monel shafts or trunnions, and not less than one thrust bearing. The valves shall see a minimum differential pressure of 1 psi.

B. **Actuators:** Unless otherwise indicated, ball valves shall have manual actuators with handwheel, position indicator, and 2-inch square operating nut. Operators for buried valves and for power-actuated valves shall be in accordance with provisions of Section 15201 - Valve and Gate Actuators.

C. Manufacturers, or Equal

1. **Apco/Willamette**
2. **GA Industries, Inc.**
3. **Grove Valve and Regulator Company**
4. **Neles-Jamesbury, Inc.**
5. **NIBCO, Inc.**

6. **Henry Pratt Company**

2.2 METAL BALL VALVES (4-INCH AND SMALLER)

A. **General:** Unless otherwise indicated, general purpose metal ball valves in sizes up to 4-inch shall have actuators in accordance with Section 15201 - Valve and Gate Actuators.

B. **Body:** Ball valves up to and including 1-1/2 inches in size shall have bronze or carbon steel 2 or 3 piece bodies with screwed ends for a pressure rating of not less than 600 psi WOG. Valves 2-inches to 4-inches in size shall have bronze or carbon steel 2 or 3 piece bodies with flanged ends for a pressure rating of ANSI 125 psi or 150 psi unless otherwise indicated.

C. **Balls:** The balls shall be solid chrome-plated brass or bronze, or stainless steel, with standard port (single reduction) or full port openings.

D. **Stems:** The valve stems shall be of the blow-out proof design, of bronze, stainless steel, or other acceptable construction, with reinforced teflon seal.

E. **Seats:** The valve seats shall be of teflon or Buna-N, for bi-directional service and easy replacement.

F. Manufacturers, or Equal

1. **Conbraco Industries, Inc. (Apollo)**

2. **ITT Engineered Valves**

3. **Neles-Jamesbury, Inc.**

4. **Watts Regulator**

5. **Worcester Controls**

2.3 PLASTIC BALL VALVES

A. **General:** Plastic ball valves for corrosive fluids shall be made of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polypropylene (PP), or polyvinylidene fluoride (PVDF), as recommended by the manufacturer for the specific application. Valves shall have manual actuators in accordance with Section 15201 - Valve and Gate Actuators, unless otherwise indicated.

B. **Construction:** Plastic ball valves shall have union ends or flanged ends to mate with ANSI B 16.5, class 150 flanges for easy removal. The balls shall have full size ports and teflon seats. Body seals, union O-ring seals, and stem seals shall be in accordance with the corrosion resistance requirements of Section 11258. External (without entering into the wetted area) seat packing adjustment is preferred. Metal reinforced stems to prevent accidental breakage are preferred. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F for PVC and CPVC, with decreasing ratings for higher temperatures and other plastics.

C. Manufacturers, or Equal

1. **ASAHI-America**

2. **George Fischer, Inc.**

3. **NIBCO Inc., (Chemtrol)**

4. **Plast-O-Matic Valves, Inc.**

5. **Spears Mfg. Co.**

6. **Watts Regulator**

PART 3 -- EXECUTION

3.1 GENERAL

A. Valves shall be installed in accordance with Section 15200. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

- END OF SECTION -

SECTION 15206 - GATE VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide gate valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 15200 - Valves, General apply to this Section.

C. The requirements of Section 15201 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall furnish submittals in accordance with Section 15200.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Buried valves shall be of the inside screw, non-rising stem type. The valve actuators shall be as indicated, with counter-clockwise opening stems, in accordance with Section 15201.

2.2 METAL-SEATED GATE VALVES (3-INCH AND LARGER)

A. **Construction:** Metal-seated gate valves for water and sewage service shall conform to ANSI/AWWA C 500 - Metal-Seated Gate Valves for Water Supply Service. The valve bodies shall be of cast iron conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, or ductile iron conforming either to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures, or to ASTM A 536 - Ductile Iron Castings, with flanged, bell and spigot, or mechanical joint-ends as indicated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 2 of ANSI/AWWA C500. The design working water pressure shall be 200 psig for valves 12 inches and smaller and 150 psig for larger valves. The valves may be of the double-disc type for tighter shut-off, or of the solid-wedge type, with rising or non-rising stem. For sewage or fluids containing solids, an outside thread shall be used. Valves 14-inch and larger installed in vertical pipes shall be fitted with bronze slides, tracks, rollers, and scrapers to assist the travel of the gate assembly. Gate valves 14-inches and larger shall be furnished with bypass assemblies.

B. **Actuators:** Unless otherwise indicated, gate valves shall have manual actuators in accordance with Section 15201.

C. Manufacturers, or Equal

1. **Clow Valve Co.;**

2. **Kennedy Valve;**

3. **M & H Valve Company;**

4. **Milwaukee Valve Company, Inc.**

2.3 KNIFE-GATE VALVES (2- to 96-inch)

A. **Construction:** Knife-gate valves shall be of the flanged or wafer design, with raised face and resilient seats for positive seating. Wetted parts shall be constructed of Type 316 stainless steel and the gates shall be finish-ground on both sides to prevent packing or seat damage. Valves 2- to 12-inches in size shall be furnished with cast stainless steel bodies; valves 14-inches and larger shall have semi-steel bodies with stainless steel linings. The valve stem shall be of stainless steel with a long life packing. The valves shall be rated for tight shut-off at the following pressures:

1. Valve sizes 4- to 12-inches 150 psi (bi-directional)

2. Valve sizes larger than 12-inches 50 psi

B. **Actuators:** Knife-gates shall have outside-screw and yoke-rising stems with manual handwheel actuators, unless otherwise indicated, in accordance with Section 15201.

C. Manufacturers, or Equal

1. **DeZurik Corporation;**

2. **Fabri-Valves;**

3. **Rovang, Inc.**

2.4 RESILIENT-SEATED GATE VALVES (3- to 16-inch)

A. **General:** Resilient-seated gate valves may be provided in lieu of metal-seated double-disc or solid-disc gate valves, at the discretion of the ENGINEER.

B. **Construction:** Resilient-seated gate valves shall conform to ANSI/AWWA C 509 - Resilient-Seated Gate Valves for Water and Sewerage Systems. The valves shall be suitable for a design working water pressure of 200 psig, with flanged, bell and spigot, or mechanical joint ends. The valve body, bonnet, and disc shall be of cast iron or ductile iron and the disc or body shall be rubber-coated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 2 of ANSI/AWWA C509. The stem, stem nuts, glands, and bushings shall be bronze, with the stem seal per ANSI/AWWA C509.

C. Protective Coating: All valves shall be factory painted and coated in accordance with Section 09800 - Protective Coating. The CONTRACTOR shall submit a test report from a coating inspector that the coating is holiday-free. The CONTRACTOR shall be aware that it may retain the services of a third party coating applicator to achieve the holiday-free requirement.

D. **Actuators:** Unless otherwise indicated, resilient-seated gate valves shall have manual actuators in accordance with Section 15201.

E. Manufacturers, or Equal

1. **Mueller Company.**

2.5 GATE VALVES (SMALLER THAN 3-INCH)

A. Construction: Gate valves smaller than 3-inch, for general purpose use, shall be non-rising stem, heavy-duty type for industrial service, with screwed or soldered ends to match the piping. The bodies shall have union bonnets of bronze conforming to ASTM B 62 - Composition Bronze or Ounce Metal Castings. The stems shall be of bronze conforming to ASTM B 62, or ASTM B 371 - Copper-Zinc-Silicon Alloy Rod. The solid wedges shall be of bronze conforming to ASTM B 62. The valves shall have malleable iron handwheels, unless otherwise indicated, and stem seals shall be of Teflon-impregnated or other acceptable non-asbestos packing. Valves shall have a pressure rating of minimum 125 psi steam, and 200 psi coldwater, unless otherwise indicated.

B. Manufacturers, or Equal

1. **Crane Company;**

2. **Milwaukee Valve Company;**

3. **Wm. Powell Company;**

4. **Stockham Valves and Fittings;**

5. **Walworth Company.**

2.6 HIGH-PRESSURE GATE VALVES (2- TO 12-INCH)

A. Construction: High-pressure gate valves, except for buried valves, shall have cast iron bodies and flanged bonnets with outside screw & yoke rising stems conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with 250 psi flanged ends. The valves shall be rated for 250 psig steam and 500 psig cold water working pressure. The solid wedges shall be of bronze or cast iron, bronze-fitted, and the stem shall be of bronze with non-asbestos fiber packing.

B. Actuators: Unless otherwise indicated, high-pressure gate valves shall have cast iron or ductile iron handwheels with 2-inch square operating nuts, in accordance with Section 15201.

C. Manufacturers, or Equal

1. **Crane Company;**

2. **Milwaukee Valve Company;**

3. **Wm. Powell Company;**

4. **Stockham Valves and Fittings;**

5. **Walworth Company.**

2.7 PLASTIC GATE VALVES (1-1/2- TO 14-INCH)

A. **Construction:** Plastic gate valves shall have PVC bodies with ANSI 150 lb. flanged ends, and polypropylene or CPVC-SBR-lined wedges for tight shut-off. The non-rising stem shall be of PVC or Type 304 stainless steel construction, with O-ring seal. The

valves shall have a coldwater pressure rating of 150 psig for sizes 1-1/2- through 8-inch, 110 psig for size 10-inch, and 70 psig for sizes 12- and 14-inch.

B. **Actuators:** Unless otherwise indicated, PVC gate valves shall have manual handwheel actuators with position indicators, in accordance with Section 15201.

C. Manufacturers, or Equal

1. **ASAHI/America;**

2. **Spears Mfg. Co.**

PART 3 -- EXECUTION

3.1 GENERAL

A. Gate valves shall be installed in accordance with the provisions of Section 15200. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

- END OF SECTION -

SECTION 15207 - PLUG VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide plug valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. Plug valves located at pig ports shall be capable of 100% opening to allow passage of the pigging device throughout the forcemain.

C. The requirements of Section 15200 - Valves, General apply to this Section.

D. The requirements of Section 15201 - Valve and Gate Actuators apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 15200.

PART 2 -- PRODUCTS

2.1 LUBRICATED PLUG VALVES (1/2-inch to 36-inch)

A. **Construction:** Lubricated plug valves shall be the tapered plug top or bottom entry type, with flanged ends for sizes 3-inch and larger, and flanged or screwed ends for smaller valves, as indicated. The body and top plate shall be of cast steel conforming to ASTM A 216 - Steel Castings, Carbon, Suitable for Fusion Welding for High-Temperature Service, or other acceptable cast or forged steel. The plug shall be of steel or cast iron and the stem shall be of stainless steel or alloy steel, with weather seal and Teflon impregnated packing. Valves up to and including 20-inch in size shall have an unobstructed port area of not less than 80 percent of full pipe area, and not less than 70 percent for larger valves. The valve body and plug shall have smoothly-finished water passages free from sharp corners when the plug is in the wide-open position. The valve shall be rated for ANSI class 300 or as indicated, between service temperatures of minus 20 to plus 100 degrees F.

B. **Sealant System:** The valves shall be provided with fittings designed to feed a sealant through a check-valve protected passage in the stem, through the side, or through a stainless steel tube for worm-gear actuated or buried valves. There shall be ducts or grooves in the face of the plug to insure the maintenance of a closed, pressurized sealant system between all contact surfaces of moving parts. All surfaces of the plug shall be coated with a dry film lubricant, such as polyfluoride or equal, to suit the service, permanently bonded to the metal surfaces. Sealant for LP gas service shall be the manufacturer's recommended type. The plug shall be held toward the seat by factory-adjusted gland assemblies set for proper sealing and operating torque. The gland assemblies shall be adjustable from the valve exterior and shall utilize either spring washers or gland deflection to allow plug unseating when pressurized sealant is injected.

C. **Actuators:** Unless otherwise indicated, valves 3-inch and smaller shall be lever-actuated; larger valves shall be equipped with manual worm-gear actuators. Valve actuators shall be in accordance with Section 15201.

D. **Lubricating Gun:** The CONTRACTOR shall furnish a manual lubricating gun for lubricated plug valves in sizes up to 6-inch, inclusive. For larger valves, the CONTRACTOR shall furnish a pneumatically-operated lubricating gun and a manual lubricating gun. For installations of more than 6 lubricated plug valves, the number of guns shall be doubled. The guns shall be from the same manufacturer as the valves. Guns shall each be equipped with flexible connectors, pressure gauge, safety valve, and be furnished in labeled tool boxes with operating instructions.

E. Manufacturers, or Equal

1. **Nordstrom Audco Valves, Inc.;**

2. **Rockwell.**

2.2 ECCENTRIC PLUG VALVES (1/2-inch to 72-inch)

A. **Construction:** Eccentric plug valves shall be of the non-lubricated, eccentric plug design with cast iron bodies conforming to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with ANSI 125 lb. flanged ends for valves 3-inch and larger, and screwed or flanged ends for smaller sizes. The plugs and shafts shall be of cast iron or ductile iron conforming to ASTM A 536 - Ductile Iron Castings, and the plugs shall be lined with a resilient coating, best suited for the specific service. The body shall be lined with a suitable elastomer, where required for a special service, or it shall be epoxy-lined in accordance with Section 09800 - Protective Coating. The seats shall be of nickel or stainless steel welded to the body. All top and bottom shaft bearings shall be of permanently lubricated stainless steel or Teflon coated stainless steel. Grit seals of Teflon, Nylatron, or similar suitable material shall be at the top and bottom plug journals. Valves up to and including 20-inch in size shall have an unobstructed port area of not less than 80 percent of full pipe area, and not less than 70 percent for larger valves. All eccentric plug valves shall have a pressure rating of not less than 150 psi WOG, for bubble-tight shut-off in the standard flow direction, and 25 psi WOG in the reverse flow direction. When equipped with worm gear actuator, the pressure rating shall be 150 psi WOG in both directions. The stem seal shall consist of field adjustable packing, replaceable without removal of the actuator, or of self-adjusting U-cup packing.

B. **Actuators:** Unless otherwise indicated, eccentric plug valves 3-inch and smaller shall have operating levers; larger valves shall have worm-gear actuators. Valve actuators shall be in accordance with Section 15201.

C. Manufacturers, or Equal

1. **DeZurik Corporation;**

2. **Clow Valve Company;**

3. **Pratt Valve;**

4. **Victaulic.**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Plug valves shall be installed in strict accordance with the manufacturer's published recommendations and the applicable provisions of Section 15200.

B. **Eccentric Plug Valves:** Unless otherwise directed, the following rules shall be observed for the installation of eccentric plug valves on sewage, sludge, or other liquid systems containing solids, silt, or fine sand:

1. The valves shall be positioned with the stem in the horizontal direction.

2. In horizontal pipelines, the plug shall swing upwards when opening, to permit flushing out of solids.

3. The orientation of the valve shall prevent the valve body from filling up with solids when closed; however, where the pressure differential through the valve exceeds 25 psi, the higher pressure for valves without worm gear, electric, or air operators shall be through the valve to force the plug against the seat.

4. Valves which may be closed for extended periods (stand-by, bypass, or drain lines) and valves with reversed flow (higher pressure on downstream side, forcing the plug away from its seat), shall be equipped with worm gear operators for all sizes.

5. For special applications or when in doubt, consult with the manufacturer prior to installation.

- END OF SECTION -

SECTION 15215 - PRESSURE REDUCING VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide pressure reducing valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 15200 - Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall furnish submittals in accordance with Section 15200, including a cavitation study from the valve manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Function:** Pressure reducing valves shall reduce a higher upstream pressure to a pre-set, lower, constant pressure, regardless of fluctuations in the upstream pressure.

B. **Operation:** The valves shall be hydraulically operated, with diaphragm or piston direct action, pilot-controlled, per paragraph 2.2, and shall be of the globe or angle pattern as indicated. All necessary repairs shall be possible without removing the valves from the pipeline. The smaller direct-acting valves with threaded ends per paragraph 2.3, shall be suitable for water or air service and shall be of the globe patterns.

2.2 FLANGED VALVES, SIZES 1 1/2 INCHES THROUGH 42 INCHES

A. **Valve Body:** The valve body shall be of cast iron to ASTM A 48 - Gray Iron Castings, or ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with [125 lb] [250 lb] flanged ends to ANSI/ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, or the body shall be of ductile iron to ASTM A 536 - Ductile Iron Castings, with [150 lb] [300 lb] flanged ends to ANSI/ASME B 16.42 - Ductile Iron Pipe Flanges and Flanged Fittings. The valve cover shall be flanged and be the same material as the body.

B. **Valve Trim:** The valve stems with position indication, springs, body seat rings, and all bolts, nuts, and washers shall be of Type 302, 303, or 316 stainless steel. The valve stems shall have top and bottom guides. All rubber parts shall be of Buna-N. The diaphragms shall be of Nylon-reinforced Buna-N, supported firmly between body and valve cover. The valve pistons and piston liners shall be bronze to ASTM B 62 - Composition Bronze or Ounce Metal Castings.

C. **Valve Controls:** The valve shall be provided with a complete, externally mounted control system, including speed control needle valves, strainers, check valve, isolation valves, and all necessary copper or stainless steel connecting tubing and fittings. The controls shall be capable of achieving all the flow and speed adjustment indicated.

D. **Factory Tests and Warranty:** All valves shall be factory tested with a hydrostatic test and a functional test and a test certificate shall be submitted to the ENGINEER prior to

delivery of the valve. The valve shall be warranted for a period of 3 years from the date of shipment to be free of defects in materials and workmanship

E. **Operating Conditions:** The valve shall be designed to operate under the following conditions:

1. Maximum inlet pressure (psi) - [ ]
2. Minimum inlet pressure (psi) - [ ]
3. Minimum outlet pressure (psi) - [ ]
4. Maximum flow (gpm) - [ ]
5. Minimum flow (gpm) - [ ]
6. Valve size (inches) - [ ]
7. Size of pipeline (inches diameter) - [ ]

F. **Spare Parts:** The following spare parts shall be furnished in accordance with Section 15200:

1. One set of all resilient seals and discs
2. One diaphragm (for diaphragm valves, only)

G. Manufacturers, or equal

1. **[Cla-Val Company]**
2. **[GA Industries]**
3. **[OCV Control Valves]**
4. **[Ross Valve Mfg. Co., Inc.]**
5. **[Singer Valve, Inc.]**
6. **[Watts, ACV]**

2.3 THREADED VALVES, SIZES 1/2 TO 2-1/2 INCHES

A. **Valve Body:** The valve body shall be bronze to ASTM B 62 or cast steel, with a minimum pressure rating of 300 psi, and with threaded ends. The valve shall be provided with an integral or an attached strainer with access cap or plug and a flanged or threaded valve cover. The valve shall be actuated by a diaphragm or piston.

B. **Valve Trim:** The valve stems, springs, body seats, and washers shall be of Series 300 stainless steel. The strainers shall be of stainless steel or monel and the diaphragms shall be of reinforced neoprene. The valve pistons and piston liners shall be bronze to ASTM B 62.

C. **Operating Conditions:** The valve shall be designed to operate under the following conditions:

1. Maximum inlet pressure (psi) - [ ]
2. Minimum inlet pressure (psi) - [ ]
3. Minimum outlet pressure (psi) - [ ]
4. Maximum flow [(cfm)] [(gpm)] - [ ]
5. Valve size (inches dia.) - [ ]

$# _____

NTS: The most desirable approach to acquiring spare parts for equipment is to list them explicitly in the equipment sections, making them part of the work for which contractors compete. There is another alternate approach (less desirable) which is discussed in a Note to Specifiers in master Section 11000 - Equipment , General, at Article 2.14.

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D. **Spare Parts:** The following spare parts shall be furnished in accordance with Section 15200:

1. One set of all resilient seals and discs
2. One diaphragm (for diaphragm valves, only)

E. Manufacturers, or equal

1. **[Cla-Val Company]**
2. **[Fisher Controls]**
3. **[GA Industries]**
4. **[Watts, ACV]**
5. **[Wilkins Regulator Div. (Zurn Industries)]**

2.4 PLASTIC VALVES, SIZES 1/4 TO 3 INCHES

A. Plastic pressure reducing valves shall be designed for not less than 150 psi water working pressure and shall be suitable for the fluid service. For chemicals and all corrosive fluids, solenoid valves shall be PVC, CPVC, polypropylene (PP), polyvinylidene fluoride (PVDF), or teflon materials of construction as recommended by the manufacturer for the specific application.

B. **Characteristics:** Valves shall open when the outlet pressure drops below a set minimum value, and maintain the pressure and open wide as flow requirements dictate. Valves shall be spring or hydraulically operated, direct acting, adjustable, diaphragm or piston type as indicated.

C. Manufacturers, or equal

1. **Corrosive Fluids**

2. **Plast-O-Matic Valves, Inc.**

3. **George Fisher**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Valves shall be installed in accordance with provisions of Section 15200.

3.2 SERVICES OF MANUFACTURERS

A. **Inspection, Startup, and Field Adjustment:** The service representative of the valve manufacturer shall be present at the Site for [ ] work days, to assist the CONTRACTOR in the installation and adjustment of the valve(s).

B. **Instruction of OWNERS Personnel:** The training representative of the valve manufacturer shall be present at the Site for [ ] work days to instruct the personnel in the operation, adjustment, and maintenance of the valve(s).

C. For the purpose of this paragraph, a workday is defined as an eight hour period, excluding travel time.]

- END OF SECTION -

SECTION 15218 - PRESSURE RELIEF VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide pressure relief valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 15200 - Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall furnish submittals in accordance with Section 15200.

PART 2 -- PRODUCTS

2.1 FLANGED PRESSURE RELIEF VALVES, SIZES 1 1/2 INCHES THROUGH 42 INCHES

A. **Valve Characteristics:** The pressure relief valve shall open when the inlet pressure exceeds a set maximum level. It shall maintain that level and gradually close as the inlet pressure drops below the maximum pressure. The valve shall be a hydraulically operated, adjustable, pilot controlled, diaphragm or piston type globe or angle valve as indicated. All necessary repairs shall be possible without removing the valve from the pipeline.

B. **Valve Body:** The valve body shall be of cast iron, ASTM A 48 - Gray Iron Castings, or ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with [125 lb] [250 lb] flanged ends to ANSI/ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, or the body shall be of ductile iron to ASTM A 536 - Ductile Iron Castings, with [150 lb] [300 lb] flanged ends to ANSI/ASME B 16.42 - Ductile Iron Pipe Flanges and Flanged Fittings. The valve cover shall be flanged and be of the same material as the body.

C. **Valve Trim:** The valve stems, springs, body seat rings, and all bolts, nuts, and washers shall be of Type 302, 303, or 316 stainless steel. The valve stems shall have top and bottom guides. All rubber parts shall be of Buna-N. The diaphragms shall be of Nylon-reinforced Buna-N, supported firmly between body and valve cover. The valve pistons and piston liners shall be bronze to ASTM B 62 - Composition Bronze or Ounce Metal Castings.

D. **Valve Controls:** The valve shall be furnished with a complete, externally mounted control system, including adjustable speed control needle valves, strainer, and all necessary copper or stainless steel connecting tubing and fittings. The controls shall be capable of achieving all the flow and speed adjustment indicated.

E. **Factory Tests and Warranty:** Valves shall be factory tested with a hydrostatic test and a functional test and a test certificate shall be submitted to the ENGINEER prior to delivery of the valve. The valve shall be warranted for a period of 3 years from the date of shipment to be free of defects in materials and workmanship.

F. **Operating Conditions:** The valve shall be designed to operate under the following conditions:

1. Total flow from pump station [gpm] - [ ]

2. Maximum inlet pressure (psi) - [ ]

3. Maximum flow through valve (gpm) - [ ]

4. Valve size (inches) - [ ]

5. Size of pipeline (inches diameter) - [ ]

G. **Spare Parts:** The following spare parts shall be furnished in accordance with Section 15200:

1. 1 set of all resilient seals, and discs

2. 1 diaphragm (for diaphragm valves, only)

H. Manufacturers, or equal

1. **[[Cla-Val Company]**

2. **[Golden-Anderson]**

3. **[OCV Control Valves]**

4. **[Ross Valve Mfg. Co., Inc.]**

5. **[Singer Valve, Inc.]**

6. **[Watts, ACV]**

2.2 THREADED PRESSURE RELIEF VALVES, SIZES 1/2 THROUGH 2-1/2 INCHES

A. **Valve Characteristics:** The pressure relief valve shall open when the inlet water pressure exceeds a set maximum level. It shall maintain that level and gradually close as the inlet pressure drops below the maximum pressure. The valve shall be a spring and hydraulically operated, direct-acting, adjustable, diaphragm or piston type globe or angle valve as indicated.

B. **Valve Body:** The valve body shall be bronze with threaded inlet and outlet to standard NPT and with flanged top, suitable for an inlet pressure of 300 psi. The spring shall be adjustable with an adjusting screw, to regulate the pressure setting.

C. **Valve Trim:** The valve trim shall be of stainless steel or bronze with stainless steel spring. The rubber seat shall be replaceable.

D. **Pressure Setting:** The valve shall be set for a relief pressure of [ ] psi.

E. Manufacturers or equal

1. **[Cla-Val Company]**

2. **[Golden-Anderson]**

3. **[Ross Valve Mfg. Co., Inc.]**

2.3 TEMPERATURE AND PRESSURE RELIEF VALVES

A. **Valve Construction:** Temperature and pressure relief valves for cold and hot water, steam, and air service, unless otherwise indicated, shall have a minimum pressure rating of 250 psi, bronze, steel, or stainless steel bodies, adjustable spring action, screwed or flanged connections, and trim to suit individual applications. Settings shall be adjusted for each specific condition.

B. Manufacturers, or Equal

1. **[A.W. Cash Valve Mfg. Corp.]**

2. **[Consolidated (Dresser Industries Valve Division)]**

3. **[Fisher Controls Company]**

4. **[Kunkle Valve Division]**

5. **[Masoneilan (Dresser Industries Valve and Controls Division)]**

6. **[Watts Regulator Company]**

7. **[Wilkins Regulator (A Division of Zurn Industries)]**

2.4 PLASTIC PRESSURE RELIEF VALVES, SIZES 1/2 THROUGH 1-1/2 INCHES

A. Plastic pressure relief valves shall be suitable for the fluid service and shall be designed for a maximum of 150 psi water working pressure. For chemicals and all corrosive fluids, solenoid valves shall be of PVC, CPVC, polypropylene (PP), polyvinylidene fluoride (PVDF), or teflon, as recommended by the manufacturer for the specific application.

B. **Characteristics:** Pressure relief valves shall open when the inlet pressure exceeds a set maximum level. It shall maintain that pressure and gradually close as the inlet pressure drops below the maximum pressure. Valves shall be spring or hydraulically operated, direct acting, adjustable, diaphragm or piston type globe or angle valve, as indicated.

C. Manufacturers, or equal

1. Corrosive fluids

a. Plast-O-Matic Valves, Inc.

b. [ ]

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Valves shall be installed in accordance with provisions of Section 15200.

3.2 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustment:** The service representative of the valve manufacturer shall be present at the Site for [ ] work days, to assist the CONTRACTOR in the installation and adjustment of the valve(s).

B. **Instruction of OWNERS Personnel:** The training representative of the valve manufacturer shall be present at the Site for [ ] work days to instruct the personnel in the operation, adjustment, and maintenance of the valve(s).

C. For the purpose of this paragraph, a work day is defined as an eight hour period, excluding travel time.]

- END OF SECTION -

SECTION 15230 - MISCELLANEOUS VALVES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide miscellaneous valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 15200 - Valves, General, apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 15200.

PART 2 -- PRODUCTS

2.1 AIR-VACUUM AND AIR-RELEASE VALVES

A. **Air and Vacuum Valves:** Air and vacuum valves shall be capable of venting large quantities of air while pipelines are being filled, and allowing air to re-enter while pipelines are being drained. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and all moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.

B. **Air-Release Valves:** Air-release valves shall vent accumulating air while system is in service under pressure and be of the size indicated. Valves shall meet the same general requirements as indicated for air and vacuum valves except that the vacuum feature will not be required. Valves shall be designed for a minimum water-working pressure of 150 psi, unless otherwise indicated.

C. **Combination Air Valves:** Combination air valves shall combine the characteristics of air and vacuum valves and air release valves by exhausting accumulated air in systems under pressure and releasing or re-admitting large quantities of air while a system is being filled or drained, respectively. Valves shall have the same general requirements as indicated for air and vacuum valves.

D. **Sewage Air Release Valves:** Sewage air release valves shall vent accumulating gases during system operation. Valves shall have long float stems and bodies to minimize clogging. The same general requirements shall apply as indicated for air and vacuum valves. Each sewage air release valve shall be furnished with the following backwash accessories, fully assembled on the valve:

1. Inlet shut-off valve.

2. Blow-off valve.

3. Clear water inlet valve.

4. Rubber supply hose.

5. Quick disconnect couplings.

E. Manufacturers, or Equal

1. **APCO (Valve and Primer Corporation);**

2. **Crispin - Multiplex Manufacturing Company;**

3. **GA Industries;**

4. **Val-Matic (Valve and Manufacturing Corporation.)**

2.2 AIR AND VACUUM VALVES FOR VERTICAL TURBINE PUMPS

A. An air and vacuum valve for the vertical turbine pump shall be installed on the pump discharge pipe indicated. The valve shall vent large quantities of air out through the orifice when pump starts, close tight when liquid enters, and permit and large quantities of air to re-enter through orifice when pump stops, to prevent vacuum forming in the pump column. They shall be of the size indicated, with flanged or screwed ends to match piping. Bodies shall be of high-strength cast iron. The float, seat, and all moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. The discharge orifice shall be fitted with a double-acting throttling device to regulate and restrict air venting, which shall establish a pressure loading on the rising column of water and eliminate damaging shock to the pump, controls, and valves during pump start. On pump stop, a double-acting throttling device shall automatically open, allowing full line unrestricted air re-entry to prevent any vacuum to form in the pump column. The valve shall be designed for minimum 250 psi water-working pressure.

B. Manufacturer or Equal

1. **APCO (Valve and Primer Corporation).**

2. **Val-Matic (Valve and Manufacturing Corporation).**

2.3 VACUUM RELIEF/AIR INLET VALVE FOR SURGE TANK

A. A vacuum relief/air inlet valve shall be installed on the surge tank. The vacuum relief/air inlet valve shall be normally closed, capable of admitting large quantities of air into the system immediately should the system pressure become negative and preventing a vacuum from forming during draining, pipeline rupture, or water column separation. The valve shall be of the size indicated, with flanged ends to match piping connections. Bodies shall be of high-strength cast iron with a steel hood. The float, seat, spring, and all moving parts shall be constructed of Type 316 stainless steel. The internal valve-plug and seat shall be heavy cast brass. The plug shall be normally closed by means of a stainless steel spring and shall open when a vacuum/pressure differential exceeds 0.25 psi or less. Seat seal shall be of Buna-N providing a drip-tight seal. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.

B. Manufacturer or Equal

1. **APCO (Valve and Primer Corporation);**

2. **Val-Matic (Valve and Manufacturing Corporation).**

2.4 BACKFLOW PREVENTER VALVES

A. **General:** Backflow preventers shall work on the reduced pressure principle. They shall consist of 2 spring-loaded check valves, automatic differential pressure relief valve, drain valves, and shut-off valves. The body material shall be bronze or cast iron for a working pressure of not less than 150 psi, with bronze or stainless steel trim. Drain lines with air gaps shall be provided. The backflow preventer valves shall be in accordance with AWWA C511 standard.

B. Manufacturers, or Equal

1. **Cla-Val Company;**
2. **Febco, (CMB Industries);**
3. **Hersey Products;**
4. **Watts, ACV;**
5. **Wilkins Regulator Division (Zurn Industries).**

2.5 BACKFLOW PREVENTERS FOR AUTOMATIC FIRE SPRINKLER SYSTEMS

A. **General:** Backflow preventers for automatic fire sprinkler systems shall be UL and Factory Mutual approved for fire protection. Flow curves shall be generated by the Foundation for Cross-Connection Control and Hydraulic Research at the University of Southern California. Backflow preventers shall work on the reduced pressure principle. In a non-flow condition, the check valves in the bypass and mainline shall be closed. Flows from zero to approximately 5 gpm shall flow through the bypass. This operation at low flow rates shall be accomplished by designing the differential pressure drop across the bypass line to be slightly less than the mainline check valve. Any flow through the fireline shall be registered by the bypass meter. Flows in excess of approximately 5 gpm shall open the mainline check valves causing flow to occur through the mainline assembly and the bypass line. They shall consist of 2 spring-loaded check valves, automatic differential pressure relief valve, drain valves, bypass double check valve, flow meter, and shut-off valves. The body material shall be bronze or cast iron for a working pressure of not less than 150 psi, with bronze or stainless steel trim. Drain lines with air gaps shall be provided. The backflow preventer valves shall be in accordance with AWWA C511 standard.

B. Manufacturers, or Equal

1. **Cla-Val Company;**
2. **Febco, (CMB Industries);**
3. **Hersey Products;**
4. **Watts, ACV;**
5. **Wilkins Regulator Division (Zurn Industries).**

2.6 CORPORATION STOPS

A. Unless otherwise indicated, corporation stops shall be made of solid brass for key operation, with screwed ends with corporation thread or iron pipe thread, as required.

B. Manufacturer, or Equal

1. **Ford Meter Box Company, Inc.;**

2. **James Jones Company (Watts, ACV;**

3. **Mueller Company.**

2.7 Mud Valves

A. Mud valves shall be flanged, non-rising stem type, with threaded stem, seat ring, and gate ring of bronze. Valves shall be provided with coupling nut, extension stem, stem guides, and operating stand, wheel, or wrench nut as indicated. Mud valve shall be installed with valve seats level.

B. Manufacturers or Equal

1. **Clow;**

2. **Mueller.**

2.8 SEWAGE SURGE RELIEF VALVES

A. **Operating Requirements:** The valve shall open immediately when the system pressure exceeds the load setting, 50 psi , of the counterweights and shall close slowly at an adjustable speed upon return of system pressure to normal.

B. **Valve Body:** Sewage surge relief valves shall be constructed of a heavy cast-iron or cast-steel body with a welded steel disc having rubber seating face, a non-corrosive shaft for attachment of counterweight or spring-loaded arms and lever, and a complete non-corrosive cushion chamber.

C. **Cushion Chamber:** The cushion chamber shall be attached to the side of the valve body externally and be constructed with a piston operating in a chamber that will effectively permit the valve to be operated without any hammering action. The cushioning shall be by oil stored in an oil reservoir attached by piping and fittings to the cushion chamber. The cushion chamber shall be so arranged that the closing speed will be adjustable to meet the service requirements.

D. Manufacturers, or Equal

1. **APCO (Valve and Primer Corporation);**

2. **GA Industries.**

2.9 SOLENOID VALVES

A. Solenoid valves shall be of the size, type, and class indicated and shall be designed for not less than 150 psi water-working pressure. Valves for water, air, or gas service shall have brass or bronze body with screwed ends, stainless steel trim and spring, Teflon or

other resilient seals with material best suited for the temperature and fluid handled. Unless otherwise indicated, for chemicals and all corrosive fluids, solenoid valves with PVC, CPVC, polypropylene (PP), polyvinylidene fluoride (PVDF), or Teflon materials of construction, suitable for the specific application shall be provided. Enclosures shall be NEMA rated in accordance with the area designations of Section 16050 - Electrical Work, General. All coil ratings shall be for continuous duty. For electrical characteristics see electrical drawings or specifications.

B. Manufacturers, or Equal

1. For general duty

a. Automatic Switch Co. (ASCO), Model "RED HAT";

b. Skinner Valve (Parker Hannifin Corporation);

c. Magnatrol Valve Corporation;

d. **J. D. Gould Co.**

2. Metallic valves for corrosive fluids

a. Valcor Engineering Corporation;

3. Plastic valves for corrosive fluids

a. +GF+ Plastic Systems, Inc.;

b. Spears Mfg. Co.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Backflow preventers shall be installed in potable water lines where required by applicable codes or regulations, and wherever there is any danger of contamination, and where indicated.

B. Valves shall be installed in accordance with the manufacturer's printed recommendations, and with provisions of Section 15200.

C. Backflow preventers, as well as air and vacuum release valves, shall have piped outlets to the nearest acceptable drain, firmly supported, and installed in such a way as to avoid splashing and wetting of floors and obstruction of traffic.

D. Valves shall not vent sewer gases to the open atmosphere. Valves shall be vented to nearest existing sanitary manhole or wet well.

- END OF SECTION -

SECTION 15500 - HEATING, VENTILATING, AND AIR CONDITIONING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide heating, ventilating, and air conditioning systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 11000 - Equipment General Provisions apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. WORK shall be in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning Systems), the local Mechanical Code, the local Building Code, Fire Code, and all other local codes. Nothing in the Contract Documents shall be construed to permit WORK in violation of the above codes, rules, and regulations. In the absence of applicable codes, installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration, and Air Conditioning Engineers.

1.3 CONTRACTOR SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01300 - Contractor Submittals.

B. **Equipment Numbers:** Equipment is identified by number code for reference and location purposes in the Contract Documents. The appropriate equipment numbers shall be included on the Shop Drawings and on other submittals.

C. **Acoustic Louver Certification:** The CONTRACTOR shall submit certified data from a laboratory substantiating the performance of acoustic louvers.

1.4 WARRANTY

A. Heaters, fans, and blowers shall carry the manufacturer's standard warranty, and all such warranties shall be furnished to the ENGINEER before final acceptance.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Quality:** All mechanisms and parts shall be amply proportioned for the stresses which may occur during operation and during fabrication and installation. Individual parts which are alike in all units shall be alike in materials workmanship, and design and shall be of the manufacturer's top of the line, industrial-commercial grade.

B. **Supports:** Equipment and appurtenances shall be firmly anchored or connected to supporting members. Supports required for the proper installation of the equipment, but not forming an integral part of the building structure, shall be provided by the heating and ventilating subcontractor, unless otherwise indicated. Equipment shall be supported on restrained spring-type vibration isolators.

C. **Noise/Vibration Control:** The system shall be free of any objectionable vibrations and noise. Flexible connections shall be provided in all ducts and piping connections to fans, compressors, and any other vibrating equipment.

D. **Electric Motors:** Electric motors shall be provided in accordance with Section 16460 - Electric Motors.

2.2 DUCTWORK AND MISCELLANEOUS ACCESSORIES

A. **Construction:** Sheet metal ducts and plenums shall be constructed with airtight joints and seams in accordance with ASHRAE standards and SMACNA Duct Construction Manual. Joints on concealed ducts shall be taped with pressureless tape and adhesive, except for welded or soldered joints. Ductwork materials shall be galvanized steel or aluminum, unless otherwise indicated. Minimum duct gauges are as follows:

Maximum Dimension of Duct (Inches)	Galvanized Steel U.S. Standard Gauge	Aluminum B and S Gauge
12 and less	26	24
13 through 30	24	22
31 through 54	20	20
55 through 84	20	18

B. **Supports:**

1. Supports for horizontal ducts and plenums shall be galvanized steel angles with hanger rods. Band iron straps shall be allowed for duct sizes recommended by SMACNA. Supports for vertical ducts shall be band iron strap or angle bracket type. Inlet ducts shall be amply braced to withstand maximum negative pressure.

2. Seismic Restraints: Duct supports and restraints shall be designed for static, dynamic, and seismic loads in zone 3 per the Uniform Building Code. Seismic restraints shall not induce stresses in the ductwork caused by thermal expansion and contraction.

C. **Balancing Dampers:** Butterfly or multi-blade dampers shall be provided as indicated and required for balancing air quantities to values indicated. A locking quadrant shall be provided on each manual damper with easy access for operation.

D. **Motorized Dampers:** Automatic control dampers shall be fabricated of 22-gauge galvanized sheet steel with 10-inch maximum blade width and 50-inch maximum blade length per section. Dampers shall be of the opposed-blade type for proportional action and parallel-blade type for 2-position action. Blades shall be set in a suitable channel frame. Blades shall have neoprene-gasketed wall frames together with weather louvers, as indicated. Damper operators shall be sized to provide modulating or 2-position action as required. Intake and exhaust dampers shall close and return damper shall open on control failure. Operators shall be provided for all motorized dampers.

E. **Inspection Doors:** Duct inspection doors shall be 12-inch by 16-inch steel frame with gasketing around periphery, and either hinged glass, or removable visual panel of **Plexiglas, Lucite,** or equal. On smaller ducts, separate 6-inch by 8-inch doors with 6-inch

by 6-inch visual panels shall be provided. Duct inspection doors shall be provided at each duct-mounted fire damper and electric duct heater.

F. **Bird Screens:** Removable bird screens shall be provided on all outside air intakes and exhaust air discharges to outside air. Screens shall be secured in frames made from the same metal as the screens. Bird screens shall be 1/4-inch mesh by 14-gauge and shall be of same material and finish as duct, hood, louver, or equipment to which the screens are attached.

G. **Flexible Connectors:** Flexible duct connections shall be made with banded or flanged 8-oz canvas, reinforced plastic, or equal at each point where a blower unit is connected to a duct. A minimum clearance of 3 inches between the duct and source of vibration shall be maintained.

H. **Registers:** Exhaust registers shall be of aluminum construction with smooth corners, flanges, and sponge rubber gaskets. Exhaust registers shall have individually adjustable blades and volume control dampers. Ceiling-mounted outlets shall be off-white. Wall-mounted outlets shall be factory prime-coated. Terminals shall be **Titus**, **Agitair**, **Krueger**, or equal.

I. **Turning Vanes:** Square-turn elbows shall be fitted with shop-fabricated double-blade turning vanes mounted inside rails. Construction shall be of the same material as the ductwork and be rigid enough to prevent vibration at high air flow.

J. **Air Extractors:** An air extractor shall be provided on each take-off from main supply duct adjacent to any diffuser, register, or grille where a splitter is not used. Air extractors shall be **Carnes**, **Tuttle and Bailey**, or equal. Extractors shall have synchronized steel curved blades, heavy side rails, and screw operator.

2.3 CONTROLS

A. General: Heating, cooling, ventilating, and air conditioning equipment shall be provided with manual or automatic control systems as indicated. Where various items of equipment are operating in conjunction with one another, they shall be controlled by an integrated control system located in a control panel as indicated. Such systems shall have 12-hour timers and 7-day setback programming for automatic setback comfort time periods to meet requirement of the Energy Conservation Standards. Unless otherwise indicated, individual cooling fans shall be controlled from HAND-OFF-AUTOMATIC line-voltage cooling thermostats, wall-mounted. Individual exhaust fans shall have manual switches for single or 2-speed motors as indicated. Exhaust fans operating in conjunction with central ventilating or air conditioning systems shall be interlocked with these systems. Electric unit heaters shall have unit-mounted contactors unless otherwise indicated and shall be controlled from wall-mounted line voltage heating thermostats.

B. Thermostats: Room thermostats shall be digital type with heating and cooling setpoints. Adjustment shall be by pressing the thermostat up or down arrows. Fan setpoints shall be adjustable from 66 to 100 degrees. Automatic setback time period shall be 7-day setback programming, with up to 2 automatic setback comfort time periods per day, a built-in setback override, adjustable from 10 minutes to 40 hours, a 7-day electric time clock, and a heat/cool/fan annunciators to indicate equipment operation and automatic heating/cooling changeover. Thermostats shall meet the Energy Conservation Standard approval where required by the State. An insulating back shall be provided where exterior wall mounting is indicated. Guards shall be provided for room thermostats installed in areas other than administrative offices or control rooms.

C. Controls shall be in accordance with Division 17 - Instrumentation.

D. Manufacturers: Control system components and thermostats shall be as manufactured by Honeywell, Johnson Controls Company, General Controls, or equal.

2.4 FANS

A. **General:** Location, type, capacity, and motor horsepower shall be as indicated. Fans shall be complete with motors, adjustable motor bases, adjustable drives, safety cages, belt guards, flexible connections to supply and/or suction ducts, vibration isolators, and necessary accessories. Fans shall be suitable for continuous operation.

B. **Performance:** Fans shall be guaranteed to deliver the quantities of standard air against the respective static pressure without deviating by more than 5 percent. Every fan wheel, regardless of size, shall be statically and dynamically balanced and shall be free from objectionable vibration or noises.

C. **Roof Fans:** Roof-mounted ventilators and exhaust fans shall include curb, flashing, bird screen, or dampers, as appropriate for installation. Roof fans supplying to or exhausting from rooms directly shall have air diffusers or exhaust grilles at ceiling and duct extensions to suspended ceiling, where necessary.

PART 3 -- EXECUTION

3.1 GENERAL

A. **Roughing-In:** The CONTRACTOR shall ascertain that all inserts, chassis, shafts, and openings are correctly located; if not, cut new openings as part of the WORK.

B. **Checking:** The CONTRACTOR shall test and tighten all WORK, furnish all equipment necessary to carry out the tests, and thoroughly clean the system before startup.

C. **System Balancing:** After completion of work, but before final acceptance, the CONTRACTOR shall have the system as a whole checked and balanced by an independent air balancing company, registered by the Associated Air Balancing Council and having one member of the company certified by the National Examination Board as a test and balance engineer. System balancing shall include the following:

1. Adjusting fans, dampers, diffusers, registers, valves, and other devices so that the quantities of air, water, and steam called for on the Drawings are supplied, returned, or exhausted.

2. Measuring and recording at least once the water and air temperatures delivered through each coil on full heating and full cooling: making all necessary adjustments to obtain the required conditions.

3. Measuring and recording current on each fan and motor, and checking for proper operation of equipment.

4. Adjusting any adjustable blade registers to the correct setting to obtain the design conditions.

- END OF SECTION -

SECTION 15870 – SOUND ATTENUATORS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide Sound Attenuators, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 15000 - Mechanical apply to the WORK of this Section.

1.2 CODES

A. WORK shall be in full accordance with the latest rules and regulations or publications of the State Energy Resources Conservation and Development Commission, the State Fire Marshall, the Industrial Safety Orders, the Health and Safety Rules (Air Conditioning Systems), the local Mechanical Code, the local Building Code, Fire Code, and all other local codes. Nothing in this Section shall be construed to permit WORK in violation of the above codes, rules, and regulations. In the absence of applicable codes, installation and workmanship shall follow the standards set by the American Society of Heating, Refrigeration, and Air Conditioning Engineers.

1.3 REFERENCES

ASTM E477	American Society for Testing and Materials, Standard method of testing duct liner material and prefabricated silencers for acoustical and airflow performance
NFPA 255	National Fire Protection Association, testing of air conditioning and ventilation systems
ASTM E84	American Society for Testing and Materials, testing of air conditioning and ventilation systems
UL-723	Underwriters Laboratories, standard for safety; duct silencers

1.4 CONTRACTOR SUBMITTALS

A. Shall comply with requirements of Section 01300 – Contractor Submittals.

B. Product Data: Submit manufacturer's product data.

C. Verify conformance of ASTM E477, ASTM E84, NFPA 255 and UL-723.

D. Certified Test Data: AMCA certified test results shall be submitted based on manufacturer's standard size silencer. Test data shall include the following performance testing.

1. Insertion loss data.

2. Pressure drop data.

E. Sound Attenuators: Shall be of the size, configuration, capacity and acoustic performance as indicated on this Specification. All sound attenuators shall be factory fabricated and supplied by the same manufacturer. Sound attenuators shall be Vibro-Acoustics, Rink or equal.

F. Alternate manufacturers must request and obtain written approval by the ENGINEER to bid the project at least 10 days prior to the bid due-date. As a condition of pre-approval, alternate manufacturers must submit to the ENGINEER a minimum of 20 different HVAC silencer test reports. Each report shall be for a sound attenuator in full accordance with the ASTM E-477-99 silencer test standard in an aero-acoustic test facility which is NVLAP accredited for the ASTM E-477-99 standard. Each test shall have been conducted within the last 12 month period. A copy of the laboratory's NVLAP accreditation certificate must be included with the submitted reports. Any changes to the specifications must be submitted and approved in writing by the ENGINEER at least 10 days prior to the bid due-date.

G. Sound attenuators inlet and outlet connection dimensions must be equal to the duct sizes indicated in the Specification. Duct transitions at sound attenuators are not permitted unless shown on the Contract Drawings. Attenuators shall inlcude flange connections for direct attachment to ductwork.

1.5 QUALITY ASSURANCE

A. Silencers licensed to bear AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with and complying with AMCA Certified Ratings Program. AMCA Certified Ratings Seal applies to acoustical and aerodynamic performance.

B. Dynamic Insertion Loss: Silencer dynamic insertion loss based on tests and procedures performed in accordance with ASTM E477 testing procedures.

C. Pressure Drop: Silencer pressure drop performance based on tests and procedures performed in accordance with ASTM E477 testing procedures.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

B. Storage: Store materials in a dry area indoors, protected from damage and in accordance with manufacturer's instructions.

C. Handling: Handle and lift silencers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. Fabrication:

1. Outer Casing: 22 gauge G90 galvanized (suitable for outdoor use) outer casing

2. Internal Liner: 22 gauge G90 galvanized (suitable for outdoor use) internal liner. Liner shall be perforated steel and shall be acoustically transparent.

3. Baffle Fill: Inorganic glass fiber acoustic material fill. Glass fiber packed under 5% compression to eliminate voids due to settling.

4. Pod Construction: Pods constructed using fully tapered pod design. Flange: Body shall extend for 1-1/2 flange past silencer.

5. Construction: Silencer constructed using Pittsburgh Lock Seam sheet metal construction.

B. Performance Data:

1. Refer to Sound Attenuator Schedule at the end of this Section for performace requirements

2. All acoustical performance data is derived from independent laboratory testing in accordance with ASTM E477 testing procedure. Testing executed in a duct-to-reverberant room laboratory, providing for airflow in both directions through the silencer. Dynamic Insertion Loss (D.I.L) calculated for:

   a. Forward Flow - air and sound move in same direction.

   b. Reverse Flow - air and sound move in opposite directions.

3. Aerodynamic performance data is derived from independent laboratory testing in accordance with ASTM E477 testing procedure. Data shall be presented for the same units as those tested to ascertain acoustical performance data.

4. Fire and smoke performance data derived from testing in accordance with ASTM E84, NFPA 255, and UL-723 testing methods. Incombustible filler material exhibits the following fire hazard classification values:

   a. FLAMESPREAD-20

   b. FUEL CONTRIBUTED-15

   c. SMOKE DEVELOPED-20

C. Media Protection

1. Dissipative Sound Attenuators

   a. Media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber.

D. HTL Casings: Sound attenuators shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality controlled transmission loss. The HTL walls shall consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls. If requested by the ENGINEER, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to insure compliance with

the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

PART 3 -- EXECUTION

3.1 CONSTRUCTION

A. Sound attenuators shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in the Section above are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The sound attenuators shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.

B. Casings shall be lockformed and sealed to provide leakage-resistant construction. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the CONTRACTOR at the jobsite.

C. All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted with protective Coating.

3.2 ACOUSTIC PERFORMANCE

A. Sound attenuators dynamic insertion loss shall not be less than that listed in this Section.

B. Sound attenuators generated noise shall not be greater than that listed in this Section.

C. Acoustic performance shall include dynamic insertion loss and generated noise for forward flow (air and noise in same direction) or reverse flow (air and noise in opposite direction) in accordance with the project's air distribution system requirements.

D. Sound attenuator ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with the ASTM E-477-99 test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.

3.3 AERODYNAMIC PERFORMANCE

A. Sound attenuator pressure drops shall not exceed those listed in the Specifications. Silencer pressure drop measurements shall be made in accordance with the ASTM E-477-99 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

3.4 CONTRACTOR SUBMITTALS

A. CONTACTOR shall submit shop drawings in accordance with Section 01300 – Contractor Submittals.

B. CONTRACTOR shall provide acoustical system calculations for all duct systems with sound attenuators to demonstrate that the resultant ductborne sound levels of the equipment as measured in the occupied spaces meet the specified criteria. In the

absence of specified background sound level criteria, the guidelines as expressed in Table 34 of Chapter 47, "Sound and Vibration Control" of the 2003 ASHRAE Handbook - HVAC Applications, shall be used.

C. The CONTRACTOR shall submit manufacturer's certified test data for each scheduled silencer. The data shall include dynamic insertion loss, generated noise and pressure drop for forward or reverse flow, meeting the project's air distribution system requirement. All ratings shall be conducted in the same facility and shall utilize the same silencer.

D. Test facilities and test reports shall be open to inspection upon request from the ENGINEER. Silencer performance must have been substantiated by laboratory testing according to ASTM E-477-99 and so certified when submitted for approval. The aero-acoustic laboratory must be NVLAP accredited for the ASTM E-477-99 test standard. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

3.5 INSTALLATION

A. CONTRACTOR shall install sound attenuators at locations indicated on the Drawings and in accordance with manufacturer's installation instructions.

B. CONTRACTOR shall assemble individual silencers with hardware to form a single modular unit. Provide angle iron framework and anchor to concrete floor or wall as required on the Drawings.

SOUND ATTENUATOR SCHEDULE

Tag ID	Location/Area Served	Dimension Size (W x H), In	Length, Size, In	Face Velocity, FPM	Pressure Drop In, WG	Octave Band Dynamic Insertion Loss at 1000 FPM							Notes
						1	2	3	4	5	6	7	
AS-1	Generator Room/Intake	24 x 24	36	375	0.041	1	6	18	8	6	6	5	1, 3
AS-2	Generator Room/Exhaust	24 x 24	36	375	0.041	1	6	18	9	6	6	5	2, 3

- END OF SECTION -

SECTION 16050 – ELECTRICAL WORK, GENERAL

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide electrical WORK, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section apply to all sections in Division 16, except as indicated otherwise.

C. The WORK of this Section is required for operation of electrically-driven equipment provided under specifications in other Divisions. The CONTRACTOR's attention is directed to the requirement for proper coordination of the WORK of this Section with the WORK of equipment specifications, the WORK of instrumentation sections, and the WORK of Section 16460 - Electric Motors.

D. Concrete, excavation, backfill, and steel reinforcement required for encasement, installation, or construction of the WORK of the various sections of Division 16 is included as a part of the WORK under the respective sections, including duct banks, manholes, handholes, equipment housekeeping pads, and light pole bases.

1.2 REFERENCE STANDARDS

A. The WORK of this Section and all sections in Division 16 shall comply with the following as applicable:

NEC (NFPA 70)	National Electrical Code
NETA	International Electrical Testing Association
NEMA 250	Enclosure for Electrical Equipment (1000 Volts Maximum)
Title 8, Subchapter 5, California Administrative Code	Electrical Safety Orders

B. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

C. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes and regulations.

D. Where the requirements of the specifications conflict with UL, NEMA, NFPA, or other applicable standards, the more stringent requirements shall govern.

1.3 SIGNAGE AND MARKINGS

A. **Identification**: Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal and state OSHA and NEC requirements.

B. Local Disconnect Switches

1. Each local disconnect switch for motors and equipment shall be legibly marked to indicate its purpose unless the purpose is indicated by the location and arrangement.

C. Warning Signs

1. 600 volts nominal, or less: Entrances to rooms and other guarded locations that contain live parts shall be marked with conspicuous signs prohibiting unqualified persons to enter.

2. Over 600 volts: Buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at greater than 600 volts nominal shall be lockable. Permanent and conspicuous warning signs shall be provided reading as follows: DANGER – HIGH VOLTAGE – KEEP OUT.

3. Indoor electrical installations that are open to unqualified persons and containing metal – enclosed switchgear, unit substations, transformers, and other similar associated equipment over 600 volts nominal shall be marked with appropriate caution signs.

4. Outside branch circuits and feeders over 600 volts – Warning signs shall be posted in plain view where unauthorized persons might come in contact with live parts – "WARNING – HIGH VOLTAGE – KEEP OUT"

D. Isolating Switches: Isolating switches not interlocked with an approved circuit interrupting device shall be provided with a sign warning against opening them under load.

1.4 PUBLIC UTILITIES REQUIREMENTS

A. The CONTRACTOR shall contact the serving utility and verify compliance with requirements before construction. The CONTRACTOR shall coordinate schedules and payments for work by all utilities.

B. Electrical service shall be as indicated and be as required by the serving utility.

C. The CONTRACTOR shall verify and provide service conduits, fittings, transformer pad, grounding devices, and service wires not provided by the serving utility.

D. The CONTRACTOR shall verify with the utility the exact location of each service point and type of service, and shall pay charges levied by the serving utilities as part of the WORK.

1.5 PERMITS AND INSPECTION

A. Permits shall be obtained and inspection fees shall be paid according to the General Conditions.

B. The CONTRACTOR shall pay inspection, connection and turn-on service charges required by the utility company.

1.6 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. **Shop Drawings:** Include the following:

1. Complete material lists stating manufacturer and brand name of each item or class of material.

2. Shop Drawings for all grounding WORK not specifically indicated.

3. Front, side, rear elevations, and top views with dimensional data.

4. Location of conduit entrances and access plates.

5. Component data.

6. Connection diagrams, terminal numbers, internal wiring diagrams, conductor size, and cable numbers.

7. Method of anchoring, seismic requirements, weight.

8. Types of materials and finish.

9. Nameplates.

10. Temperature limitations, as applicable.

11. Voltage requirement, phase, and current, as applicable.

12. Front and rear access requirements.

13. Test reports.

14. Grounding requirements.

15. Catalog cuts or photocopies of applicable pages of bulletins or brochures for mass produced, non-custom manufactured material. Catalog data sheets shall be stamped to indicate the project name, applicable Section and paragraph, model number, and options. This information shall be marked in spaces designated for such data in the ENGINEER's stamp.

C. Shop Drawings shall be custom prepared. Drawings or data indicating "optional" or "as required" equipment are not acceptable. Options not proposed shall be crossed out or deleted from Shop Drawings.

D. **Materials and Equipment Schedules:** The CONTRACTOR shall deliver to the ENGINEER within 30 days of the commencement date in the Notice to Proceed, a complete list of materials, equipment, apparatus, and fixtures proposed for use. The list shall include type, sizes, names of manufacturers, catalog numbers, and such other information required to identify the items.

E. **Owner's Manuals:** Complete information in accordance with Section 01300.

F. **Record Drawings:** The CONTRACTOR shall show invert and top elevations and routing of all duct banks and concealed below-grade electrical installations. Record drawings shall be prepared, be available to the ENGINEER, and be submitted according to Section 01300.

1.7 AREA DESIGNATIONS

A. General

1. Raceway system enclosures shall comply with Section 16110 - Electrical Raceway Systems.

2. Electric WORK specifically indicated in sections within any of the Specifications shall comply with those requirements.

3. Other electrical WORK not included in 1.7A1 and 1.7A2 shall comply with this Paragraph 1.7A3.

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	3R	7	9	12	Notes
Wet Wells			X			In accordance with NFPA 820
Valve Vaults			X			In accordance with NFPA 820

4. Electrical WORK not included in 1.7A1, 1.7A2, or 1.7A3 shall be NEMA 4X.

5. Installations in hazardous locations shall conform strictly to the requirements of the Class, Group, and Division indicated.

B. Material Requirements

1. In chlorine and hydrofluosilicic (HFS) acid areas, sealing fittings shall be provided.

2. NEMA 4X enclosures shall be 304 stainless steel except in chlorine and HFS areas where non-metallic enclosures shall be provided.

3. NEMA 7 enclosures shall be cast aluminum where used with aluminum conduit; and cast iron when used with galvanized steel conduit.

4. NEMA 1, 3R, and 12 enclosures shall be steel coated with ANSI 61 grey paint. NEMA 4X, 7, and 9 shall not be coated.

1.8 TESTS

A. The CONTRACTOR shall be responsible for factory and field tests required by specifications in Division 16 and by the ENGINEER or other authorities having

jurisdiction. The CONTRACTOR shall furnish necessary testing equipment and pay costs of tests, including replacement parts and labor, due to damage resulting from damaged equipment or from testing and correction of faulty installation.

B. Where test reports are indicated, proof of design test reports for mass-produced equipment shall be submitted with the Shop Drawings, and factory performance test reports for custom-manufactured equipment shall be submitted and be approved prior to shipment. Field test reports shall be submitted for review prior to Substantial Completion.

C. Equipment or material that fails a test shall be removed and replaced.

1.9 DEMOLITION AND RELATED WORK

A. The CONTRACTOR shall perform electrical demolition WORK as indicated. The CONTRACTOR is cautioned that demolition WORK may also be indicated on non-electrical drawings. Coordinate electrical de-energization, disconnection, and removal with all trades and the overall sequence of construction.

B. Electrical requirements associated with removed equipment shall be:

1. Remove dedicated wiring and exposed conduits back to the source.

2. Abandon in place wiring that shares conduits with other equipment wiring, except power wiring. Power wiring shall be removed from the power source to the first pullbox or manhole remote from the panel. The remainder shall be abandoned in place.

3. Abandon in place wiring routed through encased conduits. Encased conduits shall be cut flush to the floor and be grouted.

4. Remove remote mounted starters, disconnect switches, circuit breakers, sensors, and transmitters.

C. Where new lighting and receptacles are installed, old lighting, receptacles, switches, wiring, and conduits shall be removed.

D. Wiring and conduits indicated to be extended shall be terminated in a new junction box with terminal strips. The junction box shall have a NEMA rating in accordance with the area in which it is located and shall be sized as required. Wires and terminals shall be properly identified before disconnection.

E. Materials and equipment not indicated to be removed and returned to the OWNER shall, upon removal, become the CONTRACTOR's property and shall be disposed of off the Site.

F. Material and equipment indicated to be relocated or reused shall be removed and relocated, and reinstalled with care to prevent damage thereto.

G. Materials indicated to be returned to the OWNER shall be placed in boxes with the contents clearly marked and be stored at a location determined by the ENGINEER.

H. Where motor control centers or panelboards are indicated to have circuits removed and reconnected, the MCC shall have a new engraved phenolic nameplate worded as indicated or the panelboard schedule shall be modified to indicate the revised circuits.

Pencil or magic marker markings directly on the MCC or panelboard breaker are not permitted.

1.10 CONSTRUCTION SEQUENCING

A. Continuance of plant operation during demolition and the expansion process is critical. Therefore, CONTRACTOR shall carefully examine all work to be done in, on, or adjacent to existing equipment. Work shall be scheduled, subject to OWNER's approval, to minimize required plant shutdown time. The CONTRACTOR shall submit a written request, including sequence and duration of activities to be performed during plant shutdown.

B. Switching, safety tagging, etc., required for plant shutdown or to isolate existing equipment shall be performed by the CONTRACTOR after coordination with the OWNER and other interested parties including affected utilities and neighbors. In no case shall the CONTRACTOR begin any work in, on, or adjacent to existing equipment without written authorization by the ENGINEER.

C. The CONTRACTOR shall make modifications or alterations to existing electrical facilities required to successfully install and integrate the new electrical equipment as indicated. Modifications to existing equipment, panels, or cabinets shall be made in a professional manner with coatings repaired to match existing. The costs for modifications to existing electrical facilities that are required for a complete and operating system shall be included in the CONTRACTOR's Bid, and no additional payment for this WORK will be authorized. Extreme caution shall be exercised by the CONTRACTOR in digging trenches in order not to damage existing underground utilities. Cost of repairs of damages caused during construction shall be the CONTRACTOR's responsibility as a part of the WORK.

D. The CONTRACTOR shall be responsible for identifying available existing circuit breakers in lighting panels for the intended use as required by the Drawings. CONTRACTOR shall also be responsible for field verifying the available space in substation switchboards to integrate new power circuit breakers. Costs for this WORK shall be included in the CONTRACTOR's Bid.

E. The CONTRACTOR shall visit the Site before submitting a Bid to better acquaint itself with the WORK of this Contract. Lack of knowledge will not be accepted as a reason for granting extra compensation to perform the WORK.

F. Installation of Temporary Equipment

1. To facilitate continuous operation of existing equipment, the CONTRACTOR shall be required to provide the temporary equipment indicated. The CONTRACTOR shall submit installation and connection details for review and acceptance by the ENGINEER. Costs associated with these temporary installations shall be included in the Bid.

2. Temporary wiring and equipment shall remain the property of the CONTRACTOR unless indicated otherwise.

PART 2 – PRODUCTS

2.1 GENERAL

A. Equipment and materials shall be new, shall be listed by UL, and shall bear the UL label where UL requirements apply. Equipment and materials shall be the products of experienced and reputable manufacturers in the industry. Similar items in the WORK shall be products of the same manufacturer. Equipment and materials shall be of industrial grade standard of construction.

B. Where a NEMA enclosure type is indicated in a non-hazardous location, the CONTRACTOR shall utilize that type of enclosure, despite the fact that certain modifications such as cutouts for control devices may negate the NEMA rating.

C. On devices indicated to display dates, the year shall be displayed as 4 digits.

2.2 MOUNTING HARDWARE

A. Miscellaneous Hardware

1. Nuts, bolts, and washers shall be stainless steel.

2. Threaded rods for trapeze supports shall be continuous threaded, galvanized steel, 3/8-inch diameter minimum.

3. Strut for mounting of conduits and equipment shall be stainless steel. Where contact with concrete or dissimilar metals may cause galvanic corrosion, suitable non-metallic insulators shall be utilized to prevent such corrosion. Aluminum strut shall not be utilized for free standing support frames. Strut shall be as manufactured by **Unistrut, B-Line**, or equal.

4. Anchors for attaching equipment to concrete walls, floors and ceilings shall be stainless steel expansion anchors, such as **"Rawl-Bolt," "Rawl-Stud"** or **"Lok-Bolt"** as manufactured by **Rawl;** similar by **Star,** or equal. Wood plugs shall not be permitted.

2.3 ELECTRICAL IDENTIFICATION

A. **Nameplates:** Nameplates shall be fabricated from white-letter, black-face laminated plastic engraving stock, **Formica type ES-1,** or equal. Each shall be fastened securely, using fasteners of brass, cadmium plated steel, or stainless steel, screwed into inserts or tapped holes as required. Engraved characters shall be block style with no characters smaller than 1/8-inch top to bottom.

B. **Conductor and Equipment Identification:** Conductor and equipment identification devices shall be either imprinted plastic-coated cloth marking devices such as manufactured by **Brady, Thomas & Betts,** or equal, or shall be heat-shrink plastic tubing, imprinted split-sleeve markers cemented in place, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. **Incidentals:** The CONTRACTOR shall provide all materials and incidentals required for a complete and operable system, even if not required explicitly by the Specifications or the Drawings. Typical incidentals are terminal lugs not furnished with vendor supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor furnished equipment to connect with other equipment indicated in the Contract Documents.

B. **Field Control of Location and Arrangement:** The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items. Exact locations shall be determined by the CONTRACTOR in the field based on the physical size and arrangement of equipment, finished elevations, and other obstructions. Locations on the Drawings, however, shall be followed as closely as possible.

1. Where conduit development drawings or "home runs" are shown, the CONTRACTOR shall route the conduits in accordance with the indicated installation requirements. Routings shall be exposed or encased as indicated, except that conduit in finished areas shall be concealed unless specifically indicated otherwise. Conduits encased in a slab shall be sized for conduit OD to not exceed one-third of the slab thickness and be laid out and spaced to not impede concrete flow.

2. Conduit and equipment shall be installed in such a manner as to avoid all obstructions and to preserve head room and keep openings and passageways clear. Lighting fixtures, switches, convenience outlets, and similar items shall be located within finished rooms as indicated. Where the Drawings do not indicate exact locations, such locations shall be determined by the ENGINEER. If equipment is installed without instruction and must be moved, it shall be moved without additional cost to the OWNER. Lighting fixture locations shall be adjusted slightly to avoid obstructions and to minimize shadows.

3. Wherever conduits and wiring for lighting, receptacles and other panelboard loads are not indicated, it shall be the CONTRACTOR'S responsibility to provide other panelboard loads and lighting and receptacle-related conduits and wiring as required, based on the actual installed layout and the circuit designations as indicated. Wiring shall be #12 AWG minimum, and conduits shall be 3/4-inch minimum (exposed) and 1-inch minimum (encased). Where circuits are combined in the same raceway, the CONTRACTOR shall derate conductor ampacities in accordance with NEC requirements.

C. **Workmanship:** Materials and equipment shall be installed in strict accordance with printed recommendations of the manufacturer. Installation shall be accomplished by workers skilled in the work. Installation shall be coordinated in the field with other trades to avoid interferences.

D. **Protection of Equipment and Materials:** The CONTRACTOR shall fully protect materials and equipment against damage from any cause. Materials and equipment, both in storage and during construction, shall be covered in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint. Moving parts shall be kept clean and dry. The CONTRACTOR shall replace or

refinish damaged materials or equipment, including faceplates of panels and switchboard sections as part of the WORK.

E. Incoming utility power equipment shall be provided in conformance with the utility's requirements. Prior to placing an order for service equipment utility approval shall be obtained for the service entrance equipment including the following: meters, pull sections, cable/wire terminations, meter sockets, current transformer connections and support, voltage transformer connections and supports, main circuit breakers and disconnecting means, service transformer pads, service transformer grounding, service conduit installation and terminations. Furnish, install and connect all items not provided by the utility in accordance with utility requirements to result in a complete, safe operational service for each location requiring electric power.

F. The CONTRACTOR shall provide power wiring in conduit for the HVAC equipment in accordance with Section 15500 - Heating, Ventilating, and Air Conditioning. Starters shall be in accordance with Section 16480 - Low Voltage Motor Control Center for starters in MCC's and Section 16485 - Local Control Stations and Miscellaneous Electrical Devices, for starters not in MCC's, except for starters in HVAC equipment which are indicated in Section 15500. Control wiring operating at 120 volts and less shall be as indicated in Section 15500.

3.2 CORE DRILLING

A. The CONTRACTOR shall perform core drilling required for installation of raceways through concrete walls and floors. Locations of floor penetrations, as may be required, shall be based on field conditions. Verify all exact core drilling locations based on equipment actually furnished as well as exact field placement. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the OWNER prior to any core drilling activities. Damage to any encased conduits, wiring, and piping shall be repaired as part of the WORK.

3.3 CONCRETE HOUSEKEEPING PADS

A. Concrete housekeeping pads shall be provided for indoor floor standing electrical equipment. Housekeeping pads for equipment, including future units, shall be 4-inches above surrounding finished floor or grade and 2-inches larger in both dimensions than the equipment, unless otherwise indicated.

B. Concrete housekeeping curbs shall be provided for conduit stub-ups in indoor locations that are not concealed by equipment enclosures. Such curbing shall be 3-inches above finished floor or grade.

3.4 EQUIPMENT ANCHORING

A. Floor supported, wall, or ceiling hung equipment and conductors shall be anchored in place by methods that will meet seismic requirements in the area where the project is located. Wall-mounted panels that weigh more than 500 pounds or that are within 18-inches of the floor shall be provided with fabricated steel support pedestals. If the supported equipment is a panel or cabinet enclosed within removable side plates, it shall match supported equipment in physical appearance and dimensions. Transformers hung from 4-inch stud walls and weighing more than 300 pounds shall have auxiliary floor supports.

B. Leveling channels anchored to the concrete pad shall be provided for switchgear and pad-mounted transformer installations.

C. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the WORK of this Contract. Such recommendations shall be submitted as Shop Drawings under Section 01300.

3.5 EQUIPMENT IDENTIFICATION

A. **General:** Equipment and devices shall be identified as follows:

1. Nameplates shall be provided for panelboards, control and instrumentation panels, starters, switches, and pushbutton stations. In addition to nameplates, control devices shall be equipped with standard collar-type legend plates.

2. Control devices within enclosures shall be identified as indicated. Identification shall be similar to the subparagraph above.

3. Toggle switches which control loads out of sight of switch and multi-switch locations of more than 2 switches shall have suitable inscribed finish plates.

4. Equipment names and tag numbers, where indicated on the Drawings, shall be utilized on nameplates.

5. The CONTRACTOR shall furnish typewritten circuit directories for panelboards; circuit directory shall accurately reflect the outlets connected to each circuit.

3.6 ELECTRICAL SUPPORT WORK

A. **General:** The CONTRACTOR shall provide all supervision, coordination, scheduling, equipment, material and labor for electrical support work including:

1. Receipt inspection of material.

2. Installation and termination of all equipment, devices, and panels.

3. Testing.

4. Inspection.

5. Maintenance prior to acceptance.

6. Operation prior to acceptance.

7. Storage prior to acceptance.

8. Handling prior to acceptance

9. Equipment start-up.

10. System start-up.

B. **Types of Support Work:** The CONTRACTOR shall furnish the following to turn over a safe fully operational electric plant to the OWNER:

1. Training.

2. Scheduling.

3. Supervision.

4. Communications.

5. Documentation.

6. Planning.

7. Coordination.

C. **Specific Requirements:** The CONTRACTOR shall follow supplier and manufacturer recommended installation, handling, storage, testing, inspection, and maintenance of all CONTRACTOR installed material in addition to the specific Contract Document requirements. Where the CONTRACTOR can not show in writing conformance with supplier and manufacturer written recommendations prior to acceptance, the CONTRACTOR is obligated to furnish the following:

1. The labor and material to complete all applicable inspections, maintenance, and tests as outlined under Appendix H in NFPA 70B-1998 (Long Term Maintenance Guidelines),

2. The labor and material to complete all applicable inspections, maintenance, and tests as outlined under International Electrical Testing Association Inc. (NETA) 2001 Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems,

3. The labor and material to meet all requirements as outlined under the requirements in Appendix I in NFPA 70B-1998 (Equipment Storage and Maintenance During Construction).

3.7 ADDITIONAL RESTORATION REQUIREMENTS

A. **General:** All holes and openings shall be sealed with weatherproof materials and finished to match existing.

3.8 FIELD INVESTIGATION

A. **General:** The CONTRACTOR shall provide a field investigation of existing as built facility documentation combined with a walk through of the site and building. The CONTRACTOR shall identify and mark potential interference's with conduit installations by noting locations of valve boxes, pullboxes, handholes, manholes, equipment, structures, conduit stubups, conduit entries, light fixtures, light poles, receptacle outlets, anode boxes, manholes, above ground pipes, ventilation ducts, pipe cleanouts, valve operators and drains. The CONTRACTOR shall meet with maintenance and operations personnel and obtain their input on potential interferences.

B. **Marking:** The CONTRACTOR shall carefully locate and mark expected interferences based on the previous field investigation identifying potential interferences.

C. **Timing:** The CONTRACTOR shall perform all of the field investigations to locate interferences prior to performing detailed construction engineering for any raceway and equipment installation.

3.9 DETAILED CONSTRUCTION ENGINEERING

A. **Requirement:** The CONTRACTOR shall provide the detailed construction engineering for the equipment, enclosures, raceway, wire layout, construction, and installation based on the Contract Documents, approved submittals, codes and standards of the day, existing field conditions and interfacing with other trades and coordinating with other subcontractor's and suppliers in the same facility. Details such as exact locations, wire/cable terminations, conduit fittings, additional pullboxes, enclosure modifications and supports and other construction engineering details shall be coordinated, laid-out, and planned and engineered by the CONTRACTOR in accordance with the Contract Documents and codes and standards of the day.

3.10 CLEANING

A. Before final acceptance, the electrical WORK shall be thoroughly cleaned. Exposed parts shall be thoroughly cleaned of cement, plaster, and other materials. Oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and cracks and corners scraped out. Touch-up paint shall be applied to scratches on panels and cabinets. Electrical cabinets or enclosures shall be vacuum-cleaned.

- END OF SECTION -

SECTION 16110 - ELECTRICAL RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide electrical raceway systems, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01300 - Contractor Submittals, and 16050 - Electrical Work, General.

B. Shop Drawings

1. Complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.

2. Dimensioned layout drawings of cable tray routings, including elevations.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with this Section.

2.2 CONDUIT

A. Rigid Aluminum (RAL) Conduits

1. Rigid aluminum conduit shall be manufactured of 6063 alloy, temper T-1.

2. Rigid aluminum conduit shall be manufactured in accordance with ANSI C80.5 - Rigid Aluminum Conduit, and UL-6 - Rigid Metal Electrical Conduit.

3. Manufacturers, or Equal

a. **V.A.W. of America;**

b. **Alcoa.**

B. Rigid Galvanized Steel (RGS) Conduit

1. Rigid steel conduit shall be mild steel, hot-dip galvanized inside and out.

2. Rigid steel conduit shall be manufactured in accordance with ANSI C80.1 - Rigid Steel Conduit, Zinc Coated, and UL-6.

3. Manufacturers, or Equal

a. **LTV Steel;**

b. **Triangle;**

c. **Wheatland Tube.**

C. Rigid Non-Metallic Conduit

1. Rigid non-metallic conduit shall be Schedule 40 PVC, sunlight resistant.

2. Rigid non-metallic conduit shall be manufactured in accordance with NEMA TC-2 - Electrical Plastic Tubing and Conduit, and UL-651 - Standard for Rigid Non-metallic Conduit.

3. Manufacturers, or Equal

a. **Carlon;**

b. **Condux.**

D. Rigid PVC Coated Galvanized Steel (RPGS) Conduit

1. The conduit, prior to PVC coating, shall meet the requirements for RGS conduit above.

2. A PVC coating shall be bonded to the outer surface of the galvanized conduit. The bond between the coating and the conduit surface shall be greater than the tensile strength of the coating. The inside surfaces and threads of the conduit shall have a 2-mil urethane coating.

3. PVC coating thickness shall be not less than 40 mils.

4. PVC coated RGS shall be manufactured in accordance with the following standards:

a. UL-6

b. ANSI C80.1

c. Federal Specification WW-C-581E.

d. NEMA RN1 - PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

5. Manufacturers, or Equal

a. Robroy;

b. Thomas & Betts.

E. Liquidtight Flexible Conduit

1. Liquidtight flexible conduit shall be constructed of a flexible galvanized metal core with a sunlight resistant thermoplastic outer jacket.

2. Liquidtight flexible conduit shall be manufactured in accordance with UL-360 - Steel Conduits, Liquid-Tight Flexible.

3. Manufacturers, or Equal

   a. **Anaconda, Sealtite;**

   b. **Electriflex, Liquatite.**

F. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

2.3 FITTINGS AND BOXES

A. General

1. Cast and malleable iron fittings for use with metallic conduit shall be the threaded type with 5 full threads.

2. Fittings and boxes shall have neoprene gaskets and non-magnetic stainless steel screws. Covers shall be attached by means of holes tapped into the body of the fitting. Covers for fittings attached by means of clips or clamps will not be acceptable.

3. Boxes larger than standard cast or malleable types shall be 304 stainless steel, NEMA 4X.

4. In outdoor areas, conduit shall be terminated in raintight hubs as manufactured by **Myers, O.Z. Gedney, Appleton,** or equal. In other than outdoor areas, sealed locknuts and bushings shall be used.

5. Conduit, fittings, and boxes in hazardous locations shall be suitable for the Class and Division indicated.

B. Cast Aluminum Fittings and Boxes

1. Cast aluminum boxes and fittings shall have less than 0.40 percent copper content and shall be utilized with aluminum conduit.

2. Manufacturers, or Equal

   a. **O.Z. Gedney;**

   b. **Appleton;**

   c. **Crouse-Hinds.**

C. Malleable Iron Fittings and Boxes

1. Fittings and boxes for use with galvanized steel conduit shall be of malleable iron or gray-iron alloy with zinc plating.

2. Manufacturers, or Equal

   a. O.Z. Gedney;

   b. Crouse-Hinds;

   c. **Appleton.**

D. PVC Fittings and Boxes

1. Fittings for use with rigid non-metallic conduit shall be PVC, solvent welded type.

2. Boxes shall be PVC or fiberglass reinforced polyester (FRP).

3. Manufacturers, or Equal

   a. **Carlon;**

   b. **Crouse-Hinds;**

   c. **Hoffman.**

4. Provide welding solvent as required for installation of non-metallic conduit and fittings.

E. PVC Coated Fittings

1. Fittings for use with PVC coated RGS shall be PVC coated and shall be products of the same manufacturer as the conduit.

2. Male and female threads and internal surfaces shall have a 2-mil urethane coating.

F. Stainless Steel Boxes

1. Stainless steel boxes shall be used with PVC coated RGS conduit and where indicated.

2. Stainless steel boxes shall be NEMA 4X, Type 316.

3. Stainless steel shall be minimum 14-gauge thickness, with a brushed finish.

4. Doors shall have full length stainless steel piano hinges. Non-hinged boxes are not acceptable.

5. Manufacturers, or Equal

   a. **Hoffman;**

   b. **Rohn;**

   c. **Hammond;**

G. Sheet Steel Boxes

1. Sheet steel boxes shall be galvanized steel outlet and switch boxes.

2. Manufacturers, or Equal

   a. **Raco;**

   b. **Steel City;**

   c. **Appleton Electric.**

2.4 CABLE TRAYS

A. Cable tray systems shall be composed of straight sections, fittings, and accessories as defined in the latest NEMA Standards publication VE-1 - Ventilated Cable Tray.

1. The cable tray and fittings shall be stainless steel.

2. Cable tray shall be ladder type with 6-inch spacing. Tray sizes shall have 6-inch minimum usable load depth or as indicated.

3. Loading capacities shall meet NEMA weight classification with a safety factor of 1.5.

4. In corrosive locations, cable trays shall be stainless steel.

5. Cable trays and fittings shall be as manufactured by **Husky, B-Line, T.J. Cope**, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Wiring shall be run in raceway unless indicated otherwise.

B. Raceways shall be installed between equipment as indicated. Raceway systems shall be electrically and mechanically complete before conductors are installed. Bends and offsets shall be smooth and symmetrical, and shall be accomplished with tools designed for this purpose. Factory elbows shall be utilized wherever possible.

C. Where raceway routings are indicated on plan views, follow those routings to the extent possible.

D. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routings shall be the CONTRACTOR's choice and in strict accordance with the NEC and customary installation practice. Raceway shall be encased, exposed, concealed, or under floor as indicated, except that conduit in finished areas shall be concealed unless specifically indicated otherwise.

E. Routings shall be adjusted to avoid obstructions. Coordinate between trades prior to installation of raceways. Lack of such coordination shall not be justification for extra compensation, and removal and re-installation to resolve conflicts shall be by the CONTRACTOR as part of the WORK.

F. Support rod attachment for ceiling-hung trapeze and cable tray installations shall meet the seismic requirements in the area where the project is located.

G. Exposed raceways shall be installed parallel or perpendicular to structural beams.

H. Install expansion fittings with bonding jumpers wherever raceways cross building expansion joints.

I. Exposed raceways shall be installed at least 1/2-inch from walls or ceilings except that at locations above finished grade where damp conditions do not prevail, exposed raceways shall be installed 1/4-inch minimum from the face of walls or ceilings by the use of clamp backs or struts.

J. Wherever contact with concrete or dissimilar metals can produce galvanic corrosion of equipment, suitable insulating means shall be provided to prevent such corrosion.

3.2 CONDUIT

A. Exposed conduit shall be rigid galvanized steel except as follows, unless indicated otherwise:

1. In areas with chlorine or hydrofluosilicic acid, schedule 40 PVC shall be utilized.

2. In lime or ferric chloride areas, PVC coated RGS shall be utilized.

3. In Class I, Div. I or Div. II hazardous locations, rigid aluminum conduit shall be utilized.

B. Conduit concealed, buried, or encased in concrete, except for analog control conduit which shall be PVC-coated RGS, shall be Schedule 40 PVC. Where conduit emerges from concrete encasement, a PVC coated RGS elbow shall be utilized for transition from the concrete. Conduit shall emerge from the concrete perpendicular to the surface whenever possible.

C. Exposed conduit shall be 3/4-inch minimum trade size. Encased conduit shall be one-inch minimum trade size. Supports shall be installed at distances required by the NEC.

D. Conduit shall not be encased in the bottom floor slab below grade.

E. Concrete cover for conduit and fittings shall not be less than 1-1/2 inches for concrete exposed to earth or weather, or less than 3/4-inch for concrete not exposed to weather or in contact with the ground.

F. Conduits passing through a slab, wall, or beam shall not impair significantly the strength of the construction.

G. Conduits embedded within a slab, wall, or beam (other than those merely passing through) shall satisfy the following:

1. Conduits with their fittings embedded within a column shall not displace more than 4 percent of the gross area of cross section.

2. Conduits shall not be larger in outside dimension than one third the overall thickness of slab, wall, or beam in which embedded.

3. Conduits shall not be spaced closer than 3 outside diameters on centers.

H. Conduit shall be placed so that cutting, bending, or displacing reinforcement from its proper location will not be required.

I. Threads shall be coated with a conductive lubricant before assembly.

J. Joints shall be tight, thoroughly grounded, secure, and free of obstructions in the pipe. Conduit shall be adequately reamed to prevent damage to the wires and cables inside. Strap wrenches and vises shall be used to install conduit to prevent wrench marks on conduit. Conduit with wrench marks shall be replaced.

K. Wherever possible, conduit runs shall slope to drain at one or both ends of run. Wherever conduit enters substructures below grade, the conduit shall be sloped to drain water away from the structure. Extreme care shall be taken to avoid pockets or depressions in conduit.

L. Installation of rigid steel conduit though a core-drilled hole in an exterior wall below grade shall utilize a sealing device as manufactured by **Link Seal** or equal.

M. Connections to lay-in type grid lighting fixtures shall be made using flexible metal conduit not exceeding 4-feet in length. Connections to motors and other equipment subject to vibration shall be made with liquid-tight flexible conduit not exceeding 3-feet in length. Equipment subject to vibration that is normally provided with wiring leads shall be provided with a cast junction box for the make-up of connections.

N. Conduit passing through walls or floors shall have plastic sleeves. Core drilling shall be performed in accordance with Section 16050.

O. Provide conduit seal fittings at the following locations:

1. In hazardous classified locations, in strict accordance with the NEC.

2. In chlorine, ammonia, sulfur dioxide, and hydrofluosilicic acid areas to prevent passage of gases to other areas.

P. Conduit, fittings, and boxes required in hazardous classified areas shall be suitably rated for the area and shall be provided in strict accordance with NEC requirements.

Q. Empty conduits shall be tagged at both ends to indicate the final destination. Where it is not possible to tag the conduit, destination shall be identified by a durable marking on an adjacent surface. A pull-cord shall also be installed in each empty conduit. This shall apply to conduits in floors, panels, manholes, equipment, etc.

3.3 CABLE TRAYS

A. Provide cable trays in strict accordance with the manufacturer's printed instructions. Allowable cable fill areas shall meet NEC Article 318 - Cable Trays requirements. Verify cable tray fills prior to installation based on cables and trays actually provided.

B. Maintain continuous grounding of cable trays including bonding jumpers in accordance with NEC Article 318.

C. Install cable trays using hangers and supports on 8-foot centers, maximum.

- END OF SECTION -

SECTION 16111 - UNDERGROUND RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide underground raceway systems, complete and in place, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01300 - Contractor Submittals, and 16050 - Electrical Work, General.

B. Shop Drawings

1. Complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable to show proposed materials and finishes.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Manholes, pullboxes and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

2.2 MANHOLES AND PULLBOXES

A. Manholes and pullboxes shall be precast with construction and load rating as indicated.

1. Covers shall be traffic type, H-20 loading, except as indicated otherwise. Manhole and pullbox covers shall be identified as "Electric" by raised letters cast into the covers. Manhole frames and covers shall be **Neenah Foundry No. R-1755-G** or equal.

2. Manholes and pullboxes shall have frost-proof and water-tight grey iron frames and covers with solid lids and inner lids with 28-inch clear openings. Covers and lids shall be bolted to cast-in-place steel frames with corrosion resistant hardware. Frames shall be factory-primed; covers shall be cast-iron and shall have pick-holes.

B. Manholes and pullboxes shall be equipped with pulling-in irons opposite and below each ductway entrance.

C. PVC ductbank conduits shall be provided with end bells. Brackets, **Unistrut Cat. No. P2515** or equal and 60-inch concrete inserts, **Unistrut Cat. NO. P3261** or equal, shall be provided in manholes as required for racking wiring through manholes.

D. Precast manholes and pullboxes shall be **Brooks Mack, Quikset, U.S. Precast**, or equal. Cast-iron covers shall be by **U.S. Foundry,** or equal.

2.3 DUCTBANKS

A. Underground ducts shall be Schedule 40 PVC.

B. Ducts shall be encased in red-dyed concrete with steel reinforcing bars. Concrete shall have 3,000 psi compressive strength conforming to Section 03300. Colorant shall be an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete. Concrete shall be dyed red throughout the ducts. Surface treatment will not be accepted. The costs, if any, of cleaning coloring pigment from the concrete delivery equipment and other related cleanings shall be included in the Bid.

C. Ductbanks shall contain a No. 4/O bare stranded copper ground wire. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and grounding grid electrodes including ground rings and ground rods.

D. **Identification Tape:** Continuous lengths of underground warning tapes shall be installed 12-inches above and parallel to all ductbanks. Tape shall be 6-inches wide polyethylene film imprinted "CAUTION - ELECTRIC UTILITIES BELOW." Tape shall be as manufactured by **Brady,** or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Underground raceways shall be installed between manholes and pullboxes as indicated. Raceway systems shall be electrically and mechanically complete before conductors are installed. Bends and offsets shall be smooth and symmetrical, and shall be fabricated with tools designed for this purpose. Factory elbows shall be utilized wherever possible.

B. Raceway routings on plan views shall be followed to the extent possible.

C. Routings shall be adjusted to avoid obstructions. Coordinate the trades prior to installation of raceways. Lack of coordination shall not be justification for extra compensation, and removal and re-installation to resolve conflicts shall be performed by the CONTRACTOR as part of the WORK.

3.2 DUCTBANKS

A. Ductbanks shall be installed in accordance with the criteria below:

1. Duct shall be assembled using high impact non-metallic spacers and saddles to provide conduits with vertical and horizontal separation. Plastic spacers shall be set every 5-feet. The duct array shall be anchored every 5-feet to prevent movement during placement of concrete.

2. The duct shall be laid on a grade line of at least 3 inches per 100-feet, sloping towards pullboxes or manholes. Duct shall be installed and pullbox and manhole depths adjusted so that the top of the concrete envelope is a minimum of 18 inches below grade and a minimum of 24 inches below roadways.

3. Changes in direction of the duct envelope by more than 10 degrees horizontally or vertically shall be accomplished using bends with a minimum radius 24 times the duct diameter.

4. Duct couplings shall be staggered a minimum of 6 inches.

5. The bottom of trench shall be of select backfill or sand.

6. Each bore of the completed ductbank shall be cleaned by drawing through it a standard flexible mandrel one foot long and 1/4-inch smaller than the nominal size of the duct. After passing of the mandrel, a wire brush and swab shall be drawn through.

7. Spare raceways that are not indicated to contain conductors shall have a 1/8-inch polypropylene pull cord installed throughout the entire length of the raceway.

B. Duct entrances shall be grouted smooth; ducts shall be terminated with flush end bells. Sections of pre-fabricated manholes and pullboxes shall be assembled with waterproof mastic and shall be set on a 12-inch bed of gravel as recommended by the manufacturer or as required by field conditions.

C. Ductbank penetration through walls of manholes, pullboxes, and building walls below grade shall be watertight.

D. Concrete encased ductbank shall terminate at building foundations. When duct enters the building on a concrete slab on grade, duct shall not be encased, but shall transition to rigid steel PVC-coated conduits on all stub-ups.

E. Where an underground conduit enters a structure through a concrete roof or a membrane waterproofed wall or floor, provide a **Link-Seal**, or equal sealing device. The sealing device shall be utilized with rigid steel conduit. Transition from PVC to rigid steel conduit prior to building entry.

- END OF SECTION -

SECTION 16120 - WIRE AND CABLE

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01300 - Contractor Submittals and 16050 - Electrical Work, General.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Conductors, include grounding conductors, shall be copper. Aluminum conductor wire and cable will not be permitted. Insulation shall bear UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.

2.2 LOW VOLTAGE WIRE AND CABLE

A. Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be Class B Type XHHW-2 cross-linked polyethylene conforming to UL-44 - UL Standard for Thermoset-Insulated Wires and Cables. THHN/THWN wire shall not be permitted to be used for any power or control wiring in this project, except as specifically permitted within control panels per Section 17200 - Control Panels.

2. As a minimum, conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent. If larger conductors are indicated the larger conductors shall be furnished, installed and connected.

3. As a minimum, conductors for branch circuits as defined in Article 100 of the NEC, shall be sized to prevent voltage drop exceeding 3 percent at the farthest connected load or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent. If larger conductors are indicated the larger conductors shall be furnished, installed and connected.

4. Wiring for 600 volt class power and lighting shall be as manufactured by **General Cable, Okonite**, or **Southwire**.

B. Control Wire

1. Control wire in duct or conduit shall be the same type as power and lighting wire indicated above.

2. Control wiring shall be No.14 AWG.

3. Control wires at panels and cabinets shall be machine tool grade type MTW, UL approved, rated for 90 degrees C at dry locations, and be as manufactured by **American, Carol Cable,** or equal.

C. Instrumentation Cable

1. Instrumentation cable shall be rated at 600 volts.

2. Individual conductors shall be No. 16 AWG stranded, tinned copper. Insulation shall be color coded polyethylene: black-red for 2 conductor cable and black-red-white for 3 conductor cable.

3. Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 18 AWG stranded tinned copper drain wire, and a PVC outer jacket with a thickness of 0.048 inches.

4. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 9342,** or equal.

5. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 1119A,** or equal.

D. Tray Cable

1. Multi-conductor tray cable shall be rated 600 volts, listed by UL as Type TC cable per Article 340 of the NEC. The individual conductors shall be UL listed as Type XHHW-2, with a sunlight-resistant overall jacket.

2. Conductor sizes shall be the same as for power and lighting wire and control wire above.

2.3 MEDIUM VOLTAGE CABLE

A. General

1. Individual conductors shall be copper, Class B, stranded.

B. 5 KV Cable

1. Cable used in conduit or duct shall be composed of a single conductor, ethylene-propylene rubber (EPR) insulation rated at 105 degrees C, shield, and black polyvinyl chloride (PVC) jacket. Insulation level shall be 133 percent, 115 mil. Shield shall be copper tape type, or corrugated drain wire type **Unishield** as manufactured by **General Cable**. Cable shall be UL Type MV-105 in accordance with UL 1072 and ICEA-S-93-639/NEMA-WC74 - Medium Voltage Power Cables, as manufactured by **General Cable, Okonite,** or **Southwire**.

2. Tray cable shall be composed of one or 3 conductors, a copper grounding conductor, ethylene-propylene rubber (EPR) insulation rated at 90 degrees C, interlocked aluminum armor, and yellow PVC outer jacket. Insulation level shall be 133 percent, 115 mil. Tray cable shall be UL Type MV-90 in accordance with UL 1072 and ICEA-S-96-639/NEMA-WC74 as manufactured by **General Cable, Okonite,** or **Southwire.**

C. 15 KV & 25 KV Cable

1. Cable used in conduit or duct shall be composed of a single conductor, ethylene-propylene rubber (EPR) insulation rated at 105 degrees C, shield and black polyvinyl chloride (PVC) outer jacket. Insulation level shall be 133 percent. Shield shall be copper tape type, corrugated drain wire type **Unishield** as manufactured by **General Cable.** Cable shall be UL Type MV-105 in accordance with UL 1072 and ICEA-S-93-639/NEMA-WC74 as manufactured by **General Cable, Okonite,** or **Southwire.**

2.4 CABLE TERMINATIONS

A. Compression connectors shall be **Burndy "Hi Lug", Thomas & Betts "Sta-Kon,",** or equal. Threaded connectors shall be split bolt type of high strength copper alloy. Pressure type, twist-on connectors will not be acceptable.

B. Pre-insulated fork tongue lugs shall be **Thomas & Betts, Burndy,** or equal.

C. General purpose insulating tape shall be **Scotch No. 33, Plymouth "Slip-knot",** or equal. High temperature tape shall be polyvinyl as manufactured by **Plymouth, 3M,** or equal.

D. Labels for coding 600 volt wiring shall be computer printable or pre-printed, self-laminating, self-sticking, as manufactured by **W.H. Brady, 3M,** or equal.

E. Stress cone material for make-up of medium voltage shielded cable shall be as manufactured by **Raychem, 3M,** or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall provide and terminate power, control, and instrumentation conductors except where indicated.

3.2 INSTALLATION

A. Conductors shall not be pulled into raceway until raceway has been cleared of moisture and debris.

B. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

C. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.

D. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be fanned out to terminals.

E. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

3.3 SPLICES AND TERMINATIONS

A. General

1. Wire taps and splices shall be properly taped and insulated according to their respective classes.

2. In general, there shall be no cable splices in underground manholes or pullboxes. If splices are necessary, the cables shall be brought aboveground and terminated in a NEMA 4X stainless steel terminal or splice cabinet on a concrete pad. Splices in underground manholes and pullboxes may be made only with the approval of the ENGINEER.

3. Stranded conductors shall be terminated directly on equipment box lugs making sure that conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.

4. Excess control and instrumentation wire shall be properly taped and terminated as spares.

B. Control Wire and Cable

1. Control conductors shall be spliced or terminated only at the locations indicated and only on terminal strips or terminal lugs of vendor furnished equipment.

2. In junction boxes, motor control centers, and control panels, control wire and spare wire shall be terminated to terminal strips.

C. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system.

2. Two and 3 conductor shielded cables installed in conduit runs which exceed available standard cable lengths may be spliced in pullboxes. Such cable runs shall have only one splice per conductor.

D. Power Wire and Cable

1. 120/208-volt, 120/240-volt, and 480/277-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR. Cables rated above 2,000 volts shall be spliced or terminated only at equipment terminals indicated.

2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape overtaped with a minimum of 2 layers of high temperature tape.

3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.

3.4 CABLE IDENTIFICATION

A. **General:** Wire and cable shall be identified for proper control of circuits and equipment and to reduce maintenance effort.

B. **Identification Numbers:** The CONTRACTOR shall assign to each control and instrumentation wire and cable a unique identification number. Numbers shall be assigned to conductors having common terminals and shall be shown on "as built" drawings. Identification numbers shall appear within 3 inches of conductor terminals. "Control Conductor" shall be defined as any conductor used for alarm, annunciator, or signal purposes.

1. Multiconductor cable shall be assigned a number which shall be attached to the cable at intermediate pull boxes and at stub-up locations beneath free-standing equipment. It is expected that the cable number shall form a part of the individual wire number. Individual control conductors and instrumentation cable shall be identified at pull points as described above. The instrumentation cable numbers shall incorporate the loop numbers assigned in the Contract Documents.

2. 120/208-volt system feeder cables and branch circuit conductors shall be color coded as follows: Phase A - black, Phase B - red, Phase C - blue, and Neutral - white. The 120/240-volt system conductors shall be color coded as follows: Line 1 - Black, Line 2 - Red, and Neutral - White. The 480/277-volt system conductors shall be color coded as follows: Phase A - Brown, Phase B - Orange, Phase C - Yellow, and Neutral - Gray. Color coding tape shall be used where colored insulation is not available. Branch circuit switch shall be yellow. Insulated ground wire shall be green, and neutral shall be gray. Color coding and phasing shall be consistent throughout the Site, but bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs.

3. General purpose AC control cable shall be red. General purpose DC control cable shall be blue.

4. Spare cable shall be terminated on terminal screws and shall be identified with a unique number as well as with destination.

5. Terminal strips shall be identified by computer printable, cloth, self-sticking marker strips attached under the terminal strip.

3.5 TESTING

A. **Cable Assembly and Testing:** Cable assembly and testing shall comply with applicable requirements of ICEA Publication No. S-68-516 - Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy. Factory test results shall be submitted in accordance with Section 01300 prior to shipment of cable. The following field tests shall be the minimum requirements:

1. Insulation resistance testing, using a DC megohmeter, shall be performed on cables operating at more than 2,000 volts to ground. Time-resistance readings shall be

taken and recorded at intervals of 30 seconds and one minute. Time-resistance voltage levels shall be per the cable manufacturer's recommendations.

2. Power cable rated at 600 volts shall be tested for insulation resistance between phases and from each phase to a ground using a megohmeter.

3. Field testing shall be done after cable is installed in the raceways.

4. Field tests shall be performed by a certified test organization acceptable to the cable manufacturer. Test results shall be submitted to the ENGINEER for review and acceptance.

5. Cables failing the tests shall be replaced with a new cable or be repaired. Repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry.

B. **Continuity Test:** Control and instrumentation cable shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing cable in service.

- END OF SECTION -

SECTION 16140 - WIRING DEVICES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide wiring devices, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 16050 – Electrical Work, General apply to this Section.

C. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. Shop Drawings

1. Complete catalog cuts of switches, receptacles, enclosures, covers, and appurtenances, marked to clearly identify proposed materials.

2. Documentation showing that proposed materials comply with the requirements of NEC and U.L.

3. Documentation of the manufacturer's qualifications.

PART 2 -- PRODUCTS

2.1 GENERAL

A. All devices shall carry the UL label.

B. General purpose duplex receptacles and toggle switch handles shall be brown everywhere except in finished rooms where they shall be ivory. Special purpose receptacles shall have a body color as indicated. Receptacles and switches shall be specification grade and conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

2.2 LIGHTING SWITCHES

A. Local branch switches shall be toggle type, rated at 20 amperes, 120-277 vAC, and shall be **General Electric Cat. No. GE-5951-1** for single pole, **GE-5953-1** for 3-way and **GE-5954-1** for 4-way, or similar types as manufactured by **Hubbell, Leviton,** or equal.

B. Switches for hazardous locations shall be factory sealed, rated at 20 amperes, 120-277 vAC, capable of controlling 100 percent tungsten filament, fluorescent and HID lamp loads and shall be as manufactured by **Crouse-Hinds**, **Appleton,** or **Killark.**

2.3 GENERAL PURPOSE RECEPTACLES

A. Duplex receptacles rated 125 V, 20 amperes shall be polarized 3 wire type for use with 3 wire cord with grounded lead and 1 designated stud shall be permanently grounded to the conduit system (NEMA 5-20R). Duplex 120 V receptacles shall be **G.E. 5362, Hubbell 5362,** or equal. Single receptacles shall be **G.E. 4102, Hubbell 4102,** or equal.

B. Ground-fault circuit interrupting receptacles (GFCI's) shall be installed at the locations indicated and as required by the NEC. GFCI's shall be duplex, specification grade, tripping at 5 mA. Ratings shall be 125 V, 20 amperes, NEMA WD-1, Configuration 5-20R, capable of interrupting 5,000 amperes without damage. Feed-through type GFCI's serving standard receptacles will not be permitted. GFCI's shall be as manufactured by **Hubbell, Bryant, Leviton,** or equal.

C. Receptacles for hazardous locations shall be single gang receptacles with spring door. Receptacles shall have a factory sealed chamber. The receptacles shall have a delayed action feature requiring the plug to be inserted in the receptacle and rotated before the electrical connection is made. The receptacle shall not work with non-hazardous rated plugs. One plug shall be furnished with each receptacle. The receptacles shall be rated for 20 amps at 125 VAC. Hazardous location receptacles shall be **Appleton EFSB, Crouse-Hinds ENR,** or equal.

D. Where indicated, hazardous location receptacles shall be provided with ground fault protection. Ground fault protection shall be **Appleton EFSR-GFI, Crouse-Hinds GFS-1,** or equal.

2.4 FLOOR RECEPTACLE BOXES

A. Floor receptacles and jacks shall be installed in rectangular floor boxes. Floor boxes shall be 1, 2, or 3 gang as required for each installation. Floor boxes shall be cast iron and sized for the depth of the floor slab. Carpet flanges shall be provided. Covers shall be brass, with openings for a duplex receptacle voice and data jacks. Floor boxes shall be **Hubbell** or equal.

2.5 ENCLOSURES AND COVERS

A. Surface mounted switches and receptacles shall be in FS or FD type weatherproof conduit fittings.

B. Switch and receptacle covers on surface mounted boxes shall be die cast copper-free aluminum.

C. In finished areas, switch and receptacle boxes shall be provided with SUPER STAINLESS STEEL COVERS as manufactured by **Harvey Hubbell, Arrow Hart, Bryant,** or equal.

D. In areas where cast boxes are used, switch and receptacle covers shall be **Crouse-Hinds Catalogue No. DS185 and WLRD-1, or Adalet No. WSL** and **WRD,** or equal.

E. Receptacles in wet locations shall be with a hinged cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed." There shall be a gasket between the enclosure and the mounting surface and between the hinged cover and mounting plate/base. The cover shall be **TayMac Specification Grade**, or equal.

2.6 WELDING RECEPTACLES

A. Welding receptacles shall be rated 60 amperes, 600 vAC, three wire, four pole, heavy duty circuit breaking type, complete with outlet box and be connected for 480 volt service. A matching plug shall also be furnished for each three receptacles. The outlets shall be **Crouse Hinds "Arktite" ARE-6424,** with plug **APJ-6485.**

2.7 RECEPTACLE – TRANSIENT VOLTAGE SURGE SUPPRESSOR (TVSS)

A. Transient voltage surge suppressors shall be duplex style, rated for 80 joules (minimum) of energy absorption in each of three modes. Units shall be rated 125 volts AC, sized for installation in 2-inch by 4-inch outlet boxes, and as manufactured by **Arrow Hart, Pass & Seymour,** or **Hubbell.**

2.8 RECEPTACLE – SPECIAL PURPOSE

A. Special purpose receptacles shall have ratings and number of poles as indicated or required for anticipated purpose.

B. Matching plug with cord-grip features shall be provided with each special-purpose receptacle.

2.9 NAMEPLATES

A. Provide nameplates or equivalent markings on switch enclosures to indicate ON and OFF positions of each switch. ON and OFF for 3-way or 4-way switches is not acceptable. Provide receptacles for special purposes with nameplates indicating their use. Conform to requirements of Section 16050.

PART 3 -- EXECUTION

3.1 GENERAL

A. Perform work in accordance with the National Electrical Code.

3.2 CONNECTION

A. Rigidly attach wiring devices in accordance with National Electrical Code, and as indicated, avoiding interference with other equipment.

B. Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.

3.3 GROUNDING

A. Ground all devices, including switches and receptacles, in accordance with NEC, ART 250, and Section 16450 - Grounding.

B. Ground switches and associated metal plates through switch mounting yoke, outlet box, and raceway system.

C. Ground flush receptacles and their metal plates through positive ground connections to outlet box and grounding system. Maintain ground to each receptacle by spring-loaded

grounding contact to mounting screw or by grounding jumper, each making positive connection to outlet box and grounding system at all times.

3.4 FIELD TESTING

A. Provide checkout, field, and functional testing of wiring devices in accordance with Section 16050.

B. Test each receptacle for polarity and ground integrity with a standard receptacle tester.

- END OF SECTION -

SECTION 16400 – SWITCHBOARDS, CB'S AND ATS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide electrical service sections, distribution switchboards, special control panels, control and terminal cabinets, control devices, circuit breakers (CB's), and all appurtenant work, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 16050 - Electrical Work, General, apply to the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of other requirements of these specifications, all WORK herein shall conform to or exceed the applicable requirements of the National Electrical Code (NEC); provided, that where a local code or ordinance is in conflict with the NEC, the provisions of said local code or ordinance shall take precedence.

B. Codes

NEC	National Electrical Code

C. Commercial Standards

NEMA std PB-2	Dead-Front Distribution Switchboards
UL 891	Dead-Front Switchboards
ANSI/NEMA ICS-2	Devices, Controllers, and Assemblies for Industrial Control
ANSI/UL 1008	Automatic Transfer Switches, Safety Standard for
IEEE	Institute of Electrical and Electronic Engineers
NFPA	National Fire Protection Association
UL	Underwriters' Laboratories, Inc.

1.3 QUALITY ASSURANCE

A. **General:** All materials shall be inspected for compliance with Section 16050 and shall be tested per Section 16950 - Electrical Tests.

B. **Factory Tests:** Design test reports conducted on similar assemblies at the factory testing facilities shall be submitted.

1.4 WARRANTY

A. The system warranty shall be no less than one year after initial startup and shall include all costs for repair, parts, travel and living expenses, and labor.

1.5 OPERATION AND MAINTENANCE

A. The CONTRACTOR shall submit operation and maintenance procedures for the ENGINEER's review. The data sheets shall be supplemented by written text and shall include the following:

1. Operating procedures.

2. Maintenance procedures.

3. Manufacturers parts list, illustrations, assemblies, and diagrams.

1.6 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit Shop Drawings of the service section and switchboards in accordance with the requirements for of Section 01300 - Contractor Submittals.

B. After review by the ENGINEER, the Shop Drawings of the service section shall be submitted to the utility company for approval prior to fabrication.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Materials:** All materials and equipment provided under this Specification shall be new; they shall be in accordance with the requirements of the Institute of Electrical and Electronic Engineers ,the National Electrical Manufacturer's Association, the National Fire Protection Association, and the National Electrical Code. Where available, all materials and equipment shall bear the Underwriters' Laboratories label.

B. **Equipment:** All equipment for the same purpose shall be of the same make.

C. **Enclosure Requirements:** All outdoor equipment, fixtures, and wiring devices shall be of approved, weatherproof construction.

D. **Standard Products:** Materials and equipment submitted for approval shall be the cataloged products of companies regularly engaged in the manufacture of such items, of the latest standard design that conforms to the specification requirements, and shall essentially duplicate material and equipment that has been in satisfactory use for several years.

2.2 SWITCHBOARD

A. Indoor construction shall be of the universal frame type using die-formed welded and bolted members. Enclosing panels shall be 14-gauge steel, bolted in place. In addition, indoor construction shall conform to the following:

1. Switchboard shall be totally enclosed, NEMA 1, gasketed.

2. Bus bar shall be copper fully insulated. Copper shall be silver plated at joints. Bus bars shall be braced for short circuits of 65,000 amperes minimum, or more if so indicated on the Drawings. A full length copper ground bus bar shall be provided at the bottom of the switchboard enclosure.

B. Outdoor construction shall be as described in the previous paragraph, except that switchboard installation shall be rodent- and bird-proof. Outdoor switchboard construction shall be NEMA 3, non-walk-in type but sufficient enclosed aisle space shall be provided to allow draw-out circuit breakers to be withdrawn to the "test" position with the outer door closed. An insulating compound shall be applied to the interior surface of roof panels for condensation control.

C. Floor-standing distribution switchboards, and main service switchboard, shall be cataloged products of the main circuit breaker manufacturer. Switchboard shall be shipped fully assembled and tested.

2.3 MAIN SERVICE SWITCHBOARD

A. **General:** The main service switchboard shall consist of a freestanding assembly that complies with the Contract Documents, with particular reference to the provisions of the above paragraph entitled, "Switchboard."

B. **Switchboard:** Switchboards shall be front-accessible only. Switchboards shall be constructed to accommodate additional distribution sections. The switchboards shall consist of the sections described in the following paragraphs.

C. **Service Section:** The service section shall consist of an underground pull compartment and a revenue metering compartment all to utility requirements. Components such as pull boxes, meter bases, busses, lugs, and auxiliaries shall be furnished. Integration with automatic transfer switches and other components shall be furnished, installed and connected as a complete package as indicated.

D. **Main Circuit Breaker Compartment:** The main circuit breaker compartment's circuit breaker unit shall have the ratings indicated. Service neutral shall be brought to a terminal in the main circuit breaker compartment. A disconnecting link shall be provided in a bus bar connection between the neutral terminal and the switchboard ground bus.

1. The circuit breaker shall have protective features with capability of selective tripping which can be used to provide overcurrent protection from overloads, short circuits, and ground faults. Additionally, local and remote signaling of overloads or actual fault conditions that have caused the breaker to trip shall be provided.

2. Furnish, install and connect an automatic transfer switch rated for service entrance service where indicated that is fully integrated with the switchboard.

E. The circuit breaker shall be individually mounted stationary of the size and type indicated. Furnish, install and connect an automatic transfer switch rated for service entrance service where indicated that is fully integrated with the switchboard.

F. **Distribution Section:** The distribution section shall consist of stationary mounted molded case circuit breakers of the size indicated. A full length vertical bus shall be provided for each distribution section. The rating shall be 300-amperes, or more where indicated.

2.4 SWITCHBOARD METERING INSTRUMENTS

A. **Electronic Meter and Analyzing Panels (EMAP):** EMAP's shall be of the following type and manufacture, or equal:

1. Furnish, install and connect solid state metering as indicated. EMAP's shall be **G.E. "PQM, Cutler-Hammer "IQ Analyzer"** or equal.

B. The instrument transformer shall comply with ANSI/IEEE C37.20 and shall have utility grade metering accuracy with the burdens imposed. Mechanical and thermal ratings of current transformers shall be coordinated with short circuit ratings of related circuit breakers. Potential transformers shall be mounted on a disconnecting rack and shall have primary fuse protection.

2.5 AUTOMATIC TRANSFER SWITCHES

A. **Automatic Transfer Switch:** The automatic transfer (AT) switch shall be a 3-pole, double-throw, with a definite neutral position; rated at 480 volts, with the continuous current rating shown. The AT switch shall be able to withstand the short circuit currents indicated or shall have the same withstand rating as the switchboard in which it is installed. The load terminals of the AT switch shall be de-energized when the AT switch is in the neutral position; The duration of the neutral position shall be adjustable from zero to 30 seconds. The AT switch shall comply with requirements of ANSI/UL 1008 and ANSI/NEMA ICS-2.

B. The AT switch shall be manually operable but the manual operating mechanism shall be declutched when the electric operator becomes energized. Mechanical and electrical interlocks shall be provided to prevent simultaneous closure of the normal and emergency positions.

C. The automatic transfer switch shall include integrated controls featuring solid state timing and sensing relays. Protective features and indicators shall include:

1. Three-phase, close-differential undervoltage protection on the Normal source; dropout shall be adjustable from 80-85 percent; pick-up shall be adjustable from 90-95 percent.

2. Engine start and run contact closure; contact closure shall be adjustable from zero to 120 seconds after failure of the Normal source is detected. The engine run contact shall remain closed for an adjustable period of zero to 5 minutes (cool down period) after the load has been transferred back to the normal source.

3. Circuitry shall be provided to prevent transfer to the Emergency source until Emergency source voltage and frequency are within 90 percent of nominal values.

4. Adjustable time delay of retransfer of up to 10 minutes after the voltage of the Normal source has attained the pick-up setting specified in the foregoing Item No. 1 on all phases.

5. The automatic transfer switch shall be equipped with indicator lamps for the Normal and Emergency positions. Two "dry" contacts shall be provided for the Emergency position two "dry" contacts for the neutral position and two "dry" contacts for the Normal position; said contacts shall be wired to identified terminals.

6. Three-position selector switch: TEST-OFF-AUTO ; the AUTO position shall cause engine start-up, transfer, and retransfer of the load on failure and subsequent restoration of the Normal source. The TEST position shall simulate failure of the Normal source for however long the switch is in the Test position.

D. The automatic transfer switch shall be as manufactured by **Cutler-Hammer** or equal.

2.6 OVERCURRENT PROTECTIVE DEVICES

A. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal, magnetic, non-interchangeable, trip-free, sealed trip units. The breaker contact material shall be a non-weldable silver alloy. The breakers shall have arc-extinguishing chutes. Ground fault tripping, where required, shall be as required below.

B. Circuit breakers with a frame size of 225 amperes to 250 amperes shall be molded case with interchangeable thermal and adjustable magnetic trip elements

C. Circuit breakers with a frame size more than 250 amperes shall be molded case as described above. Molded case circuit breakers shall have an integral, RMS sensing solid state over-current trip unit and line current sensors. Trip units shall have adjustable long time tripping in the range of 60 to 100 percent of continuous rating, instantaneous tripping adjustable in the range of 300 to 1000 percent of continuous rating, and ground fault tripping adjustable in the range of 20 to 60 percent of continuous rating, with adjustable delay of approximately 5 to 40 cycles.

D. Minimum circuit breaker interrupting rating shall be 65 kAIC or as indicated which ever is higher for circuit breakers applied to circuits having voltages to ground exceeding 150 VAC. Minimum circuit breaker interrupting rating shall be 10 kAIC or as indicated which ever is higher for circuit breakers applied to circuits having voltages to ground less than or equal to 150 VAC. Circuit breaker interlocking shall include an anti-pumping circuit.

E. An external power source shall not be required for circuit breaker tripping. A bell alarm switch shall be provided to close only on circuit breaker overload for all main circuit breakers and service disconnecting means.

F. The circuit breakers shall be molded case **Cutler-Hammer, General Electric** or an equivalent by **Siemens** or **Square D.**

2.7 SECONDARY SURGE ARRESTERS

A. Furnish, install and connect secondary surge arresters and protective capacitors where indicated with fusing per manufacturer's instructions. For 480 volt circuits provide **GE** model number 9L15ECC001 secondary arrester and 9L18BBB301 secondary protective capacitor with 60A class T fuses and fuse blocks or equal for a 200,000 ampere interrupting capability. For 120 volt to ground circuits provide **GE** model number 9L15FCB001 secondary arrester with 60A class T fuses and fuse blocks or equal for a 200,000 ampere interrupting capability.

PART 3 -- EXECUTION

3.1 INSTALLATION - GENERAL

A. All electrical equipment shall be installed securely in place. Equipment shall be mounted parallel and perpendicular to the walls, floors, and ceilings.

B. All anchors and fasteners shall be types designed for the intended purpose and shall be capable of adequately, safely, and permanently securing the material in place. Generally, screws shall be used on wood surfaces, masonry anchors in concrete or brick, toggle bolts on hollow walls, machine screws, bolts, or welded studs on steel. Nails shall be used only for temporary attachment or support.

C. Omissions or conflicts on Drawings or between Drawings and Specifications shall be brought to the attention of the ENGINEER for clarification before proceeding with the work.

D. The CONTRACTOR shall make all necessary provisions throughout the Site to receive all equipment as construction progresses and shall provide adequate backing, supports, inserts, and anchor bolts for the hanging and support of all electrical cabinets, enclosures, conduits, panelboards, and switches, and shall provide sleeves through walls, floors, or foundations where electrical lines are required to penetrate.

E. Floor standing equipment shall be leveled with shims as required to maintain horizontal surfaces within 1/32-inch per horizontal foot; after leveling, equipment shall be anchored, then grouted so that no space exists between concrete and equipment support beams.

3.2 PREPARATION AND FINISH SYSTEMS

A. All equipment cabinets or enclosures furnished under this Section shall have a finish that will conform to Section 16480 - Low-Voltage Motor Control Center.

- END OF SECTION -

SECTION 16450 – GROUNDING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide the electrical grounding system, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 16050 - Electrical Work, General apply to this Section.

C. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals and Section 16050.

B. **Shop Drawings:** Manufacturer's product information for connections, clamps, and grounding system components, showing compliance with the requirements of this Section.

PART 2 -- PRODUCTS

2.1 GENERAL

A. Components of the grounding electrode system shall be manufactured in accordance with ANSI/UL 467 - Standard for Safety Grounding and Bonding Equipment, and shall conform to the applicable requirements of National Electrical Code Article 250 and local codes.

2.2 GROUNDING SYSTEM

A. Grounding loop conductors shall be bare annealed copper conductors suitable for direct burial. Conductors shall be No. 4/0 unless indicated otherwise.

B. Ground Rods

1. Unless indicated otherwise, the ground rod shall be a minimum of 3/4-inch in diameter, 10-feet long, and have a uniform covering of electrolytic copper metallically bonded to a rigid steel core. The copper to steel bond shall be corrosion resistant.

2. Conform to ANSI/UL 467.

3. Sectional type joined by threaded copper alloy couplings.

C. Buried cable-to-cable and cable-to-ground rod connections shall be made using exothermic welds by **Cadweld, Enrico Products,** or equal.

D. Exposed grounding connectors shall be of the compression type (connector to cable), made of high copper alloy, and be manufactured specifically for the particular grounding application. The connectors shall be **Burndy, O.Z. Gedney**, or equal.

E. Grounding clamps shall be used to bond each separately derived system to the grounding electrode conductors.

F. Equipment Grounding Circuit Conductors

1. These conductors shall be the same type and insulation as the load circuit conductors. The minimum size shall be as outlined in Table 250.122 of the National Electrical Code, unless indicated otherwise.

2. Metallic conduit systems shall have equipment grounding wires as well as being equipment grounding conductors themselves.

G. Manufacturers of grounding materials shall be **Copperweld, Blackburn, Burndy,** or equal.

PART 3 -- EXECUTION

3.1 GROUNDING

A. Provide a separate grounding conductor, securely grounded in each raceway independent of raceway material.

B. Provide a separate grounding conductor for each motor and connect at motor box. Do not use bolts securing motor box to frame or cover for grounding connectors.

C. Size as indicated and shall as a minimum be in accordance with the NEC-Article 250.

D. Route conductors inside raceway.

E. Provide a grounding type bushing for secondary feeder conduits which originate from the secondary section of each MCC section, switchboard, or panelboard.

F. Individually bond these raceways to the ground bus in the secondary section.

G. Provide a green insulated wire as grounding jumper from the ground screw to a box grounding screw and, for grounding type devices, to equipment grounding conductor.

H. Provide a separate grounding conductor in each individual raceway for parallel feeders.

I. Interconnect the secondary switchgear neutral bus to the ground bus in the secondary switchgear compartment only at service entrance point or after a transformer.

J. Bond cold water pipe system and building structure to separate grounding electrode per NEC.

K. Provide the duct bank ground system indicated, including, trenching, splices, ground rods, and connections to equipment and structures.

L. Measure ground impedance in accordance with IEEE STD 81 after installation but before connecting the electrode to the remaining grounding system.

M. **Low Voltage Grounded System (600V or less):** A low voltage grounded system is a system where the local power supply is a transformer with the transformer secondary grounded.

1. Grounding system connections for a premises wired system supplied by a grounded AC service shall have a grounding electrode connector connected to the grounded service conductor at each service, in accordance with the NEC.

2. The grounded circuit conductor shall not be used for grounding non-current carrying parts of equipment, raceways, and other enclosures except where specifically listed and permitted by the NEC.

N. Embedded Ground Connections

1. Underground and grounding connections embedded in concrete shall be UL listed compression type ground grid connectors.

2. The connection shall be made in accordance with the manufacturer's instructions.

3. The CONTRACTOR shall not conceal or cover any ground connections until the ENGINEER or authorized representative has established that every grounding connection conforms to the Contract Documents and has given the CONTRACTOR written confirmation.

O. Ground Ring

1. Furnish trenching and materials necessary to install the ground ring as indicated.

2. Bonding conductor shall be in direct contact with the earth and be of the size indicated.

3. Minimum burial depth 36 inches or as indicated on the Drawings, whichever is greater.

4. Re-compact disturbed soils to original density in 6-inch layers.

P. **Duct Bank Ground:** A grounding conductor shall be embedded in every duct bank as indicated.

Q. Ground Rods

1. Locations shall be as indicated.

2. Rods forming an individual ground array shall be equal in length.

R. Shield Grounding For Instrumentation Cabling and Wires

1. Shielded instrumentation cable shall have its shield grounded at one end only unless Shop Drawings indicate the shield will be grounded at both ends.

2. The grounding point shall be at the control panel or otherwise at the receiving end of the signal carried by the cable.

3. Termination of shield drain wire shall be on its own terminal screw.

4. Terminal screws shall be jumpered together using manufactured terminal block jumpers.

5. Connection to the ground bus shall be via a green No. 12 conductor to the main ground bus for the panel.

- END OF SECTION -

SECTION 16455 – VARIABLE FREQUENCY DRIVE UNITS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, in accordance with the Contract Documents. It is the intent of this Section to require complete, reliable, fully tested variable frequency drive systems suitable for attended or unattended operation.

B. The requirements of Section 16050 - Electrical Work, General, apply to the WORK of this Section.

C. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

D. **Coordination:** Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specifications. The CONTRACTOR's attention is specifically directed to the need for proper coordination of the WORK under this Section and the WORK under the equipment section with the WORK under Section 16460 - Electric Motors.

E. **Special Features:** The VFD's shall be rated for 50°C and constant torque to accommodate solar heating, high static pump head and lack of air conditioning even though the loads are variable torque pump loads. A common outdoor enclosure is required to house all the VFD's, auxiliary equipment and associated equipment as indicated in the drawings where VFD's are not provided a building. The common outdoor enclosure shall be provided by the VFD supplier as a complete package. The outdoor enclosure shall be low profile and have a finish that blends in with the surroundings.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.

B. **Shop Drawings:** Shop Drawings shall include the following information:

1. Equipment information

    a. Name of drive manufacturer.

    b. Type and model.

    c. Assembly drawing and nomenclature.

    d. Maximum heat dissipation capacity in kW.

2. Conduit entrance provisions.

3. Circuit breaker type, frames, and settings.

4. Information related to relays, timers, pilot devices, control transformer VA, and fuse sizes. Include catalog cuts.

5. System schematic ladder diagram and interconnection diagrams. The schematic ladder diagram shall include remote devices. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic on the Contract Drawings. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED".

6. Factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section.

C. The Technical Manual shall contain the following documentation:

1. Manufacturer's 2 year warranty.

2. Harmonic analysis report.

3. Field test report.

4. Programming procedure and program settings.

D. **Spare Parts List:** Information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide a total of 6 variable frequency drives. Equipment to be operated through variable frequency drives include the following:

Quantity	Equipment	HP	Constant or Variable Torque (C/V)	RPM	Filter*	Enclosure Type
3	Submersible Pumps – Area A	60	Sized for Constant Torque but actual load is variable torque	1800	Active Filter or equal required*	NEMA 12 in outdoor FRP NEMA 3R enclosure or equal.
3	Submersible Pumps – Area B	30	Sized for Constant Torque but actual load is variable torque	1800	Active Filter or equal required*	NEMA 12 in outdoor building by others.

*An active filter as indicated or each drive is 18 pulse or each individual drive gets a passive filter to meet a maximum of 5% total harmonic current distortion into the Utility and meet a maximum of 5% total harmonic current distortion into the standby engine generator set.

2.2 EQUIPMENT

A. The power supply shall be an adjustable frequency inverter designed to convert incoming 3 phase, 480 volt, 60 Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3 phase inverter. The inverter shall be a voltage source design producing a pulse-width-modulated type output. Inverters shall be designed to operate 460 volt, 3 phase, 60 Hertz, NEMA-B, open drip-proof (1.15 SF) or TEFC (1.15 SF), squirrel-cage high efficiency inverter duty induction motors over the range of 50-100 percent of base speed without derating or requiring any motor modifications. Inverters shall be capable of delivering nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers. The VFD shall vary both the AC voltage and frequency simultaneously to operate the motor at required speeds. Current source inverters will not be acceptable. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided. The CONTRACTOR shall be responsible for matching the controller to the load (variable torque but sized for constant torque) as well as the speed and current of the actual motor being controlled. The CONTRACTOR shall provide "clean power" 18 pulse VFD's for VFD's operating motors greater than 100 HP.

B. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent at 50 percent speed and load.

C. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases. Upon restoration of power and a "start" signal, the motor shall restart and run at the speed corresponding to the current process input signal.

D. The VFD shall be provided with additional features described below:

1. Inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent).

2. Overload capability at 150 percent for applied motor loads.

3. Adjustable acceleration and deceleration.

4. Input signal of 4 - 20 mA from process.

5. Output speed signal of 4 - 20 mA. Signals other than 4 - 20 mA are not acceptable.

6. On loss of input signal, the VFD shall operate at a preset speed.

7. A minimum of 2 selectable frequency jump points to avoid critical resonance frequency of the driven system.

8. Additional devices and functions as indicated.

E. **Protection:** The VFD shall have, as a minimum, the following protection features:

1. Input line protection provided with metal oxide varistor (MOV) and RC network.

2. Protection against single phasing.

3. Instantaneous overcurrent protection.

4. Electronic overcurrent protection.

5. Ground fault protection.

6. Overtemperature protection for electronics.

7. Protection against internal faults.

8. Conformal coating of all electronic boards and cards for corrosion protection.

9. Ability to start into rotating motor (forward or reverse rotation).

10. DVDT output filter to protect motor and cable insulation system integral to the drive enclosure.

11. Space heaters with thermostat control inside each VFD enclosure to prevent moisture condensation and corrosion.

12. Outdoor common FRP NEMA 3R enclosure housing all VFD's and auxiliary and associated electrical equipment as indicated or when not housed in building by others. Provide an enclosure color selected by the ENGINEER as part of the submittal process. Furnish, install and connect outdoor enclosure space heaters and VFD space heaters all controlled by thermostats to maintain the temperature above the dew point at all times and a temperature above 16 degrees Celsius for worst case temperature for the location and equipment unloaded and not running. Provide side and/or back mounted exhaust fans controlled by thermostat in the outdoor enclosure to maintain the temperature inside the enclosure less than 45 degrees Celsius during the worst case temperature for the location and worst case equipment loading. Furnish, install and connect interior air circulation fans to prevent uneven temperatures in outdoor enclosure. Furnish, install and connect all internal temperature controls, motor controls, short circuit protection, overload protection, control power transformers, raceway, wire and disconnecting means for the fans and heaters. VFD hot exhaust air shall be ducted to outside the common enclosure in a manner to minimize mixing with cool inlet air to keep interior temperatures down for VFD interior cool air intake. All outdoor enclosure openings shall have louvers to prevent entry of birds and large animals. All outdoor enclosure openings shall have industrial washable stainless steel wire mesh dust screens to keep out most insects and small animals. All fans shall be sized to move the required air with dust screens and louvers in place.

13. Additional protection and control as indicated and as required by the motor and driven equipment.

F. **Service Conditions:** The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.

1. Elevation to 3300 feet. For elevation greater than 3300 ft, the VFD shall be derated per the manufacturer recommendation.

2. Ambient temperature: 0 to 50 degrees C for free air around the VFD enclosure.

3. Humidity: 0 to 95 percent, non-condensing.

4. AC line voltage variation: plus 10 percent to minus 10 percent.

5. AC line frequency variation: plus and minus 2 hertz.

G. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:

1. 5 percent (minimum) input Line Reactor integral to the drive enclosure.

2. Fused 480 - 120 volt control transformer to provide system control power for the logic and pilot lamps.

3. EMI/RFI input filter to prevent pushing interfering electrical noise back into the power system or adversely affecting other equipment on the common power bus.

4. Input circuit breaker with a minimum interrupting rating of 65 kAIC at 480 volts.

5. Provide overload protection to protect the motors per the NEC.

H. The inverter signal circuits shall be isolated from the power circuits and be designed to accept an isolated 4 - 20 mA signal in the automatic mode of operation. The inverter shall follow the setting of a remote or local potentiometer control when in the manual mode. Refer to the Electrical Elementary Schematic drawings for speed control and start/stop methods. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices, or as part of a multi-function microprocessor-based keypad access device. Access to set-up and protective adjustments shall be protected by key-lockout.

1. Auto/Hand selection from a local door mounted switch. In "Auto", the inverter shall operate from the remote 4 - 20 mA input, where applicable, and in "Hand" control, shall operate from a local door mounted manually operated speed potentiometer.

2. Speed indicator calibrated in percent speed

3. Inverter fault trip pilot light and output alarm contacts

4. Trip reset pushbutton

5. "Run" and "Off" indicating lights

6. Other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the Electrical Contract Drawing Elementary Schematics

I. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation

J. Pilot devices, control relays, time delay relays, elapsed time meters, and indicators provided as a part of the VFD equipment package shall meet the applicable requirements of Section 16485 – Local Control Stations and Miscellaneous Electrical Devices.

2.3 ACTIVE HARMONIC FILTER

A. The VFD supplier shall furnish and the CONTRACTOR shall install and connect an active harmonic filter as indicated. The active filters shall be sized to achieve less than 5% total harmonic current distortion back into the utility and back into the standby engine generator set at the point of common coupling as recommended by IEEE 519-1992 under worst case load conditions with two of the drives on line.

B. An acceptable alternative to the active harmonic filter is to utilize 18-pulse rectifier drives in place of 6-pulse rectifier drives in place of furnishing a common active harmonic filter. The dimensions of the enclosures at the VFD location must be equal or less than indicated in the contract drawings. The 18-pulse drives shall achieve less than 5% total harmonic current distortion back into the utility and back into the standby engine generator set at the point of common coupling as recommended by IEEE 519-1992 under worst case load conditions with two of the drives on line.

C. An acceptable alternative is to use input filtering at each 6-pulse rectifier drive in place of furnishing a common active harmonic filter. The dimensions of the enclosures at the VFD location must be equal or less than indicated in the contract drawings. The active filters shall be sized to achieve less than 5% total harmonic current distortion back into the utility and back into the standby engine generator set at the point of common coupling as recommended by IEEE 519-1992 under worst case load conditions with two of the drives on line.

2.4 SPARE PARTS

A. The CONTRACTOR shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.

B. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.

C. The following spare parts shall be furnished:

1. One set of spare fuses of each size.

2. Ten spare control and power fuses of each type and rating.

3. Two dozen pilot lamps for replaceable incandescent lamps, as applicable.

4. One of each type of circuit board

   a. Control board.

   b. Power board.

   c. Diode bridge.

   d. Transistor module.

5. One of each size and type power diode and transistor.

6. One set of any special tools required for maintenance of VFD units.

2.5 MANUFACTURERS

A. The variable frequency drive units shall be **Robicon, Ben Shaw, ABB** or equal.

PART 3 -- EXECUTION

3.1 SERVICES OF MANUFACTURER

A. **General:** An authorized service representative of the manufacturer shall be present at the Site for 3 Days for each pump station having VFD's to furnish the services listed below for each pump station. For the purpose of this paragraph, a Day is defined as an 8-hour period excluding travel time.

B. **Inspection, Startup, Field Adjustment:** The authorized service representative shall supervise the following and certify the equipment and controls have been properly installed, aligned, and readied for operation.

1. Installation of the equipment for each pump station having VFD's

2. Inspection, checking, and adjusting the equipment for each pump station having VFD's

3. Startup and field testing for proper operation for each pump station having VFD's

4. Performing field adjustments such that the equipment installation and operation comply with requirements for each pump station having VFD's.

C. **Instruction of OWNER's Personnel:** The authorized representative shall instruct the **OWNER**'s personnel in the operation and maintenance of the equipment, including step by step troubleshooting with test equipment. Instruction shall be specific to the VFD models provided. Training shall be scheduled a minimum of 3 weeks in advance of the first session. Training shall include individual sessions for 4 shifts of plant personnel. Proposed training materials shall be submitted for review, and comments shall be incorporated. Training materials shall remain with the trainees. The **OWNER** may videotape the training for later use with the **OWNER**'s personnel.

3.2 INSTALLATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendation.

B. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFD's included in this project. Submit records of programming data in the equipment Technical Manual, including setup and protective settings

3.3 FIELD TESTING

A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer's service engineer. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer's representative.

B. The CONTRACTOR shall test the completed installation for actual harmonic distortion at the point of common coupling with the supplying utility and the supplying standby generator.

1. Harmonic analysis shall be performed in accordance with IEEE 519 - Harmonic Control and Reactive Compensation of Static Power Converters at unit full load using a harmonic analyzer by **Hewlett Packard**, or equal

C. Tests shall prove that the harmonic voltage and current distortion at the 480-volt distribution bus of the panelboard, motor control center, or switchgear serving the VFD and current back into the utility and standby generator is limited to a magnitude of 5 percent of the fundamental. Running conditions shall be with the maximum number of drives, as permitted by the process, in operation and in conformance with the applicable requirements of IEEE-519 with harmonic filters operating. The report shall include the following:

1. Actual RMS values and the associated measured percentage of the THD in the field for both current and voltage in each phase shall be measured for both standby engine generator operation and utility operation. Measurements shall be made during peak flow conditions when local residents are maximizing use of the sewer system. Records of the measurements shall be recorded and submitted for a record of compliance. The currents of interest are the currents supplied by the utility and the standby engine generator through the main disconnecting means for each power supply. The voltage of interest is the voltage on the main bus connected to the main disconnecting means for each power supply.

- END OF SECTION -

SECTION 16460 - ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide electric motors, accessories, and appurtenances complete and operable, in conformance with the individual driven equipment specifications and the Contract Documents.

B. The provisions of this Section apply to low voltage AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.

C. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals.

B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:

1. Machine name and specification number of driven machine
2. Motor manufacturer
3. Motor type or model and dimension drawing. Include motor weight.
4. Nominal horsepower
5. NEMA Design
6. Enclosure
7. Frame Size
8. Winding insulation class and temperature rise class
9. Voltage, phase, and frequency ratings
10. Service factor
11. Full load current at rated horsepower for application voltage
12. Full load speed
13. Guaranteed minimum full load efficiency. Also nominal efficiencies at 1/2 and 3/4 load.
14. Type of thermal protection or overtemperature protection, if included

15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable

16. Bearing data. Include recommendation for lubricants of relubricatable type bearings.

17. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery.

18. Power factor at 1/2, 3/4 and full load

19. Recommended size for power factor correction capacitors to improve power factor to 0.95 (lagging) when operated at full load.

C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Electric motors driving identical machines shall be identical.

B. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.

C. Motor Capacity

1. The CONTRACTOR shall size motors for the larger of the following criteria:

a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.

b. Size motors for minimum size indicated

2. In every case, motor size shall be derated from nameplate values as follows:

a. Ambient Temperature

1) For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.

2) For ambient temperatures exceeding 40 degrees but less than 50 degrees C, derate nameplate HP ratings to 85 percent.

b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters). Higher altitudes require the following derating factors:

Altitude	1.0 Service Factor	1.15 Service Factor
3300 to 9000 ft	93 percent	100 percent
9000 to 13,200 ft	91 percent	98 percent

3. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the WORK.

D. **Exempt Motors:** Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.2 DESIGN REQUIREMENTS

A. **General:** Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31.

B. **NEMA Design:** Electric motors shall be NEMA Design B unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.

C. **Motor Voltage Ratings:** Motors shall have voltage ratings in accordance with the following, unless otherwise indicated:

1. Motors below 1/2 HP shall be rated 115 volts, single-phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.

2. Motors 1/2 HP and larger shall be rated 230 volts, 460 volts, or 4160 volts, 3 phase, 60 Hz. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided leads are brought out to the conduit box.

D. **Insulation:** Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated from adjustable frequency drives shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dt as defined in NEMA MG 1-31.

E. Motors located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 unless otherwise indicated.

F. Motors for use in hazardous locations shall have enclosures suitable for the classification indicated. Such motors shall be UL listed and be stamped as such.

G. Motors larger than 50 HP installed outdoors or in unheated areas shall be provided with 120 volt AC space heaters, wired to a terminal strip in a low voltage motor junction box.

H. Premium Efficiency Motors

1. Motors with a nameplate rating of 1 HP and larger shall be "energy efficient" units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.

2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with NEMA MG 1-12.60 - Efficiency Levels of Energy Efficient Polyphase Squirrel-Cage Induction Motors: these 2 values shall be stated in the Shop Drawing submittal.

3. Premium Efficient motors shall conform to the minimum efficiency requirements of NEMA MG1, Table 12-12 latest revision for NEMA premium efficiency motors:

I. Two-speed motors shall be the 2 winding types.

2.3 ACCESSORY REQUIREMENTS

A. **General:** Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors less than 3 HP shall have the manufacturer's standard conduit boxes. Motors other than open drip-proof shall be gasketed.

B. **Lifting Devices:** Motors weighing 265 lb (120 Kg) or more shall have suitable lifting eyes for installation and removal.

C. **Special Requirements:** The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.

D. **Grounding Lugs:** Provide motor grounding lug suitable to terminate ground wire, sized as indicated.

E. **Nameplate:** Motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40.

F. The motor manufacturer shall furnish for installation by the Electrical Subcontractor power factor correction capacitors for each motor 10 HP and larger. For motors controlled through FVNR, RVR or FVTS (2-speed, high speed winding connected) starters, the capacitors shall be wired to the output of the motor starter. The capacitors shall be fused, with internal resistors, suitable enclosed for mounting adjacent to the starter, MCC, or motor. Motors controlled through FVNR-AT (auto-transformer) or solid-state starters or VFDs shall be provided with a dedicated contactor, wired to close when the motor is started and open when the motor is stopped and connected to the load side of the circuit breaker or fused disconnect at the input to the controller. The capacitors shall be sized as recommended by the motor manufacturer to improve power factor to not less than 95 percent lagging at rated full load. The capacitor dielectric materials shall be non-PCB type, non-flammable, and biodegradable.

G. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close contact when the motor is at zero speed.

2.4 MOTOR THERMAL PROTECTION

A. **Single Phase Motors:** Single phase 120, 208, or 230 volt motors shall have integral thermal overload protection or shall be inherently current limited.

B. **Thermostats:** Winding thermostats shall be snap action, bi-metallic, temperature-actuated switch. Thermostats shall be provided with one normally closed contact. The thermostat switch point shall be precalibrated by the manufacturer.

C. **RTDs**: Bearing RTDs and/or winding RTDs (2 per phase) shall be provided where indicated. RTDs shall be 100 ohm platinum.

2.5 MOTOR BEARINGS

A. **General:** Bearings shall conform to Section 11000 - Equipment General Provisions, except as indicated herein.

B. Motors greater than 2 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.

C. **Fractional Horsepower:** Motors with fractional horsepower through 2 HP shall be provided with Lubricated-for-Life ball bearings.

D. **Horizontal Motors Over 2 HP:** Motors larger than 2 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

E. **Vertical Motors Over 2 HP:** Vertical motors larger than 2 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.

F. **Water Cooled Motors:** If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.

2.6 MANUFACTURERS, OR EQUAL

A. **U.S. Motors;**

B. **Reliance Electric.**

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment.

B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 16.

C. For motors utilizing power factor correction capacitors connected to the starter output terminals, the motor overload elements or trip settings shall be adjusted downwards to reflect the reduction in line current resulting from power factor correction.

3.2 FACTORY TESTING

A. Motors rated 100 HP and larger shall be factory tested in conformance with IEEE 112, IEEE 43 - Recommended Practice for Testing Resistance of Rotating Machinery, and NEMA MG-2. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

3.3 FIELD TESTING

A. The CONTRACTOR shall perform the following field tests:

1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.

2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage.

3. Check winding and bearing temperature detectors and space heaters for functional operation.

4. Test for proper rotation prior to connection to the driven equipment.

5. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 1000 volts for 480 volt motors and 500 volts for 240 volt and lower voltage motors..

- END OF SECTION -

SECTION 16470 - PANELBOARDS AND GENERAL PURPOSE DRY TYPE TRANSFORMERS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide panelboards and general purpose dry-type transformers, complete and operable, in accordance with the Contract Documents.

B. **Single Manufacturer:** Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be in accordance with Section 01300 - Contractor Submittals and Section 16050 - Electrical Work, General.

B. Shop Drawings

1. Transformers

a. Dimension drawings
b. Technical certification sheets
c. Drawing of conduit entry/exit locations
d. Transformer ratings, including:

1) Voltage
2) Continuous current
3) Basic impulse level for equipment over 600 volts
4) Kva

e. Descriptive bulletins
f. Product sheets

2. Panelboards

a. Breaker layout drawings with dimensions and nameplate designations
b. Component list
c. Drawings of conduit entry/exit locations
d. Assembly ratings including:

1) Short circuit rating
2) Voltage
3) Continuous current

e. Cable terminal sizes
f. Descriptive bulletins
g. Product sheets
h. Installation information
i. Seismic certification and equipment anchorage details

PART 2 -- PRODUCTS

2.1 GENERAL

A. Transformers

1. The transformers shall be dry-type, designed, manufactured, and tested in accordance with the latest applicable standards of ANSI and NEMA.

2. Transformers shall be UL-listed and bear the UL label.

B. Panelboards

1. Panelboards shall be dead front factory assembled. Panelboards shall comply with NEMA PB-1-Panelboards, as well as the provisions of UL 50 - Safety Enclosures for Electrical Equipment and UL 67 - Safety Panelboards. Panelboards used for service equipment shall be UL labeled for such use. Lighting panelboards shall be rated for 120/208-volt, 3-phase operation or 120/240-volt for single phase operation as indicated. Power panelboards shall be rated for 480 volts, 3-phase, 3-wire operation.

2. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers.

2.2 TRANSFORMERS

A. Energy Efficiency: Standard dry-type transformers, 15 KVA and larger, that are manufactured after March 1, 2003, must meet the energy efficiency requirements of NEMA TP-1. The product requirements are in the appliance regulations, Title 20, and the usage requirements are in Title 24. K-factor transformers are exempt from these requirements.

B. Ratings

1. KVA and voltage ratings shall be as indicated.

2. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96 - Guide for Loading Dry Type Distribution and Power Transformers

3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:

Up to 9 kVA	40 db
10to50 kVA	45 db
51to150 kVA	50 db

C. Construction

1. Insulation Systems

a. Transformers shall be insulated as follows:

1) 2 kVA and below: 150 degrees C insulation system based upon 80 degree C rise.

2) 3 to 15 kVA: 185 degrees C insulation system based upon 115 degree C rise.15 kVA and above: 220 degrees C insulation system based upon 150 degree C rise.

b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 degrees C maximum ambient.

c. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM D 635 - Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

2. Transformer windings shall be copper.

3. Transformers shall have four 2-1/2 percent taps, two above and two below 480 volts.

D. Manufacturers: Transformers shall be floor or wall-mounted type by **General Electric, Cutler-Hammer, Square D,** or equal.

2.3 PANELBOARDS

A. Ratings

1. Panelboards rated 240 VAC or less shall have short circuit ratings not less than 10,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

2. Panelboards rated 480 VAC shall have short circuit ratings not less than 25,000 amperes RMS symmetrical or as indicated by the Short Circuit Study, whichever is greater.

3. Panelboards shall be labeled with a UL short circuit rating. Series ratings are not acceptable.

B. Construction

1. All lighting and power distribution panels shall have copper busbars.

2. Breakers shall be 1, 2, or 3 pole as indicated, with ampere trip ratings as required by the equipment. Breakers shall be quick-make and quick-break, inverse time trip characteristics, to trip free on overload or short circuit, and to indicate trip condition by the handle position.

3. The panels shall have hinged doors with combination catch and latch. The front panels shall be so arranged that when the plates are removed, the gutters, terminals and wiring will be exposed and accessible. The doors shall have inner doors within the plates to have only the breaker operating mechanism exposed when they are opened. Live conductors and terminals shall be concealed behind the plates.

4. All panelboards shall be rated for the intended voltage.

5. All circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units. No plug-in circuit breakers will be acceptable.

6. Lighting and power distribution panels which are not part of a motor control center shall be constructed in accordance with Section 16050. Panels shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel. All panelboard parts of metal other than copper, aluminum, or stainless steel shall be cadmium plated. Panelboards shall be as manufactured by **General Electric or Cutler-Hammer**.

7. Panelboards shall be UL listed except for special enclosures which are not available with UL listing.

8. Panelboards shall be suitable for use as service entrance as indicated or as otherwise required by the NEC.

PART 3 -- EXECUTION

3.1 GENERAL

A. All WORK of this Section shall be installed as indicated in Section 16050.

- END OF SECTION -

SECTION 16480 – LOW VOLTAGE MOTOR CONTROL CENTERS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide motor control centers (MCC's), complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 16050 - Electrical Work, General, apply to the WORK of this Section.

C. In the event that motors provided are larger horsepower than motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower according to Section 16460-Electric Motors. Adjustments shall be made as a part of the WORK.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Sections 01300-Contractor Submittals and 16050.

B. Shop Drawings

1. Enclosure NEMA rating and color.

2. Horizontal and vertical bus ampacities, voltage rating and interrupting capacity. Include materials of construction.

3. Ground bus size and material of construction.

4. Conduit entrance provisions.

5. Main incoming line entry provision (top or bottom).

6. Control unit nameplate schedule.

7. Circuit breaker types, frames and settings.

8. Starter NEMA sizes, auxiliary contact provisions, coil voltage.

9. Relays, timers, pilot devices, control transformer VA and fuse sizes.

10. Elementary schematic ladder diagrams for each compartment. Custom schematics shall be furnished. Diagrams shall include remote devices. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED-RESUBMIT".

11. Short circuit rating of the complete assembly.

12. Replacement parts lists and operation and maintenance procedures.

13. Seismic design certification of the anchoring system in accordance with 16050.

14. Time-current curves for protective devices.

PART 2 -- PRODUCT

2.1 GENERAL

A. The manufacturer of the low voltage motor control center shall also be the manufacturer of at least the following:

1. Molded case circuit breakers up to and including 225 ampere frame size.

2. Disconnect switches.

3. Magnetic motor starters.

4. Control and timing relays rated at 600 volts AC.

5. Pushbuttons, lights, and selector switches, including remote mounted control stations.

6. Meters, including ammeter, voltmeter, and solid-state metering devices.

B. Devices of the same type shall be products of the same manufacturer. This requirement applies to control devices, and insofar as practical, to equipment manufactured on a production basis. It also applies without exception to equipment custom fabricated for this project.

C. Motor control centers shall conform to the standards for NEMA Class IIS, type B diagrams and wiring.

D. MCC Schedule

MCC DESIGNATION	LOCATION
As Indicated	As Indicated

2.2 DESIGN, CONSTRUCTION, AND MATERIAL REQUIREMENTS

A. The motor control centers shall be 600 volt class suitable for operation on a 3 phase, 60 Hz system. The system operating voltage and number of wires shall be as indicated.

B. The motor control center shall receive power from a 3 phase, wye connected 277/480 volt transformer with a grounded neutral. Power distribution from the MCC shall be 480 volt, 3 phase, 3 wire, however the MCC shall include provision for termination of an incoming neutral conductor in conformance to NEC requirements for service entrance.

C. Enclosure shall be NEMA Type 1, gasketed enclosure. Compartment doors shall be interlocked with compartment circuit breakers. The interlock shall be fitted with a maintenance override.

D. Size and Arrangement

1. Furnish, install and connect outdoor NEMA 3R wraps or housings as indicated.

2. Motor control centers shall be of mechanical groupings of control center units, assembled into a lineup of control center sections. Each control section shall be nominally 90 inches tall by minimum 20 inches deep.

3. MCC's shall be designed to not exceed the space requirements as indicated on the Contract Drawings, including spaces, spares, and future compartments. MCC's shall be subject to rejection for exceeding the lengths indicated where allotted space is critical.

4. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing the MCC provides the spares, space, and future provisions indicated.

5. Switches and circuit breakers used as switches shall be located so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 6-feet 7 inches above the floor, including the height of the concrete pad.

E. Components

1. Busses

a. A continuous copper ground bus shall be provided with full width of the motor control center line-up.

b. The main horizontal bus shall be tin-plated copper located within an isolated compartment. The bus shall be rated 600 amperes minimum, but in no instance less than the main lug or main breaker frame size.

c. The vertical bus in each section shall consist of a single tin-plated copper conductor per phase with a current capacity of not less than 300 amps. The vertical bus shall be completely isolated and insulated, and shall extend the full height of the section wherever possible.

d. Fully rated continuous copper ground bus shall be provided through the control center. Lugs of appropriate capacity shall also be provided.

e. Power buses shall be braced to withstand 65,000 amperes, minimum.

2. Wireways: A separate vertical wireway shall be provided adjacent to each vertical unit and shall be covered by a hinged door. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the vertical wireway without disturbing adjacent unit components.

F. Cabinet

1. Structural members shall be fabricated of not less than 12 gauge steel and side and top panels and doors shall be not less than 14 gauge steel.

2. Spaces designated as "SPACE" or "BLANK" shall include blank hinged doors and vertical bus bars.

3. Control units inside compartments shall be clearly identified with tags or stencil markings.

4. Each control unit including spares, spaces and blanks, lights, and devices shall be identified by an engraved nameplate. Identification shall include circuit number as indicated.

5. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including manufacturer, sales order number, date of manufacture, and place of manufacture.

6. Where "L" or "U" shaped MCC layouts are indicated, corner compartments shall have similar current and short circuit ratings as functional compartments.

7. Fans, heat exchangers, transformers, capacitors, junction boxes, or other devices may not be mounted on the outside of the motor control center enclosure.

8. Finish for motor control center shall be light grey, ANSI 61. The panels shall be given 2 coats of primer inside and out and 2 coats of enamel finish. External colors other than ANSI 61 will not be acceptable.

2.3 MOTOR STARTERS

A. Motor starters shall be mounted in standard motor control center assemblies, arranged as indicated.

B. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device, mounted in a completely enclosed cubicle. Short circuit protective device shall be an instantaneous, magnetic only circuit breaker, **Cutler-Hammer Type HMCP, G.E. Mag-Break Motor Circuit Protector**, or equal. Circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the open position. Reset of thermal overload elements shall be possible with unit door closed. Three phase overload trip units shall be furnished to suit the full load current of the equipment installed. Overload trip unit shall be adjusted as required for power factor correction capacitors.

C. Magnetic starters shall have auxiliary contacts as required by electrical motor control diagrams, including N-O and N-C contacts as indicated, plus one each spare N-O and N-C contact. The combination motor starters shall be drawout-type for size 5 and below. The fixed-type unit assembly shall be constructed so that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.

D. Each starter unit shall have its own control power transformer. It shall have a 115 volt grounded secondary. One secondary fuse and 2 primary fuses shall be provided. Control power transformers shall be sized to accommodate the control devices indicated. Local control devices shall be mounted independently of the cover door. Starters shall have a local red "running" lamp and a green "off" light to indicate the presence of control power when the motor is not running. Starters shall be provided with elapsed time meters, hand/off/auto selector switches, and other devices as indicated. Cubicle control wires shall be terminated at a pull apart disconnecting terminal block at the cubicle.

E. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers. Each control wire shall be identified at both ends.

F. Full voltage motor starter units shall be NEMA Size 1 or larger. Each combination starter shall be rated for minimum 65,000 RMS symmetrical amperes.

G. Motor starters shall be designed to NEMA ratings. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be acceptable, either as part of any MCC, as remote starters, or as part of any equipment package.

H. Reduced voltage auto-transformer starters shall consist of a molded-case motor circuit protector in combination with a closed transition type auto-transformer starter with 50 percent, 65 percent, and 80 percent taps, and shall be set on the 65 percent tap. The starter shall have 3 phase overload relays, and shall be ambient temperature-compensated with manual reset. The auto-transformer shall include a thermal switch wired to protect itself from overheating. Timing of the starting period shall be controlled by an adjustable accelerating relay.

I. Solid state reduced voltage starters shall be UL listed and shall consist of an incoming power circuit breaker, a power section, logic board, and paralleling bypass contactor to be energized when the motor reaches full voltage. Solid state starters shall include adjustments for starting torque, acceleration rate control by voltage ramps, and current limit. Output contactors shall be provided where indicated.

J. Two speed starters shall be of the 2 winding type unless otherwise indicated.

K. Variable speed drives (VFD's) shall be in conformance as applicable to Section 16455 – Variable Frequency Drives. Externally mounted line reaction, cooling fan, and bypass contactor will not be acceptable.

2.4 MAIN AND FEEDER CIRCUIT BREAKERS (480 V)

A. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units.

B. Circuit breakers with a frame size of 225 amperes to 250 amperes shall be molded case with interchangeable thermal, and adjustable magnetic trip elements.

C. Circuit breakers with a frame size of greater than 250 amperes shall be molded case with RMS sensing electronic trip elements.

D. The interrupting capacity of main, and feeder branch circuit breakers shall be a minimum of 65,000 RMS symmetrical amperes. Service disconnects rated 1000 A or more shall provide ground fault protection of equipment.

E. Circuit breaker disconnect operators shall be capable of accommodating 3 padlocks for locking in the "open" position.

F. Circuit breaker shall also conform to requirements of Section 16400 – Switchboards and ATS paragraph on overcurrent protective devices.

2.5 CONTROL DEVICES

A. Control devices shall conform to the requirements of Section 16485 - Local Control Stations and Miscellaneous Electrical Devices.

2.6 METERING INSTRUMENTS

A. **Electronic Meter and Analyzing Panels (EMAP):** EMAP's shall be of the following type and manufacture, or equal: Furnish, install and connect solid state metering as indicated. EMAP's shall be **G.E. "PQM, Cutler-Hammer "IQ Analyzer"** or equal.

1. Furnish, install and connect solid state metering as indicated. EMAP's shall be **G.E. "PQM, Cutler-Hammer "IQ Analyzer"** or equal.

B. The instrument transformers shall comply with ANSI/IEEE C37.20 and shall have utility grade metering accuracy with the burdens imposed. Mechanical and thermal ratings of current transformers shall be coordinated with short circuit ratings of related circuit breakers. Potential transformers shall be mounted on a disconnecting rack and shall have primary fuse protection.

2.7 SECONDARY SURGE ARRESTERS

A. Furnish, install and connect secondary surge arresters and protective capacitors where indicated with fusing per manufacturer's instructions. For 480 volt circuits provide **GE** model number 9L15ECC001 secondary arrester and 9L18BBB301 secondary protective capacitor with 60A class T fuses and fuse blocks or equal for a 200,000 ampere interrupting capability. For 120 volt to ground circuits provide **GE** model number 9L15FCB001 secondary arrester with 30A class CC fuses and fuse blocks or equal for a 200,000 ampere interrupting capability.

2.8 PHASE MONITOR (PM)

A. Furnish, install and connect in each MCC a microprocessor controlled three phase monitor and relay. The phase monitor shall signal and protect motors against phase loss, improper phase sequence, under voltage, under frequency, phase unbalance and over voltage. The phase monitor shall have an adjustable time delay to operate. Repeat relays shall be furnished, installed and connected to provide the necessary contacts to protect all 3 phase motor loads not having VFD's for motor controllers and provide a monitoring signal contact to the SCADA system. Furnish, install and connect three phase monitors – **Diversified Electronics model SLM-440-ASE** or equal.

2.9 FACTORY TESTS

A. Motor control centers and their components shall be given manufacturer's standard electrical and mechanical production tests and inspections. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of components including controls, protective devices, metering, and alarm devices.

2.10 SPARE PARTS

A. The CONTRACTOR shall furnish the following for each MCC:

1. One unit control transformer of each size furnished in magnetic starters installed.

2. Three bezels of each color installed for pilot indicators.

3. One dozen panel lamps.

4. One dozen control fuses of each size installed.

B. Spare parts shall be identified by MCC number, type, size, and manufacturer.

2.11 MANUFACTURERS, OR EQUAL

A. Motor control centers shall be **Cutler-Hammer "2100" Series, General Electric "E9000,"** or **Square D, Model 6.**

PART 3 -- EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install motor control centers in accordance with manufacturer's published instructions. Conduit installation shall be coordinated with manufacturer's as-fabricated drawings so that conduit stub-ups are within the area allotted for conduit. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

B. If stored at the Site, motor control centers shall be stored in a clean, dry space. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic. Storage space shall be heated or MCC space heaters shall be energized.

C. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish. Damage shall be repaired before installation.

3.2 INSTALLATION

A. Motor control centers shall be installed on 3-1/2-inch concrete pads. After leveling and shimming, the CONTRACTOR shall anchor motor control centers to concrete pads, and shall grout so that no space exists between the pad and support beams.

B. The CONTRACTOR shall:

1. Torque bus bar bolts to manufacturer's recommendations. Tighten sheet metal and structure assembly bolts.

2. Adjust motor circuit protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor. Verify that overload devices are proper for equipment installed; make necessary changes in overload devices as required for motors having power factor correcting capacitors.

3. After equipment is installed, touch up scratches and verify that nameplate, and other identification is accurate.

4. Provide high voltage switchboard matting in front of the MCC. The mat shall be 1/4-inch thick and 36 inches wide and shall be **Model M36** as manufactured by **W.H. Salisbury & Co.,** or equal.

3.3 FIELD TESTS

A. Visual and mechanical inspection after installation

1. Inspect for physical damage, proper anchorage, and grounding

2. Verify that the ratings of the thermal overload heaters match the motor full-load current nameplate data.

3. Check tightness of bolted connections.

B. Electrical Tests

1. Insulation tests

a. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute. Test voltage and minimum acceptable resistance shall be in accordance with manufacturer's recommendations.

b. Measure insulation resistance of each starter section phase to phase and phase to ground with the starter contacts closed and the protective device open. Test voltage and minimum acceptable resistance shall be in accordance with the manufacturer's recommendations.

c. Measure insulation resistance of each control circuit with respect to ground

2. Verify proper operation of control logic in each mode of control.

- END OF SECTION -

SECTION 16485 – LOCAL CONTROL STATIONS AND MISCELLANEOUS ELECTRICAL DEVICES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide complete local control stations, panels and pedestals as indicated herein or in other Sections of the Specifications and as shown in the contract drawings. The stations, panels and pedestals shall be designed to provide the sequence of operation in Section 17100 - Process Control and Instrumentation Systems and the P&ID Drawings.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Local control stations, panels and pedestals shall comply with the requirements of NEC, NEMA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish Shop Drawings in accordance with Sections 01300 - Contractor Submittals and 16050 - Electrical Work, General.

1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.

2. Include catalog cuts of all control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide the stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation & Control specifications and the Electrical Elementary Schematics. Each station, panel and pedestal shall be fabricated with UL labelled components. Stations, panels and pedestals not specifically indicated as being WORK of other Sections shall be provided under this Section. All stations, panels and pedestals shall be wired under this Section.

B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, 3-phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 16050.

C. Each station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The stations, panels and pedestals shall be the source of power for all 120 vAC solenoid valves and instruments interconnected with the stations, panels and pedestals. All equipment associated with the stations, panels and pedestals shall be ready for service after connection of conductors to equipment, controls, instruments, stations, pedestals and panels.

D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.

E. Enclosures

1. In finished rooms, enclosures shall be NEMA 12 steel enclosures painted with ANSI 61 exterior and white interior.

2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel (prior to modifications) with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure.

3. In hazardous areas, enclosures shall be cast aluminum NEMA 7 and shall be UL listed for use in hazardous or classified locations.

4. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.

5. Outdoor mounted enclosures shall be provided with thermostatically-controlled heaters.

6. Provide screened weep holes for draining condensation.

F. Disconnect Switches

1. Heavy duty, non-fusible, single throw

2. Horsepower rated

3. UL listed

4. Padlockable in "Off" position and door interlock

5. Enclosure per area classification in Section 16050.

6. 408 V, 3 phase, 3-pole (6-pole when used with 2-speed motor).

7. Auxiliary control contact as applicable and as indicated.

8. As manufactured by **G.E., Cutler-Hammer,** or **Square D**.

G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 16050.

H. Panel-mounted devices shall be mounted a minimum of 3 feet above finished floor elevation.

2.2 STATION, PANEL & PEDESTAL COMPONENTS

A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30 mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **G.E., Cutler-Hammer,** or equal.

1. Lens colors shall be red for "run," "open," or "on"; green for "stopped," "closed," or "off"; and amber for alarm.

2. Pilot lights shall be low voltage, transformer, push-to-test type.

3. Provide hazardous location type pilot devices in classified locations.

B. Relays shall be 3 PDT with 10 amp contacts, plug-in type utilizing rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Potter Brumfield,** or equal.

C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **G.E., Cutler-Hammer,** or equal.

D. Magnetic starters shall be:

1. NEMA rated. IEC or dual NEMA/IEC rated type are not acceptable.

2. FVNR type unless indicated otherwise.

3. Combination starters with magnetic only instantaneous trip circuit breakers such as **Cutler-Hammer "MCP," G.E., "Mag-Break,"** or equal.

4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage.

E. Systems having a voltage to ground exceeding 150 volts shall be construction with equipment and protective devices including circuit breakers and fuses rated for a minimum short circuit current of 65,000 RMS symmetrical amperes at 480 volts. Systems having a voltage to ground less than or equal to 150 volts shall be construction with equipment and protective devices including circuit breakers and fuses rated for a minimum short circuit current of 10,000 RMS symmetrical amperes at 240 volts.

F. Terminal strips shall be provided for all panels and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.

G. Current-to-current converter/isolators shall be 4 - 20 mA input, 4 - 20 mA output for operation from 120 V power, and shall be by **Moore, A.G.M.,** or equal.

H. Process alarm relays shall have a 4 - 20 mA input and 2 independent SPST contact outputs as manufactured by **A.G.M.,** or equal. Power input shall be 120 V.

I. Digital indicators shall have 4 - 20 mA input and shall display the signal in process units. Zero to 100 percent as a displayed signal shall only be acceptable to indicate speed. Indicators shall be as manufactured by **Newport, Red Lion,** or equal, for operation from 120 V. Provide splash-proof covers in NEMA 4X panels, and viewing windows in NEMA 7 panels.

J. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D JCK70** or similar by **ATC**.

2.3 MOTOR PROTECTION - PHASE MONITOR (PM) & UNDERVOLTAGE

A. As indicated on the contract drawings furnish, install and connect a phase monitor for 480 volt 3-phase motor protection that is not controlled by a VFD. For lower voltage single phase systems provide an undervoltage monitor/relay to protect the motor.

B. The phase monitor shall signal and protect motors against phase loss, improper phase sequence, under voltage, under frequency, phase unbalance and over voltage. The phase monitor shall have an adjustable time delay to operate. Repeat relays shall be furnished, installed and connected to provide the necessary contacts to protect all 3 phase motor loads not having VFD's for motor controllers and provide a monitoring signal contact to the SCADA system. Furnish, install and connect three phase monitors – **Diversified Electronics model SLM-440-ASE** or equal.

C. The under-voltage monitor/relay shall be **Diversified Electronics model UOA-208-ALA** for nominal 208 volt systems and **Diversified Electronics model UOA-240-ALA** for 240 volt systems or equal motor undervoltage protection.

2.4 SECONDARY SURGE ARRESTORS

A. Furnish, install and connect secondary surge arresters and protective capacitors where indicated with fusing per manufacturer's instructions.

B. For 480 volt circuits provide **GE** model number 9L15ECC001 secondary arrester and 9L18BBB301 secondary protective capacitor with 60A class T fuses and fuse blocks or equal for a 200,000 ampere interrupting capability.

C. For 120 volt to ground circuits provide **GE** model number 9L15FCB001 secondary arrester with 30A class CC fuses and fuse blocks or equal for a 200,000 ampere interrupting capability.

2.5 FACTORY TESTING

A. Each local control station, panel and pedestal shall be factory assembled and tested for sequence of operation prior to delivery.

2.6 SPARE PARTS

A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color pilot lamp in each panel.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Stations, panels and pedestals shall be installed in accordance with in Section 16050 and in accordance with the manufacturer's recommendations.

B. Stations, panels and pedestals shall be protected at the Site from loss, damage, and the effects of weather. Stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.

C. Station, panel and pedestal interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.

D. Conduit, conductors, and terminations shall be installed in accordance with Section 16050.

3.2 FIELD TESTING

A. Each station, panel and pedestal shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

- END OF SECTION -

SECTION 16500 - LIGHTING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide lighting fixtures, and accessories, complete and operable, in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes

NFPA 70	National Electric Code
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
Uniform Building Code (UBC) Section 2329	Earthquake Requirements
Underwriters Laboratories, Inc. (UL)	
UL – 595	Standard for Safety Marine-Type Electric Lighting Fixtures
UL – 844	Standard for Safety Electric Lighting Fixtures for Use in Hazardous (Classified Locations)
UL – 924	Standard for Safety Emergency Lighting and Power Equipment
ANSI C82.1	Specifications for Fluorescent Lamp Ballasts
ANSI C84.4	Specifications for High-Intensity-Discharge Lamp Ballasts (Multiple SupplyType)

Standards of the Certified Ballast Manufacturer's Association

1.3 CONTRACTOR SUBMITTALS

A. Furnish the following product information in accordance with Section 01300 - Contractor Submittals.

1. Interior luminaires

   a. Catalog data sheets and pictures.

   b. Luminaire finish and metal gauge.

   c. Lens material, pattern, and thickness.

   d. Candle power distribution curves in two or more planes.

e. Candle power chart 0 to 90 degrees.

f. Lumen output chart.

g. Average maximum brightness data in foot lamberts.

h. Coefficients of utilization for zonal cavity calculations.

i. Mounting or suspension details.

j. Heat exchange and air handling data.

2. Exterior luminaires

a. Catalog data sheets and pictures.

b. Luminaire finish and metal gauge.

c. Lens material, pattern, and thickness.

d. IES lighting classification and isolux diagram.

e. Fastening details to wall or pole.

f. Ballast type, location, and method of fastening.

g. For light poles, submit wind loading, complete dimensions, and finish.

3. Lamps

a. Voltages.

b. Colors.

c. Approximate life (in hours).

d. Approximate initial lumens.

e. Lumen maintenance curve.

f. Lamp type and base.

4. Ballasts

a. Type.

b. Wiring diagram

c. Nominal watts and input watts.

d. Input voltage and power factor.

e. Starting current, line current, and restrike current values.

f. Sound rating.

g. Temperature rating.

h. Efficiency ratings.

i. Low temperature characteristics.

j. Emergency ballasts rating and capacity data.

5. Photocells

a. Voltage and power consumption.

b. Capacity.

c. Contacts and time delay.

d. Operating levels.

e. Enclosure type and dimensions.

f. Temperature range.

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. Specific requirements relative to execution of WORK of this section are located in the Luminaire Schedule on Drawings.

B. Feed-through type or separate junction box.

C. Ballasts: Two-lamp when possible.

D. Tandem wired for three-lamp fluorescent fixtures.

E. Wire Leads: Minimum 18 AWG.

F. Component Access: Accessible and replaceable without removing luminaire from ceiling.

G. Soffit Installations

1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.

2. Ballast: Removable, prewired.

H. Exterior Installations

1. UL Labeled: SUITABLE FOR WET LOCATIONS.

2. Ballast: Removable, prewired.

3. When factory-installed photocells are provided, entire assembly shall have UL label.

I. Marine Environments

1. UL Labeled: MARINE, OUTSIDE TYPE.

2. Housing: Copper-free, aluminum in accordance with UL - 595.

J. Emergency Lighting

1. Power Pack: Self-contained, 120/277 V, dual voltage transformer, with 6-V sealed nickel cadmium battery, and indicator switch in accordance with UL 924.

2. Lighted, push-to-test pushbutton and indicator.

3. Capable of providing full illumination for 1-1/2 hours in emergency mode.

4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.

5. Capable of protecting against excess charging and discharging.

6. Twin halogen sealed lighting heads.

7. Solid state charger.

8. Normal and emergency LED indicating lights.

9. Three wire power cord and plug set.

10. Mounting stand.

11. Time delay relays to maintain emergency lighting in areas illuminated by HID luminaires for 5 minutes after normal power has been re-stored.

12. NEMA rated enclosures in accordance with the area classifications in which they are installed.

K. Exit Signs

1. Internally illuminated

2. Universal mounting type.

3. Internal 6 V nickel cadmium battery.

4. Battery charger.

5. LED type emergency and normal indicating lights.

6. Press to test button

7. Directional arrows.

8. Red letters on a white panel.

L. Hazardous Classified Areas

1. UL Labeled: CLASS I, DIVISION 1, GROUPS C AND D.

2. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL - 844.

2.2 LAMPS

A. Fluorescent

1. Fluorescent

a. Type T-8, energy efficient

b. Color, K-4100

c. Lengths 48 inches

d. Rated burning life 20,000 hours

2. Compact Fluorescent

a. Type, double biax

b. Color, K-4100

c. Rated burning life, 10,000 hours

3. Electronic Biax Lamps

a. Type, double biax with screw shell for replacement of incandescents.

b. Color, K-2700 or higher

c. Rated burning life 10,000 hours

B. High Intensity Discharge

1. Type: High pressure sodium]and metal halide

2. Color: Color corrected

C. Incandescent

1. Type Efficiency: Energy

2. Color: Inside frosted

3. Rated burning life 2,500 hours

D. Tungsten Halogen

1. Type Efficiency:Energy

2. Color: Frosted

E. Manufacturers, or equal

1. **General Electric;**

2. **Sylvania;**

3. **North American Philips.**

2.3 BALLASTS

A. General

1. UL Listed, ETL certified.

2. High power factor, energy efficient type.

3. Meeting requirements for fixture light output, reliable starting, radio interference, total harmonic distortion, electromagnetic interference, and dielectric rating.

4. Exterior ballasts to produce reliable starting and produce full output of lamps when ballasts and lamps are operating in an ambient temperature of minus 40 degrees F at 90 percent of normal line voltage.

B. Fluorescent

1. Type: Electronic, high frequency, full output rapid start, for use with 265 mA, T-8 lamps.

2. Sound Rating: Minimum A, maximum allowable noise level of 30 decibels measured two feet from the fixture.

3. Class: P.

4. Current crest factor: 1.7

5. Manufacturers, or equal

a. **Advance Mark V;**

b. **Valmont;**

c. **Osram/Sylvania.**

C. Metal Halide

1. High power factor, normal ambient, 180 degrees C insulation class.

2. Types

a. Auto transformer with capacitor and ignitor for lamps 150 watts and less.

b. Constant wattage auto transformer with capacitor for lamps greater than 150 watts.

3. Manufacturers, or equal

a. **MagneTec Jefferson**;

b. **Advance Transformer**;

c. **Universal**.

D. High Pressure Sodium

1. High power factor, normal ambient, 180 degrees C insulation class, with capacitor and ignitor.

2. Type

a. Auto transformer for 50-watt lamps.

b. Constant wattage auto transformer for lamps 70 watts and greater.

2.4 LIGHTING CONTROL

A. Time Switch

1. Time dial indicated7-day dial and day omitting device.

2. Bypass Switch: Prewired, externally operated ON/AUTO/OFF, for each circuit indicated.

3. Contact configuration and rating for circuits as required.

4. Enclosure: NEMA 250, Type 4X.

5. Reserve Power: Spring driven, capable of operating time switch for 16 hours after power failure.

6. Wired for use with photocell indicated.

7. Manufacturers, or equal

a. **Tork**;

b. **Paragon**.

B. Photo Cell

1. Automatic ON/OFF switch photo control.

2. Housing: Self contained, die cast aluminum, unaffected by moisture, vibration, or temperature changes.

3. Setting: ON at dusk at OFF at dawn.

4. Time delay feature to prevent false switching

5. Field adjustable to control operating levels.

6. Manufacturers, or equal

a. **Tork;**

b. **Paragon.**

2.5 POLES

A. Rating (with Luminaire): 100 mph steady winds, without incurred damage.

B. Material: Extruded aluminum.

C. One piece stationary type

PART 3 -- EXECUTION

3.1 LUMINAIRES

A. General

1. Install in accordance with manufacturer's recommendations.

2. Provide necessary hangers, pendants, and canopies.

3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building and to concrete pole bases required to safely mount.

4. Install plumb and level.

5. Mounting heights indicated for wall mounted or pendant mounted luminaires are measured from bottom of luminaire to finished floor or finished grade, whichever is applicable.

6. Install each luminaire outlet box with galvanized stud.

B. Pendant Mounted

1. Provide swivel type hangers and canopies to match luminaires, unless otherwise indicated.

2. Space single stem hangers on continuous row florescent luminaires normally 48 inches apart.

3. Provide twin stem hangers on single luminaires.

C. Pole Mounted

1. Provide cast-in-place concrete base.

2. Provide branch circuit in line fuses with in-line fuse holders in pole base handhole.

3. Pole base to be installed flush with finished grade where located in grassy areas not subject to vehicular traffic and 30 inches above finished grade when the pole is located in areas subject to damage from vehicular traffic.

4. Fixture poles shall be set on anchor bolts and secured with double nuts on each bolt. After fixture has been leveled and plumbed, the fixture base shall be dry-packed with grout.

D. Finished Areas

1. Install symmetrically with tile pattern.

2. Locate with centerlines whether on centerline of tile or on joint between adjacent tile runs.

3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.

4. Combustible low density cellulose fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.

5. Junction Boxes

   a. Flush and recessed luminaires: Locate minimum 1 foot from luminaire.

   b. In concealed locations, install junction boxes to be accessible by removing luminaire.

6. Wiring and Conduit

   a. Provide wiring of temperature rating required by luminaire.

   b. Provide flexible steel conduit.

7. Provide plaster frames when required by ceiling construction.

8. Independent Supports

   a. Provide each recessed fluorescent luminaire with 2 safety chains or 2 No. 12 soft annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.

   b. Tensile strength of chain or wire, and method of fastening to structure shall be adequate to support weight of luminaire.

   c. Fasten chain or wire to each end of luminaire.

E. Unfinished Areas: Locate luminaires to avoid both conflict with other building systems and blockage of luminaire light output.

1. Fixture Suspension: Provide 3/8-inch threaded steel hanger rods. Scissor type hangers not permitted.

2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

3.2 LAMPS

A. Provide in each fixture, the number and type for which the fixture is designed, unless otherwise indicated.

3.3 BALLASTS

A. Install in accordance with manufacturer's recommendations.

B. Utilize all ballast mounting holes to fasten securely within luminaire.

C. Replace noisy or defective ballasts.

3.4 LIGHTING CONTROL

A. Outdoor Luminaires: Photocells switch lights ON at dusk and OFF at dawn.

B. Dimming Systems

1. Install in accordance with manufacturer's recommendations.

2. Do not connect ballasts or equipment to dimming system unless acceptable to dimming system manufacturer.

3.5 CLEANING FOLLOWING CONSTRUCTION

A. Remove all labels and other markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up all painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace all defective lamps at time of Substantial Completion.

- END OF SECTION -

SECTION 16620 – DIESEL STANDBY GENERATOR SYSTEM

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide a diesel engine-driven standby electrical generating system, complete and operable, in accordance with the Contract Documents.

B. The CONTRACTOR shall be responsible for coordination of interface with other equipment and for any special construction necessary to complete the WORK of this Section in an acceptable manner.

C. The supplier of the generator set shall also be the manufacturer of the engine for the generator system; however, the CONTRACTOR shall be responsible to the OWNER for the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Materials shall conform with applicable requirements of the National Electrical Code (NEC), and any other State or Municipal codes which apply. Generator system shall meet applicable standards and codes, including IEEE, NEMA, ANSI, OSHA, and UL.

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300-Contractor Submittals.

B. Shop Drawings

1. Detailed, dimensioned Shop Drawings and data demonstrating adherence to the requirements of these specifications shall be submitted and approved before fabrication, shipment, or other WORK under this Section begins. Include the manufacturer's certification that engine atmospheric emissions will comply with the limitations.

2. Certified custom drawings and custom wiring diagrams of each component in the system and a master wiring diagram showing the entire system on one sheet. This diagram shall include all AC and DC power control connections between the generator, engine, fuel tank system, batteries, and circuit breakers and shall be a custom drawing for this specific installation. A master drawing of the engine/generator set shall also be provided, showing general dimensions, bill of materials, location and size of all connections for fuel, cooling, exhaust, direct current connections, conduit locations, and connections for control and power wiring. Include wire and terminal numbers for all diagrams. Furnish KW output curves, fuel consumption curves, and certified air emission data sheets.

3. Outline drawings and connection diagrams shall be complete enough to enable the installation to be designed completely, and connection diagrams shall give both internal and external connections. Include foundation loading and clearances.

4. Certification of compliance with San Luis Obispo County Air Pollution Control District air emission requirements.

5. Storage battery calculations.

C. Technical Manuals

1. The CONTRACTOR shall prepare and submit draft and final Technical Manuals in accordance with section 01300 – Contractor Submittals.

2. Technical Manuals shall be complete with diagrams, lubrication schedules and recommended lubricants, drawings, cuts, parts lists, and other necessary data. All parts shall be numbered or otherwise clearly identified to facilitate ordering of replacements. Descriptions of all operational control devices and their functions shall also be included.

1.4 QUALITY ASSURANCE

A. The engine/generator shall be the product of a manufacturer who has been regularly engaged in the design and production of similar engine/generator sets for a minimum of 10 years.

B. The supplier shall maintain a local parts and 24-hour service facility within the State of California. The supplier shall have factory trained and authorized service representatives to furnish necessary installation, test, and start-up supervision as well as operation and maintenance training necessary for final approval and acceptance.

PART 2 -- PRODUCTS

2.1 SYSTEM COMPONENTS

A. Provide one new diesel engine-powered electric generator set. The engine generator shall have a nominal standby rating of 300 KW as indicated, KVA as indicated, 0.8 power factor, 480 volts 3 phase, 4 wire, grounded neutral, 60 Hertz. The equipment package shall include in general, and as applicable, engine and generator on a common vibration isolating base, with auxiliaries, accessories, and controls, including intake filters, discharge silencer, turbocharger, heat exchangers, foundation bolts, isolators, piping, flexible couplings, supports, complete exhaust piping, ring, and silencer, insulation, control panels, lubrication system, water jacket heaters, cooling system, fuel tank, batteries and battery rack, battery charger, spare parts, and all materials necessary to permit installation, testing and placing the system in successful operation.

B. Provide one 350 gallon fuel storage tank with double wall steel construction, integral with the base of the generator-set and generator-set enclosure.

C. Provide one load bank connection sized at 50 percent of the generator full load. Furnish, install and connect an isolation circuit breaker sized for the load bank and mounted on the engine support frame.

D. The generator-set, enclosure, base-mounted fuel tank, and accessories shall be assembled and shipped to the Site as a complete, coordinated package, ready for installation. The engine generator base, cooling system, etc., shall be factory painted before installation in the enclosure.

2.2 MANUFACTURER

A. Manufacturer of engine/generator set shall be **Caterpillar, Onan-Cummins,** or equal.

2.3 SYSTEM OPERATION

A. The system shall operate as follows:

1. Automatic Control

a. A maintained remote contact closure from the automatic transfer switch shall cause the generator-set to start and run.

b. When the remote startup contact opens, the engine shall continue to operate for an adjustable cool-down time (typically 5 to 30 minutes).

2. Local Control: The generator-set shall be capable of manual initiation or stopping from the locally mounted generator control panel. The local generator control panel shall be provided as part of this Contract.

3. Emergency Stop Control: An emergency stop pushbutton shall be provided at the generator control panel that shall cause the unit to stop without any delay.

4. Exercising: The generator may be operated through a load bank for manual exercising of the generator under load.

2.4 ENGINE

A. The CONTRACTOR shall provide a complete engine-powered standby electrical generating system of the type and capacity indicated.

B. The diesel engine shall be mounted on a common base with the generator and the direct connected radiator and shall be rated for standby service, continuously for the duration of the electric power interruption, with engine jacket water cooled by means of a direct mounted water-to-air radiator under SAE conditions at 85 degrees F, 100 feet above sea level. It should be noted that this is the rating of the engine. The minimum generator rating shall be 300 KW.

C. The diesel engine shall be 4-cycle, turbocharged, aftercooled, 1800 rpm, with individual fuel pumps and injection valve for each cylinder.

D. The engine shall have a dry type air cleaner with service indicator, fuel oil filter, full pressure positive pump lubrication with full-flow oil filters, thermostatic regulated oil cooling system, and crankcase drain with valving to be able to drain the crankcase oil without reaching under the engine.

E. The engine shall also be equipped with two 240 volt, thermostatically controlled jacket water heaters.

F. The diesel engine shall perform as indicated when operating on a commercial grade of non-premium distilled petroleum fuel oil such as No. 2 domestic burner oil and diesel fuel.

G. The engine shall be equipped with an electric 24 volt dc starting system of sufficient capacity to crank at a speed which will start the engine under conditions indicated. Include a charging alternator. The starting pinion shall disengage automatically when the engine starts. The starting system shall include relays for fully automatic operation from a remote signal.

H. The engine shall be provided with a speed control, **Woodward Type 2301** and electronic governor, **Woodward Type EG-3P,** or equal.

I. The engine shall minimize discharge of gaseous pollutants and shall comply with the discharge limitations of the San Luis Obispo County Air Pollution Control District. The CONTRACTOR shall furnish a certification from the manufacturer that the proposed generator set will comply with the limitations. The CONTRACTOR shall be responsible for acquiring all regulatory permits for the installation and operation of the generator set. The CONTRACTOR shall be responsible for supplying the exhaust particulate filter if required.

J. Specific limitations applicable under all loads are:

Pollutant	**Maximum Emission Rate (pounds per hour)**
Nitrogen oxides	As stated in current regulations
Carbon monoxide	As stated in current regulations
Non-methane hydrocarbons	As stated in current regulations

2.5 BATTERIES AND BATTERY CHARGER

A. Provide a lead-acid storage battery with sufficient capacity for three 30 second cranking cycles, allowing 10 seconds between cycles. Submit calculations verifying adequate capacity. The battery shall be on a plastic rack as close as practical to the starter motor. The CONTRACTOR shall provide vented, nonmetallic protective covers or red and black plastic or rubber boots covering all terminals to protect against an accidental short circuit as might be caused by laying a metallic object on the battery. Metallic racks and covers are not acceptable.

B. A unit-mounted battery charger for 120 V, single phase, 60 Hz input shall be provided. The battery charger shall be voltage regulated, with separate float and equalize charge voltage adjustment having a 10 amp rating. The battery charger shall include alarm relays to sense high and low dc voltage, zero current, and ac power failure, with individual output contacts wired to terminal strips for tie into remote alarms. Also, provide an ac "on" indicating pilot LED light and dc voltmeter and ammeter and annunciator. The battery charger shall be **LaMarche Model A46,** or equal.

2.6 EXHAUST SYSTEM

A. The engine shall be provided with an exhaust system consisting of flexible connection, exhaust silencer, steel piping, fittings, stainless steel hardware and supports, brackets, and rain collar. Provide a shield for external roof mounting.

B. The flexible connection shall be of the stainless steel bellows type with flanged ends. Flexible elements shall be stainless steel suitable for exhaust temperatures

recommended by the engine manufacturer. The flexible connection shall be suitable for vibration isolation and for relieving stress caused by thermal expansion.

C. The exhaust silencer shall be a critical grade manufactured by **Maxim,** or equal.

D. The silencer shall be supported horizontally from the roof of the generator building as indicated.

E. Exhaust piping shall be pitched upward from the engine and be provided with sufficient drains to eliminate condensation and rain water. Exhaust piping shall be welded steel pipe. Elbows shall be welding type, standard wall. Flanges shall be welding slip-on type, 125-pound, either forged or plate steel. Exhaust piping shall be supported independently of the silencer. The silencer and exhaust piping shall be insulated with a minimum of 2-1/2 inches of calcium silicate with a stainless steel jacket and shall be supported as required. The weight of the exhaust and silencer shall not be supported by the engine.

2.7 COOLING SYSTEM

A. The engine shall be equipped with a cooling system having sufficient capacity to effectively cool the engine when delivering full rated horsepower at the conditions stated above. A radiator and engine-driven fan of a type and capacity recommended by the engine manufacturer shall be included.

B. The radiator shall be sized in accordance with the engine manufacturer's recommendation for use with 50 percent aqueous ethylene glycol. Design ambient air temperature shall be 100 degrees F at sea level.

C. The engine shall have an engine-driven, gear driven centrifugal type water circulating pump for circulating water through the cooling system.

2.8 GENERATOR

A. The generator shall be nominally rated at 300 KW indicated at .8 PF, 480V 3 phase, 60 Hz, 4 wire wye and shall be a brushless design with solid state permanent magnet generator (PMG) exciter. Other excitation methods are not acceptable. The voltage regulator shall be solid state, generator mounted. Provide radio-interference suppression meeting commercial standards.

B. If a line to neutral short circuit occurs, the generator shall be capable of supporting 300 percent rated current for 10 seconds without externally mounted devices.

C. **Voltage Regulation Tolerance**: Plus or minus 1 percent of any present value over the 3 phase load range. Instantaneous voltage dip or rise, when measured with an oscilloscope, shall not exceed 25 percent upon full load application or rejection, and shall return to preset value within 0.5 seconds.

D. **Waveform:** Deviation factor of output voltage shall not exceed 5 percent and the value of any individual harmonic shall not exceed 2 percent of the fundamental when operating with an unbalanced load.

E. **Temperature Rise:** Temperature rise of any component shall not exceed the rise permitted by NEMA standards. The voltage regulator shall be adjustable minus 25 percent to plus 10 percent.

F. **Bearing:** Double sealed ball bearing, lubricated for life.

2.9 VIBRATION ISOLATORS

A. The engine and generator shall be mounted on a common system base and shall be provided with vibration isolators of number and size as recommended by the engine supplier to support the engine, generator, radiator, and base. The isolation mountings shall consist of steel or cast iron top and bottom housings incorporating steel springs or "donut" style isolators, located between the genset and the base, and shall be provided with built-in leveling bolts and built-in resilient chocks to control isolation and withstand lateral forces in all directions.

B. The vibration isolators shall be **Korfund Dynamics Corporation Series L**, or equal.

2.10 LUBRICATION AND COOLING FLUIDS

A. The supplier shall furnish the engine fully charged with lubricating oil and grease as specified by the manufacturer for continuous service. The cooling system shall be furnished with a full charge of 50 percent ethylene glycol.

2.11 GENERATOR SYSTEM CONTROL PANEL

A. The engine shall provided with an integrally mounted instrument and control panel, vibration isolated, NEMA 12 compliant, dead front, constructed of 14 gauge steel and containing at least the following equipment:

Coolant temperature gauge
Oil pressure gauge
Four position selector switches marked for “auto,” “manual,” “stop,” and “stop/reset.”
Automatic starting controls (2 wire start/stop)
Coolant level pre-alarm
Coolant temperature pre-alarms (low and high)
Fuel pressure pre-alarm
Low dc voltage alarm to indicate loss of charge on battery
Electrical contacts and "push to test" pilot lights for shutting down the engine on low oil pressure, high oil temperature, overcrank, high coolant temperature, and overspeed condition
Individual electrical contacts for remote indication of any pre-alarm or alarm condition
Running Time Meter (Non Resettable)
Emergency stop switch
Voltmeter and switch, ammeter and switch, frequency meter

B. Wiring

1. Signal wiring shall be segregated from power wiring and be arranged neatly to facilitate tracing of circuits.

2. Plastic wiring wraps shall be used to bundle wires, except within wiring ducts. The bundles shall be securely fastened to the steel structure at suitable intervals not exceeding 12-inches in length. No open space hanging of wires will be permitted. Flexible stranded copper wiring shall be used throughout. No solid conductor wire shall be permitted.

3. Terminal blocks shall be provided for interconnections between remote devices and local control panel wiring. The terminal blocks shall be factory assembled on a mounting channel, and the channel shall be bolted to the inside of the panel. The terminals shall have a continuous marking strip using the nomenclature on the schematic diagrams. No more than 2 wires shall be terminated at any one terminal. Wire terminals shall have sleeve wire markers properly marked to match the schematic diagrams.

2.12 ENGINE GENERATOR SYSTEM & PACKAGE REQUIREMENTS

A. Engine Generator Standards and Recommended Practices

1. The engine generator set and package shall be manufactured, constructed and installed to conform to the following standards and recommended practices. Auxiliaries and appurtenances required to comply shall be furnished as part of the system and package for the engine generator set. The following standards and codes and recommended practices shall be met at a minimum:

a. NEPA 70 (National Electric Code)

b. NFPA 30

c. NFPA 37

d. NFPA 110

e. UL 142

f. API 620

B. Fuel Tank

1. An integral UL listed underframe tank with floor and rupture basin shall be provided, consisting of the following: a 400 gallon rupture basin utilizing minimum 7 gauge. steel channel perimeter walls and bottom, a UL listed above-ground rectangular fuel storage tank of minimum 12 gauge steel, 350 gallon capacity, and a floor system consisting of fabricated or structural steel crossmembers on centers averaging 16 inches. The tank shall have venting and emergency venting per UL 12 and NFPA 30; lockable fill, low-level, and high-level alarm contacts; and a dc electric analog fuel level gauge. The rupture basin shall include a float contact to indicate tank

rupture. The crossmembers shall incorporate 3/8-inch thick steel tapping plates for gen-set mounting. The entire enclosure/fuel tank package shall be UL listed for use with a diesel engine generator system and shall meet the previously indicated codes and standards.

2. Pipe and Fittings

   a. Pipe and fitting materials shall be new and the best of their respective classes. Pipe shall be clearly marked with the manufacturer's standard trade mark or identification mark. Pipe and fittings, unless otherwise indicated, shall meet the requirements of these specifications.

   b. Piping carrying fuel oil shall be copper type "L" with wrought copper fittings silver soldered. Flexible connections shall be provided between fuel lines and the engine.

3. Hangers, Supports, and Miscellaneous Metal Work: The CONTRACTOR shall provide all necessary hangers, supports, concrete inserts, anchors, and guides for the standby generator equipment.

4. Valves: The CONTRACTOR shall provide ball valves for installation at all required points and on at least each fuel supply line. Ball valves shall be stainless steel, rated 125 pounds working pressure and in every respect be suitable for the purpose intended.

2.13 SPARE PARTS

A. Four sets of the following spare parts shall be furnished:

1. Air filters

2. Oil filters

3. Fuel filters

PART 3 -- EXECUTION

3.1 FACTORY TESTING

A. The generator system shall be witness tested at the factory before shipment to the Site. The manufacturer's standard testing procedure shall be followed, and in the event the system does not satisfy the test criteria or the requirements of this Section, it shall be repaired, modified, or replaced until it conforms.

B. Furnish the ENGINEER 2 weeks prior notice of the testing date and a copy of the manufacturer's test procedure. The OWNER and the ENGINEER will witness the factory testing and sign the test data as witnesses. The ENGINEER will not review nor approve the test procedure.

C. The CONTRACTOR shall pay the costs for the OWNER and ENGINEER to observe the tests. Such costs will include travel and subsistence for 2 persons excluding salaries.

D. Witnessed test results shall be submitted to the ENGINEER for the project file, not for review.

3.2 START-UP ASSISTANCE AND TRAINING

A. The manufacturer's representative shall furnish on-Site start-up assistance and shall inspect the installation prior to start-up to verify that equipment is installed in accordance with the manufacturer's requirements.

B. Upon completion of startup and after acceptance by the OWNER, the CONTRACTOR shall completely fill the fuel tank.

C. In addition, the manufacturer's representative shall provide on-Site training for operation and maintenance of all equipment included in this Section.

D. The following times shall be included, as a minimum, for the above tasks. A day is defined as 8 hours on-Site, exclusive of meals and travel. Each task shall be considered a separate trip to the site. Dates and times for the trips shall be coordinated with the OWNER.

1. Inspection of the installation: one day

2. Startup assistance: one day

3. Operation and Maintenance Training: one day

- END OF SECTION -

SECTION 16621 – NATURAL GAS STANDBY GENERATOR SYSTEM

PART 1 -- GENERAL

1.1 THE REQUIREMENT

The CONTRACTOR shall provide natural gas engine-driven standby electrical generating systems, complete and operable, in accordance with the Contract Documents.

The CONTRACTOR shall be responsible for coordination of interface with other equipment and for any special construction necessary to complete the WORK of this Section in an acceptable manner.

The supplier of the generator set shall also be the manufacturer of the engine for the generator system; however, the CONTRACTOR shall be responsible to the OWNER for the WORK of this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

Materials shall conform with applicable requirements of the National Electrical Code (NEC), and any other State or Municipal codes which apply. Generator system shall meet applicable standards and codes, including IEEE, NEMA, ANSI, OSHA, and UL.

1.3 CONTRACTOR SUBMITTALS

Furnish submittals in accordance with Section 01300 - Contractor Submittals.

Shop Drawings

a. 1. Detailed, dimensioned Shop Drawings and data demonstrating adherence to the requirements of these specifications shall be submitted and approved before fabrication, shipment, or other WORK under this Section begins. Include the manufacturer's certification that engine atmospheric emissions will comply with the limitations.

2. Certified custom drawings and custom wiring diagrams of each component in the system and a master wiring diagram showing the entire system on one sheet. This diagram shall include all AC and DC power control connections between the generator, engine, fuel tank system, batteries, and circuit breakers and shall be a custom drawing for this specific installation. A master drawing of the engine/generator set shall also be provided, showing general dimensions, bill of materials, location and size of all connections for fuel, cooling, exhaust, direct current connections, conduit locations, and connections for control and power wiring. Include wire and terminal numbers for all diagrams. Furnish KW output curves, fuel consumption curves, and certified air emission data sheets.

3. Outline drawings and connection diagrams shall be complete enough to enable the installation to be designed completely, and connection diagrams shall give both internal and external connections. Include foundation loading and clearances.

4. Certification of compliance with San Luis Obispo County Air Pollution Control District air emission requirements.

5. Strange battery calculations.

b. C. Technical Manuals

c. 1. The CONTRACTOR shall prepare and submit draft and final Technical Manuals in accordance with section 01300 – Contractor Submittals.

d. 2. Technical Manuals shall be complete with wiring diagrams, lubrication schedules and recommended lubricants, drawings, cuts, parts lists, and other necessary data. All parts shall be numbered or otherwise clearly identified to facilitate ordering of replacements. Descriptions of all operational control devices and their functions shall also be included.

1.4 QUALITY ASSURANCE

The engine/generator shall be the product of a manufacturer who has been regularly engaged in the design and production of similar engine/generator sets for a minimum of 10 years.

The supplier shall maintain a local parts and 24-hour service facility within the State of California. The supplier shall have factory trained and authorized service representatives to furnish necessary installation, test, and start-up supervision as well as operation and maintenance training necessary for final approval and acceptance.

PART 2 -- PRODUCTS

2.1 SYSTEM COMPONENTS

A. Provide the new natural gas engine-powered electric generator sets indicated. The engine generator shall have a nominal standby rating of the KW indicated, the KVA indicated, 0.8 power factor, 480 volts three phase, four wire, grounded neutral, 60 Hertz. The equipment package shall include in general, and as applicable, engine and generator on a common vibration isolating base, with auxiliaries, accessories, and controls, including intake filters, discharge silencer, turbocharger, heat exchangers, foundation bolts, isolators, piping, flexible couplings, supports, complete exhaust piping, ring, and silencer, insulation, control panels, lubrication system, water jacket heaters, cooling system, gas pressure regulators, batteries and battery rack, battery charger, spare parts, and all materials necessary to permit installation, testing and placing the system in successful operation.

B. The generator-set, enclosure, gas pressure regulator, isolation valves, and accessories shall be assembled and shipped to the Site as a complete, coordinated package, ready for installation. The engine generator base, cooling system, etc, shall be factory painted before installation in the enclosure.

C. Provide one load bank connection sized at 50 percent of the generator full load. Furnish, install and connect an isolation circuit breaker sized for the load bank and mounted on the engine support frame.

2.2 MANUFACTURER

A. Manufacturer of engine/generator set shall be **Caterpillar, Onan-Cummins,** or equal.

2.3 SYSTEM OPERATION

A. The system shall operate as follows:

1. Automatic Control:

a. A maintained remote contact closure from the automatic transfer switch shall cause the generator-set to start and run.

b. When the remote startup contact opens, the engine shall continue to operate for an adjustable cool-down time (typically 5 to 30 minutes).

2. Local Control: The generator-set shall be capable of manual initiation or stopping from the locally mounted generator control panel. The local generator control panel shall be provided as part of this Contract.

3. Emergency Stop Control: An emergency stop pushbutton shall be provided at the generator control panel that shall cause the unit to stop without any delay.

4. Exercising: The generator may be operated through a load bank for manual exercising of the generator under load.

2.4 ENGINE

A. A. The CONTRACTOR shall provide a complete engine-powered standby electrical generating system of the type and capacity indicated.

B. The natural gas engine shall be mounted on a common base with the generator and the direct connected radiator and shall be rated for standby service, continuously for the duration of the electric power interruption, with engine jacket water cooled by means of a direct mounted water-to-air radiator under SAE conditions at 85 degrees F, 100 feet above sea level. The minimum generator rating shall be the KW indicated.

C. The natural gas engine shall be four-cycle, turbocharged, aftercooled, 1800 rpm, with individual gas pressure regulation valve for each carburetor. The generator-set shall be Caterpillar, Onan-Cummins, or equal.

D. The engine shall have a dry type air cleaner with service indicator, fuel gas filter, full pressure positive pump lubrication with full-flow oil filters, thermostatic regulated oil cooling system, and crankcase drain with valving to be able to drain the crankcase oil without reaching under the engine.

E. The engine shall also be equipped with two 240 volt, thermostatically controlled jacket water heaters. Power shall be derived from a suitably-rated dry-type transformer and panelboard, also provided as part of the generating system, and including facilities to provide power to the battery charger and other generator-related facilities.

F. The natural gas engine shall perform as indicated when operating on a commercial grade of natural gas fuel.

G. The engine shall be equipped with an electric 24 volt dc starting system of sufficient capacity to crank at a speed which will start the engine under conditions indicated. Include a charging alternator. The starting pinion shall disengage automatically when the engine starts. The starting system shall include relays for fully automatic operation from a remote signal.

H. The engine shall be provided with a speed control, Woodward Type 2301 and electronic governor, Woodward Type EG-3P, or equal.

I. The engine shall minimize discharge of gaseous pollutants and shall comply with the discharge limitations of the San Luis Obispo County Air Pollution Control District. The CONTRACTOR shall furnish a certification from the manufacturer that the proposed generator set will comply with the limitations. The Contractor will be responsible for procuring all regulatory Air Quality Permits for installation and operation from the local Air Quality Board. The CONTRACTOR shall be responsible for supplying the exhaust particulate filter required.

J. Specific limitations applicable under all loads are:

Pollutant	**Maximum Emission Rate (pounds per hour)**
Nitrogen oxides	As stated in current regulations
Carbon monoxide	As stated in current regulations
Non-methane hydrocarbons	As stated in current regulations

2.5 BATTERIES AND BATTERY CHARGER

A. Provide a lead-acid storage battery with sufficient capacity for three 30 second cranking cycles, allowing 10 seconds between cycles. Submit calculations verifying adequate capacity. The battery shall be on a plastic rack as close as practical to the starter motor. The CONTRACTOR shall provide vented, nonmetallic protective covers or red and black plastic or rubber boots covering all terminals to protect against an accidental short circuit as might be caused by laying a metallic object on the battery. Metallic racks and covers are not acceptable.

B. A unit-mounted battery charger for 120 V, single phase, 60 Hz input shall be provided. The battery charger shall be voltage regulated, with separate float and equalize charge voltage adjustment having a 10 amp rating. The battery charger shall include alarm relays to sense high and low dc voltage, zero current, and ac power failure, with individual output contacts wired to terminal strips for tie into remote alarms. Also, provide an ac "on" indicating pilot LED light and dc voltmeter and ammeter and annunciator. The battery charger shall be LaMarche Model A46, or equal.

2.6 EXHAUST SYSTEM

A. The engine shall be provided with an exhaust system consisting of flexible connection, exhaust silencer, steel piping, fittings, stainless steel hardware and supports, brackets, and rain collar. Provide a shield for external roof mounting.

B. The flexible connection shall be of the stainless steel bellows type with flanged ends. Flexible elements shall be stainless steel suitable for exhaust temperatures recommended by the engine manufacturer. The flexible connection shall be suitable for vibration isolation and for relieving stress caused by thermal expansion.

C. The exhaust silencer shall be a critical grade manufactured by Maxim, or equal.

D. The silencer shall be supported horizontally from the roof of the generator building as indicated.

E. Exhaust piping shall be pitched upward from the engine and be provided with sufficient drains to eliminate condensation and rain water. Exhaust piping shall be welded steel pipe. Elbows shall be welding type, standard wall. Flanges shall be welding slip-on type, 125-pound, either forged or plate steel. Exhaust piping shall be supported independently of the silencer. The silencer and exhaust piping shall be insulated with a minimum of 2-1/2 inches of calcium silicate with a stainless steel jacket and shall be supported as required. The weight of the exhaust and silencer shall not be supported by the engine.

2.7 COOLING SYSTEM

A. The engine shall be equipped with a cooling system having sufficient capacity to effectively cool the engine when delivering full rated horsepower at the conditions stated above. A radiator and engine-driven fan of a type and capacity recommended by the engine manufacturer shall be included.

B. The radiator shall be sized in accordance with the engine manufacturer's recommendation for use with 50 percent aqueous ethylene glycol. Design ambient air temperature shall be 100 degrees F at sea level.

C. The engine shall have an engine-driven, gear driven centrifugal type water circulating pump for circulating water through the cooling system.

2.8 GENERATOR

A. The generator shall be nominally rated at the KW indicated on the Drawings at .8 PF, 480V 3 phase, 60 Hz, 4 wire wye and shall be a brushless design with solid state permanent magnet generator (PMG) exciter. Other excitation methods are not acceptable. The voltage regulator shall be solid state, generator mounted. Provide radio-interference suppression meeting commercial standards.

B. If a line to neutral short circuit occurs, the generator shall be capable of supporting 300 percent rated current for 10 seconds without externally mounted devices.

C. Voltage Regulation Tolerance: Plus or minus 1 percent of any present value over the 3 phase load range. Instantaneous voltage dip or rise, when measured with an oscilloscope, shall not exceed 25 percent upon full load application or rejection, and shall return to preset value within 0.5 seconds.

D. Waveform: Deviation factor of output voltage shall not exceed 5 percent and the value of any individual harmonic shall not exceed 2 percent of the fundamental when operating with an unbalanced load.

E. Temperature Rise: Temperature rise of any component shall not exceed the rise permitted by NEMA standards. The voltage regulator shall be adjustable minus 25 percent to plus 10 percent.

F. Bearing: Double sealed ball bearing, lubricated for life.

2.9 VIBRATION ISOLATORS

A. The engine and generator shall be mounted on a common system base and shall be provided with vibration isolators of number and size as recommended by the engine supplier to support the engine, generator, radiator, and base. The isolation mountings shall consist of steel or cast iron top and bottom housings incorporating steel springs or "donut" style isolators, located between the genset and the base, and shall be provided with built-in leveling bolts and built-in resilient chocks to control isolation and withstand lateral forces in all directions.

B. The vibration isolators shall be Korfund Dynamics Corporation Series L, or equal.

2.10 LUBRICATION AND COOLING FLUIDS

A. The supplier shall furnish the engine fully charged with lubricating oil and grease as specified by the manufacturer for continuous service. The cooling system shall be furnished with a full charge of 50 percent ethylene glycol.

2.11 GENERATOR SYSTEM CONTROL PANEL

A. The engine shall provided with an integrally mounted instrument and control panel, vibration isolated, NEMA 12 compliant, dead front, constructed of 14 gauge steel and containing at least the following equipment:

Coolant temperature gauge
Oil pressure gauge
Four position selector switches marked for “auto,” “manual,” “stop,” and “stop/reset.”
Automatic starting controls (2 wire start/stop)
Coolant level pre-alarm
Coolant temperature pre-alarms (low and high)
Fuel pressure pre-alarm
Low dc voltage alarm to indicate loss of charge on battery
Electrical contacts and "push to test" pilot lights for shutting down the engine on low oil pressure, high oil temperature, overcrank, high coolant temperature, and overspeed condition

Individual electrical contacts for remote indication of any pre-alarm or alarm condition
Running Time Meter (Non Resettable)
Emergency stop switch
Voltmeter and switch, ammeter and switch, frequency meter

B. Wiring

1. Signal wiring shall be segregated from power wiring and be arranged neatly to facilitate tracing of circuits.

2. Plastic wiring wraps shall be used to bundle wires, except within wiring ducts. The bundles shall be securely fastened to the steel structure at suitable intervals not exceeding 12 inches in length. No open space hanging of wires will be permitted. Flexible stranded copper wiring shall be used throughout. No solid conductor wire shall be permitted.

3. Terminal blocks shall be provided for interconnections between remote devices and local control panel wiring. The terminal blocks shall be factory assembled on a mounting channel, and the channel shall be bolted to the inside of the panel. The terminals shall have a continuous marking strip using the nomenclature on the schematic diagrams. No more than 2 wires shall be terminated at any one terminal. Wire terminals shall have sleeve wire markers properly marked to match the schematic diagrams.

2.12 ENGINE GENERATOR SYSTEM & PACKAGE REQUIREMENTS

A. Engine Generator Standards and Recommended Practices

1. The engine generator set and package shall be manufactured, constructed and installed to conform to the following standards and recommended practices. Auxiliaries and appurtenances required to comply shall be furnished as part of the system and package for the engine generator set. The following standards and codes and recommended practices shall be met at a minimum:

a. NEPA 70 (National Electric Code)

b. NFPA 30

c. NFPA 37

d. NFPA 110

B. Fuel Supply

1. Pipe and Fittings

a. Pipe and fitting materials shall be new and the best of their respective classes. Pipe shall be clearly marked with the manufacturer's standard trade mark or

identification mark. Pipe and fittings, unless otherwise indicated, shall meet the requirements of these specifications.

2. Contractor shall be responsible for procurement and installation and fees in all natural gas metering devices required by the natural gas supplier. Supply piping to the Generator shall be in accordance of the requirements of the natural gas supply utility.

3. Hangers, Supports, and Miscellaneous Metal Work: The CONTRACTOR shall provide all necessary hangers, supports, concrete inserts, anchors, and guides for the standby generator equipment.

4. Valves: The CONTRACTOR shall provide ball valves for installation at all required points and on at least each fuel supply line. Ball valves shall be stainless steel, rated 125 pounds working pressure and in every respect be suitable for the purpose intended.

2.13 SPARE PARTS

Four sets of the following spare parts shall be furnished for each engine generator set:

a. Air filters

b. Oil filters

c. Fuel filters

PART 3 -- EXECUTION

3.1 FACTORY TESTING

A. The generator system shall be witness tested at the factory before shipment to the Site. The manufacturer's standard testing procedure shall be followed, and in the event the system does not satisfy the test criteria or the requirements of this Section, it shall be repaired, modified, or replaced until it conforms.

B. Furnish the ENGINEER 2 weeks prior notice of the testing date and a copy of the manufacturer's test procedure. The OWNER and the ENGINEER will witness the factory testing and sign the test data as witnesses. The ENGINEER will not review nor approve the test procedure.

C. The CONTRACTOR shall pay the costs for the OWNER and ENGINEER to observe the tests. Such costs will include travel and subsistence for 2 persons excluding salaries for the time to test all the engine generator sets.

D. Witnessed test results shall be submitted to the ENGINEER for the project file, not for review.

3.2 START-UP ASSISTANCE AND TRAINING

A. The manufacturer's representative shall furnish on-Site start-up assistance and shall inspect the installation prior to start-up to verify that equipment is installed in accordance with the manufacturer's requirements.

B. In addition, the manufacturer's representative shall provide on-Site training for operation and maintenance of all equipment included in this Section.

C. The following times shall be included, as a minimum, for the above tasks. A day is defined as 8 hours on-Site, exclusive of meals and travel. Each task shall be considered a separate trip to the site. Dates and times for the trips shall be coordinated with the OWNER.

a. Inspection of the installation: two days

b. Startup assistance: three days

c. Operation and Maintenance Training: one day

d. - END OF SECTION -

SECTION 16800 – FIBER OPTIC CONDUITS ALONG PIPELINES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide a fiber optic conduit system including installation of the fiber optic cable (FOC) which will be furnished by the CONTRACTOR for the Los Osos Wastewater Project Wastewater Treatment Facility, in accordance with the Contract Documents.

B. A separate contractor shall perform fiber-optic-cable installation. This shall be performed under a separate contract with the OWNER. That separate contractor will monitor installation of the fiber optic conduit system. That separate contractor shall be the Los Osos Wastewater Project Wastewater Treatment Facility contractor.

1.2 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Catalog Data: Data on conduit system, pull boxes, conduit fittings, conduit sealant, pull rope, identification tape, warning signs.

2. Detailed bill of materials.

3. Drawings indicating the locations of all pull boxes with station numbers.

4. Information on at least 5 successfully performing fiber optic cable installations of comparable size and complexity in the recent past with name, address, and telephone number of facility owner, name of project and completion date, and type of conduit system and length of cable pulled.

5. The name and qualifications of the supervisory personnel that will be directly responsible for the installation of the conduit system.

PART 2 -- PRODUCTS

2.1 MATERIALS

A. **Conduit:** 4-inch diameter PVC conduit, stiffness of DB-60, in accordance with ASTM F 512-Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation.

B. **Pull Boxes:** Pull boxes shall be approximately 32 inches wide by 49-5/8 inches long by 36 inches deep, designed for H-20 traffic loading unless otherwise indicated. Covers shall be galvanized steel with the words "Fiber Optics" in raised letters on the upper surface. Covers shall have locking devices and form a watertight seal to prevent surface water from entering. Knockouts in the sidewalls shall permit underground conduit side entry and exit. Provide **George Ingraham, Vikamatic** or equal. Pull boxes shall not be installed in public streets open to vehicle traffic. In public streets open to vehicle traffic manholes shall be utilized per the contract documents and as indicated on the contract drawings. Minimum pullbox and manhole inside dimensions shall exceed or equal NEC requirements involving large wire sizes #4 AWG and larger. If larger dimensions are shown in the contract drawings the larger size shall be provided.

C. **Conduit Sealant: Semco** duct sealing compound or equal.

D. **Identification Tape:** A 6-inch wide magnetically detectable warning tape with orange protective polyethylene jacket resistant to alkalies, acids, and other destructive elements shall be installed above the conduit along the entire length of the conduit route. The polyethylene tape shall be continuously imprinted "CAUTION-FIBER OPTIC CABLE". The warning tape shall be **Teletrace by George Ingraham, Vikamatic,** or equal.

E. **Pull Rope:** Low friction, polyethylene jacketed, polypropylene rope with 1800 psi of tensile strength. Provide **Vikamatic "Fiber Glide"** or equal.

PART 3 -- EXECUTION

3.1 CONDUIT INSTALLATION

A. Conduits shall be installed on one side of the trench, at least 2 inches and not more than 12 inches from the trench wall, at a depth of 3 to 4-feet below grade along the entire pipeline route. The conduit shall not cross over the pipe.

B. Conduits shall clear concrete structures and vaults associated with the pipeline by a minimum of one-foot.

C. The conduit shall gradually and smoothly slope up to the elevation of the pull box entrance. Use of manufactured bends shall be limited to an absolute minimum. Factory bends, if required, shall be no more than 22-1/2 degrees.

D. Conduit sections shall be joined in accordance with the manufacturers' recommendations. Joints shall be watertight.

E. CONTRACTOR shall install a pull rope in the conduit.

F. Conduits entering pull boxes shall be capped or sealed watertight.

G. Bedding and backfill shall be sand backfill in accordance with Section 02200 - Earthwork, placed at least 4 inches thick below and above the conduit, compacted to at least 90 percent maximum density.

H. Conduit shall be installed in the annular space between the carrier pipe and the casing or tunnel liner for all two-pass tunnel or jack and bore sections of the pipeline alignment.

3.2 PULL BOXES

A. Field Location of Pull Boxes

1. The Drawings diagrammatically indicate the desired location of pull boxes, conduit runs and other items. Exact locations shall be determined by the CONTRACTOR based on physical size and arrangement of equipment, finished elevations, calculated cable pulling tensions, field obstructions, and the criteria below. Indicated locations should be followed as closely as possible, however, pull boxes shall be located according to the following criteria:

   a. At no point shall the cable pulling tension exceed 600 pounds. If cable pulling tension is calculated to exceed 600 pounds, additional pull boxes shall be provided at no extra cost to the OWNER.

b. The maximum distance between any 2 pull boxes shall not exceed 1,200 feet.

c. Within the 1,200 feet distance, the CONTRACTOR shall install pull boxes at locations wherever the cumulative change of direction of the conduit exceeds 180 degrees.

d. The minimum bending radius for conduit shall be 3-feet.

e. A pull box shall be installed on one side of a tunneled crossing. However, for any crossing which requires more than 180 degrees of conduit bends to account for elevation differences or route adjustments, a pull box shall be installed on both sides of the crossing.

B. Construction

1. The CONTRACTOR shall install the pull box covers so that the top of the cover is flush with the restored pavement. Pull boxes installed in soil areas shall be installed so that the top of the cover is at least one-inch but not more than 4 inches above the final grade level of the restored surface to prevent accumulation of dirt, silt and debris on the top of the hand hole cover.

2. CONTRACTOR shall perform conduit integrity tests for each section between the pull boxes after backfilling and compaction using the test and procedures described in this Section. These tests shall be performed prior to installation of the pull rope.

3. Pull box conduit entries shall be sealed with mortar to prevent the intrusion of water and debris into the pull boxes.

4. Pull boxes shall be installed on a compacted level foundation consisting of 4 inches of granular material complying with Section 02200 - Earthwork.

5. Backfilling around pull boxes shall not be done until mortar sealant has thoroughly set.

6. Compaction around pull boxes and associated details shall be performed in accordance with Section 02200 - Earthwork.

7. Upon final acceptance of the conduit system, pull boxes shall be free of debris and water and be ready for cable installation.

3.3 MODIFICATIONS

A. All dimensions and exact locations of underground substructures shall be field verified. Minor changes in locations of pull boxes which result in no additional costs for material or labor shall be made as a part of the WORK. However, the CONTRACTOR shall prepare proposals consisting of detailed material lists, cost estimates, and schedules for rerouting the conduit around existing unforseen underground utilities and structures which result in additional cost. The ENGINEER will consider the proposals in accordance with the change provisions of the General Conditions.

B. The CONTRACTOR shall consider the following when preparing proposals.

1. Manufactured bends shall be minimized.

2. Required bends shall be less than 22-1/2 degrees.

3. Clearances between conduits and other structures shall be:

Structures	Minimum Separations
Power or other foreign conduit	12 inches
Pipes for gas, oil, water, sewage	6 inches when crossing: 12 inches when parallel

3.4 CABLE MARKER SIGNS

A. The CONTRACTOR shall install marker signs for fiber optic cable on all marker posts for the pipeline as indicated.

3.5 CONDUIT SYSTEM CLEANING AND TESTING

A. Following the backfill placement and compaction, all conduits shall be cleared of loose material by brush and compressed air.

B. A test mandrel 3/8-inch smaller than the inside diameter shall be passed through all conduits to detect alignment and deformation problems. Mandrel shall be passed in both directions.

C. Cleaning and testing of the conduit shall be performed by the CONTRACTOR and witnessed by the ENGINEER. The cleaning and testing operation shall be conducted for each conduit section between adjacent pull boxes, a section at a time, for the entire route. The results of tests shall be documented by the CONTRACTOR and signed by the ENGINEER and the CONTRACTOR.

D. The CONTRACTOR shall provide a 5 day advance notice of the schedule and location of test to the ENGINEER.

E. The CONTRACTOR shall remove and replace noncompliant conduit and shall repeat the test.

- END OF SECTION -

SECTION 16950 – ELECTRICAL TESTS

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.

B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 17 - Instrumentation, shall be completed before commencement of the 7-day test of Section 01660 - Equipment Testing and Plant Startup. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.

C. The requirements of Section 16050 - Electrical Work, General, apply to the WORK of this Section.

1.2 TESTING

A. **General:** Carry out tests indicated herein for individual items of materials and equipment in other Sections.

B. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.

1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules.

2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.

4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.

5. Cable Testing: 480-volt circuits shall be tested for insulation resistance with a 1000-volt megohm meter. Testing shall be done after the 480-volt equipment is terminated. Phase-to-phase A-B, B-C, A-C and phase-to-ground insulation resistance tests shall be performed on each cable prior to 5-kV and 25-kV cable termination at equipment but subsequent to stress cone makeup. Test results shall be submitted for review 30 days prior to plant operation and any system testing. Equipment which may be damaged during this test shall be disconnected. Perform tests with all other equipment connected to the circuit. In order to be acceptable, the cable must withstand the test high voltage without breakdown, have steady or

decreasing leakage current during the high potential test, and have satisfactory comparable megger readings in each megger test. Test results shall be submitted to the ENGINEER, stating equipment used and time of test. Cable operating at more than 2,000 volts shall be tested in accordance with ICEA publications S-68-61, S-61-402, S-19-81, and S-68-516. Cable testing and report submittal shall be performed by an organization sanctioned by the manufacturer of the cable to be tested. Testing shall verify the quality of cable terminations. Test results for medium and high voltage cable shall be submitted to the ENGINEER 30 days prior to the time schedule for equipment energization.

6. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle and circuit breaker manufacturer.

C. The following test requirements supplement test and acceptance criteria that may be stated elsewhere and are required to be performed by an independent CONTRACTOR whose primary work is specializing in electrical equipment acceptance testing.

1. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:

   a. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.

2. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

3. Required testing as a minimum includes acceptance and functional testing in accordance with the 1999 International Electrical Testing Association (NETA) "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" for the following specific items:

   a. Switchboards: 1999 NETA 7.1

   b. Transformers: 1999 NETA 7.2

   c. Low Voltage Molded Case Circuit Breakers: 1999 NETA 7.6

   d. Grounding Systems: 1999 NETA 7.13

   e. Low Voltage AC Motors: 1999 NETA 7.15

   f. Low Voltage Motor Control: 1999 NETA 7.16

   g. Adjustible Speed Drive Systems: 1999 NETA 7.17

   h. Low Voltage Surge Protection Devices (TVSS): 1999 NETA 7.19

   i. Thermographic Survey: 1999 NETA 9

   j. All places where the 1999 NETA "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" has an "*" (asterisk) meaning "Optional" is noted, the "Optional" items are a required part of this project and shall be included in the base bid.

4. Testing equipment required to conduct the tests shall be furnished by the testing organization. Testing equipment shall be in good working condition and comply with the requirements of applicable industry testing standards for test equipment. Test equipment shall be calibrated as required or recommended by the test equipment manufacturer and have a sticker showing date of calibration and date calibration expires with signature of calibrator.

5. Testing shall be done in accordance with manufacturer's instructions and applicable NEMA, IEEE, ANSI and ASTM standards.

6. The testing organization is responsible for verifying that all defects and deficiencies identified are corrected as part of their work.

7. The testing organization shall cooperate with any manufacturer's representative regarding any of their equipment or systems that may be involved or affected by testing.

8. Acceptable testing organizations include **Electro-Test Inc., Power Systems Testing or equal.**

9. The ENGINEER and OWNER shall be given 5 working days prior notice of any proposed testing. The OWNER's on-site representative shall be contacted on the day testing starts prior to starting testing. The OWNER's representative shall be invited to witness testing each day testing is conducted. A signed written report shall be left with the OWNER's representative at the end of each testing day listing testing completed and any discrepancies needing correction. A finished typed report of the testing and outstanding discrepancies not corrected during testing shall be submitted for review.

D. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

E. After initial settings have been completed, each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

F. Motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a representative of the valve manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.

G. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results. Utilize the fall-of-potential method or 3-point or 4 point alternative method, in accordance with IEEE Standard 81.

H. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.

1.3 COMMISSIONING

A. Commissioning during the 7-day test in Section 01660 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.

B. Submit a motor current tabulation reflecting the values occurring during commissioning.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

- END OF SECTION -

SECTION 17100 - PROCESS CONTROL AND INSTRUMENTATION SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The CONTRACTOR shall provide all Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents.

B. The requirements of this Section apply to all components of the PCIS unless indicated otherwise.

C. Responsibilities

1. The CONTRACTOR, through the use of an Instrumentation Supplier and qualified electrical and mechanical installers, shall be responsible to the OWNER for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.

2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the Instrumentation Supplier be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under other sections with the objective of providing a completely integrated control system free of signal incompatibilities.

3. As a minimum, the Instrumentation Supplier shall perform the following WORK:

a. Implementation of the PCIS

1) prepare analog hardware submittals.

2) design, develop, and electronically draft loop drawings and control panel and back-plane designs.

3) prepare the test plan, the training plan, and the spare parts submittals.

4) procure hardware.

5) fabricate panels.

6) perform factory tests on panels.

7) perform calibrations after installation.

8) oversee and certify installation.

9) oversee, document, and certify loop testing.

10) oversee, document, and certify system commissioning.

11) conduct the performance test.

12) prepare Technical Manuals.

13) conduct training classes.

14) prepare record drawings.

b. Integration of the PCIS with instrumentation and control devices being provided under other sections;

1) Develop all requisite loop drawings and record loop drawings associated with equipment provided under other Divisions of these Specifications.

2) Resolve signal, power, or functional incompatibilities between the PCIS and interfacing devices.

4. Any Instrumentation Supplier responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the Instrumentation Supplier. Additional requirements in this Section and throughout Division 17 that are stated to be the CONTRACTOR's responsibility may be performed by the Instrumentation Supplier if the CONTRACTOR and Instrumentation Supplier so agree.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01300 - Contractor Submittals and the following:

1. The CONTRACTOR shall coordinate the instrumentation work so that the complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and record drawings.

2. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the ENGINEER, but will not alter the scope of work or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.

3. Symbology and Nomenclature: In these Contract Documents, all systems, all meters, all instruments, and all other elements are represented schematically, and are designated by symbology as derived from Instrument Society of America Standard ANSI/ISA S5.1 - Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.

B. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a Presubmittal Conference within 60 days after award of the Contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the CONTRACTOR intends to carry out its responsibilities for Shop Drawing submittal on the WORK to be provided under this Section. The CONTRACTOR, the Instrumentation Supplier, and the ENGINEER shall attend. Both the CONTRACTOR and the ENGINEER may invite additional parties at their discretion.

2. The CONTRACTOR shall allot one, 4-hour half-day for the Conference.

3. The CONTRACTOR shall present the following for discussion at the Conference:

   a. A list of equipment and materials required for the PCIS and the manufacturer's name and model number for each proposed item.

   b. A list of proposed clarifications to the Contract Documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the ENGINEER.

   c. An exact one-to-one sample of each type of submittal herein.

   d. A bar-chart type schedule for all system related activities from the Presubmittal Conference through start-up and training. Dates of submittals, design, fabrication, factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.

   e. An overview of the proposed training plan. The OWNER's staff and ENGINEER will review the overview and may request changes. All changes to the proposed training shall be resolved at the pre-submittal conference. The overview shall include the following for each proposed course.

      1) Course title and objectives.

      2) Prerequisite training and experience of attendees.

      3) Course content - a topical outline.

      4) Course duration.

      5) Course format - lecture, laboratory demonstration, etc.

4. The CONTRACTOR shall furnish 3 copies of all the items above to the ENGINEER.

5. The CONTRACTOR shall take minutes of the Conference, including all events, questions, and resolutions. Prior to adjournment, all parties must concur with the accuracy of the minutes and sign accordingly.

C. Shop Drawings

1. **General**

   a. Preparation of Shop Drawings shall not commence until adjournment of the Presubmittal Conference.

   b. Shop Drawings shall include the letter head or title block of the Instrumentation Supplier. The title block shall include, as a minimum, the Instrumentation Supplier's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing. The quantity of submittal sets shall be as indicated in Section 01300 - Contractor Submittals.

c. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized and incomplete submittals for a given loop will not be accepted.

d. Shop Drawing information shall be bound in standard size, 3 ring, looseleaf, vinyl plastic, hard cover binders suitable for bookshelf storage. Binder ring size shall not exceed 3 inches.

e. Interfaces between instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders and other equipment related to the PCIS shall be included in the Shop Drawing submittal.

2. Analog Hardware Submittal: The CONTRACTOR shall submit an analog hardware submittal as a complete bound package at one time within 60 calendar days after the commencement date stated in the Notice to Proceed, including:

a. A complete index which lists each device by tag number, type, and manufacturer. A separate technical brochure or bulletin shall be included with each instrument data sheet. The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure or bulletin may cover all identical uses of that instrument in that system. Each brochure or bulletin shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags.

b. Fully executed data sheets according to ISA S20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, for each component, together with a technical product brochure or bulletin. The technical product brochures shall be complete enough to verify conformance to Contract Document requirements. The data sheets, as a minimum, shall show:

1) Component functional description used in the Contract Documents.

2) Manufacturer's model number or other product designation.

3) Project tag number used in the Contract Documents.

4) Project system or loop of which the component is a part.

5) Project location or assembly at which the component is to be installed.

6) Input and output characteristics.

7) Scale, range, units, and multiplier (if any).

8) Requirements for electric supply (if any).

9) Requirements for air supply (if any).

10) Materials of component parts to be in contact with or otherwise exposed to process media and corrosive ambient air.

11) Special requirements or features.

c. Flow meter sizing calculations. Calculations shall be submitted on the instrument manufacturer letterhead and shall include the following:

   1) Proposed meter size based on indicated minimum, maximum and average flow rates

   2) Guaranteed meter accuracy based on the upstream and downstream straight runs associated with the location of each meter

   3) Permanent head loss associated with each meter

   4) Flow vs. differential pressure curves for all head-type devices. For compressible fluids, curves shall be pressure and temperature compensated.

   5) References to ASME standard equations used

   6) Values used for all parameters used in calculations

d. Priced list of spare parts for all devices

e. Instrument installation, mounting, and anchoring details shall be submitted in hard copy format. Each instrument shall have a dedicated 8-1/2 inch by 11-inch detail that only pertains to the specific instrument by tag number. Each detail shall be certified by the instrument manufacturer that the proposed installation is in accordance with the instrument manufacturer's recommendations and is fully warrantable. These certifications shall appear as a stamp on the hard copies. As a minimum, each detail shall have the following contents;

   1) show necessary sections and elevation views required to define instrument location by referencing tank, building or equipment names and numbers, and geographical qualities such as north, south, east, west, basement, first floor.

   2) ambient temperature and humidity of the environment that the instrument is to be installed in.

   3) corrosive qualities of the environment that the instrument is to be installed in.

   4) hazardous rating of the environment that the instrument is to be installed in.

   5) process line pipe or tank size, service and material.

   6) process tap elevation and location.

   7) upstream and downstream straight pipe lengths between instrument installation and pipe fittings and valves.

   8) routing of tubing and identification of supports.

   9) mounting brackets, stands, and anchoring devices.

10) conduit entry size, number, location, and delineation between power and signal.

11) NEMA ratings of enclosures and all components.

12) clearances required for instrument servicing.

13) list itemizing all manufacturer makes, model numbers, quantities, lengths required, and materials of each item required to support the implementation of the detail.

3. Project-Wide Loop Drawing Submittal: The CONTRACTOR shall furnish a Project-wide Loop Drawing Submittal (PLDS) which completely defines and documents the contents of each monitoring, alarming, interlock, and control loop associated with equipment provided under Division 17 sections, equipment provided under sections in other Divisions, which is to be incorporated into the PCIS. The PLDS shall be a singular complete bound package submitted within 120 days after Contract Award, and shall include the following:

   a. A complete index in the front of each bound volume. The loop drawings shall be indexed by systems or process areas. Loops shall be tagged in a manner consistent with the Contract Documents. Loop drawings shall be submitted for every analog and discrete monitoring and control loop.

   b. Drawings showing definitive diagrams for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component of each loop or system using legend and symbols from ANSI/ISA S5.4 - Instrument Loop Drawings, extending the format as shown on Drawing A/D-GI-201 and as defined by the most recent revision in ISA. Panel drawings showing PLC I/O card wiring and field terminations are not acceptable as loop drawings. Each system or loop diagram shall be drawn with no more than ten loops per drawing. Loop drawings shall be developed for loops in equipment vendor supplied packages, equipment provided under Division 17, and OWNER furnished equipment. In addition to the expanded ISA S5.4 requirements, the loop diagrams shall also show the following details:

      1) Functional name of each loop.

      2) Reference name, drawing, and loop diagram numbers for any signal continuing off the loop diagram sheet.

      3) MCC panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.

      4) Designation, and if appropriate, terminal assignments associated with every manhole, pullbox, junction box, conduit, and panel through which the loop circuits pass.

      5) Vendor panel, instrument panel, conduit, junction boxes, equipment and SCADA terminations, termination identification wire numbers and colors, power circuits, and ground identifications.

   c. Itemized instrument summary. The summary shall be prepared with Microsoft Access software and shall be submitted on compact disk and hard copy. The

instrument summary shall list all of the key attributes of each instrument provided under this Contract. As a minimum, attributes shall include:

1) Tag number

2) Manufacturer

3) Model number

4) Service

5) Area location

6) Calibrated range

7) Loop drawing number

8) Associated LCP, PLC, PCM, or RTU

4. Test Procedure Submittals

   a. The CONTRACTOR shall submit the proposed procedures to be followed during tests of the PCIS and its components.

   b. Preliminary Submittal: Outlines of the specific proposed tests and examples of proposed forms and checklists.

   c. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed test procedures, forms, and checklists. This submittal shall include a statement of test objectives with the test procedures.

5. Training Submittals: Subsequent to the receipt of the OWNER's and ENGINEER's inputs made at the Presubmittal Conference, the CONTRACTOR shall submit a training plan which includes:

   a. A resubmittal of the training plan overview from the Presubmittal Conference with incorporation of all modifications agreed upon at that meeting.

   b. Schedule of training courses including dates, durations, and locations of each class.

   c. Resumes of the instructors who will actually implement the plan.

D. Technical Manual

1. General: Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the WORK.

2. The Technical Manual shall have the following organization for each process:

   a. Section A - Process and Instrumentation Diagrams

   b. Section B - Loop Descriptions

c. Section C - Loop Drawings

d. Section D - Instrument Summary

e. Section E - Instrument Data Sheets

f. Section F - Sizing Calculations

g. Section G - Instrument Installation Details

h. Section H - Test Results

3. Signed results from Loop Testing, Precommissioning, and Performance Testing shall be included in Section H.

4. Initially, 2 sets of draft Technical Manuals shall be submitted for review after return of favorably reviewed Shop Drawings and data required herein. Following the ENGINEER's review, one set will be returned to the CONTRACTOR with comments. The Manuals shall be revised and amended as required and the final Manuals shall be submitted 15 days prior to startup of systems.

E. Record Drawings

1. The CONTRACTOR shall keep current a set of complete loop and schematic diagrams which shall include all field and panel wiring, piping and tubing runs, routing, mounting details, point-to-point diagrams with cable, wire, tube and termination numbers. These drawings shall include all instruments and instrument elements. One set of drawings electronically formatted in AutoCAD and 2 hard copies shall be submitted after completion of all Precommissioning tasks but prior to Performance Testing. All such drawings shall be submitted for review prior to acceptance of the completed WORK by the OWNER.

1.3 SPECIAL WARRANTY REQUIREMENTS

A. **Extended Period for Correction of Defects:** The CONTRACTOR shall correct all defects in the PCIS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 5 days after notification.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Code and Regulatory Compliance:** PCIS WORK shall conform to or exceed the applicable requirements of the National Electrical Code. Conflicts between the requirements of the Contract Documents and any codes or referenced standards or specifications shall be resolved according to Section 01090 - Reference Standards.

B. **Current Technology:** Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

C. **Hardware Commonality:** Instruments which utilize a common measurement principle (for example, d/p cells, pressure transmitters, level transmitters that monitor hydrostatic head) shall be furnished by a single manufacturer. Panel mounted instruments shall

have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer.

D. **Loop Accuracy:** The accuracy of each instrumentation system or loop shall be determined as a probable maximum error; this shall be the square root of the sum of the squares of certified "accuracies" of the designated components in each system, expressed as a percentage of the actual span or value of the measured variable. Each individual instrument shall have a minimum accuracy of plus and minus 0.5 percent of full scale and a minimum repeatability of plus and minus 0.25 percent of full scale unless otherwise indicated. Instruments that do not conform to or improve upon these criteria are not acceptable.

E. **Instrument and Loop Power:** Power requirements and input/output connections for all components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2-wire" transmitters is preferred, and use of "4-wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.

F. **Instrument Air:** Dry, filtered control air at 30 psig nominal pressure shall be piped to field instruments and instrument panels requiring air. Each field instrument shall be provided with an integral, non-adjustable filter/regulator assembly to provide regulated air. Each instrument panel requiring air shall be provided with an adjustable filter/regulator assembly with gauge and an air manifold to provide air to pneumatic instruments. Air shall be filtered to 5 micron maximum particle size. Pressure reducers and regulators shall be furnished with additional instrumentation as required.

G. **Loop Isolators and Converters:** Signal isolators shall be provided as required to ensure adjacent component impedance match where feedback paths may be generated, or to maintain loop integrity during the removal of a loop component. Dropping precision wirewound resistors shall be installed at all field side terminations in the control panels to ensure loop integrity. Signal conditioners and converters shall be provided where required to resolve any signal level incompatibilities or provide required functions.

H. **Environmental Suitability:** Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. All instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

I. **Signal Levels:** Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 milliamperes dc except as indicated. Signals within enclosures may be 1 to 5 volts dc. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.

J. **Control Panel Power Supplies:** Control panels shall be provided with redundant power supplies which are configured in a fault-tolerant manner to prevent interruption of service upon failure and interruption of service necessitated by the replacement of a power supply. Power supplies shall have an excess rated capacity of 40 percent. The failure of a power supply shall be annunciated at the control panel and repeated to the SCADA System.

K. **Alternative Equipment and Methods:** Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process of the Bid Forms. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

2.2 OPERATING CONDITIONS

A. The PCIS shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:

Environment	Salt in environment by the ocean
Temperature Range	32 through 104 degrees F
Thermal Shock	1 degree F per minute, max
Relative Humidity	20 through 90 percent, non-condensing

2.3 SPARE PARTS AND SPECIAL TOOLS

A. The ENGINEER will select the required spare parts from the priced list of spare parts in the Analog Hardware Submittals, and the CONTRACTOR shall furnish them. The CONTRACTOR will be paid from the corresponding allowance item in the Bid, and the total price will not exceed the amount of the allowance item.

B. The CONTRACTOR shall furnish a priced list of all special tools required to calibrate and maintain the instrumentation provided under the Contract Documents. After approval the CONTRACTOR shall furnish tools on that list.

C. In addition to the CONTRACTOR proposed special tools, the CONTRACTOR shall furnish the following:

1. One electronic magnetic flowmeter calibration device per manufacturer of flow meters.

2. One portable instrument calibrator current simulator with charger and carrying case (**RIS 4500, Fluke**, or equal).

D. Special tools and spare parts shall be submitted before startup commences, suitably wrapped and identified.

2.4 FACTORY TESTING

A. The CONTRACTOR shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the ENGINEER and OWNER to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, flow-measuring devices, and other pertinent systems and devices. A minimum of 10 working days notification shall be furnished to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER'S approval.

PART 3 -- EXECUTION

3.1 PRODUCT HANDLING

A. **Shipping Precautions**: After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.

B. **Special Instructions:** Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.

C. **Tagging:** Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. **Storage:** Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.2 MANUFACTURER'S SERVICES

A. The CONTRACTOR shall furnish the following manufacturer's services for the instrumentation listed below:

1. Perform bench calibration.

2. Oversee installation.

3. Verify installation of installed instrument.

4. Certify installation and reconfirm manufacturer's accuracy statement.

5. Oversee loop testing, prepare loop validation sheets, and certify loop testing.

6. Oversee precommissioning, prepare precommissioning validation sheets, and certify precommissioning.

7. Train the OWNER's personnel.

B. Manufacturer's services shall be furnished for the following equipment:

1. Turbidity Analyzer.

2. Chlorine Analyzer.

3.3 INSTALLATION

A. **General**

1. Instrumentation, including instrumentation furnished under other Divisions, shall be installed under Division 17 and the manufacturers' instructions.

2. Equipment Locations: The monitoring and control system configurations indicated are diagrammatic. The locations of equipment are approximate. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.

B. Conduit, Cables, and Field Wiring

1. Conduit shall be provided under Division 16 without delay to the WORK of Division 17.

2. Process equipment control wiring, 4-20 mA signal circuits, signal wiring to field instruments, PLC input and output wiring and other field wiring and cables shall be provided under Division 16.

3. PLC equipment cables shall be provided under Division 17.

4. Terminations and wire identification at PCIS equipment furnished under this or any other Division shall be provided under Division 17.

C. **Instrumentation Tie-Downs:** Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

D. **Existing Instrumentation:** Each existing instrument to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this work prior to reinstallation of each instrument.

E. **Ancillary Devices:** The Contract Documents show all necessary conduit and instruments required to make a complete instrumentation system. The CONTRACTOR shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such

changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing the work. Such changes shall not be a basis of claims for extra work or delay.

F. **Installation Criteria and Validation:** Field-mounted components and assemblies shall be installed and connected according to the requirements below:

1. Installation personnel have been instructed on installation requirements of the Contract Documents.

2. Technical assistance is available to installation personnel at least by telephone.

3. Installation personnel have at least one copy of the approved Shop Drawings and data.

4. Instrument process sensing lines shall be installed in conduit under Section 16050 – Electrical Work, General. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3 feet of rigid tubing.

5. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.

6. Differential pressure elements shall have 3 valve manifolds.

7. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.

8. Power and signal wires shall be terminated with crimped type lugs.

9. Connectors shall be, as a minimum, water tight.

10. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.

11. Wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.

12. Mounting stands and bracket materials and workmanship shall comply with requirements of the Contract Documents.

13. Verify the correctness of each installation, including polarity of electric power and signal connections, and make sure process connections are free of leaks. The CONTRACTOR shall certify in writing that discrepancies have been corrected for each loop or system checked out.

14. The OWNER will not be responsible for any additional cost of rework attributable to actions of the CONTRACTOR or the Instrumentation Supplier.

3.4 CALIBRATION

A. **General:** Devices provided under Division 17 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. **Calibration Points:** Each instrument shall be calibrated at 0,25,50,75 and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. **Bench Calibration:** Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the ENGINEER.

D. **Field Calibration:** Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. **Analyzer Calibration:** Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. **Calibration Sheets:** Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name
2. Loop number
3. Tag number
4. Manufacturer
5. Model number
6. Serial number
7. Calibration range
8. Calibration data: Input, output, and error at 10 percent, 50 percent, and 90 percent of span
9. Switch setting, contact action, and deadband for discrete elements
10. Space for comments
11. Space for sign-off by Instrumentation Supplier and date
12. Test equipment used and associated serial numbers

G. **Calibration Tags:** A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the Instrumentation Supplier sign the tag when calibration is complete. The ENGINEER will sign the tag when the calibration and testing has been accepted.

3.5 LOOP TESTING

A. **General:** Individual instrument loop diagrams per ISA Standard S5.4 - Instrument Loop Diagrams, expanded format, shall be submitted to the ENGINEER for review prior to the loop tests. The CONTRACTOR shall notify the ENGINEER of scheduled tests a minimum of 30 days prior to the estimated completion date of installation and wiring of the PCIS. After the ENGINEER'S review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop check shall be witnessed by the ENGINEER.

B. **Control Valve Tests:** Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.

C. **Interlocks:** All hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers and packaged equipment controls shall be checked to the maximum extent possible.

D. **Instrument and Instrument Component Validation:** Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

E. **Loop Validation:** Controllers and electronic function modules shall be field tested and exercised to demonstrate correct operation. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the PLC. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by Contract requirements or by published manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated. Each analog network shall be tested by applying simulated analog or discrete inputs to the first element of an analog network. For networks which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75 and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data shall be recorded on test forms attached at the end of this section which include calculated RMS summation system accuracy tolerance requirements for each output.

F. **Loop Validation Sheets:** The CONTRACTOR shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following

information and shall provide spaces for sign-off on individual items and on the complete loop by the Instrumentation Supplier:

1. Project name.
2. Loop number.
3. Tag number, description, manufacturer, and model number for each element.
4. Installation bulletin number.
5. Specification sheet number.
6. Loop description number.
7. Adjustment check.
8. Space for comments.
9. Space for loop sign-off by Instrumentation Supplier and date.
10. Space for ENGINEER witness signature and date.

G. **Loop Certifications:** When installation tests have been successfully completed for all individual instruments and all separate analog control networks, a certified copy of each test form signed by the ENGINEER or the ENGINEER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the instrumentation has been successfully calibrated, inspected, and tested.

3.6 PRECOMMISSIONING

A. **General:** Precommissioning shall commence after acceptance of all wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Precommissioning shall demonstrate proper operation of all systems with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

B. **Precommissioning Procedures and Documentation:** Precommissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system precommissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that all system precommissioning and test requirements have been satisfied.

C. **Operational Validation:** Where feasible, system precommissioning activities shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control

circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of field mounted, and software based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

D. **Loop Tuning:** Electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75 and 100 percent of span and the results checked against indicated accuracy tolerances.

E. **Precommissioning Validation Sheets:** Precommissioning shall be documented on one of two types of test forms as follows:

1. For functions which can be demonstrated on a loop-by-loop basis, the form shall include:

   a. Project name.

   b. Loop number.

   c. Loop description.

   d. Tag number, description, manufacturer, and data sheet number for each component.

   e. Space for sign-off and date by both the Instrumentation Supplier and ENGINEER.

2. For functions that cannot be demonstrated on a loop-by-loop basis, the test form shall be a listing of the specific tests to be conducted. With each test description the following information shall be included:

   a. Specification page and paragraph of function demonstrated.

   b. Description of function.

   c. Space for sign-off and date by both the Instrumentation Supplier and ENGINEER.

F. **Precommissioning Certification:** The CONTRACTOR shall submit an instrumentation and control system precommissioning completion report which shall state that all Contract requirements have been met and shall include a listing of instrumentation and control system maintenance and repair activities conducted during the precommissioning testing. Acceptance of the instrumentation and control system precommissioning testing must be provided in writing by the ENGINEER before the

performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

3.7 ON-SITE SUPERVISION

A. The CONTRACTOR shall furnish the services of an on-site resident engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The resident engineer shall be present during the total period required to effect a complete operating system. A team of engineering personnel shall be on site for 40 hours to check all equipment, perform the tests indicated in this Section, and furnish startup services.

3.8 PERFORMANCE TEST

A. The entire PCIS shall operate for 30 days without failure.

B. The CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements.

C. If any component fails during the performance test, it shall be repaired or replaced and the PCIS shall be restarted on another 30 day period.

3.9 TRAINING

A. **General:** The CONTRACTOR shall train the OWNER'S personnel on the maintenance, calibration, and repair of instruments provided under this Contract.

B. **Instructions:** The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. **Duration:** Each training class shall be a minimum of 8 hours in duration and shall cover, as a minimum, operational theory, maintenance, trouble shooting/repair, and calibration of the instrument.

D. **Schedule:** Training shall be performed during the precommissioning phase of the project. The training sessions shall be scheduled a minimum of 4 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated.

E. **Agenda:** The training shall include operation and maintenance procedures, trouble shooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment.

F. **Documentation:** Within 10 days after the completion of each session the CONTRACTOR shall submit the following:

1. A list of all OWNER personnel who attended the session.

2. An evaluation of OWNER personnel via written testing or equivalent evaluation.

3. A copy of the training materials utilized during the lesson with notes, diagrams, and comments.

3.10 ACCEPTANCE

A. For the purpose of this Section, the following conditions shall be fulfilled before the WORK is considered substantially complete:

1. Submittals have been completed and approved.

2. The PCIS has been calibrated, loop tested, and precommissioned.

3. The OWNER training has been performed.

4. Spare parts and expendable supplies and test equipment have been delivered to the ENGINEER.

5. The performance test has been successfully completed.

6. Punch-list items have been corrected.

7. Record drawings in both hard copy and electronic format have been submitted.

8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.

9. Debris associated with installation of instrumentation has been removed.

10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

- END OF SECTION -

Section 17100 Appendix A.

FIELD INSTRUMENT LIST

Instrument Tag	RTU/PLC No.	Spec	Enclosure	Range/Setpoint	Service	Drawing No.
4A-LE/LIT-1	1	17106, 2.1	NEMA 4X	0-10ft	Pump Station 4A Wetwell Level	A-I-202
4A-LSHH-1A	1	17107, 2.1	NEMA 6	Set @ 10ft	Pump Station 4A Wetwell Level Switch	A-I-202
4A-PI-1	1	17108, 2.1, 2.2	N/A	0-60 psig	Pump Station 4A Pump 1 Pressure Gauge	A-I-202
4A-PSH-1	1	17109, 2.1	NEMA 7	Set @30 psig	Pump Station 4A Wetwell Pump 1 Pressure Switch	A-I-202
4A-PI-2	1	17108, 2.1, 2.2	N/A	0-60 psig	Pump Station 4A Pump 2 Pressure Gauge	A-I-202
4A-PSH-2	1	17109, 2.1	NEMA 7	Set @30 psig	Pump Station 4A Wetwell Pump 2 Pressure Switch	A-I-202
4A-PI-3	1	17108, 2.1, 2.2	N/A	0-60 psig	Pump Station 4A Pump 3 Pressure Gauge	A-I-202
4A-PSH-3	1	17109, 2.1	NEMA 7	Set @30 psig	Pump Station 4A Wetwell Pump 3 Pressure Switch	A-I-202
7A-LE/LIT-1	2	17106, 2.1	NEMA 4X	0-9ft	Pump Station 7A Wetwell Level	A-I-202
7A-LSHH-1A	2	17107,	NEMA 6	Set @ 9ft	Pump Station 7A Wetwell	A-I-202

		2.1			Level Switch	
7A-PI-1	2	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 7A Pump 1 Pressure Gauge	A-I-201
7A-PSH-1	2	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 7A Wetwell Pump 1 Pressure Switch	A-I-201
7A-PI-2	2	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 7A Pump 2 Pressure Gauge	A-I-201
7A-PSH-2	2	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 7A Wetwell Pump 2 Pressure Switch	A-I-201
8A-LE/LIT-1	3	17106, 2.1	NEMA 4X	0-10ft	Pump Station 8A Wetwell Level	A-I-201
8A-LSHH-1A	3	17107, 2.1	NEMA 6	Set @ 10ft	Pump Station 8A Wetwell Level Switch	A-I-201
8A-PI-1	3	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 8A Pump 1 Pressure Gauge	A-I-201
8A-PSH-1	3	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 8A Wetwell Pump 1 Pressure Switch	A-I-201
8A-PI-2	3	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 8A Pump 2 Pressure Gauge	A-I-201
8A-PSH-2	3	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 8A Wetwell Pump 2 Pressure Switch	A-I-201
9A-LE/LIT-1	4	17106, 2.1	NEMA 4X	0-13ft	Pump Station 9A Wetwell Level	A-I-201
9A-LSHH-1A	4	17107, 2.1	NEMA 6	Set @ 13ft	Pump Station 9A Wetwell Level Switch	A-I-201
9A-PI-1	4	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 9A Pump 1 Pressure Gauge	A-I-201
9A-PSH-1	4	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 9A Wetwell Pump 1 Pressure Switch	A-I-201
9A-PI-2	4	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 9A Pump 2 Pressure Gauge	A-I-201
9A-PSH-2	4	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 9A Wetwell Pump 2 Pressure Switch	A-I-201
9B-LE/LIT-1	5	17106, 2.1	NEMA 4X	0-10ft	Pump Station 9B Wetwell Level	D-I-200
9B-LSHH-1A	5	17107, 2.1	NEMA 6	Set @ 10ft	Pump Station 9B Wetwell Level Switch	D-I-200
9B-PI-1	5	17108, 2.1, 2.2	N/A	0-60 psig	Pump Station 9B Pump 1 Pressure Gauge	D-I-200
9B-PSH-1	5	17109, 2.1	NEMA 7	Set @30 psig	Pump Station 9B Wetwell Pump 1 Pressure Switch	D-I-200
9B-PI-2	5	17108, 2.1, 2.2	N/A	0-60 psig	Pump Station 9B Pump 2 Pressure Gauge	D-I-200
9B-PSH-2	5	17109, 2.1	NEMA 7	Set @30 psig	Pump Station 9B Wetwell Pump 2 Pressure Switch	D-I-200
9B-PI-3	5	17108, 2.1, 2.2	N/A	0-60 psig	Pump Station 9B Pump 3 Pressure Gauge	D-I-200
9B-PSH-3	5	17109, 2.1	NEMA 7	Set @30 psig	Pump Station 9B Wetwell Pump 3 Pressure Switch	D-I-200
9C-LE/LIT-1	6	17106, 2.1	NEMA 4X	0-9ft	Pump Station 9C Wetwell Level	D-I-200
9C-LSHH-1A	6	17107, 2.1	NEMA 6	Set @ 9ft	Pump Station 9C Wetwell Level Switch	D-I-200
9C-PI-1	6	17108,	N/A	0-30 psig	Pump Station 9C	D-I-200

		2.1, 2.2			Pump 1 Pressure Gauge	
9C-PSH-1	6	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 9C Wetwell Pump 1 Pressure Switch	D-I-200
9C-PI-2	6	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 9C Pump 2 Pressure Gauge	D-I-200
9C-PSH-2	6	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 9C Wetwell Pump 2 Pressure Switch	D-I-200
10A-LE/LIT-1	7	17106, 2.1	NEMA 4X	0-12ft	Pump Station 10A Wetwell Level	A-I-201
10A-LSHH-1A	7	17107, 2.1	NEMA 6	Set @ 12ft	Pump Station 10A Wetwell Level Switch	A-I-201
10A-PI-1	7	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 10A Pump 1 Pressure Gauge	A-I-201
10A-PSH-1	7	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 10A Wetwell Pump 1 Pressure Switch	A-I-201
10A-PI-2	7	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 10A Pump 2 Pressure Gauge	A-I-201
10A-PSH-2	7	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 10A Wetwell Pump 2 Pressure Switch	A-I-201
11A-LE/LIT-1	8	17106, 2.1	NEMA 4X	0-8ft	Pump Station 11A Wetwell Level	A-I-201
11A-LSHH-1A	8	17107, 2.1	NEMA 6	Set @ 8ft	Pump Station 11A Wetwell Level Switch	A-I-201
11A-PI-1	8	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 11A Pump 1 Pressure Gauge	A-I-201
11A-PSH-1	8	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 11A Wetwell Pump 1 Pressure Switch	A-I-201
11A-PI-2	8	17108, 2.1	N/A	0-30 psig	Pump Station 11A Pump 2 Pressure Gauge	A-I-201
11A-PSH-2	8	17109, 2.1	NEMA 4X	Set @25 psig	Pump Station 11A Wetwell Pump 2 Pressure Switch	A-I-201
12A-LE/LIT-1	9	17106, 2.1	NEMA 4X	0-9ft	Pump Station 12A Wetwell Level	A-I-201
12A-LSHH-1A	9	17107, 2.1	NEMA 6	Set @ 8ft	Pump Station 12A Wetwell Level Switch	A-I-201
12A-PI-1	9	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 12A Pump 1 Pressure Gauge	A-I-201
12A-PSH-1	9	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 12A Wetwell Pump 1 Pressure Switch	A-I-201
12A-PI-2	9	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 12A Pump 2 Pressure Gauge	A-I-201
12A-PSH-2	9	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 12A Wetwell Pump 2 Pressure Switch	A-I-201
13A-LE/LIT-1	10	17106, 2.1	NEMA 4X	0-9ft	Pump Station 13A Wetwell Level	A-I-201
13A-LSHH-1A	10	17107, 2.1	NEMA 6	Set @ 9ft	Pump Station 13A Wetwell Level Switch	A-I-201
13A-PI-1	10	17108,	N/A	0-30 psig	Pump Station 13A	A-I-201

		2.1, 2.2			Pump 1 Pressure Gauge	
13A-PSH-1	10	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 13A Wetwell Pump 1 Pressure Switch	A-I-201
13A-PI-2	10	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 13A Pump 2 Pressure Gauge	A-I-201
13A-PSH-2	10	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 13A Wetwell Pump 2 Pressure Switch	A-I-201
13B-LE/LIT-1	11	17106, 2.1	NEMA 4X	0-10ft	Pump Station 13B Wetwell Level	D-I-200
13B-LSHH-1A	11	17107, 2.1	NEMA 6	Set @ 10ft	Pump Station 13B Wetwell Level Switch	D-I-200
13B-PI-1	11	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 13B Pump 1 Pressure Gauge	D-I-200
13B-PSH-1	11	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 13B Wetwell Pump 1 Pressure Switch	D-I-200
13B-PI-2	11	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 13B Pump 2 Pressure Gauge	D-I-200
13B-PSH-2	11	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 13B Wetwell Pump 2 Pressure Switch	D-I-200
15B-LE/LIT-1	12	17106, 2.1	NEMA 4X	0-9ft	Pump Station 15B Wetwell Level	D-I-200
15B-LSHH-1A	12	17107, 2.1	NEMA 6	Set @ 9ft	Pump Station 15B Wetwell Level Switch	D-I-200
15B-PI-1	12	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 15B Pump 1 Pressure Gauge	D-I-200
15B-PSH-1	12	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 15B Wetwell Pump 1 Pressure Switch	D-I-200
15B-PI-2	12	17108, 2.1, 2.2	N/A	0-30 psig	Pump Station 15B Pump 2 Pressure Gauge	D-I-200
15B-PSH-2	12	17109, 2.1	NEMA 7	Set @25 psig	Pump Station 15B Wetwell Pump 2 Pressure Switch	D-I-200
WP-LE/LIT-1	13	17106, 2.1	NEMA 4X	0-11ft	West Paso Pump Station Wetwell Level	A-I-202
WP-LSHH-1A	13	17107, 2.1	NEMA 6	Set @ 11ft	West Paso Pump Station Wetwell Level Switch	A-I-202
WP-PI-1	13	17108, 2.1, 2.2	N/A	0-60 psig	West Paso Pump Station Pump 1 Pressure Gauge	A-I-202
WP-PSH-1	13	17109, 2.1	NEMA 7	Set @30 psig	West Paso Pump Station Wetwell Pump 1 Pressure Switch	A-I-202
WP-PI-2	13	17108, 2.1, 2.2	N/A	0-60 psig	West Paso Pump Station Pump 2 Pressure Gauge	A-I-202
WP-PSH-2	13	17109, 2.1	NEMA 7	Set @30 psig	West Paso Pump Station Wetwell Pump 2 Pressure Switch	A-I-202
WP-PI-3	13	17108, 2.1, 2.2	N/A	0-60 psig	West Paso Pump Station Pump 3 Pressure Gauge	A-I-202
WP-PSH-3	13	17109, 2.1	NEMA 7	Set @30 psig	West Paso Pump Station Wetwell Pump 3	A-I-202

					Pressure Switch	
BW-LE/LIT-1	14	17106, 2.1	NEMA 4X	0-13ft	Baywood Pump Station Wetwell Level	A-I-201
BW-LSHH-1A	14	17107, 2.1	NEMA 6	Set @ 11ft	Baywood Pump Station Wetwell Level Switch	A-I-201
BW-PI-1	14	17108, 2.1, 2.2	N/A	0-30 psig	Baywood Pump Station Pump 1 Pressure Gauge	A-I-201
BW-PSH-1	14	17109, 2.1	NEMA 7	Set @25 psig	Baywood Pump Station Wetwell Pump 1 Pressure Switch	A-I-201
BW-PI-2	14	17108, 2.1, 2.2	N/A	0-30 psig	Baywood Pump Station Pump 2 Pressure Gauge	A-I-201
BW-PSH-2	14	17109, 2.1	NEMA 7	Set @25 psig	Baywood Pump Station Wetwell Pump 2 Pressure Switch	A-I-201
EP-AE/AIT-1	15	17112, 1.2	NEMA 4	0-5NTU	East Paso Harvest Well Turbidity	A-I-200
EP-AE/AIT-2	15	17112, 1.3	NEMA 4X	0-5mg/l	East Paso Harvest Well Chlorine	A-I-200
EP-FE/FIT-1	15	17102, 2.1	NEMA 4X	4", 0-100gpm	East Paso Harvest Well Discharge Flow	A-I-200
EP-PSH-1	15	17109, 2.1	NEMA 4X	Set @25 psig	East Paso Harvest Well Discharge Pressure Switch	A-I-200
EP-PI-1	15	17108, 2.1, 2.2	N/A	0-30 psig	East Paso Harvest Well Discharge Pressure Gauge	A-I-200
EP-LE/LIT-1	15	17106, 2.1	NEMA 4X	0-14ft	East Paso Pump Station Wetwell Level	A-I-201
EP-LSHH-1A	15	17107, 2.1	NEMA 6	Set @ 11ft	East Paso Pump Station Wetwell Level Switch	A-I-201
EP-PI-1	15	17108, 2.1, 2.2	N/A	0-30 psig	East Paso Pump Station Pump 1 Pressure Gauge	A-I-201
EP-PSH-1	15	17109, 2.1	NEMA 4X	Set @25 psig	East Paso Pump Station Wetwell Pump 1 Pressure Switch	A-I-201
EP-PI-2	15	17108, 2.1, 2.2	N/A	0-30 psig	East Paso Pump Station Pump 2 Pressure Gauge	A-I-201
EP-PSH-2	15	17109, 2.1	NEMA 4X	Set @25 psig	East Paso Pump Station Wetwell Pump 2 Pressure Switch	A-I-201
EY-LE/LIT-1	16	17106, 2.1	NEMA 4X	0-12ft	East Ysabel Pump Station Wetwell Level	A-I-201
EY-LSHH-1A	16	17107, 2.1	NEMA 6	Set @ 11ft	East Ysabel Pump Station Wetwell Level Switch	A-I-201
EY-PI-1	16	17108, 2.1, 2.2	N/A	0-30 psig	East Ysabel Pump Station Pump 1 Pressure Gauge	A-I-201
EY-PSH-1	16	17109, 2.1	NEMA 4X	Set @25 psig	East Ysabel Pump Station Wetwell Pump 1 Pressure Switch	A-I-201
EY-PI-2	16	17108, 2.1, 2.2	N/A	0-30 psig	East Ysabel Pump Station Pump 2 Pressure Gauge	A-I-201

EY-PSH-2	16	17109, 2.1	NEMA 4X	Set @25 psig	East Ysabel Pump Station Wetwell Pump 2 Pressure Switch	A-I-201
MV-LE/LIT-1	17	17106, 2.1	NEMA 4X	0-12ft	Mountain View Pump Station Wetwell Level	D-I-200
MV-LSHH-1A	17	17107, 2.1	NEMA 6	Set @ 11ft	Mountain View Pump Station Wetwell Level Switch	D-I-200
MV-PI-1	17	17108, 2.1, 2.2	N/A	0-30 psig	Mountain View Pump Station Pump 1 Pressure Gauge	D-I-200
MV-PSH-1	17	17109, 2.1	NEMA 4X	Set @25 psig	Mountain View Pump Station Wetwell Pump 1 Pressure Switch	D-I-200
MV-PI-2	17	17108, 2.1, 2.2	N/A	0-30 psig	Mountain View Pump Station Pump 2 Pressure Gauge	D-I-200
MV-PSH-2	17	17109, 2.1	NEMA 4X	Set @25 psig	Mountain View Pump Station Wetwell Pump 2 Pressure Switch	D-I-200
LU-LE/LIT-1	18	17106, 2.1	NEMA 4X	0-16ft	Lupine Pump Station Wetwell Level	B-I-201
LU-LSHH-1A	18	17107, 2.1	NEMA 6	Set @ 11ft	Lupine Pump Station Wetwell Level Switch	B-I-201
LU-PI-1	18	17108, 2.1, 2.2	N/A	0-60 psig	Lupine Pump Station Pump 1 Pressure Gauge	B-I-201
LU-PSH-1	18	17109, 2.1	NEMA 4X	Set @30 psig	Lupine Pump Station Wetwell Pump 1 Pressure Switch	B-I-201
LU-PI-2	18	17108, 2.1, 2.2	N/A	0-60 psig	Lupine Pump Station Pump 2 Pressure Gauge	B-I-201
LU-PSH-2	18	17109, 2.1	NEMA 4X	Set @30 psig	Lupine Pump Station Wetwell Pump 2 Pressure Switch	B-I-201
LU-PI-3	18	17108, 2.1, 2.2	N/A	0-60 psig	Lupine Pump Station Pump 3 Pressure Gauge	B-I-201
LU-PSH-3	18	17109, 2.1	NEMA 4X	Set @30 psig	Lupine Pump Station Wetwell Pump 3 Pressure Switch	B-I-201
SO-LE/LIT-1	19	17106, 2.1	NEMA 4X	0-11ft	Sunny Oaks Pump Station Wetwell Level	C-I-200
SO-LSHH-1A	19	17107, 2.1	NEMA 6	Set @ 11ft	Sunny Oaks Pump Station Wetwell Level Switch	C-I-200
SO-PI-1	19	17108, 2.1, 2.2	N/A	0-30 psig	Sunny Oaks Pump Station Pump 1 Pressure Gauge	C-I-200
SO-PSH-1	19	17109, 2.1	NEMA 4X	Set @25 psig	Sunny Oaks Pump Station Wetwell Pump 1 Pressure Switch	C-I-200
SO-PI-2	19	17108, 2.1, 2.2	N/A	0-30 psig	Sunny Oaks Pump Station Pump 2 Pressure Gauge	C-I-200
SO-PSH-2	19	17109, 2.1	NEMA 4X	Set @25 psig	Sunny Oaks Pump Station Wetwell Pump 2	C-I-200

					Pressure Switch	
PA-AE/AIT-1	20	17112, 1.2	NEMA 4	0-5NTU	Palisades Harvest Well Turbidity	B-I-200
PA-AE/AIT-2	20	17112, 1.3	NEMA 4X	0-5mg/l	Palisades Harvest Well Chlorine	B-I-200
PA-FE/FIT-1	20	17102, 2.1	NEMA 4X	4", 0-100gpm	Palisades Harvest Well Discharge Flow	B-I-200
PA-PSH-1	20	17109, 2.1	NEMA 4X	Set @25 psig	Palisades Harvest Well Discharge Pressure Switch	B-I-200
PA-PI-1	20	17108, 2.1, 2.2	N/A	0-30 psig	Palisades Harvest Well Discharge Pressure Gauge	B-I-200
LO-AE/AIT-1	21	17112, 1.2	NEMA 4	0-5NTU	Loma Harvest Well Turbidity	B-I-200
LO-AE/AIT-2	21	17112, 1.3	NEMA 4X	0-5 mg/l	Loma Harvest Well Chlorine	B-I-200
LO-FE/FIT-1	21	17102, 2.1	NEMA 4X	4", 0-140gpm	Loma Harvest Well Discharge Flow	B-I-200
LO-PSH-1	21	17109, 2.1	NEMA 4X	Set @25 psig	Loma Harvest Well Discharge Pressure Switch	B-I-200
LO-PI-1	21	17108, 2.1, 2.2	N/A	0-30 psig	Loma Harvest Well Discharge Pressure Gauge	B-I-200
PI-FI-1	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW1 Flowmeter	A-I-204
PI-FI-2	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW2 Flowmeter	A-I-204
PI-FI-3	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW3 Flowmeter	A-I-204
PI-FI-4	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW4 Flowmeter	A-I-204
PI-FI-5	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW5 Flowmeter	A-I-204
PI-FI-6	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW6 Flowmeter	A-I-204
PI-FI-7	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW7 Flowmeter	A-I-204
PI-FI-8	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW8 Flowmeter	A-I-204
PI-FI-9	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW9 Flowmeter	A-I-204
PI-FI-10	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW10 Flowmeter	A-I-204

PI-FI-11	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW11 Flowmeter	A-I-204
PI-FI-12	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW12 Flowmeter	A-I-204
PI-FI-13	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW13 Flowmeter	A-I-204
PI-FI-14	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW14 Flowmeter	A-I-204
PI-FI-15	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW15 Flowmeter	A-I-204
PI-FI-16	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW16 Flowmeter	A-I-204
PI-FI-17	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW17 Flowmeter	A-I-204
PI-FI-18	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW18 Flowmeter	A-I-204
PI-FI-19	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW19 Flowmeter	A-I-204
PI-FI-20	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW20 Flowmeter	A-I-204
PI-FI-21	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW21 Flowmeter	A-I-204
PI-FI-22	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW22 Flowmeter	A-I-204
PI-FI-23	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW23 Flowmeter	A-I-204
PI-FI-24	23	17102, 2.2	N/A	3-30gpm	Pismo Effluent Disposal Site Well No. P-DW24 Flowmeter	A-I-204
SM-FI-1	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW1 Flowmeter	A-I-204
SM-FI-2	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW2 Flowmeter	A-I-204
SM-FI-3	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW3 Flowmeter	A-I-204
SM-FI-4	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW4 Flowmeter	A-I-204
SM-FI-5	24	17102,	N/A	3-30gpm	Santa Maria Effluent	A-I-204

		2.2			Disposal Site Well No. S-DW5 Flowmeter	
SM-FI-6	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW6 Flowmeter	A-I-204
SM-FI-7	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW7 Flowmeter	A-I-204
SM-FI-8	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW8 Flowmeter	A-I-204
SM-FI-9	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW9 Flowmeter	A-I-204
SM-FI-10	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW10 Flowmeter	A-I-204
SM-FI-11	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW11 Flowmeter	A-I-204
SM-FI-12	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW12 Flowmeter	A-I-204
SM-FI-13	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW13 Flowmeter	A-I-204
SM-FI-14	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW14 Flowmeter	A-I-204
SM-FI-15	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW15 Flowmeter	A-I-204
SM-FI-16	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW16 Flowmeter	A-I-204
SM-FI-17	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW17 Flowmeter	A-I-204
SM-FI-18	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW18 Flowmeter	A-I-204
SM-FI-19	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW19 Flowmeter	A-I-204
SM-FI-20	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW20 Flowmeter	A-I-204
SM-FI-21	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW21 Flowmeter	A-I-204
SM-FI-22	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW22 Flowmeter	A-I-204
SM-FI-23	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-	A-I-204

					DW23 Flowmeter	
SM-FI-24	24	17102, 2.2	N/A	3-30gpm	Santa Maria Effluent Disposal Site Well No. S-DW24 Flowmeter	A-I-204

17102 – IN-LINE LIQUID FLOW MEASURING SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide in-line liquid flow measuring systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to this Section.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. **General:** Shop Drawings shall be submitted in conformance with the requirements of Section 17100 and Section 01300 - Contractor Submittals.

PART 2 -- PRODUCTS

2.1 MAGNETIC FLOW MEASURING SYSTEMS

A. Magnetic flowmeter systems shall be the low frequency electromagnetic induction type which produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flowmeter system. Each magnetic flow metering system shall include a metering tube, signal cable, transmitter, and flowmeter grounding rings.

1. The metering tube shall have:

a. Construction of 304 or 316 stainless steel with flanged connections

b. Minimum of 2 self-cleaning electrodes

c. Liner conforming to the manufacturer's recommendation for the intended service

d. Electrodes constructed of materials conforming to the manufacturer's recommendation for the intended service

e. Meter housing rated for NEMA 6 submergence conditions

f. Epoxy paint coating

g. Grounding rings that conform to the manufacturer's bore and material recommendation for the intended service. Grounding rings shall be designed to protect and shield the liner's edge interface from abrasion at the meter end.

2. The microprocessor-based signal converter/transmitter shall have:

a. DC pulse technique to drive flux-producing coils

b. Capability to convert DC pulse signal from the tube to a standardized 4-20 mA DC signal into a minimum of 700 ohms.

c. Six digit LCD displays for flowrate, percent of span, and totalization

d. An operator interface with keypad which responds to English text entry

e. Integral zero return to produce a consistent zero output signal in response to an external dry contact closure

f. Integral low flow cutoff and zero return

g. Automatic range change

h. Capable of measuring flow in both directions

i. Programmable parameters including meter size, full scale Q, magnetic field frequency, primary constant, time constant

j. Data retention for a minimum of 5 years without auxiliary power (main or battery)

k. Self diagnostics and automatic data checking

l. Protected terminals and fuses in a separate compartment which isolates field connection from electronics

m. "Smart" technology which employs a hand-held configuration terminal and outputs a digital flow signal superimposed on 4-20 mA DC signal and complies to HART protocol.

n. Ambient temperature operating limits of -20 to 140 degrees F (-29 to 60 degrees C)

B. **Calibration:** Each flow metering system shall be hydraulically calibrated at a facility that is traceable to the National Institute of Standards and Technologies. The calibration procedure shall conform to the requirements of ANSI/NCSL Z 540-1 Calibration. A real-time computer generated printout of the actual calibration data shall be submitted to the ENGINEER at least 30 days prior to shipment to the Site.

C. The flow metering system shall conform to the following:

1. Time constant = 0.5 to 1000 seconds; galvanic or optic isolation

2. Accuracy: 0.50 percent of flow rate from 10 to 100 percent full scale for velocities over 3 feet per second.

3. Repeatability: 0.25 percent full scale

4. Power consumption: 30 watts or less

5. Power requirements: 120 VAC, plus and minus 10 percent

D. Manufacturers, or Equal

1. **ABB**

2. **Rosemount**

3. **Khrone**

E. Refer to 17100, Appendix A for the magnetic flow measuring systems that shall be provided.

2.2 VARIABLE AREA VANE FLOWMETERS

A. Variable area vane flowmeters indicate flowrate either horizontally or vertically through a tempered glass window using an anchored vane that flexes proportionally in response to liquid flow. The meters will be totally self contained with a direct flow scale and no electrical parts.

B. The variable area vane flowmeters shall conform to the following:

1. Accuracy: +/- 2% full scale

2. Repeatability: +/- 1% full scale

3. Size: 1"

4. Housing Material: Brass

5. Fittings: Female 1" NPT

6. Flow direction: Horizontal

7. O-Rings: Buna-n

C. Manufacturers, or Equal

1. **ERDCO; See-Flo 3200 series**

2. **Universal Flow Monitors**

D. Refer to 17100, Appendix A for the variable area vane flowmeters that shall be provided.

PART 3 -- EXECUTION

3.1 GENERAL

A. In-line flow measuring systems shall be executed according to Section 17100.

- END OF SECTION -

SECTION 17106 - LEVEL MEASURING SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide level measuring systems, complete and operable in accordance with the Contract Documents.

B. "Smart" transmitters shall be furnished when or where ever possible.

C. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 17100.

PART 2 -- PRODUCTS

2.1 NON-CONTACT SONIC LEVEL MEASUREMENT

A. Sonic level measuring systems shall consist of an electronic controller-transmitter, a non-contact sonic transducer, and interconnecting cables. The controller-transmitter shall generate the sonic signal to drive the transducer, detect the return echo and convert the elapsed time to a level signal. The controller-transmitter shall have the following features; solid state design, integral level indicator, removable keypad for calibration and configuration, thermostatically controlled heaters, isolated, 4-20 mA output signal linearly proportional to level, transducer temperature compensation and a contact output upon transmitter failure (loss of echo). Input power shall be 120 VAC 60 Hz. The sonic transducer shall be housed in a NEMA 4 watertight enclosure and be constructed of corrosion resistant materials. The sonic sensor shall be provided with wall mounting hardware if available.

B. Sonic level measuring systems shall be manufactured by **Siemens Milltronics, Endress + Hauser** or equal.

C. Refer to the Field Instrument Summary included as Appendix A of specification 17100 for the Non-contact sonic level instruments that shall be provided.

PART 3 -- EXECUTION

3.1 GENERAL

A. Level measuring systems shall be executed according to Section 17100.

- END OF SECTION -

SECTION 17107 - LEVEL DETECTION SWITCHES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. General: The CONTRACTOR shall provide all level detection switches complete and operable in accordance with the Contract Documents.

B. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to this Section.

1.2 CONTRACTOR SUMITTALS

A. Furnish submittals in accordance with Section 17100.

PART 2 -- PRODUCTS

2.1 TIPPING FLOAT LEVEL SWITCHES

A. Tipping float level switches shall consist of a switch, a moving float, and a connecting cable that is anchored at the midpoint of a differential band. As the level rises and falls the float rights itself or inverts causing switching actions. The cable anchoring point shall be protected by strain relief. The hermetically sealed switches shall be SPDT with a minimum rating of 10 Amps at 120 VAC.

B. Manufacturer shall be **US Filter 9G, MAGNETROL T10** or equal.

C. Refer to the Field Instrument Summary included as Appendix A of Section 17100 for the float level switches that shall be provided.

PART 3 -- EXECUTION

3.1 GENERAL:

A. Level detection switches shall be executed according to Section 17100.

- END OF SECTION -

SECTION 17108 - PRESSURE MEASURING SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide pressure measuring systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to the WORK of this Section.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Shop Drawings, Owner's Manual, shall be submitted in conformance with the requirements of Section 17100 and Section 01300 - Contractor Submittals.

PART 2 -- PRODUCTS

2.1 PRESSURE GAUGES

A. Pressure gauges shall be 4-1/2 inches in diameter, liquid-filled bottom connected, with white laminated dials and black graduations. Windows shall have shatterproof glass window. Gauges shall have a blowout disc and be encased in phenolic, steel, or cast iron. Measuring element shall be a stainless steel bourdon tube with welded, stress-relieved joints. Socket shall have wrench flats. Movement shall be rotary geared, all stainless steel material. Pressure gauges shall be provided with a pulsation snubber constructed of 316 stainless steel and an isolation valve. Gauges shall be calibrated to read in applicable units. Accuracy shall be plus and minus 1/2 percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected. The pressure gauge shall be **Ashcroft 1279, Ametek Solfrunt Series 1900,** or equal.

B. Refer to the Field Instrument Summary included in Appendix A of Section 17100 for the pressure gauges that shall be provided.

2.2 ANNULAR RING SEALS FOR PRESSURE MEASURING SYSTEMS

A. Components

1. Flanges: Where seal elements are used to isolate pipeline flow media from a gauge, the sensor shall be flanged and bolted directly into ANSI flanged pipelines. Face to face distance shall not be greater than a wafer style butterfly valve. The flanges shall have through bolts to enable positive alignment in the pipeline. Flanges shall conform to pipe specifications.

2. Sensor: Inside diameter of the sensor shall be the same as the mating pipe for a full uninterrupted flow. There shall be no dead ends or crevices, and flow passage shall make the sensor self-cleaning. The sensor shall have an auxiliary tapped and plugged port to allow connection or other equipment.

B. **Operating Principles:** The pressure-sensing ring shall measure pressure for 360 degrees around the full inside circumference of the pipeline. The sensing ring shall also be clamped into the body for the full radial width of the sensor. Pressure shall be

transmitted to the gauge by a locked in and sealed fluid such as ethylene glycol or silicone oil. The annular seal shall be factory-assembled to the corresponding pressure instrument and be factory filled. The assembly shall be shipped with a tag stating "Do not disassemble for installation."

C. **Performance:** Wetted parts (liner) shall be capable for continuous duty handling a slurry containing 15 percent solids in a hydrocarbon oil similar to kerosene at temperatures up to 225 degrees F.

D. Manufacturers, or Equal

1. **Red Valve Co.;**

2. **Ronningen-Petter.**

PART 3 – EXECUTION

3.1 GENERAL

A. Pressure measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested according to Section 17100. The manufacturer shall furnish the manufacturer's service, supervision, and training indicated by Section 17100.

- END OF SECTION -

SECTION 17109 - PRESSURE DETECTION SWITCHES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General** The CONTRACTOR shall provide pressure detection switches, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to this Section.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 17100.

PART 2 -- PRODUCTS

2.1 PRESSURE SWITCH

A. Pressures switches shall be diaphragm-actuated, adjustable, with SPDT snap-action switch. Contacts shall be rated for a minimum of 15 Amps at 120 VAC. The dead band shall be adjustable up to 60 percent of full scale. Set points shall fall between 20 and 80 percent of the adjustable range. The pressure switch shall be rated for hazardous area locations. The diaphragm shall be Buna-N, unless otherwise indicated, and the lower housing shall be brass with a 1/4-inch bottom sensing connection, unless otherwise indicated.

B. Manufacturer shall be **United Electric Series 120**, or equal.

PART 3 -- EXECUTION

3.1 GENERAL

A. Pressure-measuring systems shall be handled, installed, calibrated, loop-tested, pre-commissioned, and performance tested according to Section 17100. The CONTRACTOR shall furnish the manufacturer's service, supervision, and training indicated by Section 17100.

- END OF SECTION -

SECTION 17112 - PROCESS ANALYZER MEASURING SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide all Process Analyzer Measuring Systems, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to this Section.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Power Input:** Analyzers shall be the fully isolated 2-wire type, unless the type is not available, in which case the analyzer shall be the fully isolated four wire type with power supply of 115 volts plus and minus 10 percent, 60 Hz plus and minus 5 percent.

B. **Signal Output:** Outputs shall be current regulated 4-20 mA DC capable of driving 0 to 600 ohms.

C. **Ambient Conditions:** Analyzers shall be suitable for continuous automatic on-line analysis of the indicated parameter under the conditions indicated.

1. Equipment shall operate satisfactorily in ambient temperatures between minus 20 degrees and plus 120 degrees or shall be provided with isothermal enclosures so that accuracies will not exceed one percent of span.

2. Process fluid temperatures will range between 40 and 100 degrees F unless indicated otherwise.

D. **Sample Flow:** Samples shall not pass through housings containing electronics unless indicated otherwise.

E. **Local Indication:** Each analyzer shall be provided with local indication scaled in process units.

F. **Calibration:** Each analyzer shall be fitted with calibration connections at the analyzer.

2.2 HIGH RANGE TURBIDITY MEASURING SYSTEMS

A. **Sensor:** The turbidimeter shall be a continuous reading on-line instrument capable of detecting Nephthelometric Turbidity Units meeting the design criteria of USEPA Method 180.1 for reporting. A bubble trap shall be provided if required for proper operation. Secondary reference standards shall be included for each instrument. A sample flow rate of 1 to 2 liters per minute is required. The interconnecting cable between the sensor and the transmitter shall be furnished by the instrument Manufacturer and shall be of sufficient length to allow proper installation of the Sensor.

B. **Transmitter:** The transmitter shall have a continuous reading of 0-9999 NTU and shall produce an output signal proportional to the turbidity. An integral analog indicator scaled

in NTU on the selected range shall be visible through a window in the transmitter enclosure. Both the transmitter and the sensor shall be suitable for surface mounting.

C. **Manufacturers:** The turbidimeter shall be **Hach Surface Scatter 6, Rosemount T1054 or equal.**

D. Refer to the Field Instrument Summary for the Turbidity Analyzers that shall be provided.

2.3 CHLORINE RESIDUAL MEASURING SYSTEMS

A. **Sensor:** Residual chlorine analyzers shall be the amperometric type designed to measure total chlorine in a continuous sample of raw water. The measuring cell shall have gold and copper electrodes with automatic temperature change compensation and a continuous direct drive cleaning system including rotating striker and plastic cleaning balls. Gravity flow to the cell shall be approximately 350 - 500 ml per minute from a built-in constant head tank. Potassium and/or buffer iodide reagents, if required, shall be fed by gravity through a rotary valve from a container with a minimum capacity of 7 days of reagent. Reagent level shall be visible from the front of the unit. Sample piping shall include self-flushing "Y" strainers and pressure reducing valves.

B. **Transmitter:** The transmitter shall produce an isolated current output proportional to chlorine residual. Sensitivity shall be 0.01 mg/l; accuracy shall be plus and minus 2 percent of reading or 0.01 mg/l, whichever is greater. Range shall be 0-5 mg/l. A local 3.5 digit LCD indicator or grapical display scaled in mg/l residual chlorine shall be provided. Microprocessor and other components shall be provided with battery backup to retain setpoints, calibration, and other information during extended power outages. Each analyzer shall be a factory wired and piped, wall mounted unit all provided by the Manufacturer. All materials in the analyzer system shall be corrosion resistant and suitable for environments containing chlorine and sulfur dioxide vapors. Each analyzer unit shall be furnished with a 16-week supply of buffer solution plus 1.0 lb. of potassium chloride and 1.0 kg of glycine.

C. **Manufacturer: Chlorine residual monitoring systems shall be Capital Controls Aztec CL 1000, Wallace & Tiernan Micro 2000.**

D. Refer to the Field Instrument Summary in specification 17100 for the Chlorine Analyzers that shall be provided.

PART 3 -- EXECUTION

3.1 GENERAL:

A. Process analyzer measuring systems shall be executed according to Section 17100 - Process Control and Instrumentation Systems.

B. Unless otherwise note analyzer measuring systems shall be installed and calibrated in strict accordance to the manufacturers instructions and recommendations.

- END OF SECTION -

SECTION 17200 – CONTROL PANELS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR shall provide control panels, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 17100 - Process Control and Instrumentation Systems apply to this Section.

C. The provisions of this Section apply to Section 17201 - Control Panel Instrumentation except where indicated otherwise.

D. The provisions of this Section apply to local panels provided in equipment systems specified in other sections unless indicated otherwise in those sections.

1.2 CONTRACTOR SUBMITTALS

A. **General:** Submittals shall be furnished in accordance with Section 01300 - Contractor Submittals.

B. **Control Panel Engineering Submittal:** The CONTRACTOR shall submit a control panel engineering submittal (CPES) for each control panel and enclosure provided under Division 17. The CPES shall completely define and document the construction, finish, layout, power circuits, signal and safety grounding circuits, fuses, circuit breakers, signal circuits, internally mounted instrumentation and SCADA system components, face plate mounted instrumentation components, internal panel arrangements, and external panel arrangements. All panel drawings shall, as a minimum, be "B" size with all data sheets and manufacturer specification sheets being "A" size. The submittal shall be in conformance with ISA-S20 - Standard Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, shall be submitted as a singular complete bound volume or multi-volume package within 120 calendar days after Notice to Proceed, and shall have the following contents:

1. A complete index shall appear in the front of each bound volume. Drawings and data sheets associated with a panel shall be grouped together with the panels being indexed by systems or process areas. Panel tagging and nameplate nomenclature shall be consistent with the requirements of the Contract Documents.

2. Scale construction drawings which define and quantify the type and gauge of steel to be used for panel fabrication, the ASTM grade to be used for structural shapes and straps, panel door locks and hinge mechanisms, type of bolts and bolt locations for section joining and anchoring, details and proposed locations for "UNISTRUT" members, stiffener materials and locations, electrical terminal box and outlet locations, electrical access locations, print pocket locations, writing board locations, and lifting lug material and locations.

3. Scaled physical arrangement drawings drawn to scale which define and quantify the physical groupings comprising control panel sections, auxiliary panels, subpanels, and racks. Cutout locations with nameplate identifications shall be shown.

4. Front of panel layouts for all control panels.

5. Schematic/elementary diagrams shall depict all control devices and circuits and their functions.

6. Wiring/connection diagrams shall locate and identify electrical devices, terminals, and interconnecting wiring. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all electrical and control devices.

7. Interconnection diagrams shall locate and identify all external connections between the control panel/control panel devices and associated equipment. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all panel ingress and egress points.

8. Control sequence diagrams to portray the contact positions or connections required to be made for each successive step of the control action. Written descriptions explaining the control sequence diagrams and system operation shall be furnished.

9. Completed ISA S20 data sheets for all instrumentation devices associated with each control panel supplemented with manufacturer specification sheets which verify conformance to the requirements of the Contract Documents

10. A bill of material which enumerates all devices associated with the control panel.

11. A priced listing of analog spare parts in conformance with Section 17100.

1.3 EXTENDED PERIOD FOR CORRECTION OF DEFECTS

A. The CONTRACTOR shall correct all defects in accordance with Section 17100.

PART 2 -- PRODUCTS

2.1 GENERAL

A. **Environmental Suitability:** Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The CONTRACTOR shall provide all power wiring for these devices. Enclosures suitable for the environment shall be provided. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

B. The control panel controls shall be 120VAC. Where the electrical power supply to the control panel is 240VAC single phase or 480VAC 3-phase, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.

C. The control panel shall be the source of power for any 120VAC solenoid valves interconnected with the control panel. Equipment associated with the control panel shall be ready for service after connection of conductors to equipment, controls, and control panel.

D. The main feeder disconnect shall have a door-mounted handle unless otherwise indicated.

E. Unless indicated otherwise, control panels shall be housed in NEMA rated enclosures in accordance with Section 16050 – Electrical Work, General. Control panels shall be either freestanding, pedestal-mounted or equipment skid-mounted, as indicated. Internal control components shall be mounted on an internal back-panel or side-panel as required.

F. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of all external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use.

G. Motor starters, where required, shall be in accordance with Section 16480 - Low Voltage Motor Control Center. Each motor starter shall be provided with contact closures for motor overload, local indication, and remote alarm. Electrical components shall be of standard American manufacture.

H. Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 5 amps at 120 VAC. Analog inputs and outputs shall be isolated 4-20 mA, 2-wire signals with power supply.

I. Programmable Logic Controllers (PLCs) may be supplied in lieu of relays, provided the programmable logic controllers match the PLCs provided under Section 17520 - PLC-Based Control Systems Hardware.

J. Control panel mounted devices shall be mounted a minimum of 3 feet above finished floor elevation. Provide all combination motor starters not furnished in a MCC but specified in Section 11000 - Equipment General Provisions.

K. **Painting:** Steel control panels shall be thoroughly cleaned and sand blasted per Society for Protective Coatings SP 6 (Commercial Blast) after which surfaces shall receive a prime coat of **Amercoat 185** or equal, 3-mils DFT, for a total thickness of the prime plus finish system of 6 mils. The finished color of the outside surfaces shall be selected by the ENGINEER, unless otherwise indicated. Interior of the control panel, back-panel, and side panels shall have a white finish coat. The CONTRACTOR shall furnish 2 one-pint containers of the finish coat for future maintenance purposes.

2.2 CONTROL PANELS

A. Materials

1. Steel panel section faces shall be No. 10 gauge minimum thickness for free standing panels and No. 14 gauge minimum thickness for wall mounted or pedestal mounted panels. Materials shall be selected for levelness and smoothness.

2. Relay rack high-density type panels shall utilize standard relay racks with No. 14 gauge steel frame and supports.

3. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.

   a. Bolting Material: Commercial quality, carbon steel bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for attaching end plates. All other bolts shall be hex end machine bolts. Nuts shall be hot pressed hex, American Standard, heavy. Standard wrought washers

shall be used for foundation bolts and attachments to building structures. Other bolted joints shall have SAE standard lock washers.

4. Construction: Dimensions shall be in accordance with vendor's requirements. Elevations and horizontal spacing shall be subject to ENGINEER'S approval.

B. Fabrication

1. End plates, top plates, and top closure panels (to hung ceiling) shall be provided when required by the material requisition. End plates, top plates, and top closure panels shall be removable with countersunk bolts to match panels. Top closure panels shall be furnished in lengths which match the widths of standard panels, except that one top closure panel may extend across two 4-foot 6-inch wide or five 2-foot wide standard panels. The vertical joints of these panels shall align with the vertical joints of the standard panels.

2. End closure or rear closure doors shall be provided where required. Such doors shall be flush fitting, gasketed, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for all doors on one panel assembly. Removable access panels shall be provided with dished handle fasteners. Screw driver 1/4 turn or Dzus type fasteners are not acceptable.

   a. The flanged edges of all panels shall be straight and smooth. Corners shall be welded and ground smooth.

   b. The face of the panel shall be true and level after flanging.

   c. All panel cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth.

   d. Adjacent panels shall assemble with faces flush. Gaps or cracks shall not be visible from the front of the assembled instrument board.

   e. Stiffeners shall be welded to the back of panels, as required to prevent panel deformation due to the weight of face mounted instruments.

   f. Panels shall be self-supporting as defined below.

C. Framework and Supports

1. The rear of each panel section shall have a steel framework assembled to it for supporting conduit, wireways, switches, piping, and instrument accessory items such as relay or terminal enclosures, transducers, pressure switches, valves, and air relays. The main framework shall be constructed of standard structural shapes. Special shapes such as **"Unistrut"** may be used for secondary supports. Framework must neither interfere with instrument connections nor interfere with access needed for maintenance or adjustments.

2. Steel framework shall extend 2-feet 4-inches back from the panel face or as indicated in the material requisition. Where indicated, individual adjustable leg supports shall be provided at the back of the framework so that the entire panel is self-supporting.

D. Preparation of Panel Surface

1. The following requirements apply to the front and rear face of the panel, both sides and the edges of all flanges, and the periphery of all holes or cutouts.

    a. High spots, burrs, and rough spots shall be ground smooth.

    b. The surfaces shall be sanded or sandblasted to a smooth, clean, bright finish.

    c. All traces of oil shall be removed with a solvent.

    d. The first coat of primer shall be applied immediately.

E. **Instrument Finishing:** The final coats applied to painted surface of instrument cases, doors, or bezels that are visible from the front of panels shall be manufacturer's standard unless otherwise indicated. Black japan or "crinkle" finishes on instrument cases are not acceptable.

F. Mounting of Instruments

1. The panel vendor shall provide cutouts, and shall mount all instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.

2. The panel vendor shall also mount behind the panels other instrument accessory items as required for functionality as indicated.

3. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal.

4. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.

G. Electrical Requirements

1. The CONTRACTOR shall provide conduit, wireways, switches, wire, and electrical fittings for 120volt circuits to instruments and other electrical devices as required for a complete and operable installation.

2. Conduit, wire-ways, junction boxes and fittings shall be provided for signal wire, thermocouple, or resistance thermometer lead-wire. Conduit or wire-way runs shall include those required between temperature sensors and temperature transmitters and between the thermocouple wire-way or junction box and instruments.

3. Each terminal connection shall have a plastic plate with a terminal and instrument tag number. Wiring shall be identified with stamped tubular wire end markers.

4. Freestanding panels shall be provided with switched 100watt incandescent back-of-panel lights. One light shall be provided for every 4-feet of panel width and shall be mounted inside and in the top of the back-of-panel area.

5. Freestanding panels shall be provided with a 15 amp, 120 volt, service outlet circuit within the back-of-panel area. The circuit shall be provided with 3 wire, 120 volt, 15 ampere, duplex receptacles, one for every 4-feet of panel width (one minimum per panel), spaced evenly along the back-of-panel area.

6. Wall mounted or pedestal mounted panels shall be so sized as to adequately dissipate heat generated by equipment mounted in or on the panel.

7. Wall mounted or pedestal mounted panels mounted outside or in unshaded areas shall be provided with thermostatically controlled heaters that maintain inside temperature above 40 degrees F.

8. Provide a hand switch controlled 100watt incandescent light and a breaker protected 120 volt, 15 amp duplex receptacle within each wall mounted or pedestal mounted panel larger than 4 cubic feet volume.

9. Wiring Methods: Wiring methods and materials for all panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise indicated.

10. Signal and Control Circuit Wiring

    a. Wire type and sizes: Conductor shall be flexible stranded copper machine tool wire, UL listed Type MTW, and shall be rated 600 volts. Wires for instrument signal circuits and alarm input circuits shall be No. 14 AWG. All other wires, including shielded cables, shall be No. 16 AWG minimum.

    b. Wire Insulation Colors: Conductors supplying 120 VAC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120V AC control circuit conductors shall be red. Wires energized by a voltage source external to the control panel shall have yellow insulation. Insulation for DC conductors shall be blue.

    c. Wire Marking: Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, **Brady Type B 500** or equal, or shall be heat shrink plastic.

    d. Flexible conduit is not acceptable except when specifically approved by the ENGINEER in writing.

    e. Conduit fittings shall be **Crouse Hinds** cast fittings or equal.

    f. Splicing of wires will only be allowed in junction boxes. Splices shall be either soldered or pressure crimped type.

    g. For case grounding, panels shall be provided with a 1/4-inch by 1-inch copper ground bus complete with solderless connector for one No. 4 AWG bare stranded copper cable. The copper cable shall be provided by the CONTRACTOR and be connected to a system ground loop.

11. Electrical Locations

    a. When the Contract Documents call for thermocouple actuated instruments, the thermocouple lead wire shall be installed without junction by the CONTRACTOR. The panel vendor shall provide dedicated empty conduits or wire-ways running from the instrument(s) to the top or bottom of the panel as called for in the material specifications or as otherwise required. Sizing of the conduit or wire-way shall be in accordance with the capacity of the instrument(s).

b. Single case (no remote logic) annunciator units shall be installed at the top of panel and may be considered as a terminal box when top of panel wire entry is indicated. If bottom of panel entry is indicated, a terminal box shall be provided at the bottom of the panel and be wired to the annunciator unit. Terminals shall be identified with plastic marker strips.

c. Terminal boxes for incoming and outgoing signal leads shall be located at the top or bottom of the panel as indicated in the material specification, or as otherwise required.

12. Power Supply Wiring

a. Unless otherwise indicated, instruments, alarm systems, and motor controls shall operate on 120 volt, 60 Hz circuits.

b. At a location near the top of the panel (or bottom), the panel fabricator shall provide terminal box connections for the main power supply entry.

c. Power supply switches for alarm units shall be 3 pole type, arranged to open both power circuits and alarm circuits. Each annunciator unit shall be equipped with a separate switch.

d. Instruments located on the same panel section and serving the same process unit may be connected to a common branch circuit from the power supply. The number of circuits depends on the circuit load as noted herein. A 15 amp, 2 pole circuit breaker shall be provided in each branch circuit. The circuit load shall not exceed 10 amp. Different panel sections or different process units must not use common branch circuits. When instruments do not come equipped with integral fuses, provide fuses as required for the protection of individual instruments against fault currents. Fuses shall be mounted on the back of the panel in a fuse holder, and each fuse shall be identified by a service nametag. Fuses shall be as manufactured by **Bussmann Manufacturing Division, Type KAW TRON** or equal.

e. Each potentiometer type instrument, electronic transducer, controller, or analyzer shall have an individual disconnect switch. Disconnect switches shall have metal or plastic tags indicating instrument tag numbers. Individual plug and cord set power supply connections may be used without switches when indicated in the material specification.

f. Where alarm units are single unit types, one switch may be used to disconnect not more than 6 alarm units located on the same or adjacent panels.

13. Alarm Wiring: The panel vendor shall install and wire alarms including light cabinets, audible signal units, test and acknowledge switches, and remote logic units as indicated. Interconnecting wiring to panel mounted initiating devices shall also be wired by the panel vendor. The wiring from external initiating devices shall be provided by the CONTRACTOR. Where plug and cord sets are provided for component interconnection, the panel vendor shall harness and support the cables in neat and orderly fashion. Where separate wire is required, panel vendor shall install No. 16 AWG with THWN or THHN insulation between all components.

14. Signal Wiring

a. Signal Wire - Non Computer Use

1) Signal wire shall be twisted pair or triads in conduit or troughs. Cable shall be constructed of No. 16 AWG copper signal wires with THWN or THHN insulation.

2) Color code for instrument signal wiring shall be as follows:

Positive (+) – Black
Negative (-) - White

3) Multiconductor cables where indicated shall consist of No. 16 AWG copper signal wires twisted in pairs, with 90-C, 600 V fault insulation. A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.

b. Signal Wire - Computer Use

1) Signal wires shall be similar to those for non-computer use but each pair shall be triplexed with a copper drain wire and aluminum polyester tape shall be applied over the triplexed group. Cable shields, including thermocouple extension leads shall be terminated in the central control room at the computer system grounding bus. Continuity of the shield shall be maintained throughout the cable runs.

c. Multi-conductor cables, wireways and conduit shall be sized to allow for 10 percent spare signal wire.

H. **Labor and Workmanship:** Panels shall be fabricated, piped, and wired by fully qualified workmen who are properly trained, experienced, and supervised.

2.3 SCADA SYSTEM ENCLOSURES

A. Each SCADA system PLC and corresponding housing, I/O modules, power supply modules, communication interface devices, and peripheral equipment shall be either mounted on a back-plane or mounted inside a NEMA enclosure in accordance with Section 16050. All of the pocket pump stations and the Baywood, West Paso and Mountain View Pump Station locations will require that all of the Instrumentation, PLC and communication hardware be mounted on a back-plane that will be fitted inside of an enclosure provided by the electrical CONTRACTOR. Refer to electrical contract drawings A-E-204, A-E-206 & D-E-202 for sizing and location details. All of the other submersible pump stations plus the Standby power facilities located at Mountain View and at 8th & El Moro Street will be located inside the standby power facility associated with the pump station. The Harvest Well locations at Loma and Palisades will have the Instrumentation, PLC and communication hardware mounted inside a NEMA enclosure in accordance with Section 16050 inside the harvest well building. The Harvest Well at East Paso will use the PLC and communication hardware provided for the submersible pump station also located at the site. All of the Effluent Disposal sites will require an outdoor standalone RTU/LCP, that will have all of the PLC and communication hardware mounted inside a NEMA enclosure in accordance with Section 16050. All of the I/O wiring from the field to the PLC shall be terminated on terminal blocks in the lower portion of the enclosure. A nameplate shall be mounted on the outside of the door of the enclosure and be engraved with "RTU-X" where "X" is the number as shown in specification 17300. Where indicated, PLC's mounted in wall or pedestal-mounted enclosures shall be 36-inches tall by 36-inches wide by 20-inches deep, minimum. Enclosures shall be as manufactured by **Hoffman**, or equal.

2.4 SPARE PARTS AND SPECIAL TOOLS

A. Control panel spare parts selected by the ENGINEER and special tools shall be furnished in accordance with Section 17100.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Preparation for Shipment and Shipping

1. Panels shall be crated for shipment using a heavy framework and skids. Panel sections shall be cushioned to protect the finish of the instruments and panel during shipment. Instruments that are shipped with the panel shall further have suitable shipping stops and cushioning material installed to protect parts that could be damaged due to mechanical shock. Each separate panel unit shall be provided with removable lifting lugs to facilitate handling.

2. Shipments shall be by air-ride van unless otherwise indicated.

3. Control panel testing and inspection shall be performed prior to shipping.

4. Control panels shall be installed in accordance with Section 17100.

3.2 CONTROL PANEL SIGNAL AND CONTROL CIRCUIT WIRING

A. **Wiring Installation:** Wires shall be run in plastic wire-ways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, (3) wiring from components on a swing out panel to components on a part of the fixed structure, and (4) wiring to panel mounted components. Wiring run from components on a swing out panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the "hinge loop" so that conductors are not strained at the terminals.

B. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.

C. Wiring to rear terminals on panel-mount instruments shall be in plastic wire-ways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

D. Shop Drawings shall show conformance to the above wiring installation requirements.

E. **Wire Marking:** Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on Shop Drawings. These numbers shall be marked on conductors at every terminal.

3.3 CALIBRATION, TESTING, AND INSTRUCTION

A. **General:** Calibration, testing, and instruction shall be performed in accordance with Section 17100.

B. Inspection and Approval

1. Panel fabricator shall conduct the following tests prior to arrival of the ENGINEER or before shipment, if the ENGINEER chooses not to witness factory testing.

   a. Alarm circuits rung out to determine their operability.

   b. Electrical circuits checked for continuity and where applicable, operability.

   c. Any other test required to place the panel in an operating condition.

2. It shall be the responsibility of the CONTRACTOR to furnish all necessary testing devices and sufficient manpower to perform the tests required by the ENGINEER.

3. Field Testing: Each control panel shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

- END OF SECTION -

SECTION 17300 - CONTROL STRATEGIES

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. The SUB-CONTRACTOR, through the use of the Instrumentation Supplier, shall provide all PLC-based Control System (PLCS) application programming required to implement the control strategies described in this section, the functions shown on the drawings and I/O schedules complete and operable in accordance with the Contract Documents.

B. The requirements of Section 17100 – Process Instrumentation and Control Systems, Section 17510 – PLC-Based Control Systems Hardware, and Section 17520 – PLC-Based Control Systems Software apply to this Section.

C. The requirement includes all PLC and Workstation programming and all other programming of PLCS interface, network and communication devices.

1.2 COMMON FUNCTIONS

A. Common functions that are generally applicable to all loops or to many similar loops are described under the heading "General Control Loop Functions." These functions are not repeated in the descriptions for each individual control strategy.

B. General Control Loop Functions

1. The following terms are used in the descriptions of PLC functions:

a. **Operator Settings**: Operator set or entered values shall be constants that are adjustable or set from operator displays. Examples of operator set or entered values are controller set points, batch set points, etc. Specific values that are required to be operator set are noted in the process control strategy descriptions.

b. **Tunable Values**: Tunable values are constants that are adjustable at engineer level displays without requiring any software reconfiguration. These values are not adjustable from operator level displays.

2. The following general control system functions shall be provided:

a. All analog and discrete inputs to the PLC shall be displayed. Both RUNNING and OFF input states shall be displayed.

b. All analog inputs shall have instrument failure alarms when the input is below 0 percent or above 100 percent for a tunable time initially set at 10 seconds.

c. All discrete FAIL inputs shall be alarmed. Other discrete inputs shall be alarmed as noted in the control strategy descriptions.

d. Where alarms are specified in the control strategy descriptions, alarms shall be initiated from the applicable inputs. If discrete inputs are not available, the specified alarms shall be initiated from the applicable analog input; alarm setpoints shall be operator adjustable.

e. All analog inputs shall be trended.

f. All flow inputs and equipment run times shall be totalized and recorded. All totalized values shall be displayed.

g. Displays shall be grouped functionally for ease of operation. Both analog and discrete functions associated with an item of equipment or a group of equipment shall be provided on the same display.

h. Unless otherwise stated or shown, all discrete outputs shall be maintained outputs. For START/STOP PLC functions, the PLC shall issue a maintained START command until a FAIL state is detected or when a STOP command is issued. When a momentary command is required, the PLC shall issue the command for two (2) seconds, then remove the signal.

i. For equipment that is controllable from the PLC, a control mode status signal will be sent to the PLC to indicate when the PLC is allowed to control the equipment. The PLC shall monitor the control mode status (LOCAL/ REMOTE) and attempt to control only that equipment which is in the REMOTE mode.

j. For equipment that the PLC is allowed to control, the PLC shall provide a FAIL alarm if the equipment fails to comply with a PLC command signal (START, STOP, OPEN, CLOSE) that has been present for more than a tunable time period. In this event, the command shall be removed subsequent to the expiration of the tunable time period.

k. For equipment that is controllable from the PLC in either a MANUAL or AUTOMATIC mode, the operator shall be provided with a software AUTO/MANUAL selector switch at the operator workstation. Transfer between the MANUAL and AUTOMATIC modes shall be bumpless.

l. All PID control functions (P, PI, and PID) shall be provided with standard analog controller functions and operator interfaces including, but not limited to, the following;

   1) AUTO/MANUAL mode selection: In AUTO, the output of controller shall be based on the PID control calculation. In MANUAL, the output of the controller shall be operator adjustable. Transfer between operational modes shall be bumpless.

   2) LOCAL/REMOTE set point selection: In LOCAL, the set point shall be operator adjustable from the equipment. In REMOTE, the set point shall be adjustable from a REMOTE set point input.

   3) Set point, process variable, and controller output shall be displayed.

   4) Provisions shall be included to prevent reset windup.

m. When equipment is tagged "OUT OF SERVICE" by the operator, all associated equipment shall have their alarms inhibited until the tagged equipment is re-tagged IN SERVICE.

n. Speed indications and speed control setpoints shall be displayed in RPM.

o. Wherever two or more pieces of equipment are provided for the same functions, for example air scour blowers, the SCADA system shall alternate the equipment after each use.

p. For all chemical storage tanks, the SCADA system shall calculate volume, amount used per shift and amount used per day.

q. All chemical feeders shall be immediately restarted following restoration of power – either from the utility or the generator.

C. The following abbreviations are used throughout this section:

SS: Selector Switch
HOR: Hand/Off/Remote
RVS: Reduced Voltage Starter
VFD: Variable Frequency Drive
LR: Local/Remote
HOA: Hand/Off/Auto
MOV: Motor Operated Valve
LOS: Lock-Out Stop

1.3 SCOPE OF THIS SECTION

A. These control strategies are intended to address systems that will be as part of Los Osos Collection System project and to describe the general operation of the systems and processes. These control strategies are not intended to be all-inclusive operational procedures for the operation of the complete facility.

POCKET PUMP STATION PUMPS

Reference Drawing: A-I-201/2 & D-I-200

General: A duplex or triplex submersible pump system will be installed in the following Pocket Pump Stations located throughout Los Osos.

Pump Station	Location	Number Of Pumps	Pump Numbers	RTU/LCP No.
4A	North End of 4th Street	3	4A-P-1, 2 & 3	1
7A	North End of 7th Street	2	7A-P-1 & 2	2
8A	North End of 8th Street	2	8A-P-1 & 2	3
9A	North End of 9th Street	2	9A-P-1 & 2	4
9B	Near Intersection of 9th & Ramona Streets	3	9B-P-1, 2 & 3	5
9C	Intersection of 9th Street & San Luis Avenue	2	9C-P-1 & 2	6
10A	North End of 10th Street	2	10A-P-1 & 2	7
11A	North End of 11th Street	2	11A-P-1 & 2	8
12A	North End of 12th Street	2	12A-P-1 & 2	9
13A	North End of 13th Street	2	13A-P-1 & 2	10
13B	Near Intersection of 13th Street & San Luis Avenue	2	13B-P-1 & 2	11
15B	Near Intersection of 15th & Ramona Streets	2	15B-P-1 & 2	12

The pumps will be controlled locally by PLC located in a control panel near each pump station.

Local Controls: Local control for the pump station shall be performed using the HAND/OFF/AUTO selector switches located on the dead panel front inside the associated local control panel. When the HAND/OFF/AUTO selector switch is in the OFF position, the corresponding pump shall not run. A pump shall run when the switch is manually turned to the HAND position. The pump shall run until the switch is manually returned to the OFF or AUTO position or until a low-level shutdown level is reached.

Local Automatic Control Mode:

The pumps shall be controlled automatically from the LCP when the HAND/OFF/AUTO switch at the LCP is set to AUTO. For a two-pump station the pumps will operate alternately. The current lead pump will start when a pump high level setpoint is reached in the wetwell. For a three-pump station all of the pumps will operate alternately in normal operation with no pump failure. First a lead pump will turn on when the lead pump on level is reached in the wetwell, if the level continues to increase a second pump will turn on when a lag pump level is reached in the wetwell. The third pump will be in standby mode. All Pump(s) will shutdown when the low-level setpoint is sensed in the wetwell. When all pumps have shutdown the standby pump will alternate and become the lead pump, the lead pump will become the lag pump and the lag pump will become the standby. Individual pump run status (green pilot lights) along with a common FAIL condition (amber pilot lights) shall be displayed on the LCP.

SCADA Input/Manual Control Mode:

Individual pump run status is transmitted to the SCADA system for indication and runtime totalization at the operator workstation at the Wastewater Treatment Plant. No manual control is provided from the SCADA system.

SCADA Automatic Control Mode:

No automatic control is provided at the SCADA system.

Interlocks:

A pump station will be prevented from operating if the level in the West Paso submersible pump station is at a High-High level alarm condition.

Alarms:

A HIGH-HIGH alarm status derived from the level float switch shall be transmitted to the SCADA system for indication at the operator workstation. A pump fail alarm shall also be transmitted to SCADA for indication at the operator workstation.

COLLECTION SYSTEM MAIN PUMP STATIONS

Reference Drawing: A-I-201, B-I-201, C-I-200 & D-I-200

General: A duplex or triplex submersible pump system will be installed in the following pump stations:

Pump Station	Location	Number Of Pumps	VFD/Constant Speed	Pump Numbers	RTU/LCP No.
West Paso	3rd Street & Paso Robles	3	VFD	WP-P-1, 2, 3	13
Baywood	2nd Street	2	Constant	BW-P-1, 2	14
East Paso	18th Street & Paso Robles	2	Constant	EP-P-1, 2	15
East Ysabel	Santa Ysabel & South Bay Blvd.	2	Constant	EY-P-1, 2	16
Mountain View	Santa Ynez Avenue & Mountain View Drive	2	Constant	MV-P-1, 2	17
Lupine	Lupine & Donna Avenue	3	VFD	LU-P-1, 2, 3	18
Sunny Oaks	Los Osos Valley Rd & Sunny Oaks	2	Constant	SO-P-1, 2	19

The pumps will be controlled by a PLC in a local control panel located either close to the pump wetwell (Mountain View, West Paso & Baywood) or will be located in the nearby standby power building associated with the site (East Paso, Sunny Oaks, Lupine & East Ysabel). The pumps will discharge into force and gravity mains that feed West Paso Submersible Pump Station.

Local Controls: Control for the pumps shall be performed using the HAND/OFF/AUTO selector switches at the local control panel. When the HAND/OFF/AUTO selector switch is in the OFF position, the corresponding pump shall not run. When set to HAND an available constant speed pump that is set to run by the alternate controls set automatically by the control panel PLC shall run. When set to HAND a VFD pump at West Paso will run at the speed set at the VFD. The pumps shall run until the switch is manually turned to the OFF or AUTO position or until a low-level shutdown level is reached.

Local Automatic Control Mode: The pumps shall be controlled automatically from the LCP when the HAND/OFF/AUTO switch at the LCP is set to AUTO. The available constant speed pumps will operate alternately when a pump on level setpoint is reached in the wetwell. If a pump has failed the other available pump will operate exclusively until the

failed pump reset at the associated starter is pressed. Then the pumps will resume alternating operation. For the VFD pumps the lead pump will turn on and run at 50% speed when the pump on level setpoint is reached. The pump speed will vary using a PID controller based on a level setpoint for the wetwell. When the lead pump speed increases to 95% the speed will be clamped and a lag pump will turn on at 50% speed the lag pump speed will then vary again based on the level setpoint in the wetwell.

Running constant speed pumps will shutdown when the pump off level setpoint is reached in the wetwell. The running lag VFD pump will shutdown when the speed of the pump decreases to 45%. The Lead pump speed will then be unclamped and the speed again will vary to control a level in the wetwell. When the lead pump speed reaches 45% it will shutdown. All operating Pump(s) shall shutdown when a low-level setpoint is reached in the wetwell. Individual pump run status (green pilot lights) along with fail condition (amber pilot lights) shall be displayed on the LCP.

SCADA Input/Manual Control Mode:

Individual RUN status for each pump is transmitted to the SCADA system for indication and runtime totalization at the operator workstation located at the Wastewater Treatment Plant. No manual control is provided from the SCADA system although level setpoints can be changed and alarms can be acknowledged.

SCADA Automatic Control Mode:

No automatic control is provided at the SCADA system.

Interlocks:

Any operating pump will be commanded to shutdown if a power failure occurs at the Wastewater Treatment Plant.

Alarms:

A HIGH-HIGH alarm status derived from the level float switch shall be transmitted to the SCADA system for indication at the operator workstation at the Wastewater Treatment Plant. A pump common fail alarm shall also be transmitted to SCADA for indication at the operator workstation. Each pump will have a fail indicator light at the LCP.

HARVEST WELLS

Reference Drawing: A-I-200 & B-I-200

General: The East Paso, Palisades and Loma Harvest Wells will be provided to pump groundwater from those locations and add a anti-corrosive agent and chlorine and then blending it with water taken from a production well before the water is pumped back into the ground at a different disposal location.

Harvest Well	Location	RTU/LCP No.
East Paso	18th Street & Paso Robles	15
Palisades	Palisades Avenue & Los Osos Valley Road	20
Loma	Loma Street & Broderson Avenue	21

The Harvest well will be controlled manually with a PLC in a local control panel located in the Harvest well building at Palisades and Loma and from the Standby Power Building at East Paso. The PLC provides the interlocking controls for the chemical feed pumps and monitoring of the chlorine and flow conditions of the well discharge.

Local Controls: Control for the well pump shall be performed using the LOCAL/OFF/REMOTE selector switches at the MCC. When the LOCAL/OFF/REMOTE selector switch is in the LOCAL position, the pump will run when the START/STOP switch is placed in START. The pump will stop when placed in STOP. Individual RUN and REMOTE status for the pump is transmitted to the SCADA system for indication and runtime totalization at the operator workstation located at the Wastewater Treatment Plant. When a well pump is called to run the power is then available to the chemical pump receptacle from the MCC. A chemical pump if set to start will operate at the speed set at the chemical pump.

Local Automatic Control Mode: No local automatic controls will be provided.

SCADA Input/Manual Control Mode: The operator at the Wastewater Treatment Plant can start and stop the well pump when the LOCAL/OFF/REMOTE switch is placed in REMOTE.

SCADA Automatic Control Mode: No automatic control is provided at the SCADA system.

Interlocks: None.

Alarms: Well and chemical pump Fail. High discharge pressure.

EFFLUENT DISPOSAL SITES

Reference Drawing: A-I-204 & C-I-201

General: The Pismo, Santa Maria and Broderson Effluent Disposal Sites will be provided to discharge Wastewater Treatment Plant effluent into the ground via a trench at Broderson and wells at Pismo and Santa Maria.

Effluent Disposal Site	Location	RTU/LCP No.
Pismo	Pismo & 12th Street	23
Santa Maria	Santa Maria Avenue & 16th Street	24
Broderson	South of Highland Drive & Alexander	25

The effluent disposal system will be controlled from the Wastewater Treatment Plant through an RTU/PLC in a local control panel located at each disposal site. The PLC will control the operation of the zone solenoid operated globe valves at each disposal site.

Local Controls: No local controls will be provided. Each well at the Pismo and Santa Maria sites will be provided with a flowmeter to determine actual flow to each well. No remote indication will be provided.

Local Automatic Control Mode: No local automatic controls will be provided.

SCADA Input/Manual Control Mode: The operator at the Wastewater Treatment Plant can open and close all of the zone solenoid operated valves manually though the workstation.

SCADA Automatic Control Mode: The opening and closing of each zone solenoid operated valve at the Pismo and Santa Maria Sites will be determined based on the number of Area pumps that are operational at the Wastewater Treatment Facility. The Broderson disposal site valves will operate based on accumulated gallons from the flowmeter on the discharge of the Broderson wetwell.

Interlocks: High water level in the Area Wetwell will open all zone solenoid valves.

Alarms: No alarms.

SECTION 17510 - PLC-BASED CONTROL SYSTEM HARDWARE

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR, through the use of an Instrumentation Supplier and electrical installers, shall furnish, supervise installation, assemble, configure, the PLC-based Control System specified under this Section, and in Section 17520 - PLC-Based Control System-Software, all in accordance with the requirements of the Contract Documents. The OWNER shall provide the PLC and workstation programming.

1. The control system equipment consists of a number of RTU/LCP's located at Pump Stations/Standby Power Facilities, Harvest Wells and Effluent Disposal Facilities throughout Los Osos. Each PLC shall be provided with power supply module(s), communication interface device(s), peripheral equipment, and UPS.

2. It is the intention of this project that the communication with the Los Osos Wastewater Treatment Facility be seamless as possible. It is required that the CONTRACTOR for the collection system projects provide the same manufacturer's equipment for both Areas A & D and Areas B & C collection projects and it is recommended that the PLC manufacturer be the same as provided as part of the Wastewater Treatment Facility project.

B. **Instrumentation Supplier:** The Instrumentation Supplier shall be responsible for verifying the selection, purchasing, installing and testing compatible hardware and base software to provide a functional Control System. The instrumentation supplier shall supply the software and appropriate hardware to the OWNER to enable the system to be programmed prior to system testing.

C. A Control System block diagram showing the communication medium that will be used for each location is provided on contract drawings AD-GI-202 and BC-GI-202.

D. The control system installation shall consist of the following:

1. The Instrument Supplier for Area A & D shall be responsible for furnishing all equipment for both the A & D and B & C projects to ensure that the products are the same for both projects. The CONTRACTOR for each project shall be responsible installing, and testing the radio, modem and fiber optic equipment required to communicate with the OWNER'S new SCADA system located at the Wastewater Treatment Plant that is included in a separate project as follows:

a. All of the Pocket Pump Stations will communicate via dial-up modem. The area A & D Instrument Supplier shall provide each Pocket Pump Station a combined Instrument and Electrical LCP located in close proximity to the pump station. The CONTRACTOR shall coordinate with the Electrical Contractor to provide a new PLC, modem, UPS and associated power supplies, with the associated level transmitter specified in section 17106 of the Contract Documents, on a single back-plane that will mount on the instrument side of a combined LCP. See electrical contract drawing AD-E-200 for sizing requirements and locations.

b. The Pismo and Santa Maria Effluent Disposal Facilities will communicate via dial-up modem. The area A & D Instrument Supplier shall provide each a new PLC, modem, UPS and associated power supplies in a weatherproof LCP.

c. The area A & D Instrument Supplier shall provide a new PLC, fiber optic modem, UPS and associated power supplies, with the associated level transmitter (specified in Section 17106 of the Contract Documents), on a single back-plane that will mount on the instrument side of a combined LCP for the Baywood and West Paso Submersible Pump Station Facilities. The West Paso LCP shall also contain a patch panel to route an incoming 24-fiber cable from the Wastewater Treatment Plant that will be provided and installed as part of the Wastewater Treatment Facility project. Four fibers shall be dedicated to the West Paso Pump Station, 16 fibers shall be routed to the Standby Power Facility at 8th and El Moro and four fibers shall be routed to the Baywood Pump Station. Eight of the fibers routed to the 8TH and El Moro Facility shall be reserved for future SCADA purposes. See electrical contract drawing A-E-200 for locations.

d. The area A & D Instrument Supplier shall provide a new PLC, fiber optic modem, UPS and associated power supplies to be installed in an LCP enclosure by the project B & C CONTRACTOR inside the Palisades Harvest Well Facility. The fiber optic cable shall be provided and installed by the Wastewater Treatment Facility project.

e. The Instrument Supplier shall provide a new PLC, radio, UPS and associated power supplies, with the associated level transmitter (specified in Section 17106 of the Contract Documents), in an LCP enclosure inside the Standby Power Building for the East Paso and East Ysabel Submersible Pump Station Facilities and the Mountain View Standby Power Facility. The East Paso Harvest well instrumentation and control will be connected to the East Paso Submersible Pump Station RTU. The LCP shall be used for both the pump station and the associated standby power facility I/O. A separate LCP shall be provided next to the Mountain View Submersible Pump Station for mounting of the instruments only. The instrument signals shall be routed to the RTU/PLC located at the standby power facility. The Instrument Supplier shall also provide the antenna cable, surge suppressor, antenna and antenna pole for these facilities.

f. The project A & D Instrument Supplier shall provide a new PLC, radio, UPS and associated power supplies to be installed in an LCP enclosure by the project B & C CONTRACTOR at the Loma Harvest well Facility. The Instrument Supplier shall also provide the antenna cable, surge suppressor, antenna and antenna pole for these facilities.

g. The project A & D Instrument Supplier shall provide a new PLC, radio, UPS and associated power supplies, with the associated level transmitter (specified in section 17106 of the Contract Documents), to be installed in an LCP enclosure by the project B & C CONTRACTOR inside the Standby Power Building for the Sunny Oaks and Lupine Submersible Pump Station Facilities. The LCP shall be used for both the pump station and the associated standby power facility I/O. The Instrument Supplier shall also provide the antenna cable, surge suppressor, antenna and antenna pole for these facilities.

h. The project A & D Instrument Supplier shall provide a new PLC, radio, UPS and associated power supplies to be installed in an LCP enclosure by the project B & C CONTRACTOR at the Broderson Effluent Disposal Facility. The Instrument Supplier shall also provide the antenna cable, surge suppressor, antenna and antenna pole for the facility.

i. The area B & C CONTRACTOR shall reconfigure the Mountain View Standby Power Facility to be a repeater station for the radio signal from the Sunny Oaks Facility.

E. **Scope of Work:** The CONTRACTOR through his area Instrument Supplier shall furnish, install, and test the Control System as specified within these Contract Documents. The CONTRACTOR shall be responsible for all equipment selection and supply, hardware and software material submittal preparation, total system integration, supervision of installation, testing, training, start-up and implementation activities for the entire Control System being furnished under this Contract. The OWNER REPRESENTATIVE shall provide the programming effort for the PLC's and also will provide assistance for control system testing and start-up. The Control System hardware and software being furnished under this Contract shall be a standardized system that utilizes off-the-shelf commercially available configurations of hardware and software modules.

F. The CONTRACTOR shall provide all installation, all labor supervision, and all engineering required to assure the proper installation and operation of the entire Control System. The CONTRACTOR shall be responsible for providing and installing a complete and operational system, to meet all the requirements of the Contract Documents. The following work, equipment, and services shall be included in this Contract but not be limited to:

1. Prepare and submit for approval Control System hardware shop drawings.

2. Furnish and install a complete and operational Control System, including all peripherals and other equipment specified herein.

3. Perform all required Control System tests, including a full fiber optic code test to ensure a fully functional system, adjustments, and calibrations.

4. Furnish labor to perform Control System installation and start-up.

5. Furnish qualified instructors to provide Control System instruction and training.

6. Furnish all required Control System tools, test equipment, spare parts, supplies, operations and maintenance manuals, reproducible "as-built" drawings as specified herein.

The CONTRACTOR's attention is directed to the construction sequencing requirements contained within the Contract Documents. The CONTRACTOR shall provide on-loan, any and all Control System equipment required for the OWNER REPRESENTATIVE to program the required PLC's and workstations.

G. **System Responsibility:** All Control System hardware and software furnished in accordance with the Contract Documents shall be done so by the CONTRACTOR. The CONTRACTOR shall have responsibility for providing a fully integrated Control System. The CONTRACTOR shall coordinate the WORK of his personnel and the Instrumentation Supplier's personnel for the installation, interconnection, testing, calibration, and operation of all Control System equipment and coordinate the scheduling along with the programming work of the OWNER REPRESENTATIVE. The CONTRACTOR shall be responsible for providing equipment that properly meets the functional intent of the Contract Documents. Substitutions for Control System functions specified are not permitted.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS.

A. PLC-based control systems-hardware reference specifications, codes, and standards shall be provided in accordance with Section 17100 - Process Control and Instrumentation Systems.

1.3 CONTRACTOR SUBMITTALS

A. **Shop Drawings:** Control System submittals shall be in accordance with the applicable requirements of Section 17100 - Process Control and Instrumentation Systems. PLC-Based Control System submittals shall however be made separately from other process control and instrumentation system submittals. For Control System software submittal requirements, see Section 17520 - PLC-Based Control System - Software.

B. **Hardware Submittals:** The Control System hardware submittal shall include hardware specified under this Section and shall be a singular all inclusive submittal which shall include but not be limited to:

1. A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tabs.

2. Complete grounding requirements for the entire Control System including any requirements for PLC's, and control room equipment, shall be indicated on catalog cut sheets or drawings.

3. Requirements for physical separation between Control System components and 120 volt, 480 volt, and 12 kV power cables shall be indicated in layout drawings and/or installation detail drawings. A minimum separation of 18 inches shall be enforced between Control System 24V wiring conduits and any control wiring conduits carrying 120V or higher.

4. UPS and battery load calculations for the units specified for each PLC location to show that the backup capacity and time meet the specified requirements.

5. A complete set of Control System diagrams which depict:

   a. All PLC's, communication devices, and communication links. All PLC's shall be shown with their current I/O allocation, future I/O allocation (current plus spares provided under this project), maximum potential I/O and all I/O addresses.

   b. All cables required to support the communication requirements. A separate diagram shall be submitted for each component fully annotated with conduit size and number associated with the power source.

6. Data sheets shall be included for each Control System component together with a technical product brochure or bulletin. These data sheets shall show: the component name as used within the Contract Documents, the manufacturer's model number or other identifying product designation, the project tag number, the project system of which it is a part, the project site to which it applies, the input and output characteristics, the requirements for electric power, the specifications for ambient operating conditions, and details on materials of construction.

7. **Complete and detailed bills of materials:** A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each component of the Control System. Bills of material shall include all items within an enclosure.

8. Site-specific arrangement and construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates, and the like. All drawings shall be scaled, as noted above, and show the position of the equipment on its intended installation location. All drawings must show a scaled representation of the placement of all equipment being provided under this Contract and its spatial relationship to all other equipment located in the abutting and adjoining areas. All acquired access and clearances associated with the equipment must be shown with a statement of compliance to manufacturer's recommendations, NEC, and other applicable codes.

9. Calibration, adjustment, and test details for all Control System components.

10. I/O List for each location including spares.

C. **OWNER'S Manuals:** General requirements for OWNER'S manuals are as described in Section 17100 - Process Control and Instrumentation Systems. The following items shall also be included in the OWNER'S manuals:

1. A documented PLC I/O list and housing configuration for each PLC and remote I/O.

2. Operation and maintenance manuals for the PLC's, workstations, and all other Control System hardware.

D. **Factory Test Procedure:** The CONTRACTOR shall prepare and submit a factory test procedure which incorporates, test sequences, test forms, samples of database lists, a Control System testing block diagram, and an estimated test duration that complies with the requirements of the factory test specified herein. The CONTRACTOR shall identify physical resources, such as simulation hardware, in the factory test procedure.

1.4 MANUFACTURER'S REPRESENTATIVE

A. The CONTRACTOR shall provide visits by, and services of, technical field representatives of the Control System PLC's and software manufacturers for installation certification, system testing, training, and start-up. These visits shall be at no separate additional cost to the OWNER.

1.5 STORAGE AND HANDLING

A. All equipment and materials delivered to the jobsite shall be stored in a location that shall not interfere with the operations of the OWNER's personnel or interfere with construction. Storage and handling shall be performed in manners that shall afford maximum protection to the equipment and materials. It is the CONTRACTOR'S responsibility to assure proper handling and on-site storage.

1.6 WARRANTY

A. The complete Control System (and associated software) included therein shall be guaranteed to meet or exceed the design requirements set forth in the Contract Documents.

B. Equipment, software, and materials that do not achieve design requirements after installation shall be replaced or modified by the CONTRACTOR to attain compliance, at no additional cost to the OWNER. Following replacement or modification, the CONTRACTOR shall retest the system and perform any additional procedures needed to place the complete Control System in satisfactory operation and attain design compliance approval from the ENGINEER.

C. The CONTRACTOR warrants the materials and workmanship used for the Control System equipment and materials furnished under the Contract and further guarantees the materials and workmanship used for any equipment and materials produced and furnished hereunder as a part of the work of this Contract to be as herein specified and agreed upon, free from injurious defects, and in all respects satisfactory for the service required.

D. The CONTRACTOR shall install in the Control System the means (e.g., modem) to communicate to the manufacturer factory in order to diagnose Control System failures remotely.

E. The CONTRACTOR shall warrant/guarantee the satisfactory performance of the equipment and materials under operating conditions for a period of one year after date of final acceptance of the **entire** Control System (i.e., completion of all contractual items including a successful full system-wide 30 day performance test as specified in Part 3). In the event that tests and inspections disclose latent defects of failure to meet the specified requirements, the Instrumentation Supplier upon notification by the ENGINEER shall proceed at once to correct or repair any such defects or non-conformance or to furnish, at the delivery point named in the Contract, such new equipment or parts as may be necessary for conformity to the specified requirements, and shall receive no additional compensation therefor. In case of any required repairs or other corrective or remedial work covered under warranty, the warranties on all such corrections, repairs, new equipment, or parts shall be extended for an additional 12 months from the date of final acceptance or 12 months from the date of completion of any such corrections, repairs, new equipment, or parts, whichever date is later. The CONTRACTOR shall reimburse the OWNER for all costs incurred in the removal of the defective material and installation of the replacement.

PART 2 -- PRODUCTS

2.1 GENERAL

A. All materials and all Control System equipment furnished under this Contract shall be new, free from defects, of first quality, and produced by manufacturers regularly engaged in the manufacture of these products.

B. Where there is more than one item of similar equipment being furnished under this Contract, all such similar equipment shall be the product of a singular manufacturer.

C. All Control System equipment furnished under this contract shall be provided with not only the resources required to meet the function requirements of this project, but in addition all equipment and resources including PLC's, memory requirements, graphic displays, hard disks, magnetic tapes, etc., shall be provided to accommodate a twofold expansion in the number of points.

D. All Control System equipment furnished under this contract shall be provided with not only the resources required to meet the functional requirements of this project in addition, all equipment and resources including PLC Memory, PLC I/O cards, PLC power supplies, UPS, graphic workstations, magnetic tapes, etc., shall be provided to accommodate a **20 percent growth in project requirements**. All Control System equipment and resources shall be provided under this Contract such that the entire 20 percent project growth can be implemented into the Control System without any additional cost to the OWNER.

E. The entire Control System being furnished under this project shall be capable of being modularly expanded to accommodate a twofold increase in process report/display requirements and manual input requirements. All equipment and resources provided under this Contract shall be able to modularly accept that anticipated future expansion without the need to replace or retire any Control System component or resource.

2.2 PLC ENCLOSURES

A. Supervisory Control and Data Acquisition System - Hardware PLC enclosures shall be provided in accordance with Section 17200 - Control Panels.

2.3 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Provide and install line interactive UPS's in each PLC location. The UPS shall receive a 120VAC, 60 HZ power input, and generate a 120VAC, 60 HZ output signal which is protected from incoming spikes, sags, noise, brownouts, and power outages. The output power from the UPS shall be fed to all devices within an enclosure and to certain external devices as shown which require a 120VAC power input.

B. The UPS shall have a battery pack, an inverter, and a microprocessor based controller to provide continuous, line-interactive, computer grade uninterruptible power. Lightning and surge protection shall meet ANSI/IEEE C62.41 categories A and B. The UPS shall be UL listed. Spike attenuation shall be 2000 to 1. The output neutral shall be bonded to ground. Noise isolation shall be 120dB common-mode, 60dB normal mode. Output voltage regulation shall be ± 3 percent with less than 5 percent total harmonic distortion. UPS efficiency shall be at least 85 percent. The UPS shall be rated for ambient temperatures from 32 degrees F to 104 degrees F and relative humidity from 0 to 95 percent.

C. Each UPS shall maintain power to all of its loads, including non-constant loads such as printers, for a minimum of 30 minutes. The equipment submittal shall include sizing calculations that support the unit selected. The UPS shall be supplied with a low output voltage cutoff to prevent damage to loads when the battery power is exhausted.

D. The uninterruptible power supplies shall be **APC Smart-UPS, Best Fortress UPS series.**

Each UPS shall have the following contact outputs that shall input to the respective PLC.

1. UPS Online

2. Battery low

2.4 HARDWARE

A. Programmable Logic Controller

1. **Construction:** Each PLC central processing unit (CPU) shall be of solid-state design. All CPU operating logic shall be contained on plug-in modules for quick replacement. Chassis wired logic is not acceptable. The controller shall be capable of operating in a hostile industrial environment (i.e., subject to heat, electrical transients, RFI, vibration, etc.) without fans, air conditioning, or electrical filtering (up to 60 degrees C and 95 percent humidity). Each PLC shall be furnished with at least 2 communication ports.

2. **Components-General:** Each PLC shall have all of the facilities required to implement the control schemes and database shown and specified in the Contract Documents. PLC's shall all have floating and PID controller modulating capability. Each CPU shall provide internal fault analysis with a fail-safe mode and a dry contact output for remote location alarming, and a local indicator on the PLC frame in the event of a fault in the PLC.

3. **Central Processors:** Each central processor shall contain all the relays, timers, counters, number storage registers, shift registers, sequencers, arithmetic capability, and comparators necessary to perform the specified control functions. It shall be capable of interfacing sufficient discrete inputs, analog inputs, discrete outputs, and analog outputs to meet the specified requirements plus at least 20 percent excess capacity. All PLC's shall be provided to support and implement closed loop floating and PID control that is directly integrated into the PLC's control program. The power supply shall contain capacitors to provide for orderly shutdown in the event that the incoming power does not meet specifications. If this occurs, the processor will cease operation, forcing all outputs off. The processor shall have a key type memory protect switch to prevent unauthorized program changes.

4. **Memory:** Each programmable controller memory shall be RAM memory with battery backup. The onboard RAM memory shall be a minimum of 256K of user memory for all PLC's. An indicator shall show the status of the batteries and a reference shall be available though the discrete outputs, to alarm the operator that the batteries should be changed. Each controller shall be supplied with an internal lithium battery that shall retain the program during power outages of up to one year.

   Each unit shall be supplied with sufficient memory to implement the specified control functions plus a reserve capacity of 20 percent of the total provided. This reserve capacity shall be totally free from any system use. The memory shall be programmed in a multi-mode configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.

5. **Controllers:** Each programmable controller shall be easily reprogrammed with a portable laptop computer.

6. **Manufacturer:** The programmable logic controllers shall be **Allen Bradley Micrologix 1500/1761 System or Modicon TSX Momentum Series** or equal.

B. **PLC Power Supply:** Each PLC power supply shall be mounted in the PLC housing and be sized to power all modules mounted in that housing and an "average module load" for any empty housing slots plus 25 percent above that total.

C. **PLC Input/Output (I/O) Modules:** All I/O housings and modules shall be suitable for industrial environments as described in Section 17100 - Process Control and Instrumentation Systems. All I/O modules shall be isolated and conform to IEEE Surge Withstand Standards and NEMA Noise Immunity Standards. The I/O shall be 4-20 mA DC for all analog inputs and outputs and shall be 120 VAC for discrete inputs and dry relay contacts for safe discrete outputs. Modules shall be removable without having to disconnect wiring from the module's terminals by means of plug-in wiring connectors.

Each PLC location shall contain the I/O modules required to provide all of the I/O points (including designated future I/O points) contained in the I/O List that is included at the end of this specification. In addition each PLC location shall contain an installed spare capacity of 20 percent of each type of I/O used at that location. All spares provided shall be wired and connected to the field terminal strip.

1. **Discrete Input Modules:** Defined as contact closure inputs from devices external to the programmable controller module. Individual inputs shall be optically isolated from low energy common mode transients to 1500 volts peak from users wiring or other I/O Modules. The modules shall have LED's to indicate status of each discrete input. Input signal level shall be 120 VAC. The discrete input module shall have a maximum of 16 points each.

2. **Discrete Output Modules:** Defined as contact closure outputs for ON/OFF operation of devices external to the programmable controller module. The output modules shall be optically isolated from inductively generated, normal mode and low energy, common mode transients to 1500 volts peak. All output modules shall have LED's to indicate status of each output point. Output contact rating shall be 0.5A at 120 VAC minimum, with a momentary surge rating of at least 2A at 120 VAC. Each output point shall be individually isolated. The output points shall be individually fused with blown fuse indication within the PLC cabinet.

3. **Analog Input Modules:** Defined as 4 to 20 mA DC signals, where an analog to digital conversion is performed with a minimum of 12-bit precision and the digital result is entered into the processor. The analog to digital conversion shall be updated with each scan of the processor. Analog input modules shall have 8 differential inputs each. Analog input modules shall be source or sink to handle 2-wire or 4-wire transmitters respectively.

4. **Analog Output Modules:** Defined as 4 to 20 mA DC output signals where each output circuit performs a digital to analog conversion with each scan of the processor. Each analog output module shall have four isolated output points which shall be rated for loads of up to 1200 ohms.

D. **PLC Housing:** The PLC, power supply, and I/O modules shall be mounted in a suitable standard housing. Individual housing slots shall be mechanically configurable to prevent insertion of incorrect modules. Each PLC location shall have a minimum of 1 empty I/O module slot.

E. **Miscellaneous Components:** The following items will be required to provide a fully functional PLC system at locations shown on Contract Drawing AD-GI-202. Additional components may be required which are not listed here. These components shall be Modicon or Allen Bradley parts:

1. Ethernet Fiber Optic Modems: **Weed Instrument Company Inc. EoTec 2000 Series or TC Communications 3210 or equal.**

2. Fiber Optic Cable: **Refer to specification 16800.**

F. **Portable Laptop:**

1. The CONTRACTOR/Instrumentation Supplier shall furnish one lap top computer. The portable laptop computer shall use the latest Intel Pentium processor. It shall contain a minimum of 128 Mb of RAM and have a compatible keyboard with a minimum of 101 keys that shall provide tactile feedback to the user. Membrane-type keyboards are not acceptable. It shall have at least a 24GB EIDE hard disk with a maximum of 18-millisecond access time. It shall have one 3.5-inch, 1.44 Mb floppy disk drive, and a minimum 24X CD-ROM. It shall include an internal 56K fax/modem. Sufficient serial and parallel ports shall be supplied to meet all system requirements. This terminal shall also be supplied with a color SVGA display with 1024 by 768 pixel resolution, compatible internal graphics adapter card with 2 Mb memory, and all necessary cables. It shall be supplied with the latest version of the Windows 2000 operating system. A carrying case, AC adapter, and spare battery pack shall also be included.

2. Each laptop shall have installed in one of the available expansion slots an ethernet adapter card. This card shall enable direct communication between the laptop, via the PLC programming software specified below and the various PLC processors over the ethernet when plugged into one of the spare ethernet ports provided in the operations building. One laptop shall also have an adapter card and a ten-foot connection cable shall be provided by the PLC manufacturer that shall enable direct connection to the PLC processor locally.

3. All PLC programming and editing shall be accomplished from the portable laptop. These functions shall be capable of being done both "on-line" while the processor is scanning, or "off-line."

4. The laptop shall be delivered to the OWNER 45 calendar days after Notice to Proceed.

5. The lap top computers shall be by **Toshiba, Dell Computer Corp., or equal**. The ethernet adapter card shall be **3COM,** or equal. The PLC adapter card shall be as approved by the manufacturer of the selected PLC system.

2.5 COMMUNICATION DEVICES

A. **General:** The RTU's shall be furnished with sufficient serial communication ports necessary to communicate with peripheral equipment and other devices to meet the functional requirements of the Control System. In addition to meeting the immediate requirement of this specification, the RTU shall be provided with the capability to accommodate 3 additional ports.

B. **Modems:** Telephone lines shall be provided by the CONTRACTOR to all of the pocket pump station locations. Refer to Contract Drawings AD-GI-202 and all specific electric site plans for each pocket pumps station and Specification 17300 for details. The Modem shall have the capability of operating at a line speed of 28.8 Kbaud in full duplex mode supporting an uncompressed PLC line speed of 19.2 Kbaud (compressed data rates up to 115.2 Kbaud). The Modem shall meet or exceed industrial operating specifications of and 0 - 95% non-condensing humidity 0° to +60° C (32° to +140° F). The Modems will operate at 24 volt DC. The Modem shall not require any addressing for start-up. The Modems shall automatically connect when they are attached to the lines

and are powered up. They will automatically reconnect, without any operator assistance required, when the data line and/or power are restored in the event of an interruption. The Modem shall be **Data-Linc Group Model #DLM4000-LL, MultiTech Systems Multi Modem II or equal.**

C. **Spread Spectrum Ethernet Radio Modems:** Radio shall be installed at several sites throughout the project, refer to contract drawings AD-GI-202 and specification 17300 for details. Radios shall be solid state and shall operate in 902-928 MHz spread spectrum range utilizing automatic frequency hopping and require no FCC license. The radios shall be interference immune, transmit data digitally at rates up to 115,200 baud, and use advanced 32-bit CRC error detection. The radios shall be field proven and shall incorporate a built-in modem to interface directly with the specified RTU's. The radios shall operate on 12VDC power and provide LED indicators for power, carrier, data in, and data out. Radio modems shall be configured at the factory for the required service and require no field settings or programming. Radio power output shall be adjustable and shall be set to follow Part 15 of the FCC Federal Regulation; If directional antennas of gain greater than 6dBi are used, transmitter output power must be reduced by the amount in dB that the antenna gain exceeds 6dBi. The spread Spectrum radio Modems shall be **Microwave Data Systems iNet 900, Data-Linc SRM6210 or equal.**

D. **Radio Antennas:** Antenna systems shall be furnished and installed at locations shown on contract drawing AD-GI-202, for communication between the remote sites and the Wastewater Treatment Plant in downtown Los Osos. Systems shall include antennas, mounting hardware, grounding cable, and coaxial radio cables and connectors. All connectors shall be N-type. The antennas at the remote sites shall be directional, while the antenna at the Wastewater Treatment Plant in downtown Los Osos shall be Omni-directional, all antennas shall be installed and aligned to maximize the transmitted signal.

Lightning suppressors shall be provided for all antenna coaxial feed lines. They shall be rated for the operating power and frequency. Lightning suppressors shall be provided by **PolyPhasor Corporation or equal.**

1. Directional Antenna: The antenna provided at the remotes site shall be Yagi directional antennas. The Yagi directional antenna shall be manufactured by **Microwave Data Systems, Kathrein-Scala Division or equal.**

2. Omni-directional Antenna: The antenna provided at the Wastewater Treatment Plant in downtown Los Osos shall be a center-fed Collinear antenna. The center-fed Collinear antenna shall be manufactured by **Microwave Data Systems, Kathrein-Scala Division or equal**

E. **Radio Antenna Cable:** The transmission cable between the antenna and the radio shall be low-loss jacketed 1/2-inch foam-helix. This cable shall be installed in conduit as shown on the drawings, which shall have a minimum bend radius of 12 inches. The antenna cable shall be manufactured by **Andrews Corporation.**

2.6 SOFTWARE

A. **General:** All PLC programming, workstations, communication, and data gathering software shall be provided under provisions of Specifications Section 17520 - PLC Based Control System - Software.

2.7 SPARE PARTS

A. PLC system spare parts shall be provided in accordance with Section 17100 - Process Control and Instrumentation Systems.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The CONTRACTOR shall utilize personnel to accomplish, or supervise the physical installation of all elements, components, accessories, or assemblies that it furnishes. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all elements, components, accessories, and assemblies it furnishes.

B. All components of the Control System shall be the installation responsibility CONTRACTOR unless specifically noted otherwise. The installation of the communication networks, both hardwired and radio, shall be the complete installation responsibility of the CONTRACTOR including all cables, connectors, transceivers, and any required electrical grounds. Grounding shall be shown on submittal drawings. After installation of the Control System is completed, the installation shall be inspected jointly by the CONTRACTOR and the Equipment Manufacturer's representatives. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the ENGINEER. The certification shall state that all PLC's communication and I/O modules, modems, system grounds, communication network, workstations, and all other components of the Control System have been inspected and are installed in accordance with the manufacturer's guidelines.

3.2 FACTORY TEST

A. **General:** Prior to the delivery and installation of the Control System at the jobsite, but after the procurement, assembly, and configuration of all components, the CONTRACTOR shall conduct a factory test. Representatives of the OWNER and/or ENGINEER shall witness this test. The factory test shall demonstrate the functionality and performance of significant specified features of the Control System as noted below. The test shall include verification of all PLC's I/O points, and addresses, plus all of the field wiring terminations. A complete system checklist shall be available during the test for recording results of selected points.

B. **Test Setup:** The complete RTU's shall be assembled and interconnected on the CONTRACTOR's factory floor. The RTU's and communication devices shall be loaded with their applicable software packages. PLC input and output modules shall be installed in their assigned housings and wired to field termination points in the enclosures. The CONTRACTOR shall have a complete, up to date set of wiring drawings, and PLC register list available for throughout the test.

The CONTRACTOR shall schedule the factory test after receiving approval of the factory test procedures submittal. The CONTRACTOR shall provide the ENGINEER with written notice of the start and expected duration of the factory test at least 21 days prior to the start of the test. The CONTRACTOR provided portable laptop shall be available for the test with the PLC programming software required for the test previously loaded.

C. **Test Procedure:** The factory test shall be conducted in accordance with the previously submitted and approved test procedures. The test procedures shall include written

descriptions of how individual tests shall be performed and shall incorporate testing the following features as a minimum. All testing shall be completed in one continuous factory test that may extend over several continuous days if necessary.

1. Analog Inputs and Outputs: Analog inputs shall be verified by using a signal generator to simulate readings at 0, 50, & 100 percent of the input range. Analog outputs shall be verified by using a current meter at the field terminations.

2. Discrete Inputs and Outputs: Discrete inputs shall be verified by simulating a contact closure across the field terminations and verifying that the closure results in a change of state at the PLC. Discrete outputs shall be forced on by the PLC and verified by a test light or meter at the field termination.

3. Power Failure: External power to enclosures shall be turned off and back on, to test the operation of the UPS units.

D. **Test Report:** The CONTRACTOR shall record the results of all factory testing on pre-approved test forms which the OWNER's and/or ENGINEER's representatives shall sign. A copy of the completed test forms and a report certifying the results shall be provided to the ENGINEER within 10 days of completing the test.

E. **Rework and Retest:** If the Control System does not operate as required, the CONTRACTOR shall make whatever corrections are necessary, and the failed part of the tests shall be repeated. If in the opinion of the ENGINEER's REPRESENTATIVE, the changes made by the CONTRACTOR to effect such a correction are sufficient in kind or scope to effect parts of system operation already tested, then the effected parts shall be re-tested also. If a reliable determination of the effect of changes made by the CONTRACTOR cannot be made, then the ENGINEER's REPRESENTATIVE may require that all operations be re-tested. The CONTRACTOR shall bear all of its own costs for the factory test, including any required re-testing.

3.3 CALIBRATION, TESTING, AND INSTRUCTION

A. **Analog Signal Testing:** All analog inputs and outputs of the Control System shall have their calibration checked at a minimum of 3 points to verify consistency with the balance of the analog loop. This calibration check shall be done in conjunction with the analog loop tests specified in Section 17100 - Process Control and Instrumentation Systems. PLC registers shall both be verified for correctness. The phrases "System Testing" and "Startup Testing" shall be as defined in Section 01660 - Equipment Testing and Startup.

B. **Discrete Signal Testing:** After the Control System installation has been certified and the analog points have been calibrated, the Control System shall be tested to verify that all discrete inputs and outputs of PLC's are correct. As much as possible, points shall be checked "end-to-end". Simulated testing shall be allowed only when no practical alternative exists. An I/O checklist shall be used to record test results and a copy provided to the ENGINEER upon completion.

C. **System Testing:** When the Control System installation has been certified and analog loop calibration and discrete I/O testing have been completed, system testing shall be performed in accordance with the approved test procedures. System testing shall operate the PLC's to verify compliance with all functional requirements specified, including the automatic control modes and Control System interlocks. Tests that fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.

The CONTRACTOR shall submit to the ENGINEER a system testing completion report when each PLC and all aspects of the system hardware have been successfully tested as described herein. The report shall note any problems encountered and what action was required to correct them. It shall include a clear and unequivocal statement that the PLC system was thoroughly tested and is complete and functional in accordance with all specification requirements.

D. **Start-Up Test:** The CONTRACTOR shall provide start-up support to include the CONTRACTOR's personnel, electrical personnel, and the Control System manufacturer's representative as required during the startup testing period to produce a fully operational system. This support shall be provided at no additional cost to the OWNER. The start-up test shall be conducted in accordance with the requirements of Section 01660 - Equipment Testing and Start-Up.

E. Performance Test:

1. **General:** Subsequent to the system and startup testing, the CONTRACTOR, in conjunction with the ENGINEER and OWNER, shall conduct a successful 30 day final acceptance test. Each shall be responsible for the portion of the Control System that they were responsible for providing under this contract. In general the OWNER REPRESENTATIVE shall be responsible for the programming of the PLC's and workstations and the CONTRACTOR shall be responsible for all other components. In the test, the entire Control System shall be continuously operated and maintained (i.e., 7 days per week, 24 hours per day) during the test period with zero downtime resulting from system failures. If a major system failure occurs, the 30 day test shall be considered a failure and not acceptable. The CONTRACTOR shall repeat the 30-day test. The Control System shall be acceptable only after all equipment and software has satisfied the performance test requirements.

2. **Failures:** Failures shall be classified as either major or minor. A minor failure would be a small and noncritical component failure that can be corrected by the OWNER's operators. This occurrence shall be logged but shall not be reason enough for stopping the test and shall not be grounds for non-acceptance. However, should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance. A major failure shall be considered to have occurred when a component, subsystem, or program fault causes a halt in operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system. A major failure shall cause termination of the acceptance test. When the causes of a major failure have been corrected, a new acceptance test shall be started.

3. **Report:** The CONTRACTOR shall submit a final acceptance test completion report which shall state that all contract requirements have been met and which shall include (1) a listing of all Control System equipment maintenance/repair activities conducted during testing and (2) a listing of all components which were unable to operate successfully. Final acceptance, in writing, of the Control System shall be provided by the ENGINEER if the results of all of the performance tests are acceptable.

F. **Instruction:** The CONTRACTOR shall provide training for the purpose of familiarizing the OWNER's maintenance and operating personnel with the use, maintenance, calibration, and repair of all components of the Control System.

The training shall be scheduled concurrent with the calibration, equipment testing, and process system testing phases of the project.

The training shall be performed by qualified representatives of the CONTRACTOR or the Manufacturer as noted in the table below. Training shall be specifically tailored to this project and reflect the Control System installation and configuration. The table below summarizes training hours required, which shall be provided at no additional cost to the OWNER. All training shall be conducted at the jobsite unless the ENGINEER and OWNER approve another location.

Training Classes Required	**Maintenance** Class (Hrs.)	**Operator's** Class (Hrs.)	**Conducted** By
1. Control Hardware/Software General Familiarity	8	8	CONTRACTOR
2. Control Hardware -			
2.a. Troubleshooting and Repair of PLC's	16	-	Manufacturer
2.b. Troubleshooting and Repair of Communications	16	8	Manufacturer

Each training class shall be a minimum of 8 hours in duration. Separate classes shall be conducted for the OWNER's maintenance and operating personnel. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the Control System. Operator classes shall stress operational theory and use of the Control System. Each of the training classes listed above for operators shall be conducted twice during separate weeks to allow for scheduling of OWNER personnel. A total of 40 hours of training for maintenance personnel and 16 hours of training for operators shall be provided.

The training classes shall be scheduled a minimum of 3 weeks in advance of when they are to be given. Proposed training material, including a resume for the proposed instructor(s) (indicating previous instructional experience) and a detailed outline of each lesson shall be submitted to the ENGINEER at least 30 days in advance of when the lesson is to be given. The ENGINEER shall review the submitted data for suitability and provide comments that shall be incorporated into the course.

Within 10 days after the completion of each class the CONTRACTOR shall present to the ENGINEER the following:

1. a list of all OWNER personnel that attended the class

2. a copy of the hard copy text utilized during the class with all notes, diagrams, and comment.

- END OF SECTION -

I/O SUMMARY SCHEDULE					
I/O Tag	**IO Type**	**RTU/ LCP No.**	**Equip Tag**	**Description**	**Drawing No.**
4A-LIC-1	AI	1	Pump Station 4A	Wet Well Level Indication	A-I-202
4A-LAHH-1B	DI	1	Pump Station 4A	Wet Well Level Alarm High-High	A-I-202
4A-JA-1A	DI	1	LCP UPS Online	Power Alarm	N/A
4A-JA-2A	DI	1	LCP UPS Battery Low	Power Alarm	N/A
4A-LAL-1A	DI	1	Pump Station 4A	Wet Well Level Alarm Low	A-I-202
4A-PAH-1A	DI	1	Pump Station 4A Pump 1	Pressure Alarm High	A-I-202
4A-PAH-2A	DI	1	Pump Station 4A Pump 2	Pressure Alarm High	A-I-202
4A-PAH-3A	DI	1	Pump Station 4A Pump 3	Pressure Alarm High	A-I-202
4A-YA-1B	DI	1	Pump Station 4A Pump 1	Fail Alarm	A-I-202
4A-YA-2B	DI	1	Pump Station 4A Pump 2	Fail Alarm	A-I-202
4A-YA-3B	DI	1	Pump Station 4A Pump 3	Fail Alarm	A-I-202
4A-YA-4A	DI	1	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
4A-YA-5A	DI	1	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
4A-YA-6A	DI	1	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
4A-YA-7A	DI	1	LCP Power Supply	Failure Alarm	N/A
4A-YI-1A	DI	1	Pump Station 4A Pump 1	Run Status	A-I-202
4A-YI-1C	DI	1	Pump Station 4A Pump 1	Auto Status	A-I-202
4A-YI-2A	DI	1	Pump Station 4A Pump 2	Run Status	A-I-202
4A-YI-2C	DI	1	Pump Station 4A Pump 2	Auto Status	A-I-202
4A-YI-3A	DI	1	Pump Station 4A Pump 3	Run Status	A-I-202
4A-YI-3C	DI	1	Pump Station 4A Pump 3	Auto Status	A-I-202
4A-HS-1B	DO	1	Pump Station 4A Pump 1	Start Command	A-I-202
4A-HS-2B	DO	1	Pump Station 4A Pump 2	Start Command	A-I-202
4A-HS-3B	DO	1	Pump Station 4A Pump 3	Start Command	A-I-202
4A-LSHH-1B	DO	1	Pump Station 4A	Wet Well Level High-High Switch	A-I-202
7A-LIC-1	AI	2	Pump Station 7A	Wet Well Level Indication	A-I-202
7A-JA-1A	DI	2	LCP UPS Online	Power Alarm	N/A
7A-JA-2A	DI	2	LCP UPS Battery Low	Power Alarm	N/A
7A-LAHH-1B	DI	2	Pump Station 7A	Wet Well Level Alarm High-High	A-I-202
7A-LAL-1A	DI	2	Pump Station 7A	Wet Well Level Alarm Low	A-I-202
7A-PAH-1A	DI	2	Pump Station 7A Pump 1	Pressure Alarm High	A-I-202
7A-PAH-2A	DI	2	Pump Station 7A Pump 2	Pressure Alarm High	A-I-202
7A-YA-1B	DI	2	Pump Station 7A Pump 1	Fail Alarm	A-I-202
7A-YA-2B	DI	2	Pump Station 7A Pump 2	Fail Alarm	A-I-202
7A-YA-3A	DI	2	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
7A-YA-4A	DI	2	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
7A-YA-5A	DI	2	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
7A-YA-6A	DI	2	LCP Power Supply	Failure Alarm	N/A
7A-YI-1A	DI	2	Pump Station 7A Pump 1	Run Status	A-I-202
7A-YI-1C	DI	2	Pump Station 7A Pump 1	Auto Status	A-I-202
7A-YI-2A	DI	2	Pump Station 7A Pump 2	Run Status	A-I-202
7A-YI-2C	DI	2	Pump Station 7A Pump 2	Auto Status	A-I-202
7A-HS-1B	DO	2	Pump Station 7A Pump 1	Start Command	A-I-202
7A-HS-2B	DO	2	Pump Station 7A Pump 2	Start Command	A-I-202
7A-LSHH-1B	DO	2	Pump Station 7A	Wet Well Level High-High Switch	A-I-202
8A-LIC-1	AI	3	Pump Station 8A	Wet Well Level Indication	A-I-202
8A-JA-1A	DI	3	LCP UPS Online	Power Alarm	N/A

8A-JA-2A	DI	3	LCP UPS Battery Low	Power Alarm	N/A
8A-LAHH-1B	DI	3	Pump Station 8A	Wet Well Level Alarm High-High	A-I-202
8A-LAL-1A	DI	3	Pump Station 8A	Wet Well Level Alarm Low	A-I-202
8A-PAH-1A	DI	3	Pump Station 8A Pump 1	Pressure Alarm High	A-I-202
8A-PAH-2A	DI	3	Pump Station 8A Pump 2	Pressure Alarm High	A-I-202
8A-YA-1B	DI	3	Pump Station 8A Pump 1	Fail Alarm	A-I-202
8A-YA-2B	DI	3	Pump Station 8A Pump 2	Fail Alarm	A-I-202
8A-YA-3A	DI	3	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
8A-YA-4A	DI	3	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
8A-YA-5A	DI	3	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
8A-YA-6A	DI	3	LCP Power Supply	Failure Alarm	N/A
8A-YI-1A	DI	3	Pump Station 8A Pump 1	Run Status	A-I-202
8A-YI-1C	DI	3	Pump Station 8A Pump 1	Auto Status	A-I-202
8A-YI-2A	DI	3	Pump Station 8A Pump 2	Run Status	A-I-202
8A-YI-2C	DI	3	Pump Station 8A Pump 2	Auto Status	A-I-202
8A-HS-1B	DO	3	Pump Station 8A Pump 1	Start Command	A-I-202
8A-HS-2B	DO	3	Pump Station 8A Pump 2	Start Command	A-I-202
8A-LSHH-1B	DO	3	Pump Station 8A	Wet Well Level High-High Switch	A-I-202
9A-LIC-1	AI	4	Pump Station 9A	Wet Well Level Indication	A-I-202
9A-JA-1A	DI	4	LCP UPS Online	Power Alarm	N/A
9A-JA-2A	DI	4	LCP UPS Battery Low	Power Alarm	N/A
9A-LAHH-1B	DI	4	Pump Station 9A	Wet Well Level Alarm High-High	A-I-201
9A-LAL-1A	DI	4	Pump Station 9A	Wet Well Level Alarm Low	A-I-201
9A-PAH-1A	DI	4	Pump Station 9A Pump 1	Pressure Alarm High	A-I-201
9A-PAH-2A	DI	4	Pump Station 9A Pump 2	Pressure Alarm High	A-I-201
9A-YA-1B	DI	4	Pump Station 9A Pump 1	Fail Alarm	A-I-201
9A-YA-2B	DI	4	Pump Station 9A Pump 2	Fail Alarm	A-I-201
9A-YA-3A	DI	4	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
9A-YA-4A	DI	4	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
9A-YA-5A	DI	4	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
9A-YA-6A	DI	4	LCP Power Supply	Failure Alarm	N/A
9A-YI-1A	DI	4	Pump Station 9A Pump 1	Run Status	A-I-201
9A-YI-1C	DI	4	Pump Station 9A Pump 1	Auto Status	A-I-201
9A-YI-2A	DI	4	Pump Station 9A Pump 2	Run Status	A-I-201
9A-YI-2C	DI	4	Pump Station 9A Pump 2	Auto Status	A-I-201
9A-HS-1B	DO	4	Pump Station 9A Pump 1	Start Command	A-I-201
9A-HS-2B	DO	4	Pump Station 9A Pump 2	Start Command	A-I-201
9A-LSHH-1B	DO	4	Pump Station 9A	Wet Well Level High-High Switch	A-I-201
9B-LIC-1	AI	5	Pump Station 9B	Wet Well Level Indication	D-I-200
9B-JA-1A	DI	5	LCP UPS Online	Power Alarm	N/A
9B-JA-2A	DI	5	LCP UPS Battery Low	Power Alarm	N/A
9B-LAHH-1B	DI	5	Pump Station 9B	Wet Well Level Alarm High-High	D-I-200
9B-LAL-1A	DI	5	Pump Station 9B	Wet Well Level Alarm Low	D-I-200
9B-PAH-1A	DI	5	Pump Station 9B Pump 1	Pressure Alarm High	D-I-200
9B-PAH-2A	DI	5	Pump Station 9B Pump 2	Pressure Alarm High	D-I-200
9B-PAH-3A	DI	5	Pump Station 9B Pump 3	Pressure Alarm High	D-I-200
9B-YA-1B	DI	5	Pump Station 9B Pump 1	Fail Alarm	D-I-200
9B-YA-2B	DI	5	Pump Station 9B Pump 2	Fail Alarm	D-I-200
9B-YA-3B	DI	5	Pump Station 9B Pump 3	Fail Alarm	D-I-200
9B-YA-4A	DI	5	Pump Wetwell Hatch	Intrusion Alarm	D-I-200
9B-YA-5A	DI	5	LCP Enclosure Door 1	Intrusion Alarm	D-I-200
9B-YA-6A	DI	5	LCP Enclosure Door 2	Intrusion Alarm	D-I-200

9B-YA-7A	DI	5	LCP Power Supply	Failure Alarm	N/A
9B-YI-1A	DI	5	Pump Station 9B Pump 1	Run Status	D-I-200
9B-YI-1C	DI	5	Pump Station 9B Pump 1	Auto Status	D-I-200
9B-YI-2A	DI	5	Pump Station 9B Pump 2	Run Status	D-I-200
9B-YI-2C	DI	5	Pump Station 9B Pump 2	Auto Status	D-I-200
9B-YI-3A	DI	5	Pump Station 9B Pump 3	Run Status	D-I-200
9B-YI-3C	DI	5	Pump Station 9B Pump 3	Auto Status	D-I-200
9B-HS-1B	DO	5	Pump Station 9B Pump 1	Start Command	D-I-200
9B-HS-2B	DO	5	Pump Station 9B Pump 2	Start Command	D-I-200
9B-HS-3B	DO	5	Pump Station 9B Pump 3	Start Command	D-I-200
9B-LSHH-1B	DO	5	Pump Station 9B	Wet Well Level High-High Switch	D-I-200
9C-LIC-1	AI	6	Pump Station 9C	Wet Well Level Indication	D-I-200
9C-JA-1A	DI	6	LCP UPS Online	Power Alarm	N/A
9C-JA-2A	DI	6	LCP UPS Battery Low	Power Alarm	N/A
9C-LAHH-1B	DI	6	Pump Station 9C	Wet Well Level Alarm High-High	D-I-200
9C-LAL-1A	DI	6	Pump Station 9C	Wet Well Level Alarm Low	D-I-200
9C-PAH-1A	DI	6	Pump Station 9C Pump 1	Pressure Alarm High	D-I-200
9C-PAH-2A	DI	6	Pump Station 9C Pump 2	Pressure Alarm High	D-I-200
9C-YA-1B	DI	6	Pump Station 9C Pump 1	Fail Alarm	D-I-200
9C-YA-2B	DI	6	Pump Station 9C Pump 2	Fail Alarm	D-I-200
9C-YA-3A	DI	6	Pump Wetwell Hatch	Intrusion Alarm	D-I-200
9C-YA-4A	DI	6	LCP Enclosure Door 1	Intrusion Alarm	D-I-200
9C-YA-5A	DI	6	LCP Enclosure Door 2	Intrusion Alarm	D-I-200
9C-YA-6A	DI	6	LCP Power Supply	Failure Alarm	N/A
9C-YI-1A	DI	6	Pump Station 9C Pump 1	Run Status	D-I-200
9C-YI-1C	DI	6	Pump Station 9C Pump 1	Auto Status	D-I-200
9C-YI-2A	DI	6	Pump Station 9C Pump 2	Run Status	D-I-200
9C-YI-2C	DI	6	Pump Station 9C Pump 2	Auto Status	D-I-200
9C-HS-1B	DO	6	Pump Station 9C Pump 1	Start Command	D-I-200
9C-HS-2B	DO	6	Pump Station 9C Pump 2	Start Command	D-I-200
9C-LSHH-1B	DO	6	Pump Station 9C	Wet Well Level High-High Switch	D-I-200
10A-LIC-1	AI	7	Pump Station 10A	Wet Well Level Indication	A-I-202
10A-JA-1A	DI	7	LCP UPS Online	Power Alarm	N/A
10A-JA-2A	DI	7	LCP UPS Battery Low	Power Alarm	N/A
10A-LAHH-1B	DI	7	Pump Station 10A	Wet Well Level Alarm High-High	A-I-202
10A-LAL-1A	DI	7	Pump Station 10A	Wet Well Level Alarm Low	A-I-202
10A-PAH-1A	DI	7	Pump Station 10A Pump 1	Pressure Alarm High	A-I-202
10A-PAH-2A	DI	7	Pump Station 10A Pump 2	Pressure Alarm High	A-I-202
10A-YA-1B	DI	7	Pump Station 10A Pump 1	Fail Alarm	A-I-202
10A-YA-2B	DI	7	Pump Station 10A Pump 2	Fail Alarm	A-I-202
10A-YA-3A	DI	7	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
10A-YA-4A	DI	7	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
10A-YA-5A	DI	7	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
10A-YA-6A	DI	7	LCP Power Supply	Failure Alarm	N/A
10A-YI-1A	DI	7	Pump Station 10A Pump 1	Run Status	A-I-202
10A-YI-1C	DI	7	Pump Station 10A Pump 1	Auto Status	A-I-202
10A-YI-2A	DI	7	Pump Station 10A Pump 2	Run Status	A-I-202
10A-YI-2C	DI	7	Pump Station 10A Pump 2	Auto Status	A-I-202
10A-HS-1B	DO	7	Pump Station 10A Pump 1	Start Command	A-I-202
10A-HS-2B	DO	7	Pump Station 10A Pump 2	Start Command	A-I-202
10A-LSHH-1B	DO	7	Pump Station 10A	Wet Well Level High-High Switch	A-I-202
11A-LIC-1	AI	8	Pump Station 11A	Wet Well Level Indication	A-I-202

11A-JA-1A	DI	8	LCP UPS Online	Power Alarm	N/A
11A-JA-2A	DI	8	LCP UPS Battery Low	Power Alarm	N/A
11A-LAHH-1B	DI	8	Pump Station 11A	Wet Well Level Alarm High-High	A-I-202
11A-LAL-1A	DI	8	Pump Station 11A	Wet Well Level Alarm Low	A-I-202
11A-PAH-1A	DI	8	Pump Station 11A Pump 1	Pressure Alarm High	A-I-202
11A-PAH-2A	DI	8	Pump Station 11A Pump 2	Pressure Alarm High	A-I-202
11A-YA-1B	DI	8	Pump Station 11A Pump 1	Fail Alarm	A-I-202
11A-YA-2B	DI	8	Pump Station 11A Pump 2	Fail Alarm	A-I-202
11A-YA-3A	DI	8	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
11A-YA-4A	DI	8	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
11A-YA-5A	DI	8	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
11A-YA-7A	DI	8	LCP Power Supply	Failure Alarm	N/A
11A-YI-1A	DI	8	Pump Station 11A Pump 1	Run Status	A-I-202
11A-YI-1C	DI	8	Pump Station 11A Pump 1	Auto Status	A-I-202
11A-YI-2A	DI	8	Pump Station 11A Pump 2	Run Status	A-I-202
11A-YI-2C	DI	8	Pump Station 11A Pump 2	Auto Status	A-I-202
11A-HS-1B	DO	8	Pump Station 11A Pump 1	Start Command	A-I-202
11A-HS-2B	DO	8	Pump Station 11A Pump 2	Start Command	A-I-202
11A-LSHH-1B	DO	8	Pump Station 11A	Wet Well Level High-High Switch	A-I-202
12A-LIC-1	AI	9	Pump Station 12A	Wet Well Level Indication	A-I-202
12A-JA-1A	DI	9	LCP UPS Online	Power Alarm	N/A
12A-JA-2A	DI	9	LCP UPS Battery Low	Power Alarm	N/A
12A-LAHH-1B	DI	9	Pump Station 12A	Wet Well Level Alarm High-High	A-I-202
12A-LAL-1A	DI	9	Pump Station 12A	Wet Well Level Alarm Low	A-I-202
12A-PAH-1A	DI	9	Pump Station 12A Pump 1	Pressure Alarm High	A-I-202
12A-PAH-2A	DI	9	Pump Station 12A Pump 2	Pressure Alarm High	A-I-202
12A-YA-1B	DI	9	Pump Station 12A Pump 1	Fail Alarm	A-I-202
12A-YA-2B	DI	9	Pump Station 12A Pump 2	Fail Alarm	A-I-202
12A-YA-3A	DI	9	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
12A-YA-4A	DI	9	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
12A-YA-5A	DI	9	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
12A-YA-6A	DI	1	LCP Power Supply	Failure Alarm	N/A
12A-YI-1A	DI	9	Pump Station 12A Pump 1	Run Status	A-I-202
12A-YI-1C	DI	9	Pump Station 12A Pump 1	Auto Status	A-I-202
12A-YI-2A	DI	9	Pump Station 12A Pump 2	Run Status	A-I-202
12A-YI-2C	DI	9	Pump Station 12A Pump 2	Auto Status	A-I-202
12A-HS-1B	DO	9	Pump Station 12A Pump 1	Start Command	A-I-202
12A-HS-2B	DO	9	Pump Station 12A Pump 2	Start Command	A-I-202
12A-LSHH-1B	DO	9	Pump Station 12A	Wet Well Level High-High Switch	A-I-202
13A-LIC-1	AI	10	Pump Station 13A	Wet Well Level Indication	A-I-202
13A-JA-1A	DI	10	LCP UPS Online	Power Alarm	N/A
13A-JA-2A	DI	10	LCP UPS Battery Low	Power Alarm	N/A
13A-LAHH-1B	DI	10	Pump Station 13A	Wet Well Level Alarm High-High	A-I-202
13A-LAL-1A	DI	10	Pump Station 13A	Wet Well Level Alarm Low	A-I-202
13A-PAH-1A	DI	10	Pump Station 13A Pump 1	Pressure Alarm High	A-I-202
13A-PAH-2A	DI	10	Pump Station 13A Pump 2	Pressure Alarm High	A-I-202
13A-YA-1B	DI	10	Pump Station 13A Pump 1	Fail Alarm	A-I-202
13A-YA-2B	DI	10	Pump Station 13A Pump 2	Fail Alarm	A-I-202
13A-YA-3A	DI	10	Pump Wetwell Hatch	Intrusion Alarm	A-I-202
13A-YA-4A	DI	10	LCP Enclosure Door 1	Intrusion Alarm	A-I-202
13A-YA-5A	DI	10	LCP Enclosure Door 2	Intrusion Alarm	A-I-202
13A-YA-6A	DI	10	LCP Power Supply	Failure Alarm	N/A

13A-YI-1A	DI	10	Pump Station 13A Pump 1	Run Status	A-I-202
13A-YI-1C	DI	10	Pump Station 13A Pump 1	Auto Status	A-I-202
13A-YI-2A	DI	10	Pump Station 13A Pump 2	Run Status	A-I-202
13A-YI-2C	DI	10	Pump Station 13A Pump 2	Auto Status	A-I-202
13A-HS-1B	DO	10	Pump Station 13A Pump 1	Start Command	A-I-202
13A-HS-2B	DO	10	Pump Station 13A Pump 2	Start Command	A-I-202
13A-LSHH-1B	DO	10	Pump Station 13A	Wet Well Level High-High Switch	A-I-202
13B-LIC-1	AI	11	Pump Station 13B	Wet Well Level Indication	D-I-200
13B-JA-1A	DI	11	LCP UPS Online	Power Alarm	N/A
13B-JA-2A	DI	11	LCP UPS Battery Low	Power Alarm	N/A
13B-LAHH-1B	DI	11	Pump Station 13B	Wet Well Level Alarm High-High	D-I-200
13B-LAL-1A	DI	11	Pump Station 13B	Wet Well Level Alarm Low	D-I-200
13B-PAH-1A	DI	11	Pump Station 13B Pump 1	Pressure Alarm High	D-I-200
13B-PAH-2A	DI	11	Pump Station 13B Pump 2	Pressure Alarm High	D-I-200
13B-YA-1B	DI	11	Pump Station 13B Pump 1	Fail Alarm	D-I-200
13B-YA-2B	DI	11	Pump Station 13B Pump 2	Fail Alarm	D-I-200
13B-YA-3A	DI	11	Pump Wetwell Hatch	Intrusion Alarm	D-I-200
13B-YA-4A	DI	11	LCP Enclosure Door 1	Intrusion Alarm	D-I-200
13B-YA-5A	DI	11	LCP Enclosure Door 2	Intrusion Alarm	D-I-200
13B-YA-6A	DI	11	LCP Power Supply	Failure Alarm	N/A
13B-YI-1A	DI	11	Pump Station 13B Pump 1	Run Status	D-I-200
13B-YI-1C	DI	11	Pump Station 13B Pump 1	Auto Status	D-I-200
13B-YI-2A	DI	11	Pump Station 13B Pump 2	Run Status	D-I-200
13B-YI-2C	DI	11	Pump Station 13B Pump 2	Auto Status	D-I-200
13B-HS-1B	DO	11	Pump Station 13B Pump 1	Start Command	D-I-200
13B-HS-2B	DO	11	Pump Station 13B Pump 2	Start Command	D-I-200
13B-LSHH-1B	DO	11	Pump Station 13B	Wet Well Level High-High Switch	D-I-200
15B-LIC-1	AI	12	Pump Station 15B	Wet Well Level Indication	D-I-200
15B-JA-1A	DI	12	LCP UPS Online	Power Alarm	N/A
15B-JA-2A	DI	12	LCP UPS Battery Low	Power Alarm	N/A
15B-LAHH-1B	DI	12	Pump Station 15B	Wet Well Level Alarm High-High	D-I-200
15B-LAL-1A	DI	12	Pump Station 15B	Wet Well Level Alarm Low	D-I-200
15B-PAH-1A	DI	12	Pump Station 15B Pump 1	Pressure Alarm High	D-I-200
15B-PAH-2A	DI	12	Pump Station 15B Pump 2	Pressure Alarm High	D-I-200
15B-YA-1B	DI	12	Pump Station 15B Pump 1	Fail Alarm	D-I-200
15B-YA-2B	DI	12	Pump Station 15B Pump 2	Fail Alarm	D-I-200
15B-YA-3A	DI	12	Pump Wetwell Hatch	Intrusion Alarm	D-I-200
15B-YA-4A	DI	12	LCP Enclosure Door 1	Intrusion Alarm	D-I-200
15B-YA-5A	DI	12	LCP Enclosure Door 2	Intrusion Alarm	D-I-200
15B-YA-6A	DI	12	LCP Power Supply	Failure Alarm	N/A
15B-YI-1A	DI	12	Pump Station 15B Pump 1	Run Status	D-I-200
15B-YI-1C	DI	12	Pump Station 15B Pump 1	Auto Status	D-I-200
15B-YI-2A	DI	12	Pump Station 15B Pump 2	Run Status	D-I-200
15B-YI-2C	DI	12	Pump Station 15B Pump 2	Auto Status	D-I-200
15B-HS-1B	DO	12	Pump Station 15B Pump 1	Start Command	D-I-200
15B-HS-2B	DO	12	Pump Station 15B Pump 2	Start Command	D-I-200
15B-LSHH-2	DO	12	Pump Station 15B	Wet Well Level High-High Switch	D-I-200
WP-LIC-1	AI	13	West Paso Pump Station	Wet Well Level Indication	A-I-201
WP-SI-1A	AI	13	West Paso Pump Station Pump 1	Speed Indication	A-I-201
WP-SI-2A	AI	13	West Paso Pump Station Pump 2	Speed Indication	A-I-201

WP-SI-3A	AI	13	West Paso Pump Station Pump 3	Speed Indication	A-I-201
WP-SC-1	AO	13	West Paso Pump Station Pump 1	Speed Control	A-I-201
WP-SC-2	AO	13	West Paso Pump Station Pump 2	Speed Control	A-I-201
WP-SC-3	AO	13	West Paso Pump Station Pump 3	Speed Control	A-I-201
WP-JA-1A	DI	13	West Paso LCP UPS Online	Power Alarm	N/A
WP-JA-2A	DI	13	West Paso LCP UPS Battery Low	Power Alarm	N/A
WP-LAHH-1B	DI	13	West Paso Pump Station	Wet Well Level Alarm High-High	A-I-201
WP-LAL-1A	DI	13	West Paso Pump Station	Wet Well Level Alarm Low	A-I-201
WP-PAH-1A	DI	13	West Paso Pump Station Pump 1	Pressure Alarm High	A-I-201
WP-PAH-2A	DI	13	West Paso Pump Station Pump 2	Pressure Alarm High	A-I-201
WP-PAH-3A	DI	13	West Paso Pump Station Pump 3	Pressure Alarm High	A-I-201
WP-YA-1B	DI	13	West Paso Pump Station Pump 1	Fail Alarm	A-I-201
WP-YA-2B	DI	13	West Paso Pump Station Pump 2	Fail Alarm	A-I-201
WP-YA-3B	DI	13	West Paso Pump Station Pump 3	Fail Alarm	A-I-201
WP-YA-4A	DI	13	West Paso Pump Discharge Valve Vault	Intrusion Alarm	A-I-201
WP-YA-5A	DI	13	West Paso Pump Wetwell Hatch	Intrusion Alarm	A-I-201
WP-YA-6A	DI	13	West Paso MCC	Intrusion Alarm	A-I-201
WP-YA-7A	DI	13	LCP Power Supply	Failure Alarm	N/A
WP-YI-1A	DI	13	West Paso Pump Station Pump 1	Run Status	A-I-201
WP-YI-1C	DI	13	West Paso Pump Station Pump 1	Remote Status	A-I-201
WP-YI-2A	DI	13	West Paso Pump Station Pump 2	Run Status	A-I-201
WP-YI-2C	DI	13	West Paso Pump Station Pump 2	Remote Status	A-I-201
WP-YI-3A	DI	13	West Paso Pump Station Pump 3	Run Status	A-I-201
WP-YI-3C	DI	13	West Paso Pump Station Pump 3	Remote Status	A-I-201
WP-HS-1B	DO	13	West Paso Pump Station Pump 1	Start Command	A-I-201
WP-HS-2B	DO	13	West Paso Pump Station Pump 2	Start Command	A-I-201
WP-HS-3B	DO	13	West Paso Pump Station Pump 3	Start Command	A-I-201
WP-LSHH-1B	DO	13	West Paso Pump Station	Wet Well Level High-High Switch	A-I-201
BW-LIC-1	AI	14	Baywood Pump Station	Wet Well Level Indication	A-I-201
BW-JA-1A	DI	14	Baywood LCP UPS Online	Power Alarm	N/A
BW-JA-2A	DI	14	Baywood LCP UPS Battery Low	Power Alarm	N/A
BW-LAHH-1B	DI	14	Baywood Pump Station	Wet Well Level Alarm High-	A-I-201

				High	
BW-LAL-1A	DI	14	Baywood Pump Station	Wet Well Level Alarm Low	A-I-201
BW-PAH-1A	DI	14	Baywood Pump Station Pump 1	Pressure Alarm High	A-I-201
BW-PAH-2A	DI	14	Baywood Pump Station Pump 2	Pressure Alarm High	A-I-201
BW-YA-1B	DI	14	Baywood Pump Station Pump 1	Fail Alarm	A-I-201
BW-YA-2B	DI	14	Baywood Pump Station Pump 2	Fail Alarm	A-I-201
BW-YA-3A	DI	14	Baywood Pump Discharge Valve Vault	Intrusion Alarm	A-I-201
BW-YA-4A	DI	14	Baywood Pump Wetwell Hatch	Intrusion Alarm	A-I-201
BW-YA-5A	DI	14	Baywood MCC Enclosure Door No. 1	Intrusion Alarm	A-I-201
BW-YA-6A	DI	14	Baywood MCC Enclosure Door No. 2	Intrusion Alarm	A-I-201
BW-YA-7A	DI	14	LCP Power Supply	Failure Alarm	N/A
BW-YI-1A	DI	14	Baywood Pump Station Pump 1	Run Status	A-I-201
BW-YI-1C	DI	14	Baywood Pump Station Pump 1	Auto Status	A-I-201
BW-YI-2A	DI	14	Baywood Pump Station Pump 2	Run Status	A-I-201
BW-YI-2C	DI	14	Baywood Pump Station Pump 2	Auto Status	A-I-201
BW-HS-1B	DO	14	Baywood Pump Station Pump 1	Start Command	A-I-201
BW-HS-2B	DO	14	Baywood Pump Station Pump 2	Start Command	A-I-201
BW-LSHH-1B	DO	14	Baywood Pump Station	Wet Well Level High-High Switch	A-I-201
EH-AI-1A	AI	15	East Paso Harvest Well	Turbidity Indication	A-I-200
EH-AI-2A	AI	15	East Paso Harvest Well	Chlorine Indication	A-I-200
EH-FI-1A	AI	15	East Paso Harvest Well	Discharge Flow Indication	A-I-200
EH-PAH-1A	DI	15	East Paso Harvest Well	Discharge Pressure High Alarm	A-I-200
EH-YA-1B	DI	15	East Paso Harvest Well Well Pump	Fail Alarm	A-I-200
EH-YI-1A	DI	15	East Paso Harvest Well Well Pump	Run Status	A-I-200
EH-YI-1C	DI	15	East Paso Harvest Well Well Pump	Remote Status	A-I-200
EH-YA-2A	DI	15	East Paso Harvest Well Sodium Hypochlorite Pump	Fail Alarm	A-I-200
EH-YA-3A	DI	15	East Paso Harvest Well Ortho Phosphate Pump	Fail Alarm	A-I-200
EH-YA-4A	DI	15	East Paso Harvest Well Building Door No. 1	Intrusion Alarm	A-I-200
EH-YA-5A	DI	15	East Paso Harvest Well Building Door No. 2	Intrusion Alarm	A-I-200
EH-YA-6A	DI	15	East Paso Harvest Well Building Door No. 3	Intrusion Alarm	A-I-200
EH-HS-1B	DO	15	East Paso Harvest Well Well Pump	Start Command	A-I-200
EP-LIC-1	AI	15	East Paso Submersible Pump	Wet Well Level Indication	A-I-201

			Station		
EP-JA-1A	DI	15	East Paso LCP UPS Online	Power Alarm	N/A
EP-JA-2A	DI	15	East Paso LCP UPS Battery Low	Power Alarm	N/A
EP-LAHH-1B	DI	15	East Paso Submersible Pump Station	Wet Well Level Alarm High-High	A-I-201
EP-LAL-1A	DI	15	East Paso Submersible Pump Station	Wet Well Level Alarm Low	A-I-201
EP-PAH-1A	DI	15	East Paso Submersible Pump Station Pump 1	Pressure Alarm High	A-I-201
EP-PAH-2A	DI	15	East Paso Submersible Pump Station Pump 2	Pressure Alarm High	A-I-201
EP-YA-1B	DI	15	East Paso Submersible Pump Station Pump 1	Fail Alarm	A-I-201
EP-YA-2B	DI	15	East Paso Submersible Pump Station Pump 2	Fail Alarm	A-I-201
EP-YA-3A	DI	15	East Paso Pump Discharge Valve Vault	Intrusion Alarm	A-I-201
EP-YA-4A	DI	15	East Paso Pump Wetwell Hatch	Intrusion Alarm	A-I-201
EP-YA-5A	DI	15	LCP Power Supply	Failure Alarm	N/A
EP-YI-1A	DI	15	East Paso Submersible Pump Station Pump 1	Run Status	A-I-201
EP-YI-1C	DI	15	East Paso Submersible Pump Station Pump 1	Auto Status	A-I-201
EP-YI-2A	DI	15	East Paso Submersible Pump Station Pump 2	Run Status	A-I-201
EP-YI-2C	DI	15	East Paso Submersible Pump Station Pump 2	Auto Status	A-I-201
EPG-YA-1A	DI	15	East Paso Standby Power Engine Generator	Common Fail Alarm	A-I-201
EPG-YA-2A	DI	15	East Paso Standby Power Building	Intrusion Alarm	A-I-201
EPG-YI-1A	DI	15	East Paso Standby Power Engine Generator	Run Status	A-I-201
EP-HS-1B	DO	15	East Paso Submersible Pump Station Pump 1	Start Command	A-I-201
EP-HS-2B	DO	15	East Paso Submersible Pump Station Pump 2	Start Command	A-I-201
EP-LSHH-1B	DO	15	East Paso Submersible Pump Station	Wet Well Level High-High Switch	A-I-201
EY-LIC-1	AI	16	East Ysabel Submersible Pump Station	Wet Well Level Indication	A-I-201
EY-JA-1A	DI	16	East Ysabel LCP UPS Online	Power Alarm	N/A
EY-JA-2A	DI	16	East Ysabel LCP UPS Battery Low	Power Alarm	N/A
EY-LAHH-1B	DI	16	East Ysabel Submersible Pump Station	Wet Well Level Alarm High-High	A-I-201
EY-LAL-1A	DI	16	East Ysabel Submersible Pump Station	Wet Well Level Alarm Low	A-I-201
EY-PAH-1A	DI	16	East Ysabel Submersible Pump Station Pump 1	Pressure Alarm High	A-I-201
EY-PAH-2A	DI	16	East Ysabel Submersible Pump Station Pump 2	Pressure Alarm High	A-I-201
EY-YA-1B	DI	16	East Ysabel Submersible Pump Station Pump 1	Fail Alarm	A-I-201
EY-YA-2B	DI	16	East Ysabel Submersible	Fail Alarm	A-I-201

			Pump Station Pump 2		
EY-YA-3A	DI	16	East Ysabel Pump Discharge Valve Vault	Intrusion Alarm	A-I-201
EY-YA-4A	DI	16	East Ysabel Pump Wetwell Hatch	Intrusion Alarm	A-I-201
EY-YA-5A	DI	16	LCP Power Supply	Failure Alarm	N/A
EY-YI-1A	DI	16	East Ysabel Submersible Pump Station Pump 1	Run Status	A-I-201
EY-YI-1C	DI	16	East Ysabel Submersible Pump Station Pump 1	Auto Status	A-I-201
EY-YI-2A	DI	16	East Ysabel Submersible Pump Station Pump 2	Run Status	A-I-201
EY-YI-2C	DI	16	East Ysabel Submersible Pump Station Pump 2	Auto Status	A-I-201
EYG-YA-1A	DI	16	East Ysabel Standby Power Engine Generator	Common Fail Alarm	A-I-201
EYG-YA-2A	DI	16	East Ysabel Standby Power Building	Intrusion Alarm	A-I-201
EYG-YI-1	DI	16	East Ysabel Standby Power Engine Generator	Run Status	A-I-201
EY-HS-1B	DO	16	East Ysabel Submersible Pump Station Pump 1	Start Command	A-I-201
EY-HS-2B	DO	16	East Ysabel Submersible Pump Station Pump 2	Start Command	A-I-201
EY-LSHH-1B	DO	16	East Ysabel Submersible Pump Station	Wet Well Level High-High Switch	A-I-201
MV-LIC-1	AI	17	Mountain View Submersible Pump Station	Wet Well Level Indication	D-I-200
MV-JA-1A	DI	17	Mountain View LCP UPS Online	Power Alarm	N/A
MV-JA-2A	DI	17	Mountain View LCP UPS Battery Low	Power Alarm	N/A
MV-LAHH-1B	DI	17	Mountain View Submersible Pump Station	Wet Well Level Alarm High-High	D-I-200
MV-LAL-1A	DI	17	Mountain View Submersible Pump Station	Wet Well Level Alarm Low	D-I-200
MV-PAH-1A	DI	17	Mountain View Submersible Pump Station Pump 1	Pressure Alarm High	D-I-200
MV-PAH-2A	DI	17	Mountain View Submersible Pump Station Pump 2	Pressure Alarm High	D-I-200
MV-YA-1B	DI	17	Mountain View Submersible Pump Station Pump 1	Fail Alarm	D-I-200
MV-YA-2B	DI	17	Mountain View Submersible Pump Station Pump 2	Fail Alarm	D-I-200
MV-YA-3A	DI	17	Mountain View Pump Discharge Valve Vault	Intrusion Alarm	D-I-200
MV-YA-4A	DI	17	Mountain View Pump Wetwell Hatch	Intrusion Alarm	D-I-200
MV-YA-5A	DI	17	Mountain View LCP Enclosure Door 1	Intrusion Alarm	D-I-200
MV-YA-6A	DI	17	Mountain View LCP Enclosure Door 2	Intrusion Alarm	D-I-200
MV-YA-7A	DI	17	LCP Power Supply	Failure Alarm	N/A
MV-YI-1A	DI	17	Mountain View Submersible Pump Station Pump 1	Run Status	D-I-200
MV-YI-1C	DI	17	Mountain View Submersible Pump Station Pump 1	Auto Status	D-I-200

MV-YI-2A	DI	17	Mountain View Submersible Pump Station Pump 2	Run Status	D-I-200
MV-YI-2C	DI	17	Mountain View Submersible Pump Station Pump 2	Auto Status	D-I-200
MVG-YA-1A	DI	17	Mountain View Standby Power Engine Generator	Common Fail Alarm	D-I-200
MVG-YA-2A	DI	17	Mountain View Standby Power Building	Intrusion Alarm	D-I-200
MVG-YI-1A	DI	17	Mountain View Standby Power Engine Generator	Run Status	D-I-200
MV-HS-1B	DO	17	Mountain View Submersible Pump Station Pump 1	Start Command	D-I-200
MV-HS-2B	DO	17	Mountain View Submersible Pump Station Pump 2	Start Command	D-I-200
MV-LSHH-1B	DO	17	Mountain View Submersible Pump Station	Wet Well Level High-High Switch	D-I-200
LU-LIC-1	AI	18	Lupine Pump Station	Wet Well Level Indication	B-I-201
LU-SI-1A	AI	18	Lupine Pump Station Pump 1	Speed Indication	B-I-201
LU-SI-2A	AI	18	Lupine Pump Station Pump 2	Speed Indication	B-I-201
LU-SI-3A	AI	18	Lupine Pump Station Pump 3	Speed Indication	B-I-201
LU-SC-1A	AO	18	Lupine Pump Station Pump 1	Speed Control	B-I-201
LU-SC-2A	AO	18	Lupine Pump Station Pump 2	Speed Control	B-I-201
LU-SC-3A	AO	18	Lupine Pump Station Pump 3	Speed Control	B-I-201
LU-JA-1A	DI	18	Lupine LCP UPS Online	Power Alarm	N/A
LU-JA-2A	DI	18	Lupine LCP UPS Battery Low	Power Alarm	N/A
LU-LAHH-1B	DI	18	Lupine Pump Station	Wet Well Level Alarm High-High	B-I-201
LU-LAL-1A	DI	18	Lupine Pump Station	Wet Well Level Alarm Low	B-I-201
LU-PAH-1A	DI	18	Lupine Pump Station Pump 1	Pressure Alarm High	B-I-201
LU-PAH-2A	DI	18	Lupine Pump Station Pump 2	Pressure Alarm High	B-I-201
LU-PAH-3A	DI	18	Lupine Pump Station Pump 3	Pressure Alarm High	B-I-201
LU-YA-1B	DI	18	Lupine Pump Station Pump 1	Fail Alarm	B-I-201
LU-YA-2B	DI	18	Lupine Pump Station Pump 2	Fail Alarm	B-I-201
LU-YA-3B	DI	18	Lupine Pump Station Pump 3	Fail Alarm	B-I-201
LU-YA-4A	DI	18	Lupine Pump Discharge Valve Vault	Intrusion Alarm	B-I-201
LU-YA-5A	DI	18	Lupine Pump Wetwell Hatch	Intrusion Alarm	B-I-201
LU-YA-6A	DI	18	LCP Power Supply	Failure Alarm	N/A
LU-YI-1A	DI	18	Lupine Pump Station Pump 1	Run Status	B-I-201
LU-YI-1C	DI	18	Lupine Pump Station Pump 1	Remote Status	B-I-201
LU-YI-2A	DI	18	Lupine Pump Station Pump 2	Run Status	B-I-201
LU-YI-2C	DI	18	Lupine Pump Station Pump 2	Remote Status	B-I-201
LU-YI-3A	DI	18	Lupine Pump Station Pump 3	Run Status	B-I-201
LU-YI-3C	DI	18	Lupine Pump Station Pump 3	Remote Status	B-I-201
LUG-YA-1A	DI	18	Lupine Standby Power Engine Generator	Common Fail Alarm	B-I-201
LUG-YA-2A	DI	18	Lupine Standby Power Building	Intrusion Alarm	B-I-201
LUG-YI-1A	DI	18	Lupine Standby Power Engine Generator	Run Status	B-I-201
LU-HS-1B	DO	18	Lupine Pump Station Pump 1	Start Command	B-I-201
LU-HS-2B	DO	18	Lupine Pump Station Pump 2	Start Command	B-I-201
LU-HS-3B	DO	18	Lupine Pump Station Pump 3	Start Command	B-I-201
LU-LSHH-1B	DO	18	Lupine Pump Station	Wet Well Level High-High Switch	B-I-201
SO-LIC-1	AI	19	Sunny Oaks Submersible Pump Station	Wet Well Level Indication	C-I-200

SO-JA-1A	DI	19	Sunny Oaks LCP UPS Online	Power Alarm	N/A
SO-JA-2A	DI	19	Sunny Oaks LCP UPS Battery Low	Power Alarm	N/A
SO-LAHH-1B	DI	19	Sunny Oaks Submersible Pump Station	Wet Well Level Alarm High-High	C-I-200
SO-LAL-1A	DI	19	Sunny Oaks Submersible Pump Station	Wet Well Level Alarm Low	C-I-200
SO-PAH-1A	DI	19	Sunny Oaks Submersible Pump Station Pump 1	Pressure Alarm High	C-I-200
SO-PAH-2A	DI	19	Sunny Oaks Submersible Pump Station Pump 2	Pressure Alarm High	C-I-200
SO-YA-1B	DI	19	Sunny Oaks Submersible Pump Station Pump 1	Fail Alarm	C-I-200
SO-YA-2B	DI	19	Sunny Oaks Submersible Pump Station Pump 2	Fail Alarm	C-I-200
SO-YA-3A	DI	19	Sunny Oaks Pump Discharge Valve Vault	Intrusion Alarm	C-I-200
SO-YA-4A	DI	19	Sunny Oaks Pump Wetwell Hatch	Intrusion Alarm	C-I-200
SO-YA-5A	DI	19	LCP Power Supply	Failure Alarm	N/A
SO-YI-1A	DI	19	Sunny Oaks Submersible Pump Station Pump 1	Run Status	C-I-200
SO-YI-1C	DI	19	Sunny Oaks Submersible Pump Station Pump 1	Auto Status	C-I-200
SO-YI-2A	DI	19	Sunny Oaks Submersible Pump Station Pump 2	Run Status	C-I-200
SO-YI-2C	DI	19	Sunny Oaks Submersible Pump Station Pump 2	Auto Status	C-I-200
SOG-YA-1A	DI	19	Sunny Oaks Standby Power Engine Generator	Common Fail Alarm	C-I-200
SOG-YA-2A	DI	19	Sunny Oaks Standby Power Building	Intrusion Alarm	C-I-200
SOG-YI-1A	DI	19	Sunny Oaks Standby Power Engine Generator	Run Status	C-I-200
SO-HS-1B	DO	19	Sunny Oaks Submersible Pump Station Pump 1	Start Command	C-I-200
SO-HS-2B	DO	19	Sunny Oaks Submersible Pump Station Pump 2	Start Command	C-I-200
SO-LSHH-1B	DO	19	Sunny Oaks Submersible Pump Station	Wet Well Level High-High Switch	C-I-200
PA-AI-1A	AI	20	Palisades Harvest Well	Turbidity Indication	B-I-200
PA-AI-2A	AI	20	Palisades Harvest Well	Chlorine Indication	B-I-200
PA-FI-1A	AI	20	Palisades Harvest Well	Discharge Flow Indication	B-I-200
PA-PAH-1A	DI	20	Palisades Harvest Well	Discharge Pressure High Alarm	B-I-200
PA-YA-1B	DI	20	Palisades Harvest Well Pump	Fail Alarm	B-I-200
PA-YA-2A	DI	20	Palisades Harvest Sodium Hypochlorite Pump	Fail Alarm	B-I-200
PA-YA-3A	DI	20	Palisades Harvest Ortho Phosphate Pump	Fail Alarm	B-I-200
PA-YA-4A	DI	20	Palisades Harvest Well Building Door No. 1	Intrusion Alarm	B-I-200
PA-YA-5A	DI	20	Palisades Harvest Well Building Door No. 2	Intrusion Alarm	B-I-200
PA-YA-6A	DI	20	Palisades Harvest Well Building Door No. 3	Intrusion Alarm	B-I-200

PA-YA-7A	DI	20	LCP Power Supply	Failure Alarm	N/A
PA-YI-1A	DI	20	Palisades Harvest Well Pump	Run Status	B-I-200
PA-YI-1C	DI	20	Palisades Harvest Well Pump	Remote Status	B-I-200
PA-HS-1B	DO	20	Palisades Harvest Well Pump	Start Command	B-I-200
LO-AI-1A	AI	21	Loma Harvest Well	Turbidity Indication	B-I-200
LO-AI-2A	AI	21	Loma Harvest Well	Chlorine Indication	B-I-200
LO-FI-1A	AI	21	Loma Harvest Well	Discharge Flow Indication	B-I-200
LO-PAH-1A	DI	21	Loma Harvest Well	Discharge Pressure High Alarm	B-I-200
LO-YA-1B	DI	21	Loma Harvest Well Well Pump	Fail Alarm	B-I-200
LO-YA-2A	DI	21	Loma Harvest Sodium Hypochlorite Pump	Fail Alarm	B-I-200
LO-YA-3A	DI	21	Loma Harvest Ortho Phosphate Pump	Fail Alarm	B-I-200
LO-YA-4A	DI	21	Loma Harvest Well Building Door No. 1	Intrusion Alarm	B-I-200
LO-YA-5A	DI	21	Loma Harvest Well Building Door No. 2	Intrusion Alarm	B-I-200
LO-YA-6A	DI	21	Loma Harvest Well Building Door No. 2	Intrusion Alarm	B-I-200
LO-YA-7A	DI	21	LCP Power Supply	Failure Alarm	N/A
LO-YI-1A	DI	21	Loma Harvest Well Well Pump	Run Status	B-I-200
LO-HS-1B	DO	21	Loma Harvest Well Pump	Start Command	B-I-200
WBG-YA-1A	DI	22	West Paso/Baywood Standby Power Engine Generator	Common Fail Alarm	A-I-201
WBG-YA-2A	DI	22	West Paso/Baywood Standby Power Building	Intrusion Alarm	A-I-201
WBG-YA-3A	DI	22	LCP Power Supply	Failure Alarm	N/A
WBG-YI-1A	DI	22	West Paso/Baywood Standby Power Engine Generator	Run Status	A-I-201
PI-YA-1A	DI	23	Pismo Effluent Disposal Site Valve Vault	Intrusion Alarm	A-I-204
PI-YA-2A	DI	23	Pismo Effluent Disposal Site LCP Power Supply	Failure Alarm	N/A
PI-ZIC-1A	DI	23	Pismo Effluent Disposal Site Zone 1 Valve	Closed Status	A-I-204
PI-ZIC-2A	DI	23	Pismo Effluent Disposal Site Zone 2 Valve	Closed Status	A-I-204
PI-ZIO-1A	DI	23	Pismo Effluent Disposal Site Zone 1 Valve	Open Status	A-I-204
PI-ZIO-2A	DI	23	Pismo Effluent Disposal Site Zone 2 Valve	Open Status	A-I-204
PI-ZC-1B	DO	23	Pismo Effluent Disposal Site Zone 1 Valve	Open/Close Command	A-I-204
PI-ZC-2B	DO	23	Pismo Effluent Disposal Site Zone 2 Valve	Open/Close Command	A-I-204
SA-YA-1A	DI	24	Santa Maria Effluent Disposal Site Valve Vault	Intrusion Status	A-I-204
SA-YA-2A	DI	24	Santa Maria Effluent Disposal Site LCP Power Supply	Fail Status	A-I-204
SA-ZIC-1A	DI	24	Santa Maria Effluent Disposal Site Zone 1 Valve	Closed Status	A-I-204
SA-ZIC-2A	DI	24	Santa Maria Effluent Disposal	Closed Status	A-I-204

			Site Zone 2 Valve		
SA-ZIO-1A	DI	24	Santa Maria Effluent Disposal Site Zone 1 Valve	Open Status	A-I-204
SA-ZIO-2A	DI	24	Santa Maria Effluent Disposal Site Zone 2 Valve	Open Status	A-I-204
SA-ZC-1A	DO	24	Santa Maria Effluent Disposal Site Zone 1 Valve	Open/Close Command	A-I-204
SA-ZC-2A	DO	24	Santa Maria Effluent Disposal Site Zone 2 Valve	Open/Close Command	A-I-204
BR-YA-1A	DI	25	Broderson Effluent Disposal Site Valve Vault No. 1	Intrusion Status	C-I-201
BR-YA-2A	DI	25	Broderson Effluent Disposal Site Valve Vault No. 2	Intrusion Status	C-I-201
BR-YA-3A	DI	25	Broderson Effluent Disposal Site Valve Vault No. 3	Intrusion Status	C-I-201
BR-YA-4A	DI	25	Broderson Effluent Disposal Site Valve Vault No. 4	Intrusion Status	C-I-201
BR-YA-5A	DI	25	Broderson Effluent Disposal Site LCP Power Supply	Fail Status	C-I-201
BR-ZIC-1A	DI	25	Broderson Effluent Disposal Site Zone 1 Valve	Closed Status	C-I-201
BR-ZIC-2A	DI	25	Broderson Effluent Disposal Site Zone 2 Valve	Closed Status	C-I-201
BR-ZIC-3A	DI	25	Broderson Effluent Disposal Site Zone 3 Valve	Closed Status	C-I-201
BR-ZIC-4A	DI	25	Broderson Effluent Disposal Site Zone 4 Valve	Closed Status	C-I-201
BR-ZIC-5A	DI	25	Broderson Effluent Disposal Site Zone 5 Valve	Closed Status	C-I-201
BR-ZIC-6A	DI	25	Broderson Effluent Disposal Site Zone 6 Valve	Closed Status	C-I-201
BR-ZIC-7A	DI	25	Broderson Effluent Disposal Site Zone 7 Valve	Closed Status	C-I-201
BR-ZIC-8A	DI	25	Broderson Effluent Disposal Site Zone 8 Valve	Closed Status	C-I-201
BR-ZIO-1A	DI	25	Broderson Effluent Disposal Site Zone 1 Valve	Open Status	C-I-201
BR-ZIO-2A	DI	25	Broderson Effluent Disposal Site Zone 2 Valve	Open Status	C-I-201
BR-ZIO-3A	DI	25	Broderson Effluent Disposal Site Zone 3 Valve	Open Status	C-I-201
BR-ZIO-4A	DI	25	Broderson Effluent Disposal Site Zone 4 Valve	Open Status	C-I-201
BR-ZIO-5A	DI	25	Broderson Effluent Disposal Site Zone 5 Valve	Open Status	C-I-201
BR-ZIO-6A	DI	25	Broderson Effluent Disposal Site Zone 6 Valve	Open Status	C-I-201
BR-ZIO-7A	DI	25	Broderson Effluent Disposal Site Zone 7 Valve	Open Status	C-I-201
BR-ZIO-8A	DI	25	Broderson Effluent Disposal Site Zone 8 Valve	Open Status	C-I-201
BR-ZC-1A	DO	25	Broderson Effluent Disposal Site Zone 1 Valve	Open/Close Command	C-I-201
BR-ZC-2A	DO	25	Broderson Effluent Disposal Site Zone 2 Valve	Open/Close Command	C-I-201
BR-ZC-3A	DO	25	Broderson Effluent Disposal Site Zone 3 Valve	Open/Close Command	C-I-201
BR-ZC-4A	DO	25	Broderson Effluent Disposal	Open/Close Command	C-I-201

			Site Zone 4 Valve		
BR-ZC-5A	DO	25	Broderson Effluent Disposal Site Zone 5 Valve	Open/Close Command	C-I-201
BR-ZC-6A	DO	25	Broderson Effluent Disposal Site Zone 6 Valve	Open/Close Command	C-I-201
BR-ZC-7A	DO	25	Broderson Effluent Disposal Site Zone 7 Valve	Open/Close Command	C-I-201
BR-ZC-8A	DO	25	Broderson Effluent Disposal Site Zone 8 Valve	Open/Close Command	C-I-201

SECTION 17520 - PLC-BASED CONTROL SYSTEM SOFTWARE

PART 1 -- GENERAL

1.1 THE REQUIREMENT

A. **General:** The CONTRACTOR, through the use of an Instrumentation Supplier and electrical installers, shall furnish, supervise installation, assemble, and place into service the PLC-based Control System specified under this Section and in Section 17510 - PLC-Based Control System Hardware, all in accordance with the requirements of the Contract Documents. All the PLC and HMI application programming for the project shall be provided by the OWNER. The HMI software will be provided as part of the Los Osos Wastewater Treatment Facility Project.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS.

A. PLC-Based Control System software reference specifications, codes, and standards shall be provided in accordance with Section 17100 - Process Control and Instrumentation Systems.

1.3 CONTRACTOR SUBMITTALS

A. **Shop Drawings:** PLC-Based Control System-Software shop drawing submittals shall be provided in accordance with Section 17100 - Process Control and Instrumentation Systems, and Section 17510 - PLC-Based Control System Hardware.

B. **Software Submittals:** The software submittal shall be included in a singular submittal that shall include but not be limited to:

1. Complete description of the standard application software programs, operating system and utility program to be furnished, including modifications. A cross-reference between the specification and the software submittal shall be provided in order to provide the ENGINEER the ability to identify how each specified section or function is being met by the CONTRACTOR.

2. A complete set of all available software algorithms.

C. **Additional Requirements:** The following items shall be submitted with the final sets of technical manuals required 15 days prior to the performance test.

1. All Program Manuals supplied by the manufacturer(s) with the standard software packages.

2. All original program disks supplied by the manufacturer(s) with the standard software packages, including any program revisions or updates issued by the manufacturer(s) during the construction period.

3. A change of ownership registration form for each standard software package supplied under this project to allow the OWNER to register the software with the manufacturer.

1.4 MANUFACTURER'S REPRESENTATIVE

A. PLC-Based Control System Software manufacturer's representative services shall be provided in accordance with Section 17510 - PLC-Based Control System - Hardware.

PART 2 -- PRODUCTS

2.1 GENERAL

A. This section covers the furnishing of standard software fully installed in the control system specified herein. It is the intent of this specification to have the CONTRACTOR furnish the latest generation, standard, field proven, fully debugged and supported PLC software package for this application with a minimum of additions or changes. Customized or specially written software shall be furnished if required to meet all of the functional requirements specified herein. Any custom applications software required shall be fully integrated into the basic software and shall not require unique command structures. No attempt has been made to list all software or list all characteristics of software required by the CONTRACTOR to meet the functional requirements specified herein.

1. Software specified herein is described in broad, functional categories. The CONTRACTOR shall furnish a complete software package including the functional requirements specified herein along with whatever additional software is required for proper and efficient operation of the Control System.

2. The software package shall provide a system capable of controlling system level activities and a higher-level process control language allowing the operator to monitor and control the process through interactive human interface. The software environment shall support a multi-programming atmosphere allowing concurrent execution of more than one program in a background/foreground mode or multi-tasking mode.

3. Throughout the execution of all software modules, the operator shall be presented with all of the command or operation choices available at that point in the program using sufficient verbiage or symbols to make the choices self-explanatory and unambiguous. Question and answer or fill-in-the-blank requests shall only be permitted where file names, tag names, or other unique text or numerical information is required.

2.2 HARDWARE

A. **General:** All PLC's, workstations, and communication equipment, etc., shall be provided under provisions of Specifications Section 17520 - PLC-Based Control System - Hardware.

2.3 PLC SOFTWARE

A. **PLC Programming Software:** All PLC programming shall be accomplished using a standard software package developed for this purpose. The software package shall be installed on the hard disk of the portable computer serving as the PLC programming terminal. The PLC Programming Software shall be either **Rockwell Software RSLogix or Modicon Concept.**

All programming, monitoring, searching, and editing shall be accomplished using this PLC programming software. It shall be useable both on-line (while directly connected to the PLC's) and off-line. The PLC programming software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical functions blocks. The software shall be able to monitor the status of all inputs, outputs, timers, counters, and coils. It shall have the capability to disable/force all inputs, outputs, and coils to simulate the elements of the ladder logic by means of color change. It shall include a search capability to locate any address or element and its program location. PLC status information, such as error indication and amount of memory remaining shall be shown on the CRT screen.

The PLC programming software shall have the capability to generate a PLC program printout that is fully documented. Fully documented program listings shall have appropriate rungs, address, and coils shown with comments to clarify to a reader what that segment of the program accomplishes. A fully documented listing shall also include a cross-reference report of program addresses. The PLC programming software shall be suitable for the PLC's furnished under Section 17510 - PLC-Based Control System - Hardware.

B. **System Level Software:** System level software shall include a complete and unmodified operating system furnished by the CONTRACTOR that provides system level functions as specified herein. Operating system software shall function automatically without operator intervention, except as required to establish file names and similar information. System level software shall include a real time operating system, a calendar/time program, a file management program and a system of diagnostic routines in addition to any compilers, editors, loaders, or assemblers required to support the PLC software.

1. **Operating System Software:** The real-time operating system software shall be the standard uncorrupted product of the PLC and shall provide the following minimum functions:

   a. Respond to demands from a program request.

   b. Dynamic allocation of the resources available in the PLC. These resources shall include main memory usage, computation time, peripheral usage, and I/O channel usage.

   c. Allotment of system resources on the basis of task priority levels such that a logical allocation of resources and suitable response times are assured.

   d. Queuing of requests in order of priority if one or more requested resources are unavailable.

   e. Resolution of contending requests for the same resource in accordance with priority.

   f. Service requests for execution of one program by another.

   g. Transfer data between programs as requested.

   h. Management of all information transfers to and from peripheral devices.

   i. Control and recovery from all program fault conditions.

j. Diagnose and report real-time hardware device errors.

2. **Program Execution:** Program execution shall be scheduled on a priority basis. A multilevel priority interrupt structure is required. A program interrupted by a higher priority program shall be entered into a list of pending programs. Its execution shall be resumed once it becomes the currently highest priority program. The system shall allow periodic programs to be scheduled. The allocation of resources to a time-scheduled program shall be based on its relative priority and the availability of resources. Initiation of programs shall, as a minimum, be activated in the following ways:

   a. In response to external interrupts.

   b. At a scheduled time of the day.

   c. On an elapsed time interval basis.

   d. On request by another program.

3. **Startup and Restart:** Software shall be provided which initializes and brings a PLC or any microprocessor based hardware unit from an inactive condition to a state of operational readiness. Initialization shall include determination of system status prior to startup of initializing operating system software and initializing application software. Initialization shall also include the loading of all memory resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.

4. **Shutdown:** The software shall provide an orderly shutdown capability for shutdowns resulting from equipment failure, including PLC processor failure, primary power failure, or a manually entered shutdown command. When the loss of primary power is sensed, a high-priority hardware interrupt shall initiate software for an immediate, orderly shutdown. When a shutdown occurs in response to a command or malfunction, the software shall control the affected hardware quickly and automatically to a secure state. The failure of the PLC shall be detected at the workstation level.

5. **Diagnostics:** Diagnostic programs shall be furnished with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures. The manufacturer's standard diagnostic routines shall be used as much as possible. Diagnostic software and test programs shall be furnished for each significant component in the Control System. Diagnostic routines shall test for power supply, central processing unit, memory, communications and I/O bus failures as a minimum.

C. **Calendar/Time Program:** The calendar/time program shall update the second, minute, hour, day, month, and year in the operating system and transfer accurate time and date information to all system level and application software. Variations in the number of days in each month and in leap years shall be handled automatically by the program. The operator shall be able to set or correct the time and date from any the data access panel, only at the highest security level.

D. **Algorithms:** PLC software shall support the implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete

data. These algorithms shall be capable of outputting positional or incremental control outputs or providing the product of calculations. The algorithms shall include alarm checks where appropriate. As a minimum, the following types of algorithms shall be provided:

1. A calculator algorithm that performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.

2. A switch algorithm that reads the current value from its input address and stores it as the value of its output address. Two types of switches shall be accommodated, two outputs with one input and one output with two inputs.

3. A three-mode Proportional-Integral-Derivative (PID) controller algorithm with each of the 3 modes independently adjustable. The algorithm shall support both direct and reverse acting modes.

4. Algorithms for lead, lag, dead time, and ratio compensators.

5. Algorithms to perform integration and totalization of analog process variables.

E. **Operator Control:** All programming commands related to changing system configuration or controlling field devices shall be performed only through the Control System and shall require more than one keystroke to protect against inadvertent operation. Control System configuration commands shall require operator confirmation of a requested action before any change is made. This shall apply to changes in the algorithms, control sequences, and similar configuration related actions, as well as file copy and file delete commands. If any sequence requiring operator conformation, the operator shall be able to cancel the operation at any point prior to executing the command.

2.4 FACTORY TEST

A. **General:** The Supervisory Control and Data Acquisition System Software factory test shall be provided in accordance with Section 17510 - PLC-Based Control System Hardware.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The Supervisory Control and Data Acquisition System Software installation shall be provided in accordance with Section 17510 - PLC-Based Control System - Hardware.

3.2 CALIBRATION, TESTING, AND INSTRUCTION

A. **General:** The Supervisory Control and Data Acquisition System Software calibration, testing, and instruction shall be provided in accordance with Section 17510 - PLC-Based Control System - Hardware.

- END OF SECTION -