Item No. 516
Vertical Turbine Pumps – Line Shaft Type

Notes to Specifier:

This is a guide specification. Engineer should use this specification with care and verify all requirements.

Delete these notes and not used paragraphs.

Where options are given, make appropriate selection and delete the other option, fill in all blanks.

Electrical sections must be reviewed by an electrical engineer.

Manufacturers should review this Section prior to Bid.

Verify all references to paragraphs within this Section and to any applicable Sections, standards or other specified sources of information.

This specification was written based on the assumption that competitive sealed proposal process will be used. If using traditional design-bid-build approach, specification must be edited to use the correct terminology (i.e., "Proposal" vs. "Bid").

Include Attachment A (pump data sheet), Attachment B (motor data sheet), and Attachment C (system curve, hypothetical pump curve, and key rated operating points) at the end of this specification.

516.1 Description

A. This item shall govern furnishing labor, materials, equipment and incidentals necessary to design, manufacture, fabricate, test, **[deliver, and install]** a total of **[one] [two] [specify other]** vertical line shaft pumping **[unit] [units]** and electric motor **[drive] [drivers]** to be used in the NBU's **[Pump Station Name].** The **[unit] [units]** shall be furnished for the **[Pump Station]** and shall be designated as:

1. **[Include tag for all pumps with horsepower, and pump number. Edit as desired to meet project requirements. The intent of the first line is to give a nominal reference to the pump. The two sections are meant to indicate two sizes or locations of pumps in a given project.]**
2. **[Pump Station Name (5 MGD/200 HP):]**
    i. **[Pump 200-1]**
    ii. **[Pump 200-2]**
3. **[Pump Station 2 (1.25 MGD/100 HP):]**
    i. **[Pump 100-1]**
    ii. **[Pump 100-2]**

4. **[{Specify quantity} barrels shall be furnished for future identical pumps.]**

B. All pumps shall be of the same pump manufacturer. All motors shall be of the same manufacturer.

Note to Specifier: Edit summary paragraph of pump units to match the Project.

C. Pumping units shall include, but not necessarily be limited to, bowl and impeller assembly, suction bell, line shaft, shaft bearings, column, **[discharge head],** motor stand, motor, motor coupling, flange bolts and gaskets, **[sole plate, anchor bolts,] [pump barrels], [suction basket screen], [vibration transducers and switches]**, special services, spare parts, all lubrication and motor oil, and all related electrical and instrumentation. Accessories shall be furnished as required for a complete functioning pumping unit in accordance with the specified performance and installation conditions.

D. For this Section, the Equipment Manufacturer is defined as the pump manufacturer or its designated representative. Equipment Manufacturer is responsible for supplying and coordinating the design, testing, and supervising the installation of the pump and motor. Equipment Manufacturer shall be responsible for the adequacy and compatibility of the pump and motor. The motor manufacturer shall act as a subcontractor of the Equipment Manufacturer. The motor manufacturer shall provide a representative who is capable of coordinating the design, testing, and installation of the motor. Contractor will install the pumping unit under the supervision and guidance of the Equipment Manufacturer's representative.

E. Pumping units shall be operated by a variable frequency drive (VFD). The motor manufacturer shall issue a letter of compatibility with the VFD manufacturer, reference Section **[insert spec section here], "[insert title of VFD spec here]".**

Note to Specifier: Delete the paragraph below if pumps will not be removed with an overhead crane. Edit as needed for each project.

F. The proposed overhead crane will be rated for **[specify]** pounds with a maximum lifting range (floor to hook eye) of **[{specify} feet and {specify} inches].** The fully assembled pumping unit, plus rigging less motor only, shall not exceed the crane's **[specify]-**pound rated capacity. The unit shall be segmented to allow installation with a **[specify]-**foot crane, including the rigging.

Note to Specifier: Delete the paragraph below if pumps and motors will not have vibration sensors and switches. If Engineer recommends vibration monitoring, the Engineer must coordinate with NBU on the type of system and how it will be monitored/controlled and used in pump controls.

G. Pumping units will be supplied with vibration sensors and switches as specified herein. Vibration sensors shall be installed at the motor factory. Field installing vibration sensors to motor will not be accepted.

Note to Specifier: Delete the paragraph below if pumps will not be bid as competitive sealed proposals. Minimum guaranteed pumping efficiency requirements must be approved by NBU.

H. Pumping units must meet the minimum guaranteed efficiencies submitted with the Proposal, as well as the minimum performance requirements indicated herein.

516.2 Approved Manufacturers

A. Pumps:

1. Flowserve.
2. ITT Goulds.
3. Patterson.
4. Pentair (Fairbanks Nijhuis).
5. Peerless.

B. Motors:

1. Baldor (Reliance).
2. General Electric (GE).
3. Nidec (US Electric Motors)
4. TECO-Westinghouse.

516.3 Quality Assurance

A. Experience Requirements:

1. Pumps and motors shall be the product of manufacturers who have had at least 10 years of successful experience in the design, manufacture, and application of pumping units of the type, size, and performance capabilities as specified. The pump manufacturer shall have at least five similar size pumps of the model, type, and size of pump in service and operational for at least 5 years. It will be acceptable for the manufacturer to meet the pump installation experience requirements by referencing installations belonging to the pump's heritage line (previous ownership of the pump by a different company). The pumps referenced for the experience requirement shall be the same pump being proposed and the pump shall not have undergone substantial, material changes in engineering, design, and/or hydraulic characteristics. The assembly shall be an existing design that has been manufactured and is in operation. Prototype pumps will not be allowed.
2. Equipment Manufacturer shall maintain a quality assurance system in compliance with ISO 9001:2015 during the life of the contract.
3. All components of the pump and baseplate shall be supplied, assembled, and warranted by one of the approved pump manufacturers. Pump components shall NOT be acquired from separate entities and assembled as a final product by a manufacturer's representative.

B. Factory Inspection and Tests:

1. Pumps:

i. **[Pumps] [Pump Bowl Assembly]** shall be factory performance tested and certified copies of test data and test curve shall be furnished to the

Engineer. The efficiency, capacity, and horsepower requirements for field conditions shall be determined for not less than 10 points throughout the specified head range from shut-off to maximum specified operating capacity. The tested points shall include Shutoff Head, MCSF, POR high flow, BEP, POR low flow and AOR high flow at 100 percent speed. In addition, test for all rated points.

ii. **[All pumps shall be tested with the previously tested job motors at maximum speed. Units shall be tested with each of their specified job motors.] [All pumps may be tested with a calibrated factory test motor or a previously tested job motor at maximum speed.]** Test with the complete pump bowl assembly. **[Factory testing with variable frequency drive is not required.]**

iii. Test procedures, interpretation, and conversion of data shall conform to the latest requirements of the Hydraulic Institute standard for Hydraulic Performance Acceptance Tests (ANSI/HI 14.6), except as modified herein.

iv. Vibration levels shall not exceed the factory testing limits specified in the latest Hydraulic Institute standard for Vibration Measurements and Allowable Values (9.6.4).

v. Equipment Manufacturer shall submit a test procedure booklet which provides a plan and profile view of the test piping layout including locations of the test instruments at least 30 days prior to the shop test. A description of the test shall be included along with the calibration sheets on the proposed instrumentation. Provide example calculations for the wire-to-water efficiency if the complete unit will not be shop tested.

vi. The pump test results shall indicate that the performance of the pump from run-out head to shut-off head is similar to the pump curve submitted with the Proposal. If the test results indicate that the pump performs substantially different from that indicated, the Owner, at its option, may accept the unit at a reduced price, or may refuse to accept the unit as a consequence of breach of contract on the part of the Equipment Manufacturer.

vii. Pumps shall be tested at maximum operating speed. If the Project VFD is used for the test, then the pump will also be tested at reduced speeds as required to meet the specified rated points.

viii. Test results shall show no minus tolerance or margin with respect to capacity, total head or guaranteed efficiency at the specified conditions. Pumps shall have a continuous down slope in the head-capacity curve. Pumps shall be within the following plus tolerance, in accordance with HI 14.6, Grade 1E, except as modified below:

1. At rated head: 0 to +/-5 percent of rated capacity.
2. At rated capacity: 0 to +/-3 percent of rated head.
3. At rated efficiency: -0% of rated efficiency.
4. Pump head capacity curve must pass through both tolerance bands.

5. The tested pump horsepower cannot exceed 95 percent of the nameplate motor horsepower when operating at any head between shutoff and minimum specified operating heads.
6. The “line from origin” method may be allowed for evaluation of guaranteed efficiency.

ix. Following completion of factory performance tests, the Equipment Manufacturer shall furnish certified copies of all test data and test curves for the pump to the Engineer for review and approval. Test curves shall also show calculated curves for expected performance at 100 percent speed for all pumps and 90, 80, 70, and 60 percent of rated speed for variable speed pumps. Engineer shall promptly review test data and will give authorization for shipment upon determining that the pump meets contract requirements. Shipment shall not be made without written approval of test data by the Engineer, except at the risk of the Equipment Manufacturer.

x. The Equipment Manufacturer shall make thorough visual inspection on all bowl and impeller castings before assembly. Perform visual inspection in accordance with MSS SP-55.

xi. The Equipment Manufacturer shall stress relieve with heat all fabricated components including column pipes and discharge head in accordance with ASME Code Section VIII, Division 1 prior to final machining.

xii. Manufacturer shall perform a hydrostatic pressure test on the bowl assembly at 1.5 times the shut-off head for a minimum of 30 minutes with no leakage.

xiii. Pumps for potable water service must be thoroughly cleaned and disinfected if testing was completed using non-potable water. Disinfection chemicals should be removed, and surfaces flushed such that corrosive chemicals are not in prolonged contact with pump parts.

2. Motors:

i. All motors shall receive a short commercial test in accordance with NEMA MG1 and IEEE 112, latest version. Substitutions or waivers of the tests and methods listed herein will not be permitted.

ii. Following completion of factory tests, the Equipment Manufacturer shall furnish to the ENGINEER for review and approval four (4) certified copies of all test data and test curves for each motor. The ENGINEER shall promptly review test data and, upon determining that the motor meets contract requirements, authorization will be given for shipment. Shipment shall not be made without written approval of test data by the ENGINEER, except at the risk of the Equipment Manufacturer.

C. Service of Manufacturer’s Representative:

1. Pump Manufacturer’s Representative:

i. The pump manufacturer shall furnish the services of a competent factory representative, who shall have had a minimum of 5 years of experience in the installation, adjustment, and operation of the equipment which is being furnished under this Section. This service is to ensure proper

installation and adjustment of the equipment; instructing operating personnel in proper operation, maintenance, and care of the equipment; for making operation tests of equipment and making recommendations for obtaining the most efficient use thereof.

ii. Contractor shall be responsible for installing the pumping units including all labor, tools, and equipment required for assembling, setting, aligning, connecting, adjusting, and testing the pump and motor assemblies.

iii. The pump manufacturer's representative shall be at the Site at any time the Contractor is assembling, setting, aligning, connecting or adjusting and testing the pump and motor assembly.

iv. The pump manufacturer's representative shall certify in writing to the Owner that the pumping unit installations have been properly completed and operated satisfactorily during acceptance tests. Contractor shall coordinate the field installation and testing.

v. The pump manufacturer shall have total responsibility to see that all connections (mechanical, electrical, and control) made to the installed pumping units are correct prior to startup and testing.

vi. The minimum time required to be on-site for 8 hours per day, not including travel time, is as follows:

Note to Specifier: Minimum time required shown below is variable. Adjust based on the number of pumps to be installed.

Service	Min. Time
Pump and motor installation	4 days (2 trips minimum)
Pump startup and testing	4 days (2 trips minimum)
Troubleshooting	2 days (1 trips minimum)
Personnel training	1 day (1 trip minimum)

2. Motor Manufacturer's Representative:

i. The motor manufacturer shall furnish the services of a competent pump and motor mechanic, who shall have had a minimum of 5 years of experience in the installation, adjustment, and operation of the equipment which is being furnished under this Section. This service is to ensure proper installation and adjustment of the motor; instructing operating personnel in proper operation, maintenance, and care of the equipment; for making operation tests of equipment and making recommendations for obtaining the most efficient use thereof.

ii. Pump manufacturer's representative may also serve as the motor manufacturer's representative upon written notification of the motor manufacturer assigning that responsibility.

iii. The motor manufacturer's representative shall verify the proper installation, alignment, wiring, lubrication, and connection of all appurtenances prior to startup. Representative shall be present during

testing, and startup and shall certify to the Owner in writing that the motors have been properly installed and operate satisfactorily.

516.4 Submittals

All submittals must be in English with US Customary Units. Submittals must be in accordance with this Section and the General Requirements. ANY DEVIATIONS FROM THE SPECIFICATIONS MUST BE CLEARLY NOTED AND IDENTIFIED IN THE SUBMITTALS.

The submittal requirements of this specification item must include:

A. Shop Drawings:

1. Drawings shall show complete physical description and performance capabilities of the equipment, including, but not necessarily limited to dimensions, weights, materials, assemblies, sectional views, performance curves, and WR^2 power requirements and ratings, rated voltage and amperage, applicable wiring diagrams, and on-site storage requirements.

2. Submittal shall include all information requested in the Data Sheet (for both the pump and motor, Attachments A and B) submitted with the Proposal. The data sheet shall be updated as necessary.

3. Submit drawings as a complete package of all equipment furnished. Partial drawings will not be reviewed. Shop Drawings shall include the following:

Note to Specifier: Adjust Shop Drawing requirements for the Project.

i. Pump Outline drawings showing all components, anchor bolts, external connections, and appurtenances.

ii. Pump Sectional drawings with all components and materials of construction identified.

Note to Specifier: Delete the appropriate subparagraph(s) below if pump sole plate and/or intake barrels will not be provided.

iii. Sole plate drawings.

iv. Pump intake barrel drawings.

v. Characteristic Pump Curves: Curves shall show the capacity, head, minimum continuous stable flow (MCSF), preferred operating range (POR), best efficiency point (BEP), allowable operating range (AOR), efficiency, required NPSH, and brake horsepower throughout the operating range of the pump from shut-off to maximum specified operating capacity. Overlay the system curves included in Attachment C. **[Submit curves with the above data at speeds of 60 to 100 percent.]** Characteristic curves shall have the capacity plotted as abscissa and the

operating head, brake horsepower, efficiency and required NPSH plotted as ordinates. Provide four quadrant curves, if available, and WR^2 for the pump. In the event four quadrant curves are unavailable for the specific pump being proposed, the Owner may consider allowing the submittal of four quadrant curves based on other similar pumps.

vi. Data Sheet: Submit information requested on the Data Sheet (for both the pump, Attachment A, and motor, Attachment B).

vii. Pump speed vs. torque curves for applicable starting conditions. This information should be provided with the submittal package and updated after factory performance testing is complete.

viii. Pipe layout drawings for drainage and seal piping.

ix. Weights, including "wet" and "dry" weights of equipment, shipping weights and dimensions, and center of gravity for lifting.

x. Bearings information, cut sheets, plan and section, data sheets, and bearing life calculations for pump and motor.

xi. Nameplate data sheets.

xii. Identify sequence and tags for terminal strips and wiring.

Note to Specifier: Delete the two subparagraphs below if vibration monitoring will not be required.

xiii. Elevations of pump and motor showing vibration sensors on the motor with associated cable routing, cable supports details, and connection details.

xiv. Terminal strip arrangement, wiring diagrams, bill of materials, cut-sheets, etc. for all vibration monitoring system components.

xv. Paint selection chart.

Note to Specifier: Delete the subparagraph below if these analyses are not specified.

xvi. Roto-dynamic analysis including raw data input into the analysis, assumptions, analysis results, and conclusions.

xvii. Certified calculations of the Forces and Moment Analysis of the pump discharge head.

Note to Specifier: Delete the subparagraph below if pump will have non-reverse rachets.

xviii. Provide analysis of backspin speed during power failure and confirmation from the motor supplier that the motor is suitable for the maximum backspin speed (for pumps not having non-reverse ratchets).

xix. Submit drawings of lab testing set-ups, test procedures, testing equipment calibration certification, and sample performance calculations.

xx. Provide a description of the components that will be shipped separately, thus requiring field assembly. Provide a general description of the installation requirements, including sequence and installation tolerances.

xxi. Submit motor documentation as required per [**Paragraph 516.10.I].** Incomplete data submitted will not be reviewed and will be returned "Not Approved, Revise and Resubmit."

xxii. Provide a copy of the Equipment Manufacturer's quality system registration to ISO 9001:2015.

xxiii. Provide resume of the Equipment Manufacturer's proposed representative for field services.

xxiv. Provide an updated plan and a schedule indicating dates for submittals, manufacturing, testing, and delivery.

xxv. Provide a quality control plan that indicates materials and components included in the pump, the quality control procedure, and the Certified Test Report that will be provided to the Engineer.

B. Operation and Maintenance Manuals:

1. Submit manuals with instructions for installation, adjustment, lubrication, operation and maintenance of the equipment.

2. Manuals shall be prepared by the Equipment Manufacturer and shall also incorporate appropriate final Shop Drawings, Certified Test Reports, certified performance curves, and test data. Manual shall include nameplate data including serial numbers. Provide O&M data for all pump, motor, and accessories. Provide set points for **[vibration sensors]**, **[motor thermal switches]**, **[RTD's]** and all other protection devices. Manuals may be manufacturer's standard instructions, supplemented as necessary to cover any special feature not included in standard material. Submit preliminary manuals for review prior to delivery of the equipment. Separate or combined manuals may be provided for the pump and motor. Draft manuals shall be in electronic format. Final manuals shall be in hard copy and electronic format.

C. Certified Test Reports:

1. Submit the following Certified Test Reports (CTR) for pump and motor at the time of factory pump performance test. Shipment shall not be made without written approval of test data by the Engineer, except at the risk of the Equipment Manufacturer.

i. Provide CTR for pump factory performance tests.
ii. Provide CTR for motor factory performance tests.

iii. Provide CTR for stress relieving of components.
iv. Provide CTR for pump bowl hydrostatic tests.

Note to Specifier: Delete the subparagraph below if barrels will not be used.

2. Submit the following Certified Test Reports for pump barrels if delivered early:

   i. Provide CTR for barrel fabrication.
   ii. Provide CTR for barrel coatings (DFT and holiday test).

3. Submit the following Certified Test Reports for pump and motor at the time of installation and field pump performance test.

Note to Specifier: Delete the subparagraph below if sole plate will not be used.

   i. Provide CTR for sole plate level measurements.

Note to Specifier: Delete the subparagraph below if barrels will not be used.

   ii. Provide CTR for barrel mounting flange level measurements.

   iii. Provide CTR (with EIR) for pump field tests.
   iv. Provide CTR (with EIR) for motor field tests.

D. Equipment Installation Report (EIR):

1. Submit EIR from the motor manufacturer, pump manufacturer, **[and vibration monitoring system manufacturer]** indicating the equipment was installed in accordance with the manufacturers' instructions and that the equipment was adjusted and aligned to be in the best operating condition.

516.5 Standards

The applicable provisions of the following standards shall apply as if written here in their entirety:

1. American National Standards Institute (ANSI) Standards:

ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings
NSF/ANSI Standard 61	Drinking Water System Components – Health Effects
NSF/ANSI Standard 372	Drinking Water System Components – Lead Content

2. American Society for Testing and Materials (ASTM) Standards:

ASTM A27	Standard Specification for Steel Castings, Carbon, for General Application
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A48	Standard Specification for Gray Iron Castings
ASTM A216	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A283	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A345	Standard Specification for Flat-Rolled Electrical Steels for Magnetic Applications
ASTM A351	Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A479	Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels
ASTM A487	Standard Specification for Steel Castings Suitable for Pressure Service
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A564	Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A582	Standard Specification for Free-Machining Stainless Steel Bars
ASTM B271	Standard Specification for Copper-Base Alloy Centrifugal Castings
ASTM E689	Standard Reference Radiographs for Ductile Iron Castings

3. American Water Works Association (AWWA) Standards:

AWWA C210	Liquid Epoxy Coating Systems
AWWA E103	Horizontal and Vertical Line-Shaft Pumps

4. Hydraulic institute Standards (ANSI/HI)

All applicable sections for Centrifugal and Rotodynamic Pumps

5. American Society of Mechanical Engineers (ASME):

Section V	Nondestructive Examination
Section VIII	Pressure Vessels
Section IX	Welding, Brazing, and Fusing Qualifications

6. American Petroleum Institute (API):

API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries

7. International Standards Organization (ISO):

ISO 21940-11:2016	Mechanical Vibration – Rotor Balancing – Part 11: Procedures and Tolerances for Rotor with Rigid Behavior
ISO 9001:2015	Quality Management System – Requirements

8. Manufacturers Standardization Society of the Valves and Fittings Industry (MSS):

SP-55	Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components, Visual Method for Evaluation of Surface Irregularities

9. National Electrical Manufacturers Association (NEMA).
10. Institute of Electrical and Electronic Engineers (IEEE).
11. National Electrical Code (NEC).
12. Underwriters Laboratories (UL).

516.6 Delivery and Storage

A. The pumping units (pumps, column, shafts, couplings, and head) may be assembled for shipment when the size allows for one unit to be shipped on one truck. The bowl assemblies (bowls, suction bell, impellers, pump shaft, and pump bearings) can be shipped assembled only if measures are taken to prevent any damage to the pump and components.

B. Openings shall be covered in a manner to protect the opening and interior. Provide steel plugs at threaded openings. Do not use non-metallic plugs or caps.

C. Coat exterior machined surfaces with rust preventative.

D. Identify lifting points and lifting lugs on equipment or equipment package. Identify recommended lifting arrangement on boxed equipment.

E. Equipment Manufacturer shall be responsible for delivery of the pumps, drivers, and accessories, to the job site in good condition and undamaged. Equipment may be delivered prior to time of installation to a storage site as may be designated by the Contractor and approved by the Owner's representative in good condition and undamaged. The manufacturer shall submit a shipping notice and storage and installation instructions at least 1 week prior to shipment.

F. Unloading and storage of the equipment shall be the responsibility of the Contractor who shall inspect the equipment for apparent damage. Equipment which is found to be damaged will not be accepted until properly repaired or replaced by the Equipment Manufacturer.

G. The pump, motor, and accessories shall be stored indoors, and the motor space heaters (if included) shall be energized. Maintain humidity, temperature and other environmental parameters within limits prescribed by the Equipment Manufacturer. If motors are to be stored for longer than 14 days, the oil reservoirs should be filled. Equipment Manufacturer is responsible for the supply of this oil. Contractor shall rotate the motor rotor by hand as recommended by the motor manufacturer, but no less than several rotations each week until the motor is placed into service.

Note to Specifier: Delete the paragraph below if engine is used.

H. Oil for motor shall be provided by the Equipment Manufacturer and shall meet the motor manufacturer's recommendations per Paragraph **[516.10]** in this Section.

I. Pump(s) and motor(s) shall be shipped and stored per these Specifications and the manufacturer's recommendations.

J. Shipping and storage crating provided by the pump supplier shall allow the impeller assembly shaft to be rotated periodically. Manufacturer shall make recommendations for rotation frequency and procedure.

K. Spare parts shall be shipped with pump(s) and motor(s). Spare parts packaging shall be suitable to enable long term storage at a location designated by the Owner.

L. Furnish **[anchor bolts] [intake barrels] [sole plates] [etc.]** as necessary to meet the Contractor's schedule.

516.7 Equipment Warranty

Note to Specifier: Adjust 12-month time window after delivery in Paragraph C if pump is expected to ship well ahead of startup. Clarify party responsible for removal and re-install and will depend on how pump was procured.

A. Equipment Manufacturer shall warrant the equipment furnished under this Section for a period of 2 years against defects in materials and workmanship, equipment design, and operational failure.
B. In the event of failure in material, workmanship, or equipment design of any part or parts of the equipment during the warranty period, and provided that the equipment has been operated and maintained in accordance with good practice, the Equipment Manufacturer shall furnish, deliver, and install a replacement for the defective part or parts at its own expense. During the warranty period, the Equipment Manufacturer will remove and load the failed/defective equipment on a vehicle provided by the Equipment Manufacturer if it is necessary to return the failed/defective equipment to the Equipment Manufacturer for correction of defects during the Warranty Period. Equipment Manufacturer will reinstall the replacement equipment when equipment is returned to the Site after defects have been corrected. Equipment Manufacturer is to provide all parts, labor and incidental cost for making repairs, shipping the replacement equipment to the Site and providing startup services in accordance with the Specifications.
C. The warranty period shall be interpreted as the **[24]**-month period following the installation, adjusting and acceptance testing, and the start of actual operation of the equipment, or **[36]** months after complete delivery, whichever occurs first.

516.8 Pumping Criteria, Performance Requirements and Data

A. General Criteria:

Note to Specifier: Adjust the conditions of the water for each project. Solids, sand, abrasive materials, oxidants, and corrosive chemicals are particular concerns.

1. **[Potable Example]** Liquid to be pumped is potable water with **[chlorine] [chloramine]** residual.

2. **[Non-Potable Example]** Liquid to be pumped is untreated water from the {intake location} with silts, sands, and abrasives.

Note to Specifier: Adjust the suction and setting description for each project. Select correct example, edit as needed, and delete the others.

3. The pump suction will be from the **[treatment plant clearwell(s)] [ground storage tank(s)] [intake tower and reservoir**], which are open to the atmosphere.

4. **[Wet Well Example]** The pumps will pump from **[circular] [rectangular]** intakes inside of wet wells. The pumps will be supported at the pump discharge head on the sole plate.

5. **[Barrel Example]** The pump will be supported on the top flange of the suction barrel. The suction barrels will be filled with water with submergence equal to the water elevation in the ground storage tank minus minor losses in the suction pipe.

Note to Specifier: Select one of the two items below for the pump design.

6. The pumps shall have product lubricated bearings.

Note to Specifier: NBU standard is for all pumps to be equipped with VFDs. Pump control valves will be used only in special cases such as interim installations pending delivery of long lead VFDs. If VFDs are to be used for motor/pump control a passive swing check valve must be provided to allow the VFD to control the ramp up/ramp down of the motor/pump. A PCV may not be installed with a VFD per NBU requirements. Adjust the description of the starting sequence accordingly. Confirm time with surge model.

7. **[Cla-Val Style PCV Example]** Pumps will be started and stopped against a closed pump control valve which will open and close slowly (2 to 5 minutes per cycle) to minimize transient pressure surges in the discharge pipeline. The pump shall be designed for full shut-off head pressures during starting and stopping.

8. **[Check Valve Example]** Pumps controlled by [VFD(s)] [SSRVS] will be started against a check valve. The check valve will open slowly (approximately **[x] [minutes] [seconds]** per cycle). During power failure, the check valve will quickly close to prevent reverse flow through the pump.

9. **[Example with Non-Reverse Ratchet]** In the event of power or pump failure, water from the system will flow in reverse through the pumps **[while the pump control valve is slowly closing]**. The motor manufacturer shall supply a non-

reverse ratchet and provide certification that the pump and motor are designed to withstand forces caused by reverse flow through the pump.

Note to Specifier: Adjust the descriptions below if using a soft-starter or an across-the-line starter.

10. The pumps will be varied by a VFD controller and will operate for extended periods of time at speeds from **[50] [60]** to 100 percent of the rated synchronous motor speed. Pumps may be operated at different speeds simultaneously. The exact speed range will be verified upon submittal of pump curves. Motor manufacturer shall confirm that operation in low speed ranges is acceptable or shall provide supplemental lubrication and motor cooling as necessary to allow operation in the low speed ranges.

11. The pumps will be started with a VFD which will ramp from 0 to **[50] [60]** percent speed in about 5 to **[10] [30]** seconds, thus filling the pump column with water. The pump discharge piping will have a flanged outlet for an air valve assembly which will release air at pump startup and allow air into the pump column when the pump stops.

12. **[VFD Bypass Example]** The pump and motor can also be started across-the-line using full-voltage non-reversing starters **[if the VFD is not in service using the installed bypass]**.

Note to Specifier: Adjust the descriptions below if using a soft-starter or an across-the-line starter.

13. The design of the pumping units shall be compatible with the mode of operation.

14. Pump shall operate alone, as well as in parallel with other pumps. The system curves in Attachment C show the maximum and minimum system heads at which the pumps will operate.

15. The pumping heads tabulated below are total dynamic heads (TDH) under field conditions and are inclusive of all pump losses from suction bell to pump discharge. The more explicit definition is “Pump Total Head” as defined by ANSI/HI 14.6, Table 14.6.1.3a, Row 3.1.31. The Total Discharge Head component of the Total Head calculation shall be understood as the head produced at the discharge flange of the pump as installed in the field. The heads shown in Paragraph **[516.12.B.1]** are not “Bowl Assembly Total Heads” as measured in a factory performance test (as defined by ANSI/HI 14.6, Table 14.6.1.3a, Row 3.1.31.1). “Bowl Assembly Total Heads” shall require the addition of calculated losses which are not accounted for in the test procedure (i.e., column losses, drive-shaft bearing losses, suction basket, etc.) in order to produce the correct value for the Pump Total Head in accordance with the Hydraulic Institute Standards.

Note to Specifier: Adjust description below. Recommend using two points and clarifying where the BEP is in relation to these points.

16. It is desired that the pump has its highest efficiency between the **[rated head and the second efficiency evaluation point]. [The efficiency at these two**

points will be averaged for the proposal evaluation.] In addition, the efficiency at the minimum and maximum operating heads may be used in evaluating the pumps.

17. Pumps shall have a continuously rising performance curve from pump run-out to shutoff head, with no intermediate flat places.

18. Horsepower requirements cannot exceed nameplate motor horsepower when operating at any head between shutoff and minimum specified operating heads.

Note to Specifier: Review for compliance with latest EPA and state rules.

19. All wetted materials shall be designed for drinking water contact and shall meet the intent of NSF/ANSI 61 and NSF/ANSI 372. Leaded bronze materials shall not be used.

Note to Specifier: Adjust description of pipe arrangement below.

20. The discharge piping includes a **[flexible pipe coupling and tie rods]** between the pump discharge flange and the pump control valve as shown in the appendices.

Note to Specifier: Delete the subparagraph below if a bridge crane will not be used. Modify accordingly for bridge crane capacity and hook height.

21. The weight of each motor and the fully-assembled pump (exclusive of motor) shall not exceed **[5] [10] [15] [20]** Tons. This weight limitation allows assembly and disassembly of the pumping units with the bridge crane rated capacity. Additionally, the maximum hook height is approximately **[specify]** feet measured from the finished floor elevation, and the pumping units shall be designed to allow assembly and disassembly of the pumping units with the bridge crane capacity and hook height, including the rigging.

22. **[Provide description of other important criteria. This might include if a change to the impeller may be desired in the future, adding stages in the future, unique starting conditions, unique operating conditions, etc.]**

B. Performance Requirements

Notes to Specifier:

Adjust pumping conditions in the table below as needed for each project. The included text and yellow highlights are examples and should be deleted or edited to fit the Project. Additional criteria should be included when needed.

1. The tabulations below show the required flows and various head conditions at which the pumps must operate and the pump setting requirements for all [number of] pumps. See Attachment C for System Curves.

PUMPING CONDITIONS AT FULL SPEED (U.N.O.)	[PUMP TAG #]	[PUMP TAG #]

PUMPING CONDITIONS AT FULL SPEED (U.N.O.)	[PUMP TAG #]	[PUMP TAG #]
Capacity at Rated Head 1, (gpm) (full speed)	1200	1200
Rated Head 1, (ft) (full speed)	187	187
Minimum Capacity at Duty Point 2, (gpm) (reduced speed)		
Head at Duty Point 2, (ft) (reduced speed)		
Maximum Shut-Off Head, (ft)	269	269
Maximum Operating Head, (ft) (full speed, w/in **[AOR] [POR]**)	225	225
Minimum Operating Head, (ft) (full speed, w/in **[AOR] [POR]**)	140 (reduced speed)	140 (reduced speed)
Impellers	**[CA-6NM Stainless][CF8M Stainless], [C95800 Ni-Al-Brz] Enclosed [or Semi-Open]**	**[CA-6NM Stainless][CF8M Stainless], [C95800 Ni-Al-Brz] Enclosed [or Semi-Open]**
Net Positive Suction Head Available @ Normal GST Water Elevation, (ft)	X	X
Net Positive Suction Head Available @ Minimum GST Water Elevation, (ft)	X	X
Maximum NPSHr at Rated Point (ft)	X	X
Available Minimum Submergence of Suction Bell, (ft)	9	9
Line Shaft Bearings	Rubber	Rubber
Line Shaft Lubrication	Product	Product
Motor Voltage	460	460
Maximum Motor Horsepower, (HP)	X	X
Maximum Motor Speed, (RPM)	1800	1800
Maximum Number of Stages	X	X
Maximum Suction Specific Speed	12,000	12,000
Preferable Maximum Impeller Specific Speed	**[3200]**	**[3200]**
Minimum Speed (% of max rated)	50	50
Minimum Pump Efficiency at Duty Points (%)		
Full Speed Rated Point **[X]** gpm @ **[X]**' TDH	X%	X%
Reduced Speed Duty Point #1, **[X]** gpm @ **[X]**' TDH Manufacturer to Confirm Speed	X%	---
Reduced Speed Duty Point #2,	X%	---

PUMPING CONDITIONS AT FULL SPEED (U.N.O.)	[PUMP TAG #]	[PUMP TAG #]
[X] gpm @ **[X]**' TDH Manufacturer to Confirm Speed		
Reduced Speed Duty Point #3, **[X]** gpm @ **[X]**' TDH Manufacturer to Confirm Speed	---	X%

2. Pumps shall meet the flow and head at the rated points. There are also other duty points with specified head requirements that shall be met as shown on the Pump Curve Exhibits, attached as Attachment C. The pump efficiencies will be evaluated at the specified heads shown in the table.

C. Pump Setting Requirements:

Note to Specifier: Adjust setting requirements for each project. Add footnotes as needed for clarifications. Setting table is for different elevation and dimension info. The yellow, blue, and cyan highlights go together and will need to be edited or deleted based on setting.

PUMP SETTING REQUIREMENTS	[PUMP TAG #]	[PUMP TAG #]
Elev. Pump Station Operating Floor, (ft)		
Elev. Pump Discharge Centerline, (ft)		
Elev. Bottom Pump Suction Bell[1] (w/o Suction Screen), (ft)		
Pump Discharge Diameter (I.D.), (in)		
Maximum Dimension Pump CL to Discharge Flange (in)		
Minimum Column Pipe Diameter (in)		
Include Parameters for Pump in Barrel		
Elev. Barrel Flange[1], (ft)		
Elev. Pump Barrel Intake Pipe Centerline, (ft)		
Pump Barrel Intake Pipe Diameter (I.D.), (in)		
Elev. Bottom of Barrel, (ft)		
Pump Barrel Diameter (O.D.), (in)		
Include Parameters for Pump with Sole Plate		
Elev. Bottom of Sole Plate (ft)	Top of conc. curb + grout	
Elev. Wet Well Floor (ft)		
Sole Plate Size, (in x in)	Dim. to outside of curb	
Floor Opening, (in x in)	Dim. to inside of curb	

PUMP SETTING REQUIREMENTS	[PUMP TAG #]	[PUMP TAG #]
Include Water Level Parameters		
Elev. Maximum **[GST, Lake, Sump]** Water Level (ft)		
Elev. Design **[GST, Lake, Sump]** Water Level (ft)		
Elev. Minimum **[GST, Lake, Sump]** Water Level (ft)		
Maximum Total Unit Weight, Wet (lb)	Structural design assumptions for pump & motor, esp. important for suspended slab	

1. Elevation of suction bell **[and barrel flange]** to be confirmed by Equipment Manufacturer and determined during pump submittal phase.
2. Manufacturer to field verify sole plate opening diameter and mounting bolt circle diameters and determine suitability for proposed pumping unit

Note to Specifier: Adjust NPSHr requirements per Project. Refer to HI 9.6.1.5.5 guideline for margin. This specification uses 5 feet minimum instead of 3.3 feet minimum from HI at BEP/POR.

D. The pump shall have suitable Net Positive Suction Head Required (NPSHr). Note that NPSHr is defined as the 3 percent head drop net positive suction head requirement. The NPSH margin, i.e., ratio of NPSHa to NPSHr shall be consistent with the suction energy conditions as defined by the HI standards. Minimum margin shall be 10 percent within POR, or 5 feet, whichever is greater. [**Minimum margin shall be 20 percent within AOR, or 5 feet, whichever is greater.]** The NPSHr with the margin applied within POR shall be less than the NPSHa with the minimum suction water level as shown in the pump setting table. The NPSHr with the margin applied at pump run-out shall be less than **[50 feet] [the NPSHA with the minimum suction water level as shown in the pump settings table]**.

516.9 Pump Materials

A. General

1. Pumps shall be line shaft type**, [single stage] [single or multi-stage]** vertical turbine or **[mixed] [axial]** flow pumps with above floor discharge. The pumps shall have **[product] [water]** lubricated shaft bearings with an open line shaft. The pumps shall have **[semi-open] [enclosed**] impellers.

2. Pumps shall be designed, manufactured, inspected and tested in accordance with the applicable requirements of AWWA E103, the Hydraulic Institute Standards and special requirements of this Section.

3. The down-thrust load imposed on the impellers and line shaft will be carried by the upper thrust bearing of the motor, which shall be designed for the maximum load imposed. The impellers may be thrust balanced at the option of

the manufacturer to assure the adequacy of the motor bearings to carry the load.

4. If an up-thrust load occurs at any specified pumping condition, including pump startup, the pumping units shall be designed to withstand the worst-case load without any damage to the units. Equipment Manufacturer shall make such measurements during the factory tests to determine that no damaging up-thrust condition exists and shall be responsible for correcting such problems that may occur.

5. Pumps shall be designed, manufactured, and installed to meet all requirements of the ANSI/HI 9.6.4-2016 standards for “Allowable Field Vibration Limits.”

6. The pump supplier shall stress relieve all fabricated components, column pipe and discharge head prior to final machining in accordance with ASME Code, Section VIII, Division 1; ASME Code Section IX, and API Standard 610.

B. Bowl Assembly:

1. Bowls:

The suction bell and pump bowls shall be of cast iron, ASTM A48 Class 30; cast ductile iron, ASTM A536; or cast steel, ASTM A27 Class 65-35 or ASTM A216 Grade WCB. Castings shall be free of blow holes, sand holes, or other detrimental defects, with smooth water passages. The top case, impeller case and suction bell shall be located by a register fit for ease of re-assembly and to maintain alignment during operation. All bowl flange fasteners shall be stainless steel.

2. Bearings:

The lower bowl shall have a suitable suction bell and permanently sealed grease lubricated lower bearing. Bowl assembly shall have a shaft bearing above and below each impeller. Bearings shall be bronze, Federalloy III-932 (bismuth-tin bronze).

3. Wear Rings and Bowl Liners:

i. Bowls for enclosed impellers shall be fitted with renewable wear rings at the running joints between the impeller and bowl. Rings shall be securely attached or doweled to prevent rotation in their seats.

ii. Bowls for semi-open or axial flow impellers shall be fitted with renewable bowl liners and wear rings at the running joint(s) with the impeller.

iii. Wear rings shall have straight face only, no L-shaped rings will be allowed.

iv. Wear ring material shall be 400 Series stainless steel and compatible with the stainless steel impeller material and shall be an alloy with a Brinell hardness of 100 points greater than the impeller wear rings.

C. Rotating Assembly:

1. Impeller Shaft: The impeller shaft shall be stainless steel, rotary stress relieved, ASTM A479 Type 410 Condition 1**,** ASTM A582 Type 416, or ASTM A564 Type 17-4PH. Keyways in the shaft shall be provided with Type 410 stainless steel keys that shall properly space the impellers on the shaft and transfer thrust and torsion loads from impeller to shaft. Assemble using anti-seize compound on fasteners as necessary to prevent galling**.**

2. Impellers:

Note to Specifier: Balance Grade 2.5 is necessary if specifying low vibration values and Grade 6.3 should only be considered if specifying 100 percent HI allowable vibration.

i. Impellers shall be of strong dense castings free of structural defects with uniform thickness of vanes and shrouds. They shall have smooth water passages for high efficiency and shall be statically and dynamically balanced. Perform a single or two plane dynamic balance to ISO 21940-11 Balance Grade G2.5 or better.

ii. Balancing shall be on the impeller hub only. Do not thin the shroud or vanes.

iii. Thinning of the shroud shall be allowed only when uniform and spread over as wide an area as possible. An engineering evaluation shall be made by the manufacturer as to the amount of thinning which can be done and still preserve the integrity of the casting. In no case shall the thickness of the shroud be less than this value.

Note to Specifier: NBU standard for impeller materials is A487 or A351 stainless steel. Cast nickel aluminum bronze may be used with NBU approval to allow for greater pool of allowable pumps or when lead times for stainless steel impellers are excessive.

iv. Impellers shall be of cast stainless steel, ASTM A487, CA-6NM Class "B" containing 13 percent chrome and 4 percent nickel or ASTM A351 CF8M containing 18 percent chrome and 9 percent Nickel **[or cast nickel aluminum bronze, ASTM B148 C95800].**

v. Impellers shall be **[enclosed] [semi-open]** type design.

vi. Welding on the raw castings will be allowed as long as the proposed repaired defect is within allowable standards and prior to any machining, polishing, and/or balancing. Welding, fillers, or coatings for head, flow, and/or efficiency performance reasons will not be allowed. Notify the Owner's representative prior to making major repairs on the impeller. Major repairs are defined as those that are: 1) > 20 percent of material thickness; 2) 1 inch or greater in depth; or 3) exceed 10 square inches. Submit welding procedures and welder qualifications prior to welding on impeller castings. Welders must be qualified to ASME Section IX.

3. Wear Rings:

i. Enclosed impellers shall be fitted with renewable wear rings at the running joints with the bowl. Rings shall be securely attached or doweled to prevent rotation in their seats. Wear rings shall have straight face only, no L-shaped rings will be allowed. No spin cast rings will be allowed. Wear rings shall be forgings.

ii. Wear ring material shall be 400 Series stainless steel and compatible with the stainless steel impeller material and shall be an alloy with 100 points Brinell softer than the bowl wear rings.

D. Open Line Shaft and Bearings:

1. Shaft:

i. Line shaft and couplings shall be stainless steel, rotary stress relieved, ASTM A479 Type 410 Condition 1, ASTM A582 Type 416, or ASTM A564 Type 17-4PH, of size conforming to AWWA E103 and shall be furnished in interchangeable sections with lengths not greater than 10 feet. Shafts shall have butting faces, machined square to the axis of the shaft to ensure accurate alignment.

Note to Specifier: Some manufacturers may not offer a shaft sleeve on smaller diameter shafts.

ii. The top line shaft section shall have a stainless steel shaft packing sleeve where it passes through the shaft seal and bushing. The shaft sleeve shall be Type 410 stainless steel and shall be 50 points Brinell greater hardness than the shaft, minimum.

iii. Shafting shall be straight to within 0.003-inches TIR at any point along the length of the shaft. Any shaft not meeting this requirement shall be replaced. Repairing or straightening shafts shall not be allowed.

2. Couplings:

i. Shaft couplings shall be designed with a safety factor of 1.5 times the shaft design strength.

ii. Couplings for shafts shall be the split ring key type couplings to prevent loosening from reverse or forward torque of the shaft. Couplings may be threaded for shafts less than 2.5 inches in diameter. Cross pin and thrust stud type couplings shall not be allowed.

iii. All parts shall be stainless steel, and threaded parts shall be assembled using an anti-seize compound.

3. Bearings:

i. Line shaft bearings shall be cutless rubber, Neoprene 65 shore, and shall be bronze backed marine style with low swell rubber compound. Pop-in or glue-in bearings are not acceptable.

ii. Bearings shall be lubricated with the liquid being pumped and mounted securely in bearing retainers which are integrally welded to

the column at each top column flange. The bore of the integrally welded bearing retainer shall be machined concentric to the column flange registers and perpendicular to the flange faces.

E. Pump Column:

1. Column pipe material shall conform to ASTM A53.

2. The column pipe shall be such that the friction loss does not exceed 5 feet per 100-feet of column at the rated capacity of the pump. Column pipe 24 inches in diameter and larger shall have a minimum wall thickness of 0.5-inches. Column pipe less than 24 inches in diameter shall have a minimum wall thickness of 0.375 inches. The pipe shall be furnished in interchangeable sections of not more than 10-foot lengths.

3. Column pipe shall be connected with flanged type connections using stainless steel bolts and nuts with hardened washers on both ends, and anti-seize compound. Column flanges shall have an O-ring suitable for pump shut-off pressure. O-ring groove shall be on the upward facing flange of each segment.

4. Column pipe shall be stress relieved with heat prior to machining of flanges and shaft retainers.

5. The ends of each flanged section shall be faced parallel and machined accurately with register fit to ensure proper alignment when assembled. Concentricity of shaft bearing to column flange register fit shall be 0.005 inches TIR or manufacturer's recommended tolerance, whichever is less. Parallelism of column pipe shall be 0.005 inches TIR or manufacturer's recommended tolerance, whichever is less. All flange registers shall be identical so that any section of column and shaft can be installed in any location in the column.

6. For column pipe 24 inches in diameter or larger, include two combination lifting lugs and support pads welded on all column sections. Lifting lugs and support brackets on each column section shall be capable of supporting the full weight of the pump assembly including the discharge head.

F. Discharge Head Assembly:

1. Discharge head assembly material shall conform to ASTM A36, A283 or A53.

Note to Specifier: Modify the subparagraph below for the discharge connection.

2. The horizontal discharge shall be located above the pump base and shall terminate with an AWWA C207 standard flange end, as shown in **[the Drawings and details] [Appendix X].** Coordinate with discharge piping. Discharge shall be drilled and tapped for 1-inch pressure gauge connection. Design the discharge head and flange to withstand shut-off head of the pump.

Note to Specifier: Include only one of the subparagraphs below.

3. The 90-degree elbow shall be designed to minimize turbulence and pressure drop and shall consist of at least three miter sections.

4. For discharge elbows 24 inches in diameter or larger, use a true long radius 90-degree elbow or a five-piece mitered elbow to minimize losses.

Note to Specifier: Use the subparagraph below when pump is supported on a sole plate. Sole plate is used when pump is suspended above a wet-well or above a barrel (but not connected).

5. Pump base shall be machined flat and perpendicular to the shaft centerline on the bottom and designed to support the pump and driver and attach to an appropriate sole plate.

Note to Specifier: Use the subparagraph below when pump barrel can be pressurized because of suction tank head and pump is supported on a flange.

6. Pump base shall be circular and fasten to the pump barrel flange. Provide stainless steel flange bolts and O-ring gasket to form a water-tight seal for sole plate mounting. Design shall be suitable for 50-psi pressure without leaking or damage. Flat-faced gaskets are not allowed. Pump base shall be connected to sole plate using stainless steel bolts, washers, nuts, and anti-seize compound.

7. Machine flange faces to be parallel to within 0.005 inches TIR or manufacturer's recommended tolerances, whichever is less. Machine motor, stuffing box, and column flange registers to be concentric to within 0.005 inches TIR or the manufacturer's recommended tolerances whichever is less.

8. Stress relieve head fabrications with heat prior to machining.

G. Sole Plate:

Note to Specifier: O-ring is not typically needed for a sole plate application where water from wet well cannot reach base of the pump.

1. Provide a steel sole plate of material matching the discharge head for anchoring to the structure with appropriate size opening to remove the pump. Pump base will attach to the sole plate. Furnish **[top O-ring gasket and]** stainless steel bolts to attach the pump base to the sole plate and assemble with anti-seize compound. **[O-ring shall be suitable for 50-psi pressure.]**

2. The top surface of the sole plate mounting flange shall be sufficiently flat to allow the Contractor to level these surfaces to within 0.002 inches per foot of diameter. Provide sole plate jacking bolts to assist the leveling process. Design jacking bolts so they can be removed after the grout has cured. Provide sufficient instruction to the Contractor so that the leveling process is accomplished without undue trouble. After installation, the sole plate flange shall be level within 0.002 inches per foot of diameter. If this is not the case, then the manufacturer shall re-machine the sole plate flange in the field to be within 0.002 inches per foot of diameter or shall replace the sole plate.

3. Drill the sole plate to receive a suitable number of foundation bolts as shown on the Drawings. Provide stainless steel foundation bolts.

Note to Specifier: Verify 2-inch minimum thickness is adequate.

4. The sole plate thickness shall be a minimum of **[2]** inches. Evaluate the thickness, dimensions and additional reinforcement required for the installation as part of the pump design analyses specified above. In no case will the slab opening size be modified. Include proposals for revised base plate dimensions with Shop Drawings.

5. If additional reinforcing is welded to the sole plate, provide stress relief of the sole plate prior to drilling of holes.

H. Shaft Seal:

1. For open line shaft pumps, provide the discharge head with a renewable bronze bushing, ASTM B271, Alloy C93200, and a shaft packing box with split stainless steel 316L packing gland with four (4) stainless steel gland bolts. Provide Chesterton 442 mechanical split seals with a carbon stationary face and a silicon carbide rotary face, Viton O-rings.

I. Motor Stand:

1. Provide a motor stand above the discharge head to support the motor above and the pump below. The motor stand may be an integral part of the discharge head or a separate stand bolted to the pump base of material matching the pump base. Provide a motor stand with openings with heavy duty hinged stainless steel guard screens on opposite sides to permit access to the shaft seal, lubrication connections and shaft coupling.

2. Machine the base plate bearing surface, stuffing box mounting surface, and motor flange surface parallel to one another and perpendicular to the shaft axis. Machine the column and stuffing box aligning registers concentric to one another and the shaft axis. Stress relieve the motor stand with heat prior to final machining.

3. Provide four heavy duty jack bolts on the motor stand for pump/motor shaft alignment purposes. Provide stainless steel bolts for bolting motor to motor stand.

4. Provide 3/4-inch minimum drain connection and facilities to completely drain all packing discharge and all water which collects in the motor stand. Adequately slope motor base to drain so the water does not pond. Non-shrink grout may be used in the motor base to provide a sloped bottom.

J. Motor Couplings: Motor to pump coupling for solid shaft motors shall be a three-piece rigid adjustable coupling for adjusting the impeller setting. Zinc plate or anodize the non-machined coupling parts to reduce corrosion. Provide aligning registers on mating surfaces on coupling components. Furnish all coupling bolts, nuts, washers and keys.

Note to Specifier: Delete the paragraph below if suction screen will not be used.

K. Suction Screen:

1. Provide a basket type suction screen for attaching to the suction bell for suppression of submerged vortices. Screen shall be cylindrical in shape with a structural frame, grating bottom, wire mesh on the sides and solid plate cruciform. All material shall be ASTM Type 316L stainless steel.

2. Basket frame shall attach securely to the suction bell by means of stainless steel bolts tapped directly into the bowl casting or be securely flanged to the suction bell. The threaded fasteners are to be bolted to the suction bell, however bolts tapped directly to the bowl casting shall not be attached to the narrow flange of the suction bell. The use of “clips” is not acceptable. Bottom of the basket shall clear the bottom of the barrel by at least 6 inches, or as recommended by the manufacturer.

3. The detailed design and fabrication of the basket screen’s height and mesh selection shall be the responsibility of the pump manufacturer so that it will be both efficient and effective in suppressing vortices and preventing cavitation. An inverted right angle cone with four vertical vanes (spaced at 90 degrees around the suction screen) shall be mounted on the bottom of the suction screen to prevent vortices from forming on the bottom of the suction screen. The length of each vane shall be one-half the diameter of the bell. The height of the four vanes and the right angle cone shall be 3 inches less than the height of the suction screen as determined by the pump manufacturer.

4. A detail of the suction screen clearly showing the attachment to the suction bell shall be included in the Shop Drawings.

L. Pump Painting:

Note to Specifier: Verify spec and system references with coating specs.

1. The pumping unit, except for the exterior of discharge head and interior of bowl, shall be painted (interior and exterior) per System No. SS-5 as specified in Item No. 530 “High-Performance Coatings.” The prime coatings and the final coat shall be shop-applied prior to shipment. Discharge head (exterior) shall be painted per System No. SS-2 as specified in Item No. 530 “High-Performance Coatings.” The prime coatings **[and final coat shall be shop-applied prior to shipment] [shall be shop-applied prior to shipment and the final coat shall be field-applied prior to installation to match adjacent piping].** Between the prime coat and intermediate coat, apply a separate stripe coat on all angles, edges, welds, and bolted connections where coating film build will be reduced. Color of the exposed sections shall be matched to adjacent piping.

2. Coat interior of pump bowls with a ceramic epoxy coating to enhance pump efficiency. Prepare surface to SSPC-SP 5 minimum, or as recommended by the coating manufacturer. Prime and finish coat shall be 10 mils each DFT Belzona 1341 NSF efficiency enhancement coating system for potable water.

Note to Specifier: Use subparagraph below when factory coating is sufficient. Delete if using the two subparagraphs above.

3. Interior pumps surfaces shall be coated with liquid epoxy, AWWA C210, to give a minimum total dry fil thickness of 15 mils and shall be Tnemec Pota-Pox Series 20 or approved equal. All exterior surfaces, including the pump base, shall be cleaned, primed, and painted with two coats of manufactures standard exterior machinery enamel. Furnish extra touch-up paint for the Contractor’s use. Color shall be selected and approved by the Owner.

4. Holiday test all coatings using high voltage spark testing at a maximum voltage of 125 volts per mil. Wet sponge holiday testing will not be acceptable.

Note to Specifier: Delete or include as described earlier.

M. Impeller Jacking Unit: The pumps shall be furnished with a hydraulic jacking unit for setting the bowl-impeller clearance. The jacking assembly shall consist of a minimum of two hydraulic ram jacks, a hydraulic hand pump, pressure gauge, hose and hose fittings. The pump and jacks shall be capable of lifting the weight of the shaft impeller assembly with the rams bearing against the hub of the pump shaft half-coupling and extension legs which bear on the pump base. The pressure gauge shall be such that, at three quarters of full scale, it will indicate a pressure equal to the weight of the rotating element divided by the total ram piston area, in pounds per square inch.

Note to Specifier: Delete the paragraph below if pump barrels will not be used.

N. Pump Barrel:

1. Barrel:

i. Suction barrels shall be welded steel construction with a flat bottom, cylindrical walls, inlet pipe and heavy flanged top. The barrels shall be constructed of low carbon steel A53 Gr B and A36 or better.

ii. Provide four lifting lugs below the floor level for setting barrels.

iii. Stiffener rings shall be provided to ensure the barrel does not come out of round during handling and installation of the barrel.

iv. Provide flow straightening vanes as shown in the pump details that are welded to the inside of the barrel from the bottom of the barrel to the top flange to reduce pre-rotation.

2. Top Flange:

i. Top flange shall support the pump and motor, have a 125 RMS finish, and shall match the pump base. Furnish top O-ring gasket and stainless steel flange bolts, nuts and washers to anchor pump base and seal the connection. O-ring shall be suitable for 10-psi pressure.

ii. The finished suction barrel mounting flange will be shipped loose for field leveling and welding by the Contractor. The top flange and spool piece shall be a sufficient length, minimum 12 inches, so that the connection to the barrel can be field welded during installation. Fabricate angle iron for jacking bolts to assist the leveling process at eight locations (minimum) equally spaced around the diameter of the top flange spool piece and adjacent can piece in the manufacturing facility. Jacking bolts shall be stainless steel.

iii. [Provide connections in the suction barrel top as shown on plan sheets for air release valve outlet.]

3. Installation Tolerance:

i. The top surface of the suction barrel mounting flange shall be sufficiently flat to allow the Contractor to field level these machined surfaces to within 0.002 in/ft of diameter.

ii. The suction barrel's design and number of components shall be sufficient for handling and installation by the Contractor so that the installed barrel is plumb to within +/- 1/8 inch and the top flange is level to within 0.002 in/ft of diameter.

iii. Provide sufficient instruction to the Contractor so that the leveling and welding process is accomplished without undue trouble.

iv. Pump supplier shall provide the structural design of the pump barrel to accommodate the forces and moments for the largest pump within the station with a minimum factor of safety of 3.0 applied. Design of the barrel flange and head mounting shall be the manufacturer's responsibility.

4. Dimensions:

i. All barrels shall be of the diameter and length indicated in the pump setting schedule.

ii. The barrels shall have a plain end outlet of the diameter and centerline elevation indicated in the pumps setting schedule suitable for welding the pump barrel to the suction piping.

iii. The bottom of the pump barrel shall be a flat steel plate with a minimum 1-inch thickness. Provide anchor rings on the outside of the barrel to anchor into the concrete encasement of the barrel. Provide four 4-inch by 4-inch by 1-inch thick steel plate leveling legs at the bottom of the barrels, located at 90 degrees spacing.

iv. The walls of the barrel shall be minimum 1/2 inch thick.

5. Painting:

i. Exterior of barrel below the mounting flange will be concrete encased and may be supplied with a primer coat only. All other interior and exterior metal surfaces of suction barrel shall be coated per **[System No. SS-5 as specified in Item No. 530 "High Performance Coatings."]**

ii. All metal surfaces shall be abrasively blasted to an SSPC-SP 5, white metal blast, and coated as specified. Where polyamide epoxy is required three coats shall be required. Between the prime coat and intermediate coat, apply a separate stripe coat of polyamide epoxy on all angles, edges, welds, and bolted connections where coating film build will be reduced. Alternate color of each coat of epoxy with final color. Color shall be selected and approved by the Owner.

iii. Final coating shall have a minimum dry film thickness of 12 mils and shall not exceed manufacturer's maximum film build recommendations.

iv. Holiday test coating using high voltage spark testing at a maximum voltage of 125 volts per mil. Wet sponge holiday testing will not be acceptable.

O. Pump Marking and Nameplates:

1. Pump and motor shall each have a standard manufacturer's stainless steel nameplate securely affixed with tapping screws in a conspicuous place, showing the ratings, speed, rotation direction, serial number, model number, manufacturer, and other pertinent data. Pump nameplate shall include impeller setting data if applicable. Nameplate must be on vertical section of pump head.

2. Provide a nameplate with the pump tag number at a readily visible location on the pump head opposite the discharge outlet. Use polymer nameplates, white with black lettering, and attach with stainless steel screws. Lettering is to be minimum 3-inches tall. Provide Safe-T-Mark by Rowmark or equal.

3. Pump column sections and shafts shall be marked to indicate the installation sequence.

516.10 460-Volt Motors

Note to Specifier: This is a guide specification. Engineer should use this specification with care and verify all requirements. Adjust for type of starter. Do not use without editing by Electrical Engineer.

A. General:

Note to Specifier: NBU prefers the motor be inverter-duty rated, whether motor starting method is across-the-line, soft-start, or VFD-driven.

1. Motors shall be vertical, air cooled, solid shaft, copper wound stator, NEMA design B, random wound, **[copper] [aluminum]** bar rotor construction, squirrel cage induction type. Motors shall be designed for use with variable frequency drives and across-the-line starters.

2. Motors shall be of a premium efficiency design and rated for inverter duty in accordance with MG-1, Part 31. The variable speed pumps will be varied by a variable frequency drive motor controller **[(provided by others under Division 26)]** and will be operated for extended periods of time at speeds from **[X to 100]** percent of rated synchronous motor speed.

3. The VFD and motor shall be completely compatible electrically. VFD manufacturer and motor manufacturer shall together issue a letter of compatibility at the time Shop Drawings are submitted. The VFD and motor manufacturer shall determine the insulation voltage rating required to accommodate common mode voltages and prevent insulation failure.

4. Horsepower nameplate rating of motor, at the 1.0 service factor, shall be equal to or greater than the total horsepower requirement of the pump when operating at any head between maximum and minimum specified operating heads as specified herein**,** including power requirements for bowl assembly, column and line shaft bearing loss, and motor thrust bearing loss from pump load. Motor shall have a service factor of 1.15 and shall be designed and manufactured 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.

5. The locked rotor torque and breakdown torque shall not be less than shown in NEMA MG-1 20.10.

6. The locked rotor KVA/HP shall not exceed NEMA code Letter **[G]**, **[6.29]** KVA/HP.

7. Motor shall have a sound power level of no more than 85 dBA average at 1-meter (3.3 ft) distance when measured per IEEE Std. 85 “Test Procedure for Airborne Measurements on Rotating Electrical Machinery.”

8. Rotor shall be precision balanced to within an amplitude, peak to peak, in accordance with the requirement of NEMA MG-1.

9. Rotor bars and end rings shall be **[copper] [aluminum]** or copper alloy (no substitution). The rotor bars shall be swaged. The end rings shall be joined to the rotor bars by high frequency induction brazing. The rotor cores shall be held together by through-bolts and end plates.

10. The stator shall have all connections brazed with silver brazing alloy. The stator shall be braced and supported to eliminate any detrimental winding movement.

11. Motor shall be rated at 460 volts, 3 phase, 60 Hertz.

12. Motor efficiency shall not be less than **[XX%]** percent and (uncorrected) power factor not less than **[85]** percent when operating at maximum speed, full load, and rated voltage and frequency.

Note to Specifier: Include only one of the two subparagraphs below.

13. Motors shall be capable of bringing the pumps up to speed with a closed **[control] [check]** valve and 80 percent of rated voltage.

14. Motors shall be capable of bringing the pumps up to speed with valve at 5 percent open.

15. The motor leads shall have the same insulation level as the motor.

16. Motors shall be painted in the factory with two coats of manufacturer’s standard exterior enamel. Furnish touch-up paint for the Contractor’s use. Motor color shall be selected by the Owner.

Note to Specifier: For paragraph below, NBU requires all vertical motors have NRR

17. Motors shall be provided with non-reverse ratchets.

18. Motor shall be rated for VFD use.

B. Enclosure: Motor enclosure shall be **[Totally-Enclosed Fan Cooled (TEFC)]** as indicated in pumping conditions schedule and in accordance with NEMA MG-1. Provide adequate circulation for all operating speeds and loads. **[Motor to be suitable for an outdoor environment.]**

C. Insulation:

1. Motor windings shall be full Class F insulated. After stator assembly, the stator assembly shall be sealed vacuum-pressure impregnation (VPI) of epoxy resin. The stator shall receive two VPI treatments, each treatment consisting of a dip followed by an oven bake. After the final cure, the stator assembly shall receive a final (third) coating of a durable epoxy varnish to further protect against dust, moisture, and chemical degradation. The windings shall comply with the latest applicable provisions of NEMA MG 1, and end winding coils shall be braced to limit displacement to no more than 5.0 mils under any condition of starting or running.

2. Motor shall operate continuously at rated voltage and frequency (6 to 60 Hz) at 50 deg. C ambient temperature, with a temperature rise not to exceed both.

   i. A Class B rise (70 deg. C), per NEMA MG-1 20.8 measured by resistance at a 1.0 service factor when operating at 100 percent of the nameplate rated horsepower.

   ii. [And a Class B rise (80 deg. C) per NEMA MG-1 20.8 measured by embedded resistance temperature detector (RTD) at a 1.0 service factor when operating at 100 percent of the nameplate rated horsepower.]

3. Insulation shall be capable of preventing failure as a result of common mode voltages.

D. Bearings:

1. Motor bearings shall be designed for the maximum load imposed by the pump and motor and shall be selected for a 5-year minimum life and a 25-year average life as defined by the AFBMA. Bearings shall be insulated as necessary to prevent shaft-bearing-frame current. Insulating means shall also be provided for any oil-supply connections and monitoring equipment to prevent electrical bypassing of the bearing insulation.

2. Thrust bearing on top of motor shall be of the anti-friction with oil reservoir and other necessary appurtenances. Lower radial guide bearings shall be oil-lubricated, anti-friction with oil reservoir. Thrust bearing shall be of the air-cooled type.

E. Motor Terminal Box:

1. Motor terminal box shall be suitable for terminations without exceeding the minimum bending radius of the conductors per the National Electrical Code.

Note to Specifier: Delete the subparagraph below item if not required.

2. Motor terminal box shall be oversized to accept the following without exceeding the minimum bending radius of the conductors per the National Electrical Code:

   i. **[Specify]** sets of **[specify]** per phase, **[specify]** ground conductor (**[specify]-**inch conduits).

3. **[Motor terminal box shall be NEMA Type II with motor leads landing on three-phase, insulated bus drilled with NEMA 2-hole pads to terminate the feeder cables. Direct cable-to-cable connections shall not be permitted.]**

Motor terminal box shall be located **[90 degrees clockwise] [135 degrees counter-clockwise]** from the pump discharge. Bottom and front of box shall be removable. Motor terminal box shall receive motor cables from the bottom. Terminal box shall be adequately insulated to prevent excessive vibration.

4. Terminal box size, position, and layout shall be submitted to the Owner's representative for review and approval.

Note to Specifier: Edit the subparagraph below to align with design considerations for 1) Motor space heaters, 2) RTD's or thermal switches, and 3) Vibration monitoring system. NBU prefers to use thermal switches. For motors 300HP and greater, RTD's are the preferred choice for temperature monitoring. If Engineer recommends vibration monitoring, the Engineer needs to coordinate with NBU on the type of system and how it will be monitored/controlled and used in pump controls.

F. Accessories Terminal Boxes:

1. Motor shall have accessory leads from **[space heaters]**, **[RTDs]** and **[vibration sensors]** terminated in separate boxes. Leads for **[space heaters]**, **[RTDs]**, and **[vibration sensors]** shall be terminated on **[600 V NEMA rated]** barrier type terminals with stainless steel screws. **[Leads from vibration sensors shall be terminated on vibration switch terminals.] [Leads for bearing and winding RTDs shall be brought to the same box.]** Leads shall be suitably marked and identified with heat shrink markers. Accessories terminal boxes shall be located **[on the opposite side of the] [90 degrees counterclockwise from]** motor terminal box. Accessories boxes shall have phenolic nameplates, black and white letters, attached with stainless steel screws. The nameplates shall say **["SPACE HEATER"]**, **["WINDING & BEARING RTDs"]**, **["VIBRATION SENSORS"]**, etc. Accessories boxes shall be bottom **[or side entry]** and shall be supported by the motor.

2. Terminal boxes shall have provisions for terminating the following conduits:

   i. **[RTD Terminal Box: One 1-1/2-inch conduit.]**

   ii. **[Space Heater Box: One 1-inch conduit.]**

   iii. **[Vibration Sensors: One 1-1/2-inch conduit and One-1-inch conduit.]**

3. **[RTD terminals shall be clearly labeled with nameplate/wire tag identifying which Bearing RTD- Upper/Lower and which Winding RTD- Phase A/B/C they are associated with].**

G. Grounding Means: 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 and suitable for terminating **[#X]** ground wire. Provide two NEMA 2-hole ground pads located near the base of the motor mounted 180 degrees apart. Ground pads shall be stainless steel and suitable for terminating **[#X]** ground conductor.

H. Appurtenances:

1. All wires and electrical connections shall be copper. All wiring penetrating motor frame shall be protected against chaffing with a rubber grommet.

Note to Specifier: Edit the subparagraphs below to align with NBU requirements. NBU prefers for the Motor Space Heater (MSH) to be powered from the motor controller. For renovation projects (existing site) coordinate with NBU for exact source for MSH circuit.

2. Space Heaters: Motor shall be equipped with space heaters for operation on 120-volt, 60-Hertz, single-phase power. They shall maintain the internal temperature above dew point when motor is not operating. Space heaters shall not be located directly in the access holes where they may pose a danger of burn or shock to servicemen. Space heater wiring shall be routed to prevent wire being between the frame and space heater.

Note to Specifier: Use one of the following two paragraphs. For motors 300HP and greater, RTD's are the preferred choice for temperature monitoring.

3. Temperature Monitors: Motors shall be equipped with six 100-ohm platinum RTDs, two per phase, spaced around the motor windings and located at the hot spots of the stator. In addition, each thrust and guide bearing shall have a 100-ohm platinum RTD installed for sensing bearing temperature. RTDs for bearings shall be integral to the bearing housing.

4. Thermal switches: Motors to be equipped with bi-metallic, snap action, temperature actuated switches on the end turns of each phase of the windings. Thermostats to be **[normally open contacts wired in parallel]** and be wired to a set of terminals for customer's use.

Note to Specifier: If Engineer recommends vibration monitoring, the Engineer needs to coordinate with NBU on the type of system and how it will be monitored/controlled and used in pump controls.

5. **[Vibration sensors/switches: (add description here).]**

6. All appurtenance boxes shall be laid out to avoid overlap and access limitation to the boxes. Appurtenance boxes shall be secured with stainless steel.

7. Conduits:

    i. Liquidtight flexible metal conduit shall be Anaconda Sealtite, Type HTUA by Anamet Electrical, or equal. Fittings used with liquidtight flexible metal conduit shall be of the screw-in type with insulated throat by Thomas & Betts Co.; no equals.

    ii. Rigid aluminum conduit, couplings, factory elbows, and fittings shall be 6063 alloy by Allied Tube & Conduit Co. or approved equal. Conduit hubs shall be insulated throat by Crouse-Hinds.

    iii. Liquidtight strain relief cord and cable connectors shall be Series LS by Crouse-Hinds or approved equal.

    iv. Design neat layout of conduit from **[vibration sensors] [and] [bearing RTDs]** to the accessory terminal boxes. Submit a detailed layout drawing to the Owner's representative for review.

    v. All conduits and wire shall be routed and installed in an identical fashion for like motors.

vi. Minimum conduit size shall be 3/4 inch.

8. Mounting Hardware: All mounting hardware including but not limited to strut channels, clamps, etc. shall be 316 stainless steel.

Note to Specifier: Edit the subparagraphs below to align with associated pump/motor supporting hardware, such as bearings, vibration monitoring system, temperature monitoring, etc..

I. Documentation: Motor manufacturer shall supply documentation for the motors as follows:

1. Complete dimensional data including the following:

   a) Dimensional outline drawings.

   b) Maintenance clearances.

   c) locations and sizes of lubrication connections, vents, drains, etc.

2. Data Sheet: Fill out and submit with the Shop Drawing submittal the information requested on the Motor Submittal Data Sheet (Attachment B) for each size motor being provided.

3. Complete nameplate data.

4. Letter of Compatibility: The pump/motor supplier in conjunction with the VFD supplier shall issue a letter of compatibility stating that the VFD and motor are compatible.

5. Allowable time periods between starts.

6. Subtransient reactance and X/R.

7. Speed-torque curve at 100 percent and 80 percent of rated voltage.

8. Speed-current curve at 100 percent and 80 percent of rated voltage.

9. Acceleration time at 100 percent and 80 percent of rated voltage.

10. Thermal damage curve (I2t).

11. Locked rotor withstand time.

12. Rotor inertia.

13. Schematic and interconnection diagrams.

14. Bearing descriptions.

15. Motor weights.

16. **[Alarm and Trip temperatures for winding and bearing RTDs.]**

17. **[Alarm and shutdown values (in./sec.) for vibration sensors (X and Y axis).]**

18. Detailed conduit layout for motor.

19. Cutsheets on terminal blocks used in accessories terminal boxes.
20. Dimensions (internal and external) and layouts of terminal box and accessories terminal boxes. For main motor terminal box, clearly show the distance from the bottom of the enclosure to the termination lugs. Indicate all dimensions in inches. Final dimension and location are subject to approval by the Engineer.
21. Motor insulation voltage rating.
22. Measured locked rotor current and torque and locked rotor power factor.
23. Motor no load data (i.e., amps, power factor, etc.).
24. Maximum kVAR allowed for power factor correction. Maximum kVAR shall be included on motor nameplate as well.
25. Locked rotor power factor.
26. Instruction manual.
27. Bill of Materials with manufacturer's cut sheets for all major equipment, **[RTD's],** bearings, **[vibration sensors and transducers],** terminal blocks, etc. Clearly identify on cut sheets the exact model number of equipment being provided.
28. Results of motor tests.
29. All documentation listed above shall be supplied with the motor's initial submittal with the exception of the motor test results and instruction manual which shall be furnished later in the Project. Incomplete submittals will be returned "NOT APPROVED - REVISE AND RESUBMIT."

516.11 Spare Parts

Review spare parts closely with NBU.

A. Provide spare parts as follows**. [Provide a set for each size of pump.]**

1. Provide the Owner with a sufficient quantity of lubricant for required service during the first [12] months after startup.
2. One complete set of line shaft bearings.
3. One complete set of bowl bearings.
4. One complete set of bowl wear rings.
5. One complete set of impeller wear rings.
6. [One shaft sleeve.]
7. One complete set of gaskets and O-rings.
8. One complete stuffing box assembly.

9. Three sets of packing for the pump stuffing box.
10. One complete set of mechanical seals.

516.12 Construction Methods

A. General

1. Equipment Manufacturer's representative, including motor manufacturer, have responsibilities in the installation and field testing of the equipment as described in this Section. Installation of equipment shall be performed by the Contractor who shall be required to assemble the equipment and install it in accordance with installation, operation and maintenance instructions which shall be furnished by the Equipment Manufacturer, the installation Drawings for this Project and applicable installation instructions of the Hydraulic Institute Standards.
2. Contractor shall schedule the service of the Equipment Manufacturer to assist in the assembly installation, lubrication, adjustment, testing and acceptance of the equipment.
3. Contractor shall furnish all labor, tools, equipment and machinery necessary to receive, inspect, unload, store, protect, and install completely, in proper operating condition, the equipment. Contractor shall protect and store the motors indoors and as recommended by the manufacturer, keeping bearings lubricated and the motor space heaters energized during storage and until they are put into service.
4. Contractor shall also furnish such incidental items not supplied with the equipment, but which may or may not be described in the Drawings and Specifications, for complete installation, such as welding, drain lines, gaskets, flange bolts for suction and discharge piping, connecting piping, wiring, conduit, ducts, mounting brackets, anchors and other appurtenances as necessary.
5. Certain items of equipment due to its size or character will be disassembled for shipping and shall be assembled by the Contractor as it is installed. It is the Contractor's responsibility, in establishing their costs for installation, to determine the degree of disassembly that the equipment will be shipped in.
6. Equipment Manufacturer shall inspect and determine that the **[pump barrel mounting flange] [sole plate]** has been installed correctly and to the recommended tolerance prior to installation of the pump. The recommended tolerance is that the discharge head connection nozzle is in alignment with the piping to within +/- 1/16-inch and that **the [sole plate] [mounting flange]** is level to within 0.002 in/ft of span. This determination shall be made prior to grouting with the **[sole plate] [mounting flange]** properly shimmed. Before placing the grout scarify the adjoining concrete and pour a non-shrink epoxy grout. After properly curing, remove the temporary wedges or shims and hand pack voids with grout. Then torque the anchor bolts to the appropriate values. A second inspection shall be made after the **[sole plate] [mounting flange]** has been completely grouted in place, but prior to installation of the pump. Installation includes leveling and grouting the pump barrel.

7. **[Contractor shall use a Class III non-shrink epoxy grout under the sole plate. The Class III non-shrink grout shall have a compressive strength of at least 12,000 psi after 28 days. Installation contractor shall provide a submittal on the proposed grouting procedure and grout products to be used.]**
8. Contractor shall make the power, control, and instrumentation connections at points designated by the Equipment Manufacturer.
9. Equipment Manufacturer shall supply touch up paint and Nedox for installation. Nedox shall be used on all threaded parts, bolts, and nuts.

B. Installation

1. Install **[one] [two] [three] [four]** vertical line shaft pumping units.
2. Install **[specify quantity] [intake barrels] [circular intakes]** to the required tolerances.
3. Assemble the bowl assembly, column, line shaft and discharge head and anchor to sole plate.
4. Set and align motor, assemble shaft coupling and adjust impeller setting. After running the pumping unit, readjust impeller.
5. Make up the thrust harness components and make all other necessary connections as part of the assembly and alignment activities.
6. Furnish and install drain lines.
7. **[Furnish and install shaft lubrication and bottom bowl grease appurtenances (for greased lower tail bearing).]**
8. Furnish and install wiring, conductors, conduits, cable trays, and connections for motor leads, control wiring, etc.
9. Conduct acceptance tests and submit an installation report as required in Paragraph **[516.12.C.2.viii**].
10. Equipment Manufacturer's representatives shall be present for all equipment installation and testing.

C. Field Quality Control

1. General:
    i. [Equipment Manufacturer shall inspect and determine that the pump barrel and pump barrel flange has been installed correctly and to the recommended tolerance prior to welding flange to barrel and installation of the pump.]
    ii. [Equipment Manufacturer shall inspect and determine that the sole plate has been installed correctly and to the recommended tolerance prior to installation of the pump.]

iii. Calibrated testing equipment shall be provided by the Equipment Manufacturer to measure setting, alignment, speed, noise, temperature and vibration of the pump. Vibration data shall be recorded with a Vibscanner as manufactured by Pruftechnik or approved equal.

iv. [The motor manufacturer shall provide a testing apparatus to check the proper installation and calibration of RTDs, prior to final acceptance. The apparatus shall be Altek RTD calibrator model 211 or equal.]

v. Equipment Manufacturer shall supply calibrated pressure gauges on discharge of pump for use during testing.

2. Preliminary Operational Test:

Note to Specifier: Determine acceptable startup procedure or source of water for startup.

i. After the pumps have been installed, including all piping connections, and electrical system construction is complete, and after the piping has been tested, the Contractor, with assistance from the Equipment Manufacturer, shall perform preliminary operational tests over a period of not less than **[two 10-hour tests or one 24-hour test]**. The test shall be conducted in a manner approved by and in the presence of the Owner's representative. Equipment shall be checked for excessive noise, alignment, vibration and lateral deflection, general performance, etc.

ii. The pumping units shall be operated throughout its full range of operating heads, if possible, **[and at pump speeds from maximum speed to minimum speed,]** recording data including suction pressure, pump discharge pressure, pump speed, flow rates, water levels, motor voltage and current, power factor, vibration, noise, deflection, pump and motor bearing temperatures, and motor winding temperatures, as applicable. This information shall be properly documented and included in the Equipment Installation Report. The unit must perform in a manner acceptable to the Owner and Engineer before Final Acceptance of the installation will be made.

iii. [Vibration shall be no greater than the "Allowable Field Vibration Limits" as defined by the Hydraulic Institute Standards and as modified by this Section above. Vibration shall be measured in the x, y and z direction at the bottom motor flange and at the motor upper bearing housing.]

iv. [Vibration data shall be recorded for variable speed pumps within the specified operating speed range at increments of 5 percent from minimum speed to full speed. Actual pump rotational speed shall also be recorded with each vibration data set.]

v. A field "bump" test of the installed pump and motor shall be made under the supervision of the Equipment Manufacturer to confirm that the Reed Frequency is not within 25 percent of any operational exciting frequency.

Note to Specifier: Delete the subparagraph below if pumps will have non-reverse rachet. Delete the subparagraph if using a check valve.

vi. **[Conduct a backspin test of the installed pumping unit to check for excessive backspin speed and excessive vibration during the pump backspin. The test will be conducted by simulating a power failure. Review detailed procedure with the Engineer prior to the field test. Allow reverse flow from the discharge piping at full operating head. Measure backspin speed and vibration of the pump and motor. Speed and vibration shall not exceed manufacturer's recommended limits.]**

vii. The Contractor and Equipment Manufacturer shall be responsible for operating the equipment and recording and submitting the necessary data from the test. All information required above shall be properly documented and included in the Equipment Installation Report. The units must perform in a manner acceptable to the Owner and Engineer prior before Final Acceptance of the installation will be made.

viii. Equipment Manufacturer shall submit an Equipment Installation Report to the Contractor certifying that the equipment is properly installed, lubricated, is in accurate alignment and is free from undue stress from connecting appurtenances, that it has been operated under full load conditions and that it is operating satisfactorily. Contractor shall provide copies of the report.

3. System Operational Test:

i. After the preliminary operational test is complete and prior to final acceptance of the Project, the Contractor shall conduct a 30-day system operational test. Owner will be responsible for operating the equipment and recording data during this test. The Equipment Manufacturer, Contractor, and any subcontractors will be responsible for troubleshooting and adjustments to the equipment during the test. **[The purpose of the test is to demonstrate and check the ability of the pump to operate continuously as the system requires.] [The 30-day test is not required to achieve Substantial Completion.]**

D. Painting:

1. Touch-up all damage of painting of the pumping unit with extra paint furnished by the manufacturer.

516.13 Measurement

Vertical Turbine pumps will be measured per each.

516.14 Payment

A. **[Pump Vendor]** shall submit Applications for Payment filled out and signed by **[Vendor]** and accompanied by such supporting documentation as is required by the Procurement

Documents and also as the Owner's representative may reasonably require. The first Application for Payment will be submitted to the Owner after review and acceptance by Owner's representative of all Shop Drawings, Product Data, and Samples required by the Procurement Documents. The Application for Payment will be limited to 5 percent of the total contract amount.

Milestone	Cumulative % of Contract Price
Approval of Shop Drawings & Product Data	5%
Delivery of pre-installation materials to the Project Site (**[barrels,] [sole plates,]** anchor bolts)	**[10%] [Invoice value as materials on hand]**
Approval of factory performance tests (pump and motor), Delivery of equipment to job site in good condition and approved Preliminary Operation and Maintenance Manuals	80%
Installation, Testing, Completion of Installation reports, submittal of final Operation and Maintenance Manuals, Completion of special services	95%
Final acceptance of the installed and tested equipment, approved Final Operation and Maintenance Manuals, completed Owner personnel training and other required information	100%

B. The next Application for Payment will be submitted after review and acceptance of the preliminary operation and maintenance manuals by the Engineer, satisfactory completion of all factory tests, and after delivery of the Goods has been accepted by the Buyer, and will be accompanied by a bill of sale, a Certification of Acceptable Delivery, Unloading, and Storage signed by the Contractor and other documentation satisfactory to the Buyer warranting that the Goods are delivered free and clear of all liens, charges, security interests, and encumbrances. Such documentation shall include releases and waivers from all parties who, during Vendor's performance under the Procurement Documents, might have obtained or filed any such lien, charge, security, or encumbrance. The Application for Payment will be limited to 80 percent cumulative of the total contract amount. Portions of this amount may be paid in monthly pay estimates following partial deliveries proportionate to the amount of Goods delivered provided an itemized Schedule of Values has been submitted and approved.

C. The next Application for Payment will be submitted after completion of equipment installation, testing, completion of the specified Installation Report, submittal of the final operation and maintenance manuals, and completion of Special Services. The Application for Payment will be limited to 95 percent cumulative of the total contract amount.

D. Final payment will be submitted after final acceptance of the pump and motors following the 30-day satisfactory operational test.

Pay Item: _____ Pump, _____Dia, _____ rpm Per Each

Notes to Specifier:

Edit the data sheets in Attachment A and B as needed to fit the specifications. The notes to require with the Bid/Proposal need to be included if using CSP or efficiency evaluation for the pumps. Include system curves with hypothetical pump curve and specified duty points as Attachment C. Show duty points for a single pump and total curve for all pumps.

VERIFY ALL NOTES TO SPECIFIER HAVE BEEN DELETED

END

ITEM NO. 516 "VERTICAL TURBINE PUMPING UNITS" – ATTACHMENT A, SUBMITTAL PUMP DATA SHEET

Equipment Supplier: _____

Submit the following data for each size of Pumping Unit:

Pump Data	**Tag:**
Make and Type Design	
Rated Speed	
Bowl Size	
Number of Bowls	
Impeller Diam. vs. Max. Impeller Diam. for Bowls	
Impeller Material	
Bowl Shaft Diameter and Material	
Line Shaft Diameter and Material	
Enclosing Tube Diameter and Material	
Column Diameter and Thickness	
Maximum Shaft Thrust Load	
Shutoff Head	
Max Allowable Operating Head at 100% Speed	
Min Allowable Operating Head at 100% Speed	
Impeller Specific Speed	
Maximum Backspin Speed	
Suction Specific Speed	
Maximum Brake Horsepower	
NPSH Required at Rated Head	
NPSH Required at Minimum Head	
Wire-to-Water Efficiency at Rated Point No. 1	
Wire-to-Water Efficiency at Rated Point No. 2	
Rotor polar moment of inertia WR^2	
Weights	
Pump and Motor Stand	
Motor	
Complete Unit (Dry)	
Complete Unit (Wet)	

THIS FORM MUST BE RETURNED WITH THE [PROPOSAL] [SHOP DRAWING]

END OF ITEM – ATTACHMENT A

ITEM NO. 516 "VERTICAL TURBINE PUMPING UNITS" – ATTACHMENT B, SUBMITTAL MOTOR DATA SHEET

Submit the following data for each size and type of motor:

Manufacturer		Motor HP	
Frame		Enclosure	
Type		RPM	
Voltage		Phase	
Starting Method		Hertz	
Shaft Size		Rotor WK2 (lb-ft^2)	
Insulation Class		Duty	
Full Load Amps		No Load Amps	
Locked Rotor Amps		Locked Rotor Torque	
Locked Rotor Torque		% Breakdown Torque	
Locked Rotor KVA/HP			

NEMA Design	
Service Factor	
Inrush Current (% of Full Load)	
Max Safe Stalled Time (seconds)	
Number of Safe Starts Per Day	
Number of Consecutive Starts	
*Full Load Temp Rise, in Degree Celsius over 50 deg. C Ambient (at 1.0 S.F.)	
*Service Factor Temp Rise, in Degree Celsius over 50 deg. C Ambient (at 1.15 S.F.)	
*Limiting Temperature Rise	

Resistance (at 25 deg. C)		Bearings:	
Exhaust Air (CFM)		Type/Size	
Exhaust Air Temp Rise (F)		Life	
		Lubrication	

	Efficiency	Power Factor	Current
1.15 S.F. Load			
4/4 Load			
3/4 Load			
1/2 Load			
1/4 Load			

Vibration Alarm and Trip Set Points	
RTD Types and Mounting	
RTD (Winding & Bearing) Trip Set Points	
Motor Sound Power Level	
Maximum kVAR Allowed for power factor correction without overexciting the motor	
Space Heater Voltage	
Space Heater Wattage	

THIS FORM MUST BE RETURNED WITH THE [PROPOSAL] [SHOP DRAWING]

END OF ITEM – ATTACHMENT B

ITEM NO. 516 “VERTICAL TURBINE PUMPING UNITS” – ATTACHMENT C PUMP AND SYSTEM CURVES

END OF ITEM – ATTACHMENT C