

SECTION 432321.14 - AXIALLY SPLIT CASE PUMPS – HIGH SERVICE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Horizontally Mounted axially split case pumps, including their respective motors and variable frequency drives.
2. Supervisory services during installation and field testing of each unit and instructing the regular operating personnel in the proper care, operation and maintenance of the equipment.
3. Pump manufacturer or supplier shall have unit responsibility for the pumping system, including, but not limited to, pumps, motors, and variable frequency drives.

1.3 COORDINATION

- A. Section 013100 “Project Management and Coordination”.
- B. Coordinate installation and startup of Work of this Section with Owner’s operations.

1.4 ACTION SUBMITTALS

- A. Section 013300 “Submittal Procedures”: Requirements for submittals.
- B. If manufacturing techniques differ, completely describe all aspects that do not conform to specifications.
- C. Product Data: Submit literature, which may include drawings, describing the equipment in detail, including materials of construction, to indicate full conformance with the specifications.
 1. Prior to Manufacture: Submit dynamic vibration analysis report describing the analysis process, assumptions utilized in the analysis, and analysis conclusions as described in Paragraph 2.4. Report to identify the specified limitations will be met with the pump installed per the Specification. For the dynamic vibration analysis described, minimum and maximum operating speeds will be in accordance with conditions of operation specified in Table 432321.14-1 for each pump station.
 2. The total weight of the equipment including the weight of the single largest item.
 3. A complete materials table for all equipment establishing compliance with these specifications.

4. A list of the Manufacturer's recommended spare parts with the Manufacturer's current price for each item. Include gaskets, packing, etc. on the list. List all bearings by the bearing manufacturer's numbers only.

D. Shop Drawings:

1. Descriptive literature, bulletins, and/or catalogs of the equipment.
2. Include statement indicating location of manufacturer and distance to Project for each regionally manufactured material.
3. Certified shop and erection drawing showing parts arrangement, details, including pick points for rigging, and materials of construction and dimensions.
4. Equipment baseplate drawing indicating size and location of bolt holes for anchorage plus details of anchorage of equipment to foundation including anchor bolt type, size, materials, embedment depth, and minimum edge distance.
5. Complete Bill of Materials (may be submitted as a part of O&M manual).
6. Data on the characteristics and performance of each pump.
 - a. Catalog sheets showing a family of curves covering full range selection of impeller diameter (not sufficient without the addition of the following, to establish detailed compliance with project requirements).
 - b. Performance Curve Requirements:
 - 1) Guaranteed performance curves, based on actual shop tests on similar units, showing the specified requirements for head, capacity, efficiency, guaranteed maximum net positive suction head required (NPSH3), and brake horsepower.
 - 2) Guaranteed performance curves to ANSI/HI 14.6 acceptance grade 1U for specified (intermediate) design point and acceptance grade 1E for the other specified points,
 - 3) Curves to be plotted on 8 ½-in by 11-in sheets at as large a scale as practical specifically for the pump proposed from no flow at shut off head to pump capacity at minimum specified TDH. The POR and AOR (refer to ANSI/HI 9.6.3) shall be clearly shown on the curves.
 - 4) For variable speed pumps, submit variable speed curves with five evenly spaced speeds plotted from maximum to minimum recommended speeds.
7. Prior to Manufacture: Submit required vibration analyses detailing requirements have been met. For the dynamic vibration analysis, minimum and maximum operating speeds will be in accordance with the conditions of operation specified in PART 2.
8. Description of painting and protective coatings.
9. Complete master wiring diagrams, elementary or control schematics, including coordination with electrical equipment and control devices, and suitable outline drawings showing such details as are necessary to locate conduit stub-ups and field wiring.
10. Data for electric motors in accordance with Section 400593.
11. Data for variable frequency drives in accordance with Section 262419.

E. Manufacturer's Certificates

1. A statement and supporting data indicating motor bearing life meets or exceeds specified value.

2. Manufacturer's certification of installation meeting Manufacturer's installation, operation and maintenance manuals and as specified in PART 3.
3. Welder certifications.

F. Test and Evaluation Reports

1. Certified motor test data as described in Section 400593.
2. Tabulated data for the drive motors including rated horsepower, full load rpm, power factor and efficiency curves at 1/2, 3/4 and full load, service factor and kW input, including when the pump is at its design point. Submit a certified statement from the motor manufacturer that the motors are capable of continuous operation on the power supply from the variable frequency drives to be furnished without affecting the design life of bearings or windings.
3. Description of proposed pump factory test procedures and equipment.
4. Factory and field performance test data as specified in PART 2 and PART 3.
5. A schedule of the date of factory testing and delivery of the equipment to the job site.
6. Inspection report of pumps prior to shipment
7. Six-month follow up vibration testing report as specified in PART 3.

G. Manufacturers' Installation Instructions

H. Source Quality-Control Submittals:

1. Indicate results of factory tests and inspections.

I. Field Quality-Control Submittals: Indicate results of Contractor furnished tests and inspections.

1. Identify the entity and experienced individual who will inspect the installation.
2. Manufacturer's field report as specified in PART 3.

J. Compliance with noise levels as specified in Section 400593.

K. Complete description of surface preparation and shop painting for pumps and motors.

L. Critical speed analyses report submittal including backup documentation and a statement of guarantee that the critical speed analyses as required in Paragraph 2.4 of this Section have been completed and that the specified limitations will be met.

1.5 INFORMATIONAL SUBMITTALS

- A. Critical speed analyses report submittal including backup documentation and a statement of guarantee that the critical speed analyses as required in Paragraph 2.4 of this Section have been completed and that the specified limitations will be met.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 017000 "Execution and Closeout Requirements" for closeout requirements.
- B. Operation and Maintenance Data.

- C. Warranty Documentation: submit warranty complying with requirements herein and Section 017700 "Closeout Procedures."
- D. Project Record Documents

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish all special tools and test equipment required for the proper servicing of all equipment as specified in Section 011310. All such tools and test equipment shall be furnished in a suitable steel tool chest complete with lock and duplicate keys.
- B. All spare parts shall be properly protected for long periods of storage and packed in containers that are clearly identified with indelible markings as to contents.
- C. Furnish the following spare parts for each size pump:
 - 1. Two mechanical seals.
- D. Provide to the Owner a list of all spare and replacement parts with individual prices and location where they are available. Prices shall remain in effect for a period of not less than one year after start-up and final acceptance.
- E. Special tools and spare parts shall be furnished in accordance with Section 011310.
- F. Section 017000 - Execution and Closeout Requirements specifies requirements for maintenance materials.

1.8 QUALITY ASSURANCE

- A. Provide units furnished by a single manufacturer. To assure unity of responsibility, the motors, variable frequency drives and supporting base plate shall be furnished and coordinated by the Manufacturer or Supplier.
- B. Manufacture pumps in accordance with the Hydraulic Institute Standards, except where otherwise specified.
- C. Manufacturer: Equipment furnished under this Specification shall be new and unused, shall be the standard product of manufacturers having a successful record of manufacturing and servicing similar equipment and systems for a minimum of five years.
- D. Manufacturer or its representative shall have an authorized warranty center within a 300 mile radius of the job site, fully staffed with factory trained mechanics, and equipped with a stock of strategic spare parts for each model of pump furnished under this contract. The service facility and strategic spare parts shall be established prior to delivery of equipment for this project.
- E. The Manufacturer shall be certified to the ISO 9001 standard for design and manufacture of this type of pump.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 “Product Requirements”: Requirements for transporting, handling, storing, and protecting products.
- B. Ship pumping units with motor space heaters connected to a terminal board ready to be energized. Promptly energize motor space heaters during storage. House pumping units in weatherproof enclosures at all times during storage.
- C. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage. As necessary, provide inspection report to Manufacturer identifying any damage and rework necessary prior to installation.
- D. Store pumps and all appurtenances according to Manufacturer’s instructions.
- E. Do not disassemble factory assembled parts and components for shipment unless written permission received from Engineer.
- F. Long Term Storage:
 - 1. Follow Manufacturer's detailed recommendations for long term storage.
 - 2. Properly protect all parts so that no damage or deterioration occurs.
- G. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote for construction operations areas.
 - 2. Provide additional protection according to manufacturer’s instructions.
 - 3. Protect unpainted finished iron and steel surfaces to prevent rust and corrosion.
 - 4. Protect finished surfaces of exposed flanges with wood or equivalent blank flanges.
 - 5. Protect bearings against formation of rust in accordance with bearing manufacturer’s recommendations. For bearings that are not pre-lubricated, apply corrosion inhibiting treatment for protection during transportation, storage, handling, installation, and lapse of time prior to start-up.
 - 6. Intermittently manually rotate equipment prior to start-up to ensure distribution of lubricant/protection.

1.10 SITE CONDITIONS

- A. Ambient Conditions
- B. Field Measurements: Verify field measurements prior to fabrication. Indicate field measurements on Shop Drawings.

1.11 WARRANTY

- A. Section 017700 “Closeout Procedures” specifies closeout requirements for warranties.

- B. Pump Manufacturer or supplier shall warranty all equipment supplied under this Section for a period of one year. ~~Warranty period shall commence on the date of Substantial Completion, as outlined in Divisions 00 and 01.~~
- C. The Manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.
- D. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it shall be replaced in the machine(s) and the unit(s) restored to service at no expense to the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Peerless; (Primary pump model: 8AE15G, jockey pump model: 4AE10)

~~Flowserve; (Primary pump model: 6LR18B, jockey pump model: D8144x3x9f)~~

B. Or approved equal by:

1. Flowserve
2. Aurora
3. Goulds
4. American Marsh

~~A.~~

~~B. Peerless; (Primary pump model: 8AE15G, jockey pump model: 4AE10)~~

~~C. Aurora; (Primary pump model: 410-5x6x17, jockey pump model: 410-4x5x10B)~~

2.2 SYSTEM DESCRIPTION

- A. The pumps will pump water from the above-grade water storage reservoir to the distribution system. The on/off pump operation will be controlled by pressure in the distribution system.
- B. Equipment to include 3 primary and 2 jockey horizontal mounted axially split case finished water pumps. Motors, variable frequency drives, and accessories for each pump shall be included, as specified herein and as shown on the Drawings.
- C. For control descriptions and control sequences, refer to Section 406196 Process Control Descriptions. Coordinate for proper operation and compatibility.
- D. Pumping Units:
 1. Supply by one Manufacturer.
 2. Complete system including pumps, motors, variable frequency drives, and appurtenances such as, but not limited to, couplings, guards and gauges.

3. Materials, including the coatings in the pumps, conform to AWWA E-103, Horizontal and Vertical Line-Shaft Pumps Standard and ANSI/NSF 61 and ANSI/NSF 372.
 4. Provide ample room for inspection, repairs and adjustments.
- E. Pump(s): Capable of temporary operation at and near shut off head for 30 seconds maximum, during opening and closing of the pump discharge check valve as the pump is ramped by the VFD during starts and stops.
- F. Design and build pumps, motors, variable frequency drives, for 24-hour continuous service at any and all points within the required range of operation, without overheating, excessive vibration or strain.

2.3 PERFORMANCE AND DESIGN CRITERIA

- A. Pumps of same service type shall be identical in every respect with all parts interchangeable.
- B. Design each pump for design conditions listed herein and for operation within the system head curve envelope as appended.
- C. Head – Capacity Performance Curve: continuously rising from runout to shutoff with no points of inflection at any operational speed for stable operation within the AOR.
- D. Operate throughout the specified range within the vibration limitations specified herein.
- E. Maximum sound pressure level from one pump/motor when operating on utility power measured 3-feet from the equipment and 5-feet above the floor shall be 90 dBA.
- F. When the pump is operating at any point on its performance curve within the specified operating range at maximum speed, nameplate ratings of the motor shall not be exceeded, nor shall the design service factor be reduced.

TABLE 432321.14-1
PUMPING UNIT DESIGN REQUIREMENTS – PRIMARY PUMP

Item Description	Design Conditions – Primary Pump
Service	Finished Water
Number of Pumps (operating/standby)	3 (2/1)
Maximum Motor Full Load Speed (FLS) (rpm)	1765
Maximum Allowable Motor Horsepower (non-overloading throughout operating range) (HP)	150
Motor Design Voltage/Phase/Frequency	460 V/3 ph/60 Hz
Minimum Pump Discharge Nozzle Size (inches)	6
Minimum Pump Suction Nozzle Size (inches)	10
Pump Shut-Off Head at Motor FLS Acceptable Range (minimum/maximum) (feet)	210/225
Flow Rate at Secondary Operation Point (gpm)	1200
Minimum TH at Secondary Operation Point (feet)	205
Minimum Pump Efficiency at Secondary Operation Point (%)	60
Maximum allowable NPSH3 at Secondary Operation Point (feet)	20

Intermediate (Design) Point Flow Rate (gpm)	1800
TH at Intermediate (Design) Point (feet)	195
Minimum Pump Efficiency at Intermediate (Design) Point (%)	72
Maximum NPSH3 at Intermediate (Design) Point (feet)	20
Best Efficiency Point (BEP) Flow Rate Acceptable Range (minimum/maximum) (gpm)	2000/3000
Minimum Pump Efficiency at BEP (%)	75
Primary Operating Point TH (feet)	110
Minimum Flow Rate at Primary Operating Point (gpm)	2700
Minimum Pump Efficiency at Primary Operating Point (%)	60
Maximum NPSH3 at Primary Operating Point (feet)	28
Pump Model Used for Design	Peerless Model 8AE15G

PUMPING UNIT DESIGN REQUIREMENTS – JOCKEY PUMP

Item Description	Design Conditions – Jockey Pump
Service	Finished Water
Number of Pumps (operating/standby)	2 (2/0)
Maximum Motor Full Load Speed (FLS) (rpm)	3550
Maximum Allowable Motor Horsepower (non-overloading throughout operating range) (HP)	60
Motor Design Voltage/Phase/Frequency	460 V/3 ph/60 Hz
Minimum Pump Discharge Nozzle Size (inches)	4
Minimum Pump Suction Nozzle Size (inches)	5
Pump Shut-Off Head at Motor FLS Acceptable Range (minimum/maximum) (feet)	195/210
Flow Rate at Secondary Operation Point (gpm)	350
Minimum TH at Secondary Operation Point (feet)	190
Minimum Efficiency at Secondary Operation Point (%)	50
Maximum NPSH3 at Secondary Operation Point (feet)	20
Intermediate (Design) Point Flow Rate (gpm)	500
Minimum TH at Intermediate (Design) Point (feet)	195
Minimum Pump Efficiency at Intermediate (Design) Point (%)	60
Maximum NPSH3 at Intermediate (Design) Point (feet)	20
Best Efficiency Point (BEP) Flow Rate Acceptable Range (minimum/maximum) (gpm)	800/1000
Minimum Efficiency at BEP (%)	70
Primary Operating Point TH (feet)	120
Minimum Flow Rate at Primary Operating Point (gpm)	1000
Minimum Pump Efficiency at Primary Operating Point (%)	60
Maximum NPSH3 at Primary Operating Point (feet)	25
Pump Model used for Design	Peerless model 4AE10

See attached pump and system curve envelope in Figure 432321.

2.4 SOURCE QUALITY CONTROL

- A. Dynamic vibration analysis shall be performed by
 - 1. Mechanical Solutions Inc. (MSI) of Whippany, NJ,
 - 2. DynaTech Engineering, Inc. of Auburn, CA,
 - 3. Engineering Dynamics Inc. (EDI) of San Antonio, TX.
 - 4. Approved equal.
- B. Provide lateral rotordynamic vibration analysis of the pump rotating system, including pump and motor rotor, coupling, and installed bearing stiffness.
 - 1. Identify and predict that the first lateral critical speed shall have a separation margin of at least 20 percent above the maximum pump speed or 20 percent below the minimum pump speed.
 - 2. If a design modification (i.e., such as changing the shaft diameter or different coupling arrangement) cannot resolve a separation margin deficiency or is not practical, a forced damped response analysis shall be performed to demonstrate that deflections at the bearings or at the impeller wear rings, if applicable, will not exceed 35% of the available clearances.
- C. Provide torsional rotordynamic vibration analysis of the complete rotating system (pump, motor, shafting, and coupling).
 - 1. Identify and predict that no torsional natural frequencies occur within a separation margin extending from 20 percent below to 20 percent above the specified pump operating speed range.
 - 2. Additionally, no natural frequencies shall be +/- 10% of 2x times running speed, line frequency, 2x line frequency, vane pass frequency, and VFD control frequencies (if applicable) within the specified multiple of the pump operating speed range.
 - 3. If a design modification (i.e., such as a shaft diameter change or different coupling arrangement) cannot resolve a separation margin deficiency or is not practical, a forced damped response analysis shall be performed to show that infinite life will be achieved with a safety factor of at least two.
- D. Submit Campbell diagrams documenting lateral rotordynamics, and torsional rotordynamic analysis results and graphically demonstrating the separation margins specified above.
- E. Maximum Vibration Velocity: Per ANSI/HI 9.6.4 as measured in the field for all specified operating conditions.
- F. Maximum Vibration Displacement: Field vibration displacement peak-to-peak shall conform to the requirements of ANSI/HI 9.6.4 for specified operating conditions at or below 600 rpm. This only applies if full or reduced speeds will be below 600 rpm.

2.5 PUMP CONSTRUCTION - GENERAL

- A. Mount the pump and driving motor on a fabricated steel drip-rim baseplate with provision to collect leakage and shall be of sufficient size and rigidity to support the unit and prevent

harmful or damaging vibration. A minimum 1/2-in drain tap and copper pipe nipple shall be provided. The steel base shall be attached to a concrete support base with grout holes.

- B. All necessary anchor bolts, nuts, and washers will be furnished and be of Type 316 stainless steel to attach the steel base to the concrete support base. Anchor bolts shall be supplied by the contractor.
- C. Design and construct the pump and motor to successfully withstand a maximum reverse runaway speed equal to 150 percent of synchronous speed or the runaway speed that would occur at an applied head equal to the head at the best efficiency point, whichever is higher, resulting from backflow through the pump.
- D. Casing:
 - 1. Type: Axially split; removable top portion.
 - 2. Material: Cast iron conforming to ASTM A48, Class 25 or Class 30
 - 3. Sufficient thickness and suitably ribbed to withstand all stresses and strains of service at full operating pressure.
 - 4. Suction and discharge nozzle cast integrally with the lower half.
 - 5. Removal of the upper half of the casing must allow the rotating element to be removed without disconnecting the suction and discharge flanges.
 - 6. Lifting eyes shall be cast into the upper casing.
 - 7. Design pressure: 150 psi.
 - 8. Connections:
 - a. Air vent for air vacuum valve connection on the top of the casing: not less than 2-inch
 - b. Suction and discharge pressure gauge connections: 1/4 inch
 - 9. End Connections:
 - a. Flanged.
 - b. Comply with ASME B16.1, Class 125
- E. Impellers:
 - 1. Impeller Design Type: double suction.
 - 2. Cast ASTM A743 CF8M cast stainless steel or nickel aluminum bronze.
 - 3. Provide certified analysis of the impeller pour metal.
 - 4. Two-plane dynamic balance in accordance with 1940-1 quality grade G2.5.
- F. Wearing Rings:
 - 1. Casing wear ring material: nickel aluminum bronze ASTM B148, alloy 95800 or Stainless Steel, A487 Grade CA15.
 - 2. The wearing surfaces parallel to the axis of rotation.
 - 3. Securely fasten wearing rings to prevent any relative motion and designed for easy replacement.
- G. Shafting:

1. Pump shafting shall be equal to SAE designation 1045 or better.
2. The shafting shall be true and parallel over its entire length.
3. Shafting and couplings shall be dynamically balanced.

H. Pump Bearings:

1. Heavy duty single row inboard and double row outboard anti-friction type.
2. Arranged for grease or oil lubrication.
3. Minimum L-10 life per ABMA Standards: 50,000 hours.
4. No external cooling allowed.
5. Removable bearing housings shall be bolted and doweled to bearing brackets that are cast integral with the pump lower half casing.

2.6 SEALS AND ACCESSORIES

A. Stuffing box/seal box sealed with cartridge mechanical seal:

1. Discharge head shall be fitted with a mechanically sealed type stuffing box arranged for fresh water flush of stuffing box flushing water supply from pump volute (API Plan 11).
2. Shaft Sleeve:
 - a. Section of line-shaft that extends through or into the stuffing box shall be fitted with a replaceable 316 stainless steel sleeve that extends beyond the face of the stuffing box far enough to accommodate the total length of the mechanical seal.
 - b. Sleeve shall be held to the shaft with threaded section or set screws to prevent rotation and shall be sealed to prevent leakage between the shaft and the sleeve.
 - c. Minimum shaft sleeve thickness: 1/4 inch
3. Seal: Hydraulically balanced, self-aligning faces and threaded port for flushing/venting.
 - a. Stationary design.
 - b. Capable of handling full vacuum to 150 psi.
 - c. All components shall be split.
4. Seal materials of construction: 316 stainless steel for all wetted parts and Hastelloy C springs.
5. Seal faces shall be of carbon rotating face and silicon carbide.
6. Isolate springs from the pumpage.
7. Ensure that shaft movement and seal chamber pressures at all specified operating conditions are fully compatible with the mechanical seal system provided.
8. Dynamic o-rings shall be on the shaft sleeve O.D. and seal to a micro polished surface to eliminate hang up and hysteresis.
 - a. O-rings shall be Viton® or compatible with the fluid being pumped.
 - b. The gland shall be of a universal design to fit varied bolt sizes and circles.
 - c. The gland shall have a minimum of one tapped flush/by-pass port that can be rotated 360 degrees to accommodate flush piping.
 - d. Stuffing box/seal box sealed with single-piece mechanical seal.
9. Throat Bushing:

- a. Install a nickel aluminum bronze throat bushing in the bottom of stuffing box to throttle flow out of seal area.
 - b. System shall be configured in accordance with flushing system, API Plan 11.
10. Provide mechanical seal manufactured by:
- a. A.W. Chesterton,
 - b. Equal by John Crane,
 - c. Equal by Flowserve,
 - d. or equal.

2.7 OPERATION

A. Motors:

1. Pump Drive:

- a. Horizontal inverter duty rated squirrel cage induction electric motor with a maximum horsepower and speed as specified in 2.3 above.
- b. Provide winding temperature detectors for each motor. Winding temperature detectors shall be a factory installed, embedded, bi metallic switch type with leads terminating in the main conduit box. This device shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure. The switch shall have normally open contacts. Not less than three detectors shall be furnished with each motor.
- c. Enclosure: Totally Enclosed Fan-Cooled TEFC
- d. Provide 120 V motor space heaters
- e. Meet requirements of Section 400593
- f. Provide thrust bearing capable of handling both mechanical and hydraulic thrust of the pump.
- g. Bearings will be anti-friction, grease lubricated type.
- h. Minimum L-10 life per ABMA Standards: 50,000 hours

- 2. Pump Motors: Suitable for driving the pumps continuously over the entire pumping range. Furnished by the Manufacturer. Constructed and guaranteed to withstand pump reverse runaway speed equal to 150 percent of synchronous speed or the runaway speed that would occur at an applied head equal to the head at the best efficiency point, whichever is higher.
- 3. All lubrication fittings shall be brought to the outside of all equipment so that they are readily accessible from the outside without the necessity of removing covers, plates, housings, or guards, or without creating falling hazards. Fittings shall be buttonhead type. Lubrication fittings shall be mounted together wherever possible. Pressure grease-lubricated fittings shall be the "Zerk Hydraulic" type or the "Alemite" type. Housings of grease-lubricated bearings shall be automatically exhausted to the atmosphere to prevent excessive greasing.
- 4. Motors shall be mounted to the Baseplate with Heavy Hex Grade 8 bolts, nuts and washers torqued to the Manufacturer's recommended value.

B. Motor to Pump Coupling:

1. Pump drive shaft shall be directly connected to the motor by means of a Falk or equal all metal flexible coupling, suitably sized to transmit the required driving torque and axial unbalanced thrust.

C. Variable Frequency Drives:

1. Speed control for variable speed pumps will be Variable Frequency Drives, as specified in Section 262419, suitable for installation as shown on the Drawings.
2. Provide by the Manufacturer or Supplier.
3. Coordinate with pumps and pump driving motors.
4. Include all internal auxiliaries required to meet the functional specifications.
5. Design for a speed range of 70% to 100% of full load motor speed.
6. Incorporate components to receive temperature data from the pump motor.

2.8 SHOP PAINTING

- A. Prepare, shop-prime and finish-coat each piece of equipment in accordance with the Manufacturer's standard practice prior to shipment.
- B. Colors shall be Manufacturer's standard. Coating for Variable Frequency Drives shall be as specified in Section 262419. Furnish adequate supply of touch-up paint from the Manufacturer.
- C. Clean all interior and exterior surfaces of pump of all rust, mill scale, grease, dirt, other foreign matter and provide Manufacturer's standard epoxy coatings.
- D. All coatings on wetted surfaces shall be epoxy type and shall comply with AWWA E-103 and ANSI/NSF 61 and ANSI/NSF 372 for use with drinking water systems. Surface preparation shall conform to the coating manufacturer's recommendations.
- E. Protect all nameplates during painting.

2.9 ACCESSORIES

A. Nameplates:

1. Each major piece of equipment shall be furnished with a stainless-steel nameplate (with embossed data or equivalent) securely mounted to the body of the equipment.
2. At a minimum, the nameplate for the pumps shall include the Manufacturer's name and model number, serial number, rated flow rate, head, and speed.
3. At a minimum, nameplates for motors shall include the manufacturer's name and model number, serial number, horsepower, speed, input voltage, amps, number of cycles and power and service factors.
4. Nameplate information for the variable frequency drives shall include the manufacturer's name and serial number, input speed, voltage, current and frequency and horsepower at full load.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Take all necessary measurements in the field to determine the exact dimensions for all work and the required sizes of all equipment under this Contract. All pertinent data and dimensions shall be verified.

3.2 INSTALLATION

- A. Install in strict accordance with the Manufacturer's instructions and recommendations in the locations shown on the Contract Documents and pump shop drawings. Provide required oil and grease for initial operation in accordance with the Manufacturer's recommendations.
 - 1. If the Contractor does not provide qualified installation staff on the job during the pump installation, the Engineer may direct the Contractor to provide the services of a Manufacturer's factory representative to give the necessary instructions to ensure a proper installation.
 - 2. Connection of piping to pumps shall be done in the presence of the Engineer. All piping connections to the pump shall be done without bending and/or twisting the piping to mate with the pump flange connections.
 - 3. A certificate from the Manufacturer shall be submitted stating that the installation of their equipment is satisfactory, that the equipment is ready for operation, and that the Owner's operating personnel have been suitably instructed in the operation, lubrication and care of each unit.
- B. Mechanical equipment, including electric motors shall be supplied and installed in accordance with applicable OSHA regulations including requirement for guards on all rotating assemblies.

3.3 ATTACHMENT

- A. Rigidly and accurately anchor pump base plate, precisely leveled and aligned, so that the completed installation is free from stress or distortion.
- B. Proportion baseplate to support each entire pump/motor assembly and the loads (including the results of the dynamic vibration analysis) to which it may be subjected during operation.
- C. Provide anchor bolts, plates, nuts and washers and conform to the recommendations and instructions of the Manufacturer.
- D. Pump Manufacturer shall validate base plate installation by on-site inspection during installation.
- E. Bolt pump base plate to the concrete foundation:
 - 1. Bolts and Washers: Type 316 stainless steel epoxy type
 - 2. Nuts on Stainless Steel Anchor Bolts: Monel.
 - 3. Anti-Seize Compound: Molybdenum disulfide base Molycoat G or approved.

4. Anchor bolt configuration and installation in accordance with API RP 686 and ACI 318-08.

F. Pump Support/Anchors and Associated Accessories:

1. Support pump on anchor bolts and located as shown on the Drawings.
2. Provide special slings, strongbacks, or other devices necessary to handle the pump during loading, unloading, erection, installation, and subsequent disassembly.
3. Install, level and grout base plate in accordance with API RP 686, Chapter 5 – Mounting Plate Grouting.
4. Provide jacking bolts and Five Star non-shrink epoxy grout for leveling pump base plate assembly. Back leveling jacking bolts off after grouting so that they do not support any of the load.
5. Provide anchor bolt layout to aid in placement of anchor bolts.
6. Use of shims or leveling nuts on anchor bolts is specifically prohibited.
7. Grout for use under the base plate: Five Star DP Epoxy Grout, an expansive, non-shrink, low exothermic epoxy system, or approved equal, mixed and applied according to the Manufacturer's directions to a thickness as specified under Grout Placement. Manufacturer's representative required to be present during the pouring of the epoxy grout.
8. Use of rigid non-absorbing formwork and a head box are mandatory.
9. Cover surface of formwork in contact with epoxy grout with a layer of paste wax.
10. Clearance between the concrete surface and bottom surfaces of the base plate shall be per Manufacturer's recommendation.
11. Grout Placement:
 - a. Chip concrete in contact with epoxy grout to present a slightly rough surface and remove the laitance.
 - b. Clean surface of all dust, moisture and oil.
 - c. Place 1-inch minimum diameter by 0.25-inch thick stainless-steel disk, with full radiused edges under each jack bolt.
 - d. Place thin layer of leveling grout under metal.
 - e. Radius metal edges in contact with the epoxy grout to a minimum 0.5-inch radius to prevent stress risers in the epoxy grout.
 - f. Place plastic vent tubes under the base plate, sized and spaced per Manufacturer's recommendation, to vent air during grouting and prevent voids in the epoxy grout.
 - g. Fill annular space between the anchor bolts and the anchor bolt sleeve with expanding urethane foam.
 - h. Cover threads of both anchor bolts and jack bolts in contact with the grout with paste wax and a layer of duct tape.
 - i. After all alignment tolerances are met, tighten anchor bolts to prevent movement during the pour.
 - j. Epoxy grout shall not be allowed to extend above the top edge of the base plate (or drip rim).
 - k. Remove the jack bolts after the epoxy grout has fully cured, within 24 to 48 hours after pouring, and tighten anchor bolts to torque levels recommended by the Manufacturer.
 - l. Coat threaded jack bolt holes with grease and remove paste wax and duct tape then reinsert and secure in position with a lock nut to within 0.25 inch of the bottom of the hole.
 - m. After grouting, patch chipped edges to present a smooth finish.

3.4 INSPECTION AND TESTING

A. General:

1. The Engineer shall have the right to inspect any equipment to be furnished under this Section prior to their shipment from place of manufacture.
2. Engineer shall be notified in writing no fewer than ten working days prior to the factory performance test, so that arrangements can be made for inspection by the Engineer.
3. Field tests shall not be conducted until such time that the pumping system, including controls, is complete and ready for testing.

B. Factory Pump Testing:

1. Factory test each pump as described in ANSI/HI 14.6, American National Standard for Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
2. Manufacturer shall perform hydrostatic test on the pressure-containing parts in accordance with ANSI/HI 14.6. Test shall be conducted on each pump prior to shipment.
3. Visually inspect cast surfaces of all components per MSS SP-55.
4. Factory pump tests shall be the basis of acceptance of the hydraulic performance of the pumps. Manufacturer shall factory test all pumps prior to shipment in accordance with the Hydraulic Institute standards. Flow rate, total head, efficiency and input KW shall be tested and recorded for at least five points on the pump performance curve. Test shall be performed to demonstrate that the pumps meet ANSI/HI 14.6, acceptance grade 1U for specified (intermediate) design point and acceptance grade 1E for the other specified points. The five points shall include the points specified in Article 2.3. If any pump tested fails to meet any specification requirement it will be modified until it meets all specification requirements. If any pump tested fails to meet the flow rate, head or efficiency requirements for any of the conditions listed in Article 2.3 of this specification and all reasonable attempts to correct the inefficiency are unsuccessful, the pump(s) shall be replaced with a unit(s) that meets the specified requirements.
5. Submit certified pump performance curves, including total head, flow rate, pump efficiency and total brake horsepower for each pump supplied. Test data shall be submitted for approval by the Engineer prior to shipment.
6. If the Manufacturer does not have historical test records for NPSH3 at the specified design pump speed, one pump shall be tested to demonstrate NPSH3 versus flow rate.
7. All meters, gauges, and other test instruments shall be calibrated within the manufacturer's established time period prior to the scheduled test and certified calibration data shall be provided. If the Manufacturer has no ISO standard calibration period, Hydraulic Institute Standards shall govern.
8. The pumps shall be tested at 100 percent of the design speed. Reduced speed curves will be determined using affinity laws.
9. Each pump shall be tested through the specified range of flow, and head/flow rate/efficiency curves plotted at maximum output speed. During each test, the pump shall be run at each head condition for sufficient time to accurately determine flow rate, head, power input, and efficiency. In addition, during the tests, the overall efficiency shall be determined at each test point. The pump under test shall be modified until the specified conditions are met or replaced with a pump that will meet the specified conditions.
10. All pumps shall receive a non-witness factory test.

C. Field Testing:

1. In the presence of the Engineer, necessary tests shall be performed to indicate that the pumps, variable frequency drives and motors generally conform to the operating conditions specified (flow rate, total head,). The factory testing specified above will be the basis of performance acceptance. A 30 day operating period of the pumps will be required before acceptance. If pump performance does not generally agree with the factory test results, corrective measures shall be taken, or the pump shall be removed and replaced with a pump that satisfies the conditions specified. Provide, calibrate and install all temporary gauges and meters, make necessary tapped holes in the pipes, and install all temporary piping and wiring required for the field acceptance tests. Written test procedures shall be submitted to the Engineer for approval no fewer than 30 days prior to testing.
2. When full speed operation can be accomplished, and in the presence of the Engineer, perform vibration tests in accordance with ANSI/HI 9.6.4 on each unit by a minimum level III qualified vibration technician as defined by Vibration Institute or equivalent to (a) demonstrate compliance with specified limitations, and (b) demonstrate that there are no field installed resonant conditions due to misalignment, the foundation, or the connecting piping and its supports, when operating at any speed within the specified operating range.
3. Motor tests:
 - a. Prior to any pump mechanical test, the Contractor shall megger each motor winding before energizing the motor, and, if insulation resistance is found to be low, shall notify the Engineer and shall not energize the motor.
 - b. Prior to any pump mechanical test, the Contractor shall check all motors for correct clearances and alignment and for correct lubrication in accordance with the motor manufacturer's instructions. The Contractor shall check direction of rotation of all motors prior to any pump mechanical test and reverse connections, if necessary.
 - c. The Contractor shall meet all the testing requirements of Section 400593.
4. If required, take corrective action and have the units retested to ensure full compliance with the specified requirements. All costs associated with the field tests or any required corrective action shall be borne by the Contractor.

3.5 MANUFACTURER SERVICES INCLUDING OPERATING INSTRUCTIONS

A. Operating and Maintenance Manual:

1. Operating and maintenance manual shall be furnished by the Manufacturer to the Engineer as provided for in Section 017823. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, description, etc. that are required to instruct operating and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include trouble shooting data, full preventative maintenance schedules, and complete spare parts lists with ordering information.

B. Installation Inspection and Startup:

1. The Contractor shall include in his bid price the services of a Manufacturer's factory representative who has complete knowledge of proper operation and maintenance shall be provided to instruct representatives of the Owner and the Engineer on proper

operation and maintenance. This work may be conducted in conjunction with the inspection of the installation and start-up. If there are difficulties in operation of the equipment because of the Manufacturer's design or fabrication, additional service shall be provided at no additional cost to the Owner. The listed service requirements are exclusive of travel time and shall not limit or relieve the Contractor of the obligation to provide sufficient service necessary to place the equipment in satisfactory and functioning condition. VFD training shall be as specified in Division 017900. Also refer to additional requirements in PART 3 of this Section.

2. Installation inspection: Complete review of installation in accordance with Section 014000. Provide written certification that the installation is complete and operable in all respects, and that no conditions exist which may affect the warranty. The Manufacturer shall supply the installation inspection services of an experienced Manufacturer's factory representative to verify the proper pump installation.
3. Qualified supervisory services, including Manufacturers' Factory representatives, shall be provided to ensure that the installation is done in a manner fully approved by the Manufacturer. The Manufacturer's factory representative shall specifically approve the installation and alignment of the pump with the motor, the grouting, and the alignment of the connecting piping and the installation of the field installed packing or mechanical seal. If there are difficulties in the start-up or operation of the equipment due to the Manufacturer's design or fabrication, additional service shall be provided at no additional cost to the Owner. Services of the Manufacturer's factory representative and training shall be provided when the first pump is started, with follow-up visits upon start-up of each subsequent pump.

a. Minimum time on-site shall be one 8-hour day per pump station.

4. Start-Up: Provide written report, summarizing test procedures, tested and measured variables (flow rates, total heads, shaft-speed, vibration measurements, alignment check, etc.):

a. Minimum time on-site shall be one 8-hour day per pump station.

C. Training:

1. Field and classroom instruction on operation and maintenance of the equipment, including start-up, shut-down troubleshooting, lubrication, maintenance and safety.
2. The Manufacturer shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.
3. The Manufacturer shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to Owner.

a. Minimum time on-site shall be one 8-hour day per group of identical pumps.

- D. The Contractor alone shall be responsible for requesting these services and shall coordinate these requests with all other relevant trades, to ensure the effectiveness of the Manufacturers' service. In the event that the lack of coordination by the Contractor results in the need to recall the Manufacturer's factory representative, the lost time shall not be counted against the above days.

- E. The manufacturer's authorized service person shall provide precision laser alignment of the motor to the driven pump using equipment that provides a computer generated alignment report showing the angular and parallel offset data for each pump prior to start-up. Reports shall demonstrate the absence of pipe stress on the pump and no "soft foot" for the motor.

END OF SECTION 432321.14