

SAN ANTONIO WATER SYSTEM PURCHASING DEPARTMENT

Issued By: **D. Anthony Rubin**
BID NO.: **18-18091**

Date Issued: **July 10, 2018**

**FORMAL INVITATION FOR BIDS
EARLY PROCUREMENT OF HORIZONTAL SPLIT CASE PUMPS FOR THE
CENTRAL WATER INTEGRATION PIPELINE PROJECT
ADDENDUM 2**

Sealed bids addressed to the Purchasing Director, San Antonio Water System, 2800 US Hwy 281 North, Administration Bldg., 5th Floor, San Antonio, TX 78212 will be received until **3:00 p.m. July 13, 2018** and then publicly opened and read aloud for furnishing materials or services as described herein below,

The San Antonio Water System Purchasing Department is willing to assist any bidder(s) in the interpretation of bid provisions or explanation of how bid forms are to be completed. Assistance may be received by visiting the Purchasing Office in the SAWS Main Office, 2800 US Hwy 281 North, San Antonio, TX 78212, or by calling (210) 233-3819.

This invitation includes the following:

Invitation for Bids
Terms and Conditions of Invitation for Bids

Specifications and General Requirements
Price Schedule

The undersigned, by his/her signature, represents that he/she is authorized to bind the Bidder to fully comply with the Specifications and General Requirements for the amount(s) shown on the accompanying bid sheet(s). By signing below, Bidder has read the entire document and agreed to the terms therein.

Signer's Name: _____ Firm Name: _____
(Please Print or Type)

Address: _____

Signature of Person Authorized to Sign Bid _____ City, State, Zip Code: _____

Email Address: _____ Telephone No.: _____

Fax No.: _____

Payment Terms are Net 30.

Please check the following blanks which apply to your company:

Ownership of firm (51% or more):

Non-minority Hispanic African-American Other Minority (specify) _____

Female Owned Handicapped Owned Small Business (less than \$1 million annual receipts or 100 employees)

Indicate Status: Partnership Corporation Sole Proprietorship Other (specify) _____

Tax Identification Number: _____

To report suspected ethics violations impacting the San Antonio Water System, please call 1-800-687-1918.

This **Addendum 2** is issued to answer the following questions and issue changes to the bid documents for this procurement. All other terms and conditions of the original bid document remain unchanged.

QUESTIONS AND CLARIFICATIONS

- Q1. Section 11110, Part 1.01.A – Scope of work includes vibration switches. However, there is no guidance on what type of switch, desired mounting location or number of switches. Please provide guidance on what is required. Scope also requires RTDs. The motor specification (16151.2.14.B) lists bearing & winding (2 per phase) and one ambient RTD. However, the pump specification is unclear. Are bearing RTD's on the pumps inboard & outboard bearings required?
- A1. Refer to Addendum 1, Q5/A5 and Q9/A9.
- Q2. Section 11110, Part 1.04.E Level 1 submittal requirements. Given the minimal amount of time allowed, roughly 2 weeks, to prepare Level 1 submittals many of the required items will not be available. We respectfully request the following deviations to the requirements. Please advise if this is acceptable.
5. General support and anchor bolt drawings in lieu of “certified” can be supplied.
 6. Material Certifications will not be available until after manufacture.
 7. Thrust, radial load & L10 bearing life calculations not available in such a short time. Note: ITT Goulds standard model 3410 design ensures L10 life of 100,000 or greater. Can a statement on bearing life be supplied in lieu of calculations?
 8. ITT Goulds maximum shaft deflection is .002”. Can a statement be supplied in lieu of calculations?
 10. “Certified drawings” will not be available in such a short time. Can general drawings be supplied in lieu of certified?
 11. “Forces and moments analysis” will not be available in such a short time.
 13. Schedules for factory witnesses can only be estimated. Firm schedule & notices will be available after release to production.
 14. Factory test book is not available until after test completion.
 16. Motor data may be limited in such a short time.
- A2. Refer to Addendum 1, Q12/A12
- Q3. Section 11110, 2.08.A & C Mechanical Seals - Mechanical Seals are required in “A” to be “Split Type”. However, the only listed seal in “C” is John Crane Type 1 which is a standard, non-cartridge, non-split seal. Additionally, the John Crane Type 1 seal is not NSF 61 certified. Is a split type or non-split seal required? If NSF 61 compliance is desired, we recommend either the Chesterton 155-NSF (cartridge non-split) or Chesterton 442-NSF (cartridge split)
- A3. Non-split mechanical seals are required. See section 2.08 C, for approved manufacturers.
- Q4. Section 11110, 2.08, A calls for "pump shall be supplied initially with mechanical type split seals which are interchangeable with conventional packing". Please confirm the mechanical seals to be provided are to be John Crane Type 1 seals that are **not** of the split type design? Also, please confirm the pump stuffing box need to be interchangeable with conventional packing?
- Q4. See response to Q3 above. Provide pump stuffing box interchangeable with conventional packing.
- Q5. Section 11110, 2.12 does not specify "heat-stress relieving of the baseplate". Please confirm that is a SAWS requirement? It has been required and supplied on other SAWS projects we have supplied.
- A5. Provide heat stress relieving of the baseplate.
- Q6. Section 11110, Part 2.24.A – Shop Testing- Hydraulic Institute acceptance testing is specified as “Grade 1B”. This grade allows for -3% efficiency in testing. In past projects SAWS has not allowed any negative efficiency. Was this SAWS intent or is grade 1E or 1U, which do not allow negative testing efficiencies, desired?

- A6. Refer to Addendum 1, Q14/A14
- Q7. Section 16151, 2.03, N states that the motor efficiency is in Section 11110. However, the min motor efficiency isn't listed in Section 11110. Please confirm the minimum motor efficiency required.
- A7. Motor efficiency shall not be less than 95% and power factor not less than 85% when operating at maximum speed, service factor load and rated voltage and frequency.
- Q8: Section 16151, Part 2.18.B Factory Tests - Please advise test required IEEE 112 test method (B?) and if efficiency and power factor at 100%, 75%, and 50% full load are required. Recommended for calculating wire-to-water efficiency.
- A8: All testing to determine wire to water efficiency shall be provided.
- Q9. Section 11110, Performance & Design Criteria – The performance requirements list a “minimum pump efficiency”. However, the testing requirements of 2.24.C.1 & 3.04.C states “guaranteed wire-to-water efficiency” is required. Please advise which is required, a minimum “pump” or “wire-to-water” efficiency. Note: We interpret “wire-to-water” to mean pump efficiency x motor efficiency. “Wire-to-water” efficiency will be calculated by multiplying our witness tested pump efficiency by the stated motor efficiency from the motor manufacturer.
- Q9. Testing requirements shall require guaranteed pump efficiency. Motor efficiency section has been updated per this addendum. Pump testing shall provide the actual measured wire to water efficiency.
- Q10. Section 11110, 1.04 Submittals Paragraph A Item 1 Submittals – Preliminary
The specifications require preliminary submittals with the bid, most pump manufactures will not provide this as it takes engineering time for a proposal they may not win. We can submit a general outline drawing and pump curve and if favored with the order supply submittals as required
- A10. Refer to Addendum 1, Q12/A12
- Q11. Section 1.05 Reference Standards
Paragraph 1 Item 18 & 19 NSF 61
Some of the items you specify may not be listed as a NSF 61 Components, example John Crane Type 1 seal.
- A11. See response to Q3 above

REVISIONS TO CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS

SECTION 11110 – HORIZONTAL SPLITCASE CENTRIFUGAL PUMPS

- a) Delete Section 11110 in its entirety and replace with new Section 11110 provided; all changes to this specification are detailed below.
- b) Part 1.01. A revised to:
- This specification describes the equipment, materials, and incidentals required for the horizontal split-case pumps package for the Stone Oak Pump Station to be furnished by a single responsible Pump Manufacturer for installation by Others (Contractor). The Pump Manufacturer will be required to provide pumps, drivers, motors and drive arrangements with seals, couplings, base plates, guards, supports, anchor bolts and appurtenances as shown on the Drawings and specified in this Section, including RTDs as shown on the P&IDs.
- c) Part 1.04.E.11: Delete entirely.
- d) Part 1.04, G.,4 and Part 1.04.G.5: Delete entirely.

- e) Add the following to Part 1.05.A:
24. Texas Commission on Environmental Quality (TCEQ) Rules, Chapter 290
- f) Table in Part 2.02.A: Revise Primary Condition, Minimum Pump Efficiency to 83%
- g) Delete Table in Part 2.02.A in its entirety and replace with the following:

Pump Tag	50-PMP-01, 50-PMP-02, 50-PMP-03, 50-PMP-04
Design Points:	
Primary Condition (2 pumps) ^(a) :	
Capacity per pump:	5,208 gpm (7.5 MGD)
Total Design Head (TDH)	249 ft
Minimum Pump Efficiency	83%
Secondary Condition ^(a) :	
Capacity per pump:	4,653 gpm (6.7 MGD)
Total Design Head (TDH):	257 ft
Minimum Pump Efficiency	80%
Low head condition ^(a) :	
Capacity per pump:	6,250 gpm (9 MGD)
Total Design Head (TDH):	227 ft
Minimum Pump Efficiency	80%
Operating head range for full speed continuous operation	200-280 ft
Minimum shutoff head	290 ft
Minimum NPSHA	40.6 ft
Maximum nominal pump speed.	1,800 rpm
Motor size required	450 HP
Pump rotation as viewed from driven end	See drawings
Minimum pump suction nozzle size	12 in
Minimum pump discharge nozzle size	10 in

- h) Part 2.08 A revised to:
“Pumps shall be supplied initially with mechanical type non-split seals which are interchangeable with conventional packing and in conformance with NSF-61.”
- i) Part 2.08 C revised to:
C. Manufacturer
 1. John Crane
- j) Add to Part 2.12:
F. Stress relieve welded fabrication prior to machining
- k) Part 2.24.C.1. revised to:

“Each constant speed pumping unit shall be tested with its job motor by the Pump Manufacturer at their plant prior to shipment. Each pumping unit shall be tested with water in accordance with the Standards of the Hydraulic Institute, Centrifugal Pump Section Test Code and Rotodynamic Pumps for Hydraulic Performance Acceptance Tests to determine compliance with Pump Manufacturer’s head-capacity curve and confirm guaranteed pump efficiency. Pump testing shall provide the actual measured wire to water efficiency. A hydrostatic test of the pump

casing shall also be performed. Model tests will not be accepted. Factory testing shall be the final criteria for acceptance by the Owner for the tests specified in Paragraph 2.24.E. of this Section. Acceptance criteria for vibration as specified in this section shall include both factory and field tests. Field testing will be the final criteria for acceptance by the Owner for the tests specified in Paragraph 2.24.E. Factory test data and results shall be submitted for review prior to the equipment being shipped to the jobsite.”

l) Part 2.24.C.3: Deleted entirely.

m) Part 2.24.C.4 revised to:

“3. The factory test report shall be certified by a licensed Professional Engineer. Certified copies of the test data for each pump shall be furnished to the Owner as part of the Test Book referenced in Paragraph D. Test curves and data sheets shall include head-capacity curve, brake horsepower curves, pump efficiency curves, motor Manufacturer’s efficiency curves, pump efficiency curves, NPSH requirements, and a sketch of the test installation. Data for the entire pump range (from minimum head to shut-off) shall be included.”

n) Part 2.24.E.1 revised to:

“Hydrostatic Test: Each new pump unit shall be hydrostatically tested to one and one half times its maximum working pressure or 150 psi, whichever is greater. Maximum working pressure is defined here as the shutoff head pressure. Test duration shall be 30 minutes. Submit certified hydrostatic test results and test procedures.”

o) Part 2.24.E.3: Delete entirely

p) Part 3.02: Delete entirely.

q) Part 3.03 Delete entirely.

r) Part 3.04 C.2 revised to:

“Penalty for Efficiency: If, as a result of the factory test, the efficiency of any pumping unit (pump and motor) is less than the specified minimum pump efficiency at Rated Point, the Owner, at his discretion, may reject the equipment, and require the Pump Manufacturer to provide a pump and motor as specified.”

s) Part 3.04 C.3 revised to:

“There is no credit for efficiency values obtained during factory testing that are greater than the guaranteed pump efficiency.”

SECTION 16151– LARGE INDUCTION MOTORS

a) Delete Section 16151 in its entirety and replace with new Section 16151 provided; all changes to this specification are detailed below.

b) Part 2.03, F. revised to:

Voltage: Motor voltage, phase and frequency shall be 4160V and as specified with the driven equipment.

c) Part 2.03, N. revised to:

Efficiency: Motor efficiency shall be evaluated and determined by the pump manufacturer as specified in Section 11110. All motors shall have the efficiency evaluated with the pump. Motor efficiency shall not be less than 95% and power factor not less than 85% when operating at maximum speed, service factor load and rated voltage and frequency.

d) Part 2.06, A., 6. revised to:

6. Couplings shall be as specified in Section 11110.

e) Part 2.08, B. Delete entirely.

f) Part 2.08, C. Delete entirely.

g) Part 2.14, B., 3. Delete entirely.

SECTION 11110

HORIZONTAL SPLIT-CASE CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This specification describes the equipment, materials, and incidentals required for the horizontal split-case pumps package for the Stone Oak Pump Station to be furnished by a single responsible Pump Manufacturer for installation by Others (Contractor). The Pump Manufacturer will be required to provide pumps, drivers, motors and drive arrangements with seals, couplings, base plates, guards, supports, anchor bolts and appurtenances as shown on the Drawings and specified in this Section, including RTDs as shown on the P&IDs.
 - 1. Provide four (4) horizontally mounted, axial split-case, single stage, double suction, centrifugal pumps for the Stone Oak Pump Station.
 - a. Equipment Tags: 50-PMP-01, 50-PMP-02, 50-PMP-03, 50-PMP-04
- B. The unit shall be furnished with all necessary accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not, and as required for an installation incorporating the highest standards for the type of service, including field testing and instructing the regular operating personnel in the care, operation, and maintenance of all equipment.
- C. The Pump Manufacturer will be selected and issued a Purchase Order by the Owner for early submittal of shop drawings prior to advertising and bidding of the Terminus Treatment Facilities Bid Package, which will be awarded to a General Contractor, referenced herein as Contractor. The Pump Manufacturer shall be responsible for coordination with the construction schedule of the Contractor to ensure that equipment is delivered to the site in accordance with the Contractor's schedule. The Pump Manufacturer shall also coordinate with the Contractor to ensure that all related systems furnished under the Contractor's scope of work will form a complete integrated operating system. The Pump Manufacturer for this project shall coordinate the pumps with the equipment as described herein and on the drawings supplied by the Contractor, and their manufacturers.
- D. The Pump Manufacturer shall confirm the pump rotation from the plans prior to manufacture.

1.02 RELATED WORK

- A. Section 01300 Submittals
- B. Section 01600 Material and Equipment
- C. Section 01640 Manufacturer's Field Services

- D. Section 01730 Operation and Maintenance Data
- E. Section 01752 Facility Startup Commissioning Requirements
- F. Section 16151 Large Induction Motors

1.03 DEFINITIONS

- A. Relevant terminology shall be defined according to the American National Standard for Centrifugal Pumps for Nomenclature, Definitions, Application and Operation; and the Hydraulic Institute Standards (HI) ANSI/HI 1.1-1.5.

1.04 SUBMITTALS

- A. Pre-Purchase Contract Schedule: It is anticipated that this pre-purchase contract will follow the approximate schedule below:
 - 1. Submittals- Preliminary (with the bid)
 - 2. Purchase Order for Submittals Only: July 13, 2018
 - 3. Submittals – Level 1: August 1, 2018
 - 4. Submittals – Level 2: August 31, 2018
- B. All submittals shall use English units and shall be written in English.
- C. Submittals shall be made in accordance with the requirements in Section 01300 and as specified herein.
- D. The Pump Manufacturer shall submit the following with the bid:
 - 1. Certified dimensional drawings and weights of each item of equipment and auxiliary apparatus to be furnished, including pump, motor and base plate.
 - 2. Submit Manufacturer's certified rating curves for each pump, showing pump characteristics for discharge head, Allowed Operating Range (AOR), Preferred Operating Range (POR), capacity, brake horsepower, pump efficiency at the "rated" point, pump efficiency curve for pump, and guaranteed net positive suction head required (NPSHR) over the entire range of pumping requirements. This information shall be prepared specifically for each pump provided. Catalog sheets showing a family of curves will not be acceptable.
 - 3. Submit motor data sheets per Section 16151, Part 1.03.C.1-10.

- E. The Pump Manufacturer shall submit the following with Level 1 submittals (August 1, 2018):
1. Submit pump/motor coupling manufacturer, model number, AGMA 9002-A clearances and tolerances.
 2. Cross-sectional drawings with detailed construction of each component in the pump along with the ASTM material designations.
 3. Bill of materials.
 4. Shaft seal drawing and shaft coupling.
 5. Certified pump support and anchor bolt plans and details.
 6. Materials certifications for castings, impellers, shafts, and shaft sleeves.
 7. Submit hydraulic thrust and radial load calculations along with L10 bearing life calculations of each bearing. L10 bearing life is 100,000 hours.
 8. Shaft design calculations along with worst case shaft deflections at the wear rings and at the mechanical seals.
 9. Data sheets applicable to proposals, purchase, and as-built drawings.
 10. Certified drawings of auxiliary systems.
 11. Manufacturer's installation instructions.
 12. Factory test procedure.
 13. Schedules for factory witness testing.
 14. Factory test book per Paragraph 2.24.D.
 15. Motor data per Section 16151.
 16. Preservation; packing, and shipping-procedures per Section 01730.
 17. QA/QC program as described herein.
 18. Spare parts recommendations and price lists.
 19. Material safety data sheets.
- F. The Pump Manufacturer shall submit the following with Level 2 submittals (August 31, 2010):
1. Electrical and instrumentation schematics, wiring diagrams, and bills of materials.
 2. Electrical and instrumentation arrangement drawings and lists of connections.
 3. Drawings of bearing temperature sensors (RTDs), location and mounting details.
 4. Drawings of oil level alarm switches.
- G. The Pump Manufacturer shall submit the following with Level 3 submittals:
1. Certified test data for-factory acceptance testing.
 2. Certified hydrostatic test data.

3. Vibration analysis data for pump and motor.
4. Noise test results of factory test.
5. Manufacturing progress reports.
6. Certified motor test data as specified in Section 16151.
7. Installation operations and maintenance manuals per Section 01730. Manuals shall include data for each pumping unit, including pump and motor.
8. Report of installation, inspection, testing, and observations for each pumping unit.
9. Letter of Certification.

1.05 REFERENCE STANDARDS

- A. Design, manufacture, and assembly of elements of the equipment herein specified shall be in accordance with, but not limited to, current published standards of the following, as applicable:
1. American Bearing Manufacturer's Association (ABMA).
 2. American Gear Manufacturer's Association (AGMA).
 3. American Institute of Steel Construction (AISC).
 4. American Iron and Steel Institute (AISI).
 5. American Society of Mechanical Engineers (ASME).
 6. American National Standards Institute (ANSI).
 7. American Society for Testing Materials (ASTM).
 8. American Welding Society (AWS).
 9. Anti-Friction Bearing Manufacturer's Association (AFBMA).
 10. American Water Works Association (AWWA).
 11. Hydraulic Institute Standards (HI).
 12. Institute of Electrical and Electronics Engineers (IEEE).
 13. Instrumentation, Systems, and Automation Society (ISA).
 14. International Standards Organization (ISO).
 15. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS).
 16. National Electrical Code (NEC).

17. National Electrical Manufacturer's Association (NEMA).
18. NSF International Strategic Registrations, Ltd. (NSF).
19. NSF Standard 61 - Drinking Water System Components.
20. Occupational Safety and Health Administration (OSHA).
21. Society of Automotive Engineers (SAE).
22. Steel Structures Painting Council (SSPC).
23. Underwriters' Laboratories, Inc. (UL).
24. Texas Commission on Environmental Quality (TCEQ) Rules, Chapter 290

1.06 QUALITY ASSURANCE

- A. The equipment covered by these Specifications is intended to be standard pumping equipment of proven ability as manufactured by reputable companies having extensive experience in the production of such equipment. The equipment furnished shall be designed and constructed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown on the Drawings. The manufacturer of the pump units shall have a quality management system in place and shall be ISO 9001 and 14001 certified.
- B. The Pump Manufacturer shall be fully responsible for the design, arrangement, and operation of all connected rotating components, including soleplates, if any, of the assembled pumping unit mounted on a fabricated steel base plate to ensure that neither harmful nor damaging vibrations occur at any speed within the specified operating range.
- C. The new high service water pumping units shall be complete, including pump, motor, RTDs, and terminal boxes. The high service water Pump Manufacturer shall be responsible for the furnishing and performance of the complete pumping units.
- D. The Pump Manufacturer shall have furnished pumping units in the United States which are similar in design, type, and service, and comparable in size, head, and capacity to those specified to be furnished. Such comparable pumping units shall have been in satisfactory operation for a period of not less than five years.
- E. The Pump and Motor Manufacturers shall currently have maintenance and repair facilities established and in operation in the United States for a period of not less than three years. Such facilities shall be fully equipped and staffed with qualified personnel for making repairs to damaged pumps and motors shall stock or have direct access to a full line of maintenance spare parts.
- F. Vibration:

1. The Pump Manufacturer shall review the Specifications and Drawings, including piping, pipe supports, harnessing arrangements, and foundations to fully evaluate the field installation conditions prior to bidding.
2. Acceptable field vibration and factory vibration limits shall be in accordance with the latest version of the HI Standards. Vibrations in excess of specified limits shall not be acceptable.
3. The Pump Manufacturer's field representative shall measure and record unfiltered vibration amplitudes in velocity units in/sec rms at each of the pump and driver bearing housings in two planes in a radial orientation and in one plane axially. The amplitude measured shall not exceed the limit specified above at any point within the pump's Preferred Operating Range (POR), and it shall not exceed 130% of the limit at any point outside the POR but within the Allowable Operating Range (AOR).

G. Services of Manufacturer's Representative:

1. Provide services of Pump Manufacturer's factory service Engineer specifically trained in the installation, operation, and maintenance of pumping units as specified herein. The services of the Manufacturer's Representative shall be made available during the installation period for assistance to the Contractor for adjusting and checking equipment.
2. The factory representative(s) shall be provided for trips and durations as shown below.

	<i>Services Provided by Factory Representative</i>	<i>Minimum Number of Trips ^{(a),(b)}</i>	<i>Minimum Time at Site Per Trip (Hours)</i>
1	Supervise Setting of Pump Bases, Installation of Pumps, and Check Pump Leveling and Pre-Alignment ^(c)	1	8
2	Inspect Final Pump Alignment ^(d) , Supervise Startup and Initial Run to Demonstrate Successful Operation, Instruct Engineer and Owner's Reps in Proper Startup and O&M	1	8
3	Additional Trips for Troubleshooting Following Installation ^(e)	-	-

(a) Representative(s) shall be present at frequent enough intervals to ensure proper installation, testing, and initial operation of the equipment.

(b) This assumes all pumps are shipped together. Additional trips shall be included for additional shipments.

(c) Before piping connection.

(d) After piping connection. The Manufacturer's representative shall provide to the Design Engineer a written certification that each pump has been installed in accordance with the Manufacturer's recommendations.

(e) Representative(s) shall be present as necessary to operate successfully following start-up. Additional trips/duration address issues associated with equipment defects will be at the cost of the manufacturer.

- H. Casting Quality Assurance/Control: The Pump Manufacturer shall submit an internal quality control - quality assurance program for the review by the Design Engineer. As a minimum the QA/QC program shall include the following:
1. Before manufacture:
 - a. A list of all subcontractors/suppliers outside of the contiguous United States that will be supplying parts and materials for the pumps, and their experience on similar projects for the past 10 years. The list of subcontractors is to be provided within 45 days of the Pump Manufacturer's Purchase receipt of Purchase Order.
 - b. Copies of a dimensional control protocol to establish the manner in which the machining of the castings will be performed, and the control for dimensions for the upper and lower casing castings and the impeller casting.
 - c. Copies of the quality control protocols and reports to confirm that the patterns have been correctly produced.
 2. After manufacture:
 - a. Three-dimensional checks to confirm that castings are within Pump Manufacturer's standards. Copies of all reports are to be provided to the Design Engineer for review.
 - b. For each heat number, the mechanical properties of the pour.
 - c. For each heat number, the chemical composition of the pour.
 - d. Documentation of all heat numbers and pours for the project, to include those castings that were scrapped by the foundry.
 - e. Photographic documentation that the castings comply with the requirements of MSS SP-55.
 - f. Copies of magnetic particles test reports or Hydro and visual reports for the volute and impeller.
 - g. Copies to the protocols for hydrostatic testing and copies of the hydrostatic testing reports.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. The Pump Manufacturer shall provide unloading, storage, and handling instructions prior to shipment.
- B. Pumping units shall be shipped with the motor space heaters connected to a terminal board and ready to be energized.
- C. All equipment shall be delivered in good, sound condition, and free from damage. Equipment which has been damaged will be rejected. Pump Representative shall be on the site to witness the arrival, inspection, and unloading process as specified.

- D. The Contractor shall be responsible for proper unloading, handling, and storage of equipment in accordance with the Manufacturer's instructions.

1.08 MAINTENANCE

- A. Pump Spare Parts: Furnish the Manufacturer's standard set of spare parts for each size pump, including at least the following:
 - 1. One set of pump bearings.
 - 2. One complete mechanical seal.
- B. Motor/Coupling Spare Parts: Furnish the Manufacturer's standard set of spare parts for each size pump, including at least the following:
 - 1. One spare gasket to fit between coupling hub flanges.
 - 2. One complete flexible couplings.
- C. Spare Parts Delivery/Storage: Crate and deliver spare parts in substantial wood boxes with hinged covers. Clearly and indelibly identify the contents of each box on its exterior. Each part shall be sealed, wrapped, or otherwise protected from corrosion during storage.

1.09 PERFORMANCE GUARANTEE

- A. The Manufacturer shall guarantee the performance of each pumping unit to meet or exceed the specified performance. The guarantee shall include the complete pumping unit assembly, and shall cover speed, capacity, head, efficiency, brake horsepower, motor horsepower, and the performance curves for the pump. The capacity, head, and efficiency guarantee shall apply to the Rated Point (Primary Condition) on the pump's head capacity curve at the specified head and capacity specified herein. If the pumping units fail to meet the efficiency at Rated Point, corrective measures shall be taken as indicated in Part 2.

1.10 WARRANTY

- A. The Pump Manufacturer's warranty period shall be concurrent with the Contractor's for two (2) years, commencing at the time of final acceptance by the Owner which shall begin no later than April 15, 2020. Guarantee shall cover all necessary labor, equipment, materials, and replacement parts resulting from faulty or inadequate equipment design, improper assembly, defective workmanship and materials, leakage, breakage or other failure of all equipment and components furnished by the manufacturer.

PART 2 PRODUCTS

2.01 GENERAL

- A. Manufacturer List, no equals:
 - 1. Fairbanks Nijhuis
 - 2. Flowserve, Inc.
 - 3. Goulds
 - 4. Patterson
 - 5. Sulzer

- B. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

2.02 PERFORMANCE AND DESIGN CRITERIA

- A. Pumping units shall be designed for the operating conditions as follows:

Pump Tag	50-PMP-01, 50-PMP-02, 50-PMP-03, 50-PMP-04
Design Points:	
Primary Condition (2 pumps) ^(a) :	
Capacity per pump:	5,208 gpm (7.5 MGD)
Total Design Head (TDH)	249 ft
Minimum Pump Efficiency	83%
Secondary Condition ^(a) :	
Capacity per pump:	4,653 gpm (6.7 MGD)
Total Design Head (TDH):	257 ft
Minimum Pump Efficiency	80%
Low head condition ^(a) :	
Capacity per pump:	6,250 gpm (9 MGD)
Total Design Head (TDH):	227 ft
Minimum Pump Efficiency	80%
Operating head range for full speed continuous operation	200-280 ft
Minimum shutoff head	290 ft
Minimum NPSHA	40.6 ft
Maximum nominal pump speed.	1,800 rpm
Motor size required	450 HP

Pump rotation as viewed from driven end	See drawings
Minimum pump suction nozzle size	12 in
Minimum pump discharge nozzle size	10 in

^(a) The conditions listed shall operate within the pump's preferred operating range (POR), as described per HI Standard 9.6.3.

- B. All specified conditions shall be at rated speed, unless otherwise indicated.
- C. The minimum hydrostatic test pressure shall be 1.5 times shutoff head.
- D. The pump manufacturer shall account for up to 2 minutes of ball valve travel time to account for the duration of run time at shutoff head conditions.

2.03 CASINGS

- A. Materials:
 - 1. Pump casings shall be cast iron conforming to ASTM A48.
 - 2. 125 lb flange rating – ANSI/ASME B16.1, Class 125 raised-face dimensions and drilling.
- B. Design/Fabrication:
 - 1. Casings shall be of sufficient thickness and suitably ribbed, if necessary, to withstand all stresses and strains to which it may be subjected during erection, testing, and operation.
 - 2. Casings shall be of sufficient strength, weight and thickness to provide accurate alignments and prevent excessive deflection.
 - 3. Free of blowholes, sand holes, and other detrimental defects, with smooth water passages.
- C. Split-Case Provisions: Casings shall be split on the horizontal centerline with suction and discharge nozzles cast integrally with the lower half. Removal of the upper half of the casing shall allow the rotating element to be removed without disconnecting the suction and discharge flanges or without disturbing pipe connections or pump alignment. Lifting eyes or lugs shall be cast into the upper casing. Provide tapped holes in flange of upper casing with jack bolts that allow the casing halves to be separated during disassembly.
- D. Taps and plugs: Casings shall be tapped for drains, vents, priming, water seal, and pressure gages. All taps shall be shipped with brass plugs. Plugs will be removed in the field, as necessary, to make connections for the miscellaneous piping and appurtenances. Provide a ¾" tap in the top of the volute for an air release valve.
- E. Finishes: Apply special interior coating as specified under Paragraph 2.22, Interior Finish for Casings.

2.04 IMPELLERS

- A. Materials: Entirely made of nickel aluminum bronze ASTM B148 UNS C958 or AISI Stainless Steel Type 316.
- B. Type: Double suction, enclosed type.
- C. Design/Fabrication:
 - 1. Designed with ample strength and stiffness for maintaining the maximum capacity of the unit.
 - 2. The impeller shall be a one-piece casting completely machined on all exterior surfaces and dynamically balanced. The interior water passage shall have uniform sections and smooth surfaces and shall be free from cracks and porosity.
 - 3. Statically and dynamically balanced to prevent whipping and vibration throughout the operating range, from shutoff head to run out. Perform a precision balance of the entire rotating assembly to ANSI S2.9, G6.3 and provide the balance certificate in the quality control section of the O&M Manual.
 - 4. Pump impeller assemblies shall be statically and dynamically balanced to within 0.5% or W times R squared, where W equals weight and R equals impeller radius.
 - 5. No fillers of any type will be allowed.
- D. Mounting: The impeller shall be mounted on the shaft with a single key which extends beyond the impeller hub, locking the impeller and shaft sleeves against rotation on the shaft.

2.05 WEAR RINGS (CASING AND IMPELLER)

- A. Each pump casing and impeller shall be fitted with removable wearing rings.
- B. Materials:
 - 1. Casing Wear Rings: AISI Type 316 Stainless Steel
 - 2. Impeller Wear Rings: Match impeller material as specified above.
 - 3. Casing Wear Rings and Impeller Wear Rings shall have a Brinell hardness difference of 50.
- C. Type: Full labyrinth double-ring type, single labyrinth double-ring type, or "L" double-ring type.
- D. Design/Fabrication:

1. The casing wear rings shall be positioned in the casing and locked against rotation by the upper half of the case.
2. Wear rings shall be designed and machined to close tolerances to minimize leakage. The diametrical clearance shall not exceed 0.030-inch, and be not less than 0.001-inch per inch of ring diameter.

2.06 SHAFT

- A. Materials: High Grade Alloy 416 Stainless Steel.
- B. Design/Fabrication:
 1. Stress relieved, machined to true dimension, accurately ground and polished over the entire length.
 2. The shaft shall be provided with oil throwers or Inpro seal to prevent oil creeping from the bearings. All parts shall have polished surfaces.
 3. The pump shaft shall be fitted with threads, lock nut, and keyway to fasten the pump half-coupling hub securely.
 4. Shaft diameter shall be sized to prevent torsional and flexural deflection which would cause whipping and vibrating under any condition.
 5. Maximum allowable flexural shaft deflection shall be not more than 75 percent of the radial wearing ring clearance.

2.07 SHAFT SLEEVES

- A. Shafts, where exposed to water or passing through glands and stuffing boxes, shall be protected by renewable (removable) sleeves. Stuffing boxes shall have hardware constructed of corrosion-resistant metals.
- B. Materials:
 1. AISI Type 316 Stainless Steel
- C. Design/Fabrication:
 1. The sleeves shall be secured in place, for both directions of pump rotation, with shaft nuts incorporating set screws for locking purposes.
 2. The sleeves shall be provided with O-rings to prevent leakage between the shaft and sleeves.
 3. Shaft sleeve nuts shall be threaded.

2.08 SHAFT MECHANICAL SEALS

- A. Pumps shall be supplied initially with mechanical type non-split seals which are interchangeable with conventional packing and in conformance with NSF-61.
- B. Materials:
 - 1. Stationary Seal Face: Carbon.
 - 2. Rotary Holder: Stainless Steel, Grade 316.
 - 3. Rotary Seal Face: Ceramic or Silicon Carbide.
 - 4. Seal Glands: Stainless Steel, Grade 316.
 - 5. Springs: Stainless Steel, Grade 316.
 - 6. Elastomers: Viton or Ethylene Propylene
- C. Manufacturer:
 - 1. John Crane
- D. Design/Fabrication:
 - 1. Seal glands shall have a flush connection at the top and along the vertical centerline or at 30 to 45 degrees from the horizontal centerline.
 - 2. Seal must consist of assemblies which fit together over a shaft to form a self-setting and aligning cartridge seal design.
 - 3. The seal must eliminate the need for shims or dimensions to be taken for proper installation.
 - 4. Provide water flushing per API Plan 11 with stainless steel seal water tubing, with stainless steel hand valve, from the pump casing to the gland flush connection. The hand valve shall be tagged with a stainless steel warning tag indicating the valve is to be open at all times during operation.
 - 5. Any additional equipment required, such as pressure relief valve, flow switch, or flow indicator shall be provided by Manufacturer at no additional cost to the Owner. Any instrumentation required for these devices shall be provided by the Manufacturer.

2.09 MISCELLANEOUS FITTINGS

- A. Small fittings and accessories inside the pump and around the shaft sleeves, such as set screws, bolts, and nuts that are exposed to water or water spray, shall be made of non-corrosive materials such as bronze or stainless steel.
- B. Materials: Bronze, stainless steel, or other approved non-corrosive materials.

2.10 PUMP BEARINGS

- A. Pump bearings shall be antifriction, double row, deep-groove type ball bearings. They shall be designed and sized for 100,000 hours calculated minimum L10 rated bearing life at 25% BEP per ANSI/HI 1.3-2013. Each bearing shall be capable of carrying both line and thrust type loads. All bearings shall be manufactured in the United States.
- B. Provide Inpro bearing isolators.
- C. Pump bearings shall be ring oil lubricated or oil bath lubricated. A constant oil level oiler shall be provided. Pump design shall allow for the bearing to be removed without disturbing the upper casing for inspection and replacement of the bearings, seals and shafts.
- D. Bearing housing shall be designed to maintain shaft alignment and ensure long bearing and lubricate life.

2.11 BEARING BRACKETS

- A. The bearing brackets shall be accurately machined and doweled to the casing or with 360 degrees attachment to the upper and lower casing for a perfect shaft alignment by full register fit to the casing. The manufacturer shall have the option of constructing the bearing brackets integral to or separate from the pump casing.

2.12 PUMP BASE PLATE

- A. A support base for pump and motor shall be provided.
- B. The support base shall be structurally capable of supporting the weight of the pump and motor and resisting torsional movement.
- C. The support base shall have adequate drainage.
- D. Submittal of support base design to the Design Engineer prior to fabrication is required.
- E. The pump and motor shall be mounted on a steel base plate or a steel drip rim base plate with integral drip channels incorporated on each side. Pump and motor mounting surfaces shall be machined for ease of realignment after motor replacement.
- F. Stress relieve welded fabrication prior to machining

2.13 ACCESSORIES

- A. Lifting Lugs: Shall be provided and positioned to provide balance during lifting.
- B. Equipment base shall be manufactured and provided by the pump manufacturer and assembled together with the pump.
- C. Jacking Bolt kit or a horizontal alignment tool set shall be provided. Jack bolts should be present at HSP motors to allow alignment in both directions (8 bolts – 2 each).
- D. Oil lubricated units shall be provided with constant level oilers or will sight glasses arranged to indicate operating and static oil levels as described in Section 2.14 herein.
- E. Pump impeller shall be balanced as described in Section 2.04.C.4. to ensure that all rotating parts shall operate smoothly without excessive vibration as defined by manufacturer.

2.14 LUBRICATION

- A. Bearings shall be ring oil lubricated reservoir type. Lubrication oil for bearings shall be food grade.
- B. Oil reservoirs shall include an opening for filling, an overflow opening, a drain at the lowest point, an oil level site glass, and an oil level indicator. Under each oil bearing housing install ESCO oil site conditioning glass. Oil site glass shall be external to the bearing house with proper oil level marks on bearing housing or site glass.

2.15 ANCHOR BOLTS

- A. Design/Manufacturing:
 - 1. Pump Manufacturer shall provide the anchor bolts requirements to the Contractor prior to construction of the structural equipment pad as described below. The Contractor shall provide anchor bolts based on Pump Manufacturer's requirements.
 - 2. Anchoring system shall be appropriately sized and provided by the Pump Manufacturer to adequately handle all loads applied for the piping configuration shown on the drawings in accordance with the Hydraulic Institute Standards. Minimum size: 1/2" diameter anchor bolts.
 - 3. Bolts shall be of adequate length and design to transfer loads into the structural equipment pad.
 - 4. Structural and seismic calculations for pumps: Include calculations for reactions at anchor bolts and selection of the size depth and number of bolts required for use with Simpson Set Epoxy anchor system. Manufacturer can assume Grade 60 Rebar and 4,000 psi concrete. Seismic design parameters are as follows:

<i>Seismic Design Parameters</i>				
<i>Site Classification</i>	F_a	F_v	S_s	S_I
B	1.0	1.0	0.074 g	0.030 g

Where: F_a = Site coefficient
 F_v = Site coefficient
 S_s = Mapped spectral response acceleration for short periods
 S_I = Mapped spectral response acceleration for a 1-second period

2.16 SUCTION AND DISCHARGE CONNECTIONS

- A. Flange Type: Flanges: Suction and discharge nozzles shall be Class 125 lb, flanged, drilled, and machined to match AWWA C207 flanges of connecting pipe. Flanges shall be flat- faced.
- B. Design/Fabrication:
 - 1. Designed for through bolting and straddling vertical and horizontal centerline.
 - 2. Gaskets shall conform to AWWA C207.

2.17 PUMP/MOTOR COUPLINGS

- A. Flexible couplings shall be the heavy-duty type, designed so that each pump shaft may be removed without disturbing the positing or adjustment of the driving unit. Coupling shall be Falk Lifelign Gear Coupling, as manufactured by the Rexnord Corporation. Minimum factor of safety of 1.5 times shaft strength shall be used. Horizontal surface of the couplings shall be machined parallel to the axis of the shaft, and faces shall be machined perpendicular to the axis of the shaft. Provide appropriate coupling gaurgs, acceptable to OSHA< securely attached to the pump base with stainless steel bolts and nuts. Supply couplings with a precision balance certificate from the Pump Manufacturer.
- B. The drive shaft coupling gear shall be gear type and all metal.
- C. Lubrication: Oil or grease.
- D. Baseplate: Cast iron or fabricated steel.

2.18 EQUIPMENT APPURTENANCES

- A. Pumping equipment shall be provided with all necessary equipment appurtenances to make the pumping units functional.
 - 1. Bolts and nuts shall conform to the requirements of ASTM A307.
 - 2. Threads shall be clean-cut and shall conform to ASME B1.1.
 - 3. Stainless steel bolts, nuts, and washers shall be Type 316.

4. Unspecified bolts, nuts, washers shall be zinc coated after being threaded by the hot-dip process conforming to ASTM A123 as appropriate.
- B. Metal equipment guards shall be provided on all equipment driven by open shafts.
1. Guards shall be designed to enclose the drive mechanism completely and be easily removable.

2.19 INFORMATION PLATES / MARKINGS

- A. Materials:
1. Nameplate: 16-gauge stainless steel with ¼-inch die-stamped equipment tag number securely mounted in a readily visible location.
- B. Pump Nameplate: The nameplate shall clearly show pump information and complete performance data, including:
1. Manufacturer's name.
 2. Pump size, type, and model number.
 3. Serial number.
 4. Speed.
 5. Impeller diameter.
 6. Primary Duty Point- Capacity and head rating.
 7. Bearing identification, name, and number.
 8. Pump weight, motor weight.
 9. Date of manufacture.
 10. Other pertinent data.

2.20 ASSEMBLY, MOUNTING, & ALIGNMENT

- A. Factory Pre-mounting and Alignment. Pumps with their job motors shall be pre-mounted and pre-aligned. Mounting holes shall be drilled and tapped at Pump Manufacturer's factory. Factory alignment data shall be furnished to the Contractor. Pump Manufacturer shall drill pump and motor feet only for dowels. Do not drill base plate or install dowels at factory; ship loose.
- B. The Pump Manufacturer shall approve and sign off on proper installation.

- C. A qualified factory-trained manufacturer's representative shall personally inspect the equipment at the jobsite and shall certify in writing that the equipment has been installed, adjusted, and tested, in accordance with the manufacturer's recommendations.

2.21 INTERIOR FINISH FOR CASINGS

- A. Coat interior of pump casings with ceramic epoxy coating to enhance pump efficiency. Prepare and shop-prime, as stated in this Section.
- B. Materials: Prime and Finish Coating: Belzona 1341N efficiency enhancement coating for potable water (ceramic epoxy coating) or fusion bonded epoxy.
- C. Procedure:
 - 1. Surface Preparation: As recommended by coatings Manufacturer, minimum blast clean to near white SSPC-SP-10.
 - 2. Application (prime and finish coating): Apply 25 mils DFT of Belzona coating or fusion bonded epoxy.
 - 3. Testing: Perform Holiday Test.
 - 4. Touchup: After testing is complete and prior to shipment, touch up surfaces. Provide touch up kit for contractors use during installation. If holiday test is required, perform at shop prior to shipment and provide certification.

2.22 EXTERIOR FINISH

- A. Exterior of pumps, motors, frames, base plates, and appurtenances shall be painted prior to shipment from factory. Pump units shall be prepared and shop-primed as follows:
 - 1. Surface Preparation:
 - a. All bare metals or areas that were shop primed that have been damaged shall be abrasive blast cleaned to SSPC-SP6, commercial blast cleaning standards.
 - b. Shop primed items, stored on site for a prolonged period prior to coating, shall be prepared for coating following the coating manufacturer's recommendations prior to applying touch-up and subsequent coats. Surface preparation may include brush-off abrasive blasting or spot blasting to SSPC-SP6, commercial blast cleaning standards, for areas where the primer has been damaged and bare metal is showing.
 - c. Non-ferrous metals shall be degreased and cleaned by washing with a water based dispersant such as Carboline Surface Cleaner #3. Rinse thoroughly with clean water after cleaning.

2. Coating System:
 - a. Prime coat for ferrous and non-ferrous metal: Two part epoxy primer. Tnemec's Series 140, must be white, at 4.0 mils DFT.
 - b. Intermediate coat for ferrous metal: Two part epoxy. Tnemec Series 140 with beige color at 3.0 mils DFT.
- B. Contractor to apply finish coating in the field: Two coats of epoxy primer and polyurethane finish coat at 4-6 mils nominal DFT per coat.

2.23 DRIVE UNITS

- A. Electric Motors.
 1. The electric motors shall be designed as specified in Section 16151 – Large Induction Motors.

2.24 SHOP TESTING

- A. Each pumping unit, including pump and motor, shall be witness tested at the Pump Manufacturer's factory as specified herein. Each unit shall be hydrostatically tested in accordance with the Hydraulic Institute Standards. Acceptance testing shall be per HI Standards Table 14.6-3.4, Grade 1B.
- B. FACTORY WITNESS TESTING
 1. One representative from the Owner and one representative from the Engineer will witness the High Service Pump factory pumping unit test.
 2. Witness Test Trip
 - a. The Contractor shall reimburse the Engineer for Engineer's time at a rate of \$1,200 per day times the number of days required for the factory test visit, travel days included.
 - b. The Contractor shall arrange to provide an interpreter/guide for the entire time that the Owner's representatives are in the country for trips outside North America.
 - c. Provide a testing schedule before the trip agenda is set. Tests may not start any sooner than 12 hours after arrival at hotel for trips outside North America. Owner and Engineer will review agenda to ensure adequate time is allowed for shorter flights.
 - d. For trips outside North America, the Contractor shall provide and pay for at least one cellphone to be used by the Owner's representatives, purchased in the United States with a United States phone number that works at all times and locations as required by the witness testing.
 - e. The Contractor shall obtain any letters of invitation to enter the country in question on business and be responsible for paying for and making all arrangements to obtain the visa for each person.

- f. Each of the Owner's Representatives shall be responsible for obtaining their own passport. This is not the responsibility of the Contractor.
- g. The Contractor shall designate a local firm that does Visas to collect each passport, send it overnight to their representative. The Contractor's local firm shall be responsible for all Visa processing requirements and then overnight each passport directly back to each person. Each Owner's and Engineer's Representative shall have the Visas in hand at least two weeks before the flight.
- h. Provide Economy Class (Coach) Flight arrangements. Provide confirmed reservations at least two weeks before the trip.
- i. Owner's and Engineer's Representatives shall be allowed to return at any time. Contractor shall be responsible for any penalties, if applicable. Owner and the Engineer will stay no more than two weeks for factory testing. For factory test requiring more than two weeks, Contractor shall make travel arrangements for additional personnel from Owner and Engineer.
- j. For each additional trip after the first that is required due to witnessed testing partial/complete failure or incomplete occurrence because the Contractor or Manufacturer is not ready, any component of the motors/pumps are not ready for testing, or any other reason caused by the Manufacturers, Contractor, or his Subcontractors/Suppliers, the Contractor shall pay all costs described in 2.24.B.2. In addition, Contractor shall reimburse Engineer for Engineer's labor at \$1,200 per day.

C. FACTORY TESTING

1. Each constant speed pumping unit shall be tested with its job motor by the Pump Manufacturer at their plant prior to shipment. Each pumping unit shall be tested with water in accordance with the Standards of the Hydraulic Institute, Centrifugal Pump Section Test Code and Rotodynamic Pumps for Hydraulic Performance Acceptance Tests to determine compliance with Pump Manufacturer's head-capacity curve and confirm guaranteed pump efficiency. Pump testing shall provide the actual measured wire to water efficiency. A hydrostatic test of the pump casing shall also be performed. Model tests will not be accepted. Factory testing shall be the final criteria for acceptance by the Owner for the tests specified in Paragraph 2.24.E. of this Section. Acceptance criteria for vibration as specified in this section shall include both factory and field tests. Field testing will be the final criteria for acceptance by the Owner for the tests specified in Paragraph 2.24.E. Factory test data and results shall be submitted for review prior to the equipment being shipped to the jobsite.
2. All factory pumping unit tests shall be performed with actual motors to be supplied to ensure that the same motor/pump units that are factory tested together are installed together in the field.

3. The factory test report shall be certified by a licensed Professional Engineer. Certified copies of the test data for each pump shall be furnished to the Owner as part of the Test Book referenced in Paragraph D. Test curves and data sheets shall include head-capacity curve, brake horsepower curves, pump efficiency curves, motor Manufacturer's efficiency curves, pump efficiency curves, NPSH requirements, and a sketch of the test installation. Data for the entire pump range (from minimum head to shut-off) shall be included.
4. Shop tests shall be made at the speeds and horsepower required by the pump. Suction conditions for the test shall duplicate the Net Positive Suction Head available for continuous operation under which the pump will operate. Pumps shall have a minimum NPSH margin of 25%.
5. All tests for pumps shall be run at specified speeds indicated in the respective specification over the full range of the curve.
6. Pump Manufacturer shall provide one digital copy of video recordings with sound for each size pumping unit showing disassembly and reassembly of the pumps. Written copies of the sound script shall also be bound and provided to the Owner for their use in operation and maintenance.
7. Only after receipt, review, and approval of all factory test data, and preliminary O&M Manuals for pumps and motors, the Owner will give permission to Pump Manufacturer for shipment of pumping units.

D. FACTORY TEST BOOK

1. The Pump Manufacturer shall prepare and submit a Test Book for the Owner's review at least 60 days before any testing is scheduled. The Test Book shall be the test report minus test data and shall contain the following information:
 - a. Description of tests to be conducted.
 - b. Description of test procedures.
 - c. Copy of test standards.
 - d. Calibration of Instruments. All instruments shall be calibrated in accordance with Hydraulic Institute Standards just prior to and after all performance testing. Manufacturers performing the shop tests shall furnish the Owner approved certifications of calibrations. Bourdon or bellows gages shall be calibrated at the time of each test.
 - e. A certified curve showing the calibration of the flowmeter used in the pump capacity test shall be furnished as part of the data and permanently bound with all other data. The data shall include coefficient of discharge and flow versus differential pressure if an orifice plate or venturi is used.
 - f. Dimensional layout of test assembly and reservoir.
 - g. Photos of test facility.

E. FACTORY TESTS TO BE PERFORMED

1. Hydrostatic Test: Each new pump unit shall be hydrostatically tested to one and one half times its maximum working pressure or 150 psi, whichever is greater. Maximum working pressure is defined here as the shutoff head pressure. Test duration shall be 30 minutes. Submit certified hydrostatic test results and test procedures.
2. Performance Test: Record data at a minimum of ten flows vs. head conditions with three of the points being those indicated below. Enough points shall be tested so that a smooth curve may be drawn through the points.
 - a. Allowable tolerances for the desired points shall be as defined in the Hydraulic Institute Standards, Section 14.6, acceptance grade 1B.
 - b. The manufacturer shall make continuous measurements and record the maximum down-thrust and maximum up-thrust for all conditions of its operation, including momentary loads from start-up and shut-down.
 - c. The pump test results shall specify the pump performance curve to be performed to at least minimum head within the allowable operating range to shut-off head and define minimum head.
 - d. The performance test for all pumping units shall be conducted with the pump and job motor.
 - 1) Shut-off head.
 - 2) Rated point.
 - 3) Minimum head point for continuous operation without cavitation.
3. Noise Tests. Noise readings shall be taken and recorded at points specified below:
 - a. Maximum Noise Level: The maximum noise level of each assembled pumping unit located within or outside a structure shall not exceed 85 dBA at a distance of one meter (3.281 feet) from the nearest surface of the machine. Measurements shall be made on each complete unit, which includes the pump, motor, and coupling.
 - b. Sound tests shall be recorded at a minimum of five flow versus head conditions, including shut-off head, rated point, and minimum head point for continuous operation without cavitation. Sound level measurements shall be made on the pumping unit under single unit operation. All sound level testing in the factory may be witnessed by the Owner, Pump Manufacturer and Motor Manufacturer.
4. Test Log: Record the following:
 - a. Total Head.
 - b. Flow capacity measured by factory instrumentation and storage volumes.

- c. Power requirements.
 - d. Average difference in elevation of water surface in suction well to pump discharge centerline for duration of test.
 - e. Pump suction and discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.
 - f. Pump speed.
 - g. Water temperature.
 - h. Elevation of test stand.
 - i. F.F.T. vibration plots of amplitude versus time out to 150,000 cycles/min at twelve points (three points per bearing, x, y, z). Vibration levels on test stand shall meet the specified vibration limits at the factory. Field vibration analysis will be performed by an independent testing laboratory on installed pump unit.
 - j. Perform noise test in accordance with Section 2.24.E.6.
5. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards, if necessary.

PART 3 EXECUTION

3.01 LEVELING

- A. The base plate will be set to true level using machinist's level. The tolerance for leveling will not exceed 2/1000 inch per foot length along any side of the base plate. The Representative for the Pump Manufacturer shall be present during the leveling. The Pump Manufacturer shall certify that the leveling is in accordance with the limits specified herein and is acceptable to the Manufacturer.

3.02 FIELD QUALITY CONTROL

- A. Conduct field test as specified below:
 - 1. Each pump system shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, cavitation, or overheating of bearings.
 - 2. The following field testing shall be conducted:
 - a. Startup, check, and operate the pump system over its entire speed range. Unless otherwise specified, vibration shall be within the amplitude limits recommended by the Hydraulic Institute Standards at a minimum of three pumping conditions defined by the engineer.
 - b. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least four pumping conditions at each pump rotational speed. Check each power lead to the motor for proper current balance.

- c. Determine bearing temperatures by contact type thermometer. A run time of at least 20 minutes, or until temperature is stabilized, shall precede this test, unless insufficient liquid volume is available.
 - d. Electrical and instrumentation tests shall conform to the requirements of the Section under which that equipment is specified.
 - 3. Field testing will be witnessed by the Engineer. The Contractor shall furnish three weeks advance notice of field-testing.
 - 4. In the event any pumping system fails to meet the test requirements, it shall be modified and retested as above until it satisfies the requirements.
 - 5. After each pump 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 test, and the test data.
 - 6. The Contractor shall bear 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.
- B. Functional Tests: Conduct on each pump.
 - 1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation. Pump and motor shall be aligned using a laser alignment instrument at final site.
 - 2. Vibration Test:
 - a. Test with units installed and in normal operation, and discharging to connected piping systems at rates between the low discharge head and high discharge head conditions specified, and with the actual building structures and foundations provided shall not develop at any frequency or in any plane, peak-to-peak vibration amplitudes exceeding the limits specified.
 - b. If units exhibit vibration in excess of the limits specified, adjust or modify as necessary.
 - 3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
 - 4. Noise Test: Test pumping for noise in accordance with Paragraph 2.24.E.4. Equipment installed that exceeds allowable noise level limits must be re-worked, reinstalled, balanced or adjusted to reduce noise. Methods to reduce noise, including equipment insulation, must be approved by the Engineer.

C. Owner's Acceptance Basis

1. The Owner will accept the pumps after demonstration of proper functioning of all components and upon successful completion of the factory and field acceptance tests.
2. Penalty for Efficiency: If, as a result of the factory test, the efficiency of any pumping unit (pump and motor) is less than the specified minimum pump efficiency at Rated Point, the Owner, at his discretion, may reject the equipment, and require the Pump Manufacturer to provide a pump and motor as specified.
3. There is no credit for efficiency values obtained during factory testing that are greater than the guaranteed pump efficiency.
4. If, as a result of the factory and field testing of the pumping units for vibration failed to meet the acceptance criteria, the Owner may reject the pumping units or required pumping unit supplier to modify the units to comply with specified vibration limits. All expense of retesting the units by Independent Testing Laboratory shall be borne by the Pump Manufacturer.

3.03 TRAINING

- A. The Pump Manufacturer shall provide instructional training on the operation and maintenance of the equipment, including pump and motor, as specified in this section.
1. Provide manufacturer's services for training of plant personnel in operation and maintenance of the equipment furnished under this section.
 2. The training shall be for a period of not less than one eight-hour day.
 3. The cost of training program to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.
 4. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.
 5. The training session shall be conducted by a manufacturer's qualified representative.

END OF SECTION

SECTION 16151

LARGE INDUCTION MOTORS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies the requirements for custom-built, premium electric motors as specified. Unless otherwise shown or specified, the motors shall be single speed, single winding, in strict compliance with the requirements specified herein. The driven equipment manufacturer shall select the exact motor speed.
- B. Medium Voltage Induction Motors
 - 1. The provisions of this Section shall apply to all medium voltage AC squirrel cage induction motors.

1.02 RELATED WORK

- A. Section 11110 Horizontal Split-Case Centrifugal Pumps

1.03 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Section 01300 and as specified herein.
- B. Submittals for equipment specified herein shall be made as a part of equipment furnished under other Sections. Individual submittals for equipment specified herein will not be accepted and will be returned unreviewed.
- C. Shop Drawings and Product Data. For each motor specified under this Section, submit the following information:
 - 1. Nameplate data in accordance with NEMA MG-1.
 - 2. Additional Rating Information:
 - a. Service factor
 - b. Locked rotor current
 - c. No load current
 - d. NEMA insulation system classification
 - e. Temperature rise at rated full load, by resistance temperature detector (RTD) and by resistance.
 - 3. Maximum ambient temperature for which motor is designed.
 - 4. Frame size, outline dimensions, net weight and weight of rotating element. Include surge protection dimensions and weight.

5. Conduit box dimensions and usable volume as defined in NEMA MG-1 and NFPA 70 and internal arrangements.
 6. NEMA machine type (ODP, WP-1, TEFC, etc.).
 7. Bearing size and calculation, based on L10 life.
 8. Lubrication (compatible with pump manufacture).
 9. Efficiency at 1/4, 1/2, 3/4, full load, and service factor.
 10. Power factor at 3/4 and full load.
 11. Space heater voltage and wattage.
 12. Surge protection information, including mounting details.
 13. Platinum resistance temperature detector (RTD) literature with wiring diagram.
 14. ALARM and TRIP temperatures for winding and bearing RTDs.
 15. Locations and sizes of lubrication connections, vents, drains, etc.
 16. Locked rotor withstand time.
 17. Allowable time periods between starts
 18. Schematic and interconnection diagrams.
 19. Instruction manual.
 20. Maximum sound level in accordance with NEMA MG-1.
 21. Date of Manufacture
 22. Cable terminations
 23. Maximum Power Factor Capacitor Bank KVAR that can be switched with the motor.
 - 24.
- D. Factory Tests. Submittals shall be made for factory tests specified herein.
- E. Field Test Reports. Submittals shall be made for field tests specified herein.
- F. Operation and Maintenance Manuals.
1. Manufacturer's contact address and telephone number for parts and service.
 2. Project record drawings clearly indicating operating features and including as-

- built shop drawings, outline drawings, and schematic and wiring diagrams.
3. Instructions for erection, alignment (including tolerances), and preparation for use.
 4. Complete description of safety equipment, safety procedures, and safety precautions.
 5. Normal starting, running and shutdown procedures, as well as emergency shutdown procedures.
 6. Recommended number of starts in any 24-hour period.
 7. Normal maintenance, inspection and lubrication procedures.
 8. Recommended spare parts list.
 9. Recommended renewal parts list
 10. Record Documents for the information required by the submittals above.

1.04 REFERENCE STANDARDS

- A. Motors shall be designed, built, and tested in accordance with the latest revision of the following standards:
 1. National Electrical Manufacturers Association Inc. (NEMA)
 - a. NEMA MG1 Part 20 – Large Machines.
 - b. NEMA MG2 - Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators.
 - c. NEMA MG3 - Sound Level Prediction for Installed Rotating Electrical Machines.
 2. National Fire Protection Association (NFPA)
 - a. NFPA-70 - National Electrical Code.
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
 - a. IEEE Std 1 - General Principles for Temperature Limits in the Rating of Electric Equipment.
 - b. IEEE Std 43 - Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - c. IEEE Std 85 - Test Procedures for Airborne Sound Measurements on Rotating Electric Machinery.

- d. IEEE Std 112 – Standard Test Procedure for Polyphase Induction Motors and Generators.
 - e. IEEE Std 275 - Recommended Practice for Thermal Evaluation of Insulation Systems for AC Electric Machinery Employing Form-wound Pre-insulated Stator Coils, Machines Rated 6,900 V and Below.
 - f. IEEE Std 429 - Standard Test Procedure for the Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form-wound Stator Coils.
4. Anti-Friction Bearing Manufacturer's Association Inc. (AFBMA):
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DEFINITIONS

- A. Motors specified herein are three-phase, squirrel cage induction type, except as specifically specified elsewhere in these Specifications.
- B. The word "Drive" shall be construed to mean the driven equipment, i.e. pump, hoist, fan, compressor.
- C. If there is inconsistency of size on different Drawing sheets or between Drawings and other sections of Specifications, relating to the horsepower designation, then the larger size shall be required.

1.06 QUALITY ASSURANCE

- A. Unit Responsibility. The electric motor shall be furnished guaranteed by the driven equipment manufacturer, to assure single unit responsibility.
- B. When motors are furnished with driven equipment, the driven equipment supplier shall be responsible for mounting the motor and driven equipment as a complete unit, correctly aligned and coupled with the coupling or sheave specified on the driven equipment data sheet, and for designing vibration, special, or unbalanced forces resulting from equipment operation.
- C. The Contractor, at no additional cost to the Owner, shall make structural, mechanical and electrical changes that are necessitated because the Contractor selects equipment with dimensional, power or mechanical differences from that shown on the Drawings. All engineering costs associated with revisions shall also be borne by the Contractor.
- D. Motor Compatibility. The Contractor shall satisfy himself that the motor included with the drive is compatible with driven equipment and complies with these Specifications. In the event that the motors described in these Specifications cannot be applied to the application or equipment offered, the Contractor may submit an exception, stating clearly the deviations and the reasons for such deviations. The acceptance or rejection of such deviations shall be at the sole discretion of the Owner/Engineer.

- E Motors manufactured prior to the date of this Contract will not be acceptable.

1.07 JOBSITE DELIVERY, STORAGE AND HANDLING

- A The equipment shall be delivered as specified in Section 11110.
- B Where space heaters are provided in motors, provide temporary electrical power and operate space heaters, during jobsite storage and after motors are installed in permanent location, until equipment is placed in service.
- C The motor shaft shall be rotated on a monthly basis, if such is recommended or required by the motor manufacturer; the date recorded, and copies of the record provided to the Owner/Engineer and the manufacturer. The manufacturer shall confirm receipt of the rotation record.

1.08 WARRANTY

- A The Manufacturer's warranty period shall be concurrent with the Contractor's for two (2) years, commencing at the time of final acceptance by the Owner which shall begin no later than April 15, 2020. Guarantee shall cover all necessary labor, equipment, materials, and replacement parts resulting from faulty or inadequate equipment design, improper assembly, defective workmanship and materials, leakage, breakage or other failure of all equipment and components furnished by the Manufacturer.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

- A Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - 1. General Electric
 - 2. US Motors
 - 3. TECO – Westinghouse
 - 4. Siemens
 - 5. Toshiba
- B The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 GENERAL REQUIREMENTS:

- A Each motor provided shall have an Identification Tag Number, conforming to the numbering system and equipment name shown on the Drawings.

- B. Specific motor data such as HP, RPM, enclosure type, etc., is specified under the detailed specification for the mechanical equipment with which the motor is supplied.
- C. Motors shall have sufficient horsepower and torque capacity to drive the equipment without overloading under all conditions, without exceeding the nameplate rating of the motor and without use of the service factor.
- D. Motors shall be NEMA Design B standard, unless otherwise specified.
- E. All motors shall be continuous time rated suitable for operation in a 50 degrees C ambient, unless specified otherwise.
- F. The motors shall be provided with an anti-reverse ratchet to prevent reversing due to phase reversal or backspin at shutdown.
- G. Each motor shall have couplings keyed to shafts. Coordinate with the driven equipment manufacturer with regard to finished product.
- H. Where frequent starting occurs, the design for frequent starting duty shall be equal to the duty service required by the driven equipment.
- I. Altitude: Under 3300 FT.
- J. The motor manufacturer's nameplates shall be engraved or embossed on stainless steel and fastened to the motor frame with stainless steel screws or drive pins. Nameplates shall indicate clearly all of the items of information enumerated in NEMA Standard MG1, as applicable, including but not limited to the following information:
 - 1. Main Nameplate
 - a. Horsepower (output).
 - b. RPM at full load.
 - c. Time rating.
 - d. Frequency.
 - e. Number of phases.
 - f. Model number.
 - g. Rated voltage.
 - h. Service factor.
 - i. Full load amps.
 - j. Insulation class.
 - k. NEMA design letter.
 - l. NEMA code letter.
 - m. Temperature Rise.
 - n. Manufacturer's Frame size
 - o. Date of manufacture.
 - p. Direction of rotation (if uni-directional).
 - q. Thermal protection.
 - r. Motor Weight
 - s. Ambient temperature rating
 - t. Max KVAR for power factor correction

- u. Efficiency
 - v. Power factor
- 2. Heater Nameplate.
 - a. Voltage and wattage.
- 3. Bearings Nameplate.
 - a. Bearing manufacturer's name, identification, and recommended lubricant.
- 4. Dynamic Balance Nameplate.
 - a. Furnish and mounted on motor.
- K. Motors shall have a breather drain in each end bracket of a TEFC motor enclosure. Stainless steel automatic breather drains shall be provided in the lowest part of both end brackets to allow drainage of condensation.
- L. Motors shall have an oversized, gasketed, cast iron conduit box, field adjustable in 90-degree increments unless the box contains equipment, diagonally split with tapped NPT threaded conduit entrance hole, and shall exceed the minimum volumes defined in IEEE 841-2001. Neoprene conduit box cover gasket and neoprene lead seal gasket with flexible nipples to ensure the seal is maintained as the leads are moved shall be furnished. Provision for grounding shall be provided in the conduit box utilizing a mounted clamp-type lug.
- M. Provide separate accessory lead conduit boxes. Minimum size entrance hub shall be ¾" C. Resistance temperature detector leads shall not occupy the same box with any other type of power or monitoring leads.
- N. Provide lifting lugs on the motor frame.

2.03 RATING

- A. Description. Unless otherwise specified, the motors shall be induction motors, single speed. The driven equipment manufacturer shall determine the speeds. Nameplate horsepower of the motor shall not be less than that shown on the Drawings, and as specified herein.
- B. Nameplate horsepower rating of motor shall be equal to or greater than the total horsepower requirement for the driven equipment. Motor shall be designed in accordance with applicable provisions of the latest NEMA Standard Publication for Motors and Generators, MG-1, Part 20, subject to modifications and additions as herein set forth.
- C. Motors shall be suitable for full voltage direct-on-line starting.
- D. All motors shall have a service factor of 1.15.

1. In sizing motors, no portion of a motor's service factor above 1.0 shall be used in normal continuous operation of the motor.
- E. All motors shall have Class H insulation and shall be rated at the following temperature rises:
1. For motors 1500 horsepower and less, the motor windings shall be capable of operating continually at 115% of nameplate horsepower, with rated voltage and frequency applied, and with a temperature rise by embedded detector not exceeding 80 C over a 50 C ambient temperature.
 2. The ambient air temperature shall be defined as air immediately surrounding the motor.
- F. Voltage: Motor voltage, phase and frequency shall be 4160V and as specified with the driven equipment.
- G. Power Factor: Minimum Power Factor at Full Load: greater than 0.85. The motor manufacturer shall not utilize correction capacitors to achieve this power factor.
- H. Starting Voltage: Each motor shall be capable of accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90% of motor rated voltage.
- I. Locked Rotor Current: The locked rotor current of the motor shall be limited in accordance with the National Electrical Code and NEMA MG-1 standards, to a maximum of Code Letter G, (6.29 kVA per horsepower). The code letter shall be clearly shown on the nameplate.
- J. Safe Stall Time: Safe stall time shall not be less than 15 seconds.
- K. Noise Measurement: The noise level as measured by IEEE Standard 85, the maximum noise level shall be 85 dBA at 1 meter and shall be coordinated with pump manufacturer, and submitted for approval.
- L. Slip: The full load RPM shall match or exceed the pump design RPM.
- M. The Contractor shall coordinate with the motor manufacturer and Division 16484 motor control manufacturer to provide the correct capacitor kVAR to correct the power factor as specified. The capacitors shall be mounted in each individual motor controller.

2.04 Efficiency: Motor efficiency shall be evaluated and determined by the pump manufacturer as specified in Section 11110. All motors shall have the efficiency evaluated with the pump. Motor efficiency shall not be less than 95% and power factor not less than 85% when operating at maximum speed, service factor load and rated voltage and frequency.STATOR

- A. The stator core shall be built up with high grade, non-aging laminated silicon steel, C5 or better. Each lamination core shall be plated to minimize eddy current losses. The laminations shall be adequately secured to the stator frame and securely held in place at each end. There shall be no perceptible buzzing of laminations during operation. Provide

slot wedges for rigidity.

- B. The motor stator winding shall be provided with premium grade full Class H insulation or better. Silicone rubber insulation is not acceptable
1. A VPI insulation system shall be used to provide high resistance to moisture and other contaminates.
 2. All windings shall be copper; assembled using form wound coils of the same size and shape. Random wound coils are not acceptable.
 3. The form wound coils shall be constructed with copper wire. The stator construction method shall accommodate VPI treatment. The coils shall be covered with strand insulation consisting of Dacron polyester glass fiber film or other high temperature insulating film.
 4. Provide full length slot liners rated 5000 volts minimum which extend beyond the stator core iron to reduce the possibility of tracking to ground.
 5. Coil insulation shall be tightly applied to eliminate all air voids.
 6. Coils shall be tightly inserted into the stator slots without damage. Coils shall be secured to surge ring or treated rope and securely laced to one another as necessary to prevent distortion and expansion.
 7. The end turns shall be blocked top, sides and bottom. The surge ring shall be designed and installed to prevent movement during starting and short circuit conditions.
 8. The entire stator shall be oven cured to provide a completely sealed insulation system.

2.05 ROTOR

- A. The shaft shall be steel, accurately machined, smoothly finished, with sufficient strength to withstand all stresses resulting from normal operation at any speed up to and including a 25% over-speed condition. Provide shaft end details coordinated with pump and shafting as specified.
- B. The core shall be built up with high-grade non-aging silicon steel, each single piece lamination core plated to minimize eddy current losses. Core mechanical integrity shall not rely on any electrically active component
- C. Rotor bars and end ring shall be copper or copper alloy with uniform resistance characteristics so as to equalize thermal stresses. The bars shall be rectangular or shaped to meet motor starting and running torque requirements. Each copper rotor bar shall be mechanically locked or secured in the rotor pole slots to minimize movement and vibration. Rotor end rings shall be free of circumferential joints and shall be 100% swaged to the rotor bars by an induction or torch brazing process.

- D. Rotors shall be statically and dynamically balanced prior to assembly. Balancing shall be checked after assembly with the motor running at rated speed. Run out on the shaft shall be checked and in no case shall they exceed 0.001 inch measured with a precision indicator with the reading taken at the end of the shaft.
- E. The cage bars shall be copper or a copper alloy with uniform resistance characteristics so as to equalize thermal stresses. ALUMINUM ROTOR BARS ARE NOT ACCEPTABLE. Rotor bar shall be in tension at all times and shall be brazed at the end ring connections. Fabricated aluminum rotors are unacceptable.

2.06 BEARINGS

A. Horizontal Motors

1. Motors shall have anti-friction open or single-shield, vacuum-degassed steel ball or roller bearings, electric motor quality, with extended pipe zerk fitting and 1/2-lb relief fitting for external lubrication while machine is in operation. The bearing shield shall be on the motor winding side of the bearing unless the design is a flow through system. If so, the bearings shall not be shielded.
2. Heavy brackets mounted from the motor frame shall support the bearing housings.
3. The bearings shall have a rated fatigue life of L10 100,000 hours for direct coupled applications, minimum.
4. When a continuous axial thrust condition exists, the motor shall be provided with a supplement thrust bearing or two anti-friction bearings of adequate size to handle the momentary and continuous thrust conditions specified.
5. A high-quality bearing seal shall be provided to prevent moisture and contaminants from entering the shaft end into the bearing, and provided with means of flushing old lubricant and introducing new lubricant. This shall be supplied in addition to tight mechanical bearing housing fits.
6. Couplings shall be as specified in Section 11110.
7. The opposite drive end bearing shall be insulated from shaft-bearing-frame current. Bearing temperature detectors shall also be insulated.

2.07 LEADS

- A. Motor Leads. Use ASTM B 173, Class G, stranded copper.
- B. Provide permanent identification numbers on leads according to NEMA MG 1-2.02. Provide each lead with additional identification within six inches of the stator frame. Use crimp-on, solderless copper terminals on leads and place heat-shrink insulation sleeves or covers between leads and terminals.
- C. The motor leads shall have the same class of insulation as the motor stator windings.

Leads shall be numbered for clockwise rotation when facing the opposite of the shaft end.

- D. Cable termination material shall be as manufactured by Raychem; 3M Corp.; Elastimold or equal. All material used in terminating medium voltage cables shall be as recommended by the cable manufacturer. Cables shall be terminated in accordance with the kit supplier's drawings.
- E. Cable terminations shall meet or exceed IEEE Standard 48, Class I requirements.
- F. The motor leads and medium voltage cables shall not be spliced.
- G. Cable accessories shall be by one manufacturer to assure adequate installer training and application assistance.

2.08 ENCLOSURE

- A. Unless otherwise specified, motor enclosure shall be TEFC, as specified herein and be in compliance with NEMA MG-1.
- B.

2.09 HARDWARE

- A. Use structural bolts, washers, nuts, pins, and similar items manufactured of high-strength stainless steel. Use only hexagon-head bolts and hexagon nuts.

2.10 TERMINAL BOXES

- A. Description. Provide custom built, gasketed, oversized conduit boxes and terminal housing cabinets for all wiring connections to motor. The cable entrance to the boxes shall be from the bottom side. Unless otherwise shown on the Drawings, all terminal boxes shall be located on the same side of the motor. Verify exact location of cable entry, before design, from the Contract Drawings.
- B. Main Terminal Housing. The main terminal box shall be custom designed to accommodate all conductors and specified accessories located in the Terminal Housing.
 - 1. Provide NEMA multiple-hole pads with standoff insulators, as defined in NEMA MG 1 Table 20.3 to terminate the incoming motor leads.
 - 2. The motor terminal box shall be sized to accommodate prefabricated shrink-on cable terminators as manufactured by 3-M or RayChem without exceeding the minimum bending radii per cable manufacturer.
 - 3. Motor leads shall be marked for permanent identification.
 - 4. Provide grounding lug in box for incoming equipment grounding conductor(s). The main terminal box shall be installed integral with the motor.

5. Where lightning arrestors, and/or surge capacitors are shown or specified to be located in the Terminal Housing, the size of the housing shall be increased to accommodate the additional equipment.
 6. Refer to plans for conduit size entering terminal box.
- C. Space Heater Terminal Box: Provide a separate terminal box on the motor for termination of the wires on strap screw or tubular clamp terminal blocks.
 - D. RTD Terminal Box: Provide a separate terminal box on the motor for termination of motor, bearing and ambient RTD leads, for termination of the wires on tubular screw clamp terminal blocks. Box shall accommodate a 2-1/2" C minimum.
 - E. Signal leads using low voltage or current shall not be housed in the same connection box as leads carrying 120 volts or currents in excess of 1/2 ampere.
 - F. Leads shall be suitably marked and identified with heat shrink markers.
 - G. Accessories boxes shall have stainless steel nameplates, attached with stainless steel screws. The nameplates shall say "SPACE HEATER", BEARING RTD's", "WINDING RTD's", etc.
 - H. Accessories boxes shall be bottom entry.
 - I. Use only corrosion-resistant materials.
 - J. Permanently identify all leads and terminals.
 - K. All wires and electrical connections shall be copper.
 - L. All wiring penetrating the motor frame shall be protected against chaffing with grommets.

2.11 SURGE PROTECTION

- A. Provide Lightning arrester (4.5Kv) to limit the magnitude of the transient voltage spike and surge capacitor (0.5 microfarad) to limit the rate of rise of voltage. Both shall be located in the Terminal Box on the motor. The surge capacitor shall be connected between the motor and lightning arrester and capacitor lead length shall be less than three (3) feet.

2.12 GROUNDING MEANS

- A. Provide a grounding lug threaded into the motor frame within the motor terminal box and other motor conduit boxes. Lug shall be similar and equal to Burndy KC Servit. Provide two NEMA 2-hole ground pads located near the base of the motor mounted 180° apart.

2.13 SPACE HEATERS

- A. Type. Electric resistance, 120 volts, silicon rubber clad or rubber epoxy or equivalent non-oxidizing exterior, with maximum surface temperature of 130 degrees C (266 degrees F).
- B. Alternatively, provide two stainless-steel-sheathed conventional space heaters, each with rated watts at the specified voltage equal to twice the required value, and connect in series.
- C. Space heaters shall maintain the internal temperature above dew point when motor is not operating.
- D. Heaters shall not be located directly in access opening where they may pose a danger of burn or shock to servicemen.
- E. Space heater wiring shall be routed to prevent wire being between the frame and space heater.

2.14 RESISTANCE TEMPERATURE DETECTORS (RTDs)

- A. Type: Platinum, 100 OHM at 0 degrees C.
- B. Quantity.
 - 1. Six: Two per phase for the motor windings.
 - 2. Two: One for each Motor Bearing. Each thrust bearing and lower radial guide bearing shall have a 100-ohm platinum RTD installed for sensing bearing temperature.

2.15 SPARE PARTS

- A. Manufacturer's standard shop paints for prime and finish coats are acceptable. Include one pint of finish paint for each motor. If environmental regulations prohibit paint shipment, the Contractor may supply the same paint type and color from a local source.

2.16 SPECIAL TOOLS

- A. Furnish with the equipment, one (1) set of any special tools or devices required for the assembly, operation, and maintenance of all equipment furnished.
- B. Motor manufacturer shall furnish one Altek RTD calibrator model 211, or equal, to check the proper installation of RTD's prior to final acceptance.

2.17 LUBRICANT

- A. Furnish with the equipment, oil of the recommended type and grade, in sufficient quantity for initial filling and for operation during acceptance tests and installation.
- B. The Manufacturer shall provide a list of lubricants available sources. In addition, provide the Owner with a sufficient quantity of lubricant for required service during the first 12

months after start-up.

2.18 FACTORY TESTS

- A. Perform Routine Factory Tests for Polyphase Medium Induction Motors and the tests specified herein: The method of testing shall be in accordance with IEEE Std 112, and shall be in accordance with NEMA MG1. The following tests shall be included and done at the factory on the motors provided, and certified test reports shall be submitted.
1. No load power at rated voltage
 2. Measurement of locked rotor current
 3. Power factor
 4. Speed
 5. Current at rated horsepower
 6. KW input at rated horsepower
 7. No-load readings of current and speed at normal voltage and frequency.
 8. High-potential test per MG1-20.18 and IEEE Std 43.
- B. In addition, the motors shall receive a complete test in accordance with IEEE 112, and certified copies of the test data recorded on appropriate forms of IEEE 112, together with a certified statement of compliance with minimum specified power factor and efficiencies shall be furnished to the Owner/Engineer. The recorded data on the forms shall be in sufficient clarity and detail to permit third-party longhand validation and verification of any computer-generated results.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The Contractor shall install motors in accordance with the Manufacturer's instructions and recommendations.
- B. The Contractor shall align motor carefully and properly with the driven equipment.
- C. The Contractor shall secure equipment to mounting surface with anchor bolts. Provide anchor bolts meeting Manufacturer's recommendation and of sufficient size and number for the specified load conditions.
- D. Inspect each motor for physical damage.
- E. Inspect each motor for proper installation, rated voltage, phase and speed.
- F. Provide electrical wiring and connections as specified herein and in Division 16.

- G. Lubricate oil-lubricated bearings.
- H. Check for proper phase and ground connections.

3.02 MOTOR MANUFACTURER SERVICE ENGINEER: FIELD TESTING

- A. The motor manufacturer shall furnish the services of a competent service engineer, who shall have had a minimum of five years experience in the installation, adjustment, and operation of the equipment that is being furnished under this contract. This service is to ensure proper installation and adjustment of the motor, instruct personnel in proper operation, maintenance, and care of the equipment, for making operation tests of equipment, and recommendations for obtaining the most efficient use thereof.
- B. The service engineer shall arrive at the site after the motor installation but prior to testing and start-up. He shall verify the proper installation, alignment, wiring, lubrication, and connection of all appurtenances prior to start-up. He shall be present during testing, and start-up and shall certify to the Owner in writing that the motors have been properly installed and operate satisfactorily.
- C. Minimum 24 hours required to be on-site, not including travel time, on at least four (4) different occasions to be coordinated with field service requirements in Section 11110:
 - 1. Check motor installation
 - 2. Pump start-up and testing
 - 3. Troubleshooting
 - 4. Personnel training
- D. Field-Testing: The following tests shall be performed on the motors after installation in the field.
 - 1. Polarization Index Test: Measure and record the motor's insulation resistance polarization index (10 minute \ 1 minute ratio), at 2500 VDC, per IEEE Standard 43. Minimum acceptable polarization index ration shall be greater than 2.0 (>2.0).
 - 2. Motors shall have a 1-hour run-in while uncoupled from the driven load. The motor temperatures shall be monitored and recorded, every 5 minutes from just before start to the end of the hour test. Record operating amps, voltage, and vibration levels.
 - 3. Monitor motors during startup and commissioning to record operating amps, voltage and operating vibration levels.
 - 4. Submit test report and all recorded field data. Submit copies of the raw data recorded in the field, signed by the person recording the data, and typewritten reports certified by the Contractor. The motors will not be accepted until the reports are submitted and approved.

- E. Inspect for unusual mechanical or electrical noise or signs of overheating during initial test run.

3.03 EQUIPMENT PROTECTION AND RESTORATION

- A. Touch-up and restore damaged surfaces to factory finish, as approved by the manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.04 MANUFACTURER'S CERTIFICATION

- A. A qualified factory-trained manufacturer's engineer shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.
- B. The Contractor shall provide an electronic copy of the manufacturer's service engineer's certification.

3.05 TRAINING

- A. Motor Manufacturer shall provide services for training in accordance with Section 11110.
- B. The cost of training program to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the equipment being supplied.
- C. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.
- D. The training session shall be conducted by a manufacturer's qualified representative.
- E. The Owner shall have the right to videotape the training for the Owner's use.

END OF SECTION

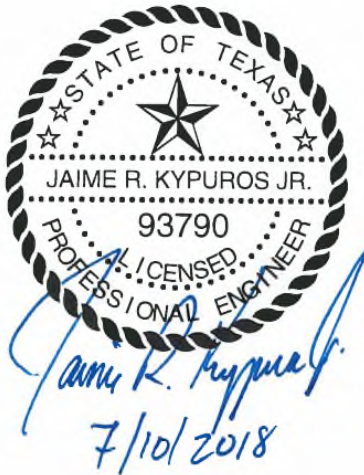


Pre-Purchase of Horizontal Split Case Pumps
for the
Central Water Integration Pipeline Project

SAWS Job No. 18-8616
Solicitation No. 18- 18091

Addendum #2
July 2018

DIVISIONS 1, 11



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