SECTION 1201

VERTICAL TURBINE BOOSTER PUMPS

1201.0100 GENERAL

1201.0101 Description of Work. The work under this Section shall consist of furnishing all labor, materials, equipment, and appurtenances required for the installation and testing of vertical turbine pumping unit assemblies, all in accordance with the details shown on the plans and specifications and the requirements of this Section. The pumping unit assembly shall be provided by the pump manufacturer. The pumping unit assembly shall include, but not be limited to:

- Line shaft driven vertical turbine pump
- Column pipe
- Discharge head
- Motor
- Pump can

It is the intent of this Section to obtain pumps of heavy-duty construction for heavy-duty service capable of pumping water for continuous service or for intermittent service, whichever imposes the most severe service on the pump.

All pumping unit assemblies shall be field tested. Pumps with mechanical defects or not meeting the range of head vs. capacity characteristics, horsepower, efficiency, and vibration requirements will be rejected after testing and shall be replaced at no additional cost to the Owner for furnishing, removal, reinstallation and retesting. Mechanical defects shall include the following:

- Excessive vibration, as determined by the Hydraulic Institute ANSI/HI 9.6.4-2000 and per Subsection 1201.0304
- Improper balancing of any rotating parts
- Improper tolerances
- Binding
- Excessive bearing heating
- Defective materials, including materials that do not conform to the specifications
- Improper fitting of parts
- Any other defect that will, in time, damage the pump or unreasonably impair its efficiency

All necessary and required accessory equipment and auxiliaries, whether specifically mentioned in this Section or not, shall be furnished and installed as required for an installation incorporating the highest standards for this type of service. Also included shall be supervisory services during installation and field testing of each unit, and instructing the regular operating personnel in the proper care, operation, and maintenance of the equipment.

1201.0103 Submittals. All submittals shall reference the Tucson Water project plan number.

Shop drawings shall be submitted in accordance with the provisions of the project specifications and as follows.

(A) Pumping Unit Assembly. Submittals shall detail each item of equipment and auxiliary apparatus to be furnished, and include the following:

(1) Machine drawings of the discharge head, as well as dimensional drawings together with literature showing the entire pumping unit assembly. Machine and dimensional drawings shall include both plan and section views.

(2) Pump make and model.

(3) Number of stages in pump.

(4) Pump bowl material and diameter, including ASTM specification compliance and pump bowl lining and coating specification.

(5) Pump bowl bearing material.

(6) Impeller type, material, and diameter.

(7) Column pipe material and diameter.

(8) Line shaft material and diameter.

(9) Pump shaft diameter.

(10) Pump bowl bearing to line shaft clearances with a note as to the maximum allowable clearance.

(11) Pump bowl wear area to impeller skirt clearances with a note as to the maximum allowable clearance.

(12) Installation, operation, and lubrication instructions.

(13) Any other noteworthy design features.

(B) Pump Performance Curve. For each pump to be supplied, submittals shall furnish the actual pump performance curve for the fully assembled multistage pump and its specific impeller diameter. This shall include:

(1) Pump head and capacity curve

(2) Horsepower requirement curve

(3) Efficiency curve

(4) Thrust factor (K) curve

(5) NPSH curve

(6) Impeller lateral

(7) Recommended impeller setting

(8) Weights of the pumping unit components

(9) A statement of guarantee that the critical speed analyses as required under Subsection 1201.0304 have been completed and that the specified limitations will be met

Curves shall show the full recommended range of performance and include shutoff head. This information shall be prepared specifically for the pump proposed. Catalog sheets showing a family of curves will not be acceptable; see sample at the end of this Section for required information and proper data plotting. Failure to comply with these requirements will result in rejection of the pump.

(C) Test Reports. Submittals shall include the following test reports:

(1) Shop Testing as specified in Subsections 1201.0305(A) and 1201.0201(E)

(2) A statement that the pump will function properly as installed with respect to the suction and discharge piping layout as shown on the Drawings and as specified herein

(D) Operation and Maintenance Data. Complete operating and maintenance instructions shall be furnished for all included equipment. Maintenance instructions shall include troubleshooting data, full preventative maintenance schedules, and complete spare parts lists with ordering information. Manuals shall be submitted prior to pump testing.

1201.0104 Delivery, Storage, and Handling. All parts shall be properly protected such that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is complete and the unit and equipment are ready for operation.

All equipment and parts must be properly protected against any damage during shipment. Equipment shall be stored in accordance with the manufacturer's recommendations.

Factory-assembled parts and components shall not be dismantled for shipment unless approved in writing by the Engineer.

The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted thereto.

Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

No shipment shall be made until written approval of the pumping unit assembly submittals has been received.

Bearings shall be properly processed to protect them during shipment and installation. If pre-lubricated, anti-friction bearings shall be protected in accordance with the bearing manufacturer's recommendations against formation of rust during a long period of storage while awaiting completion of installation and startup of the machine in which the bearings are used.

If not pre-lubricated, anti-friction bearings shall be properly treated with the application of Exxon Rust-Ban No. 392, or equal, in accordance with the bearing manufacturer's recommendations against formation of rust during a long period of storage while awaiting completion of installation and startup.

1201.0200 PRODUCTS

1201.0201 Materials.

(A) Vertical Turbine Pumps. Vertical turbine pumps and the materials used in their manufacture shall comply with the most recent revision of the following standards:

See Table 1201-1 on the next page.

Table 1201-1
Standards

Subject	Standard Designation
Horizontal and Vertical Line Shaft Pumps	ANSI/AWWA E103-07
Protective Epoxy Interior Coatings for Valves and Hydrants	ANSI/AWWA C550
Steel Structures Painting Council Surface Preparation Specification No. 10	SSPC-SP-10/NACE 2
Suction and Discharge Cases (Flanged and Bolted)	Cast iron ASTM A48 Class 30
Pump Bowl (Flanged and Bolted)	Cast iron ASTM A48 Class 30
Impellers (Enclosed)	Bronze ASTM B584-836
Pump Shaft (Bowl Shaft) and Couplings	ASTM A582 type 416 stainless steel PSQ
Discharge Case Bearing	ASTM B584-836 or ASTM B505-932
Suction Case Bearing	ASTM B584-836 or ASTM B505-932
Intermediate Bowl Bearing(s)	ASTM B584-836 or ASTM B505-932
Bowl Assembly Bolts, Studs, Nuts	ASTM A276 type 316 stainless steel

The vertical turbine pumps shall be product lubricated, and conform to the specific requirements contained herein.

Impellers shall be cast bronze ASTM B584-836, of enclosed design, and statically and dynamically balanced. Semi-open or open impeller designs will not be considered.

For pump bowls 6 to 14 inches in size, the water passages shall have vitreous enamel lining. For pump bowls 16 inches and larger, the water passages shall be lined with fusion-bonded epoxy to provide optimum long-term performance. The outside of the bowl assembly shall be coated with an NSF-approved 2-part epoxy paint system.

The pump shall come equipped with a bolt-on type 304/316 stainless steel strainer having a total open area at least 4 times the cross-sectional area of the suction casing. The method of attachment shall assure the Engineer that the strainer will remain attached throughout the service life of the pump.

Collets and all hardware shall be stainless steel ASTM A276, type 316. Bowl shaft shall be type 416 stainless steel and “pump shaft quality” (PSQ).

(B) Column Pipe and Line Shaft. Discharge columns shall be fabricated from ASTM A53, Grade B steel with flanged and bolted connections. Discharge column sections shall not exceed 5 feet in length with line shaft bearings every 5 feet.

All flange hardware shall be ASTM A276, type 316 stainless steel.

The minimum wall thickness on all columns shall be 0.375 inch. Column assembly shall consist of column pipe with flanges, line shaft, line shaft coupling, bearing retainer, and line shaft bearing.

The column pipe shall be of the flanged product-lubricated type, and shall be painted inside and out with an NSF-approved 2-part epoxy.

Bearing retainers shall be supplied for each column section, including the top column section that attaches to the head. Bearing retainers shall be bronze ASTM B584-836, fitted with a neoprene bearing.

Line shaft bearings shall be removable, self-flushing rubber type, mounted in bronze bearing spiders located at discharge column flanges on 5-foot centers.

(C) Pump Discharge Head. The discharge head shall be fabricated of ASTM A53, Grade B steel designed for aboveground discharge with sufficient strength and rigidity to support the motor mounted on it and to carry the suspended weight of the attached column and bowl assembly. The discharge flange shall be faced and drilled to match the discharge piping flanges and pressure class. The discharge size shall be the same size as the discharge piping. All water passages and wetted parts of the discharge head shall be coated with an NSF-approved 2-part epoxy paint system.

The discharge head shall include a stuffing box and have extra-large openings for pump adjustment and seal maintenance. It shall also include a suitably sized drain connection and a continuous bypass to maintain low stuffing-box pressure and assure positive stuffing-box bushing lubrication. The flange at the base of the discharge head shall be drilled and tapped for connection of the mechanical seal recirculation line. A 1-inch thread-o-let shall be placed on the discharge piping before the flange to allow for the installation of a combination air/vacuum valve. The discharge head shall have a hinged safety door with hasp to cover the discharge head open area and guard the shaft.

A mechanical seal shall be provided as required by the project plans and specifications. The seal shall allow for a recirculation line.

The base of the discharge head shall be circular and fully machined to match the drilling of the top suction can flange as selected by the pump manufacturer. Baseplate shall not be less than 1-1/2 inch thick.

The top of the discharge head shall have a registered fit for mounting driving motor.

The pump and motor shaft sections shall be joined with a 4-piece spacer-type coupling. This coupling shall be of a steel design suitable to transmit the required torque and horsepower of the pump. The upper and lower halves of the coupling shall be keyed to the motor and head

shaft. A threaded adjusting nut shall be located between the lower coupling half and the spacer. The coupling design shall be such that the specified mechanical seal can be easily removed through the discharge head openings without moving the motor. The 4-piece coupling shall have no more than 0.003 inch total indicator runout (TIR).

(D) Pump Can/Suction Barrel. The pump can shall be below ground suction type, in accordance with the project plans and specifications, and constructed of ASTM A53, Grade B steel with minimum wall thickness of 3/8 inch and suitable for a working pressure of 150 pounds per square inch gauge.

The diameter and length of the pump can shall be selected by the pump manufacturer to ensure proper delivery of flow into the first stage impeller. However, the diameter and length shall not be less than that shown on the drawings.

The pump can shall be polyurethane coated and epoxy lined as specified by the project plans and specifications.

The pump can shall be of heavy duty construction, and reinforced as necessary to resist all horizontal and vertical loads.

A continuous 3/4-inch thick steel shear key projection or plate ring extending 2 inches beyond the barrel's outside diameter shall be installed as shown on the drawings.

The interior of the pump cans shall be fitted with fixed fluid straightening vanes as shown on the drawings. The intent of these straightening vanes is to provide laminar flow to the inlet of the pump. Pump cans without the specified straightening vanes will not be accepted.

Construction of the pumps and position and number of column pipe flanges shall be such that the pumps can be readily installed and removed for repairs using normal methods of operation and handling without undue difficulties.

The natural frequency of the assembled pump and its supporting structure shall be at least 25 percent higher than the maximum pump speed with no dangerous sub-frequencies near the design speed.

(E) Motors.

(1) General. Motors for all pumps shall be vertical solid shaft squirrel cage premium efficiency motors, USEM or approved equal. The motor shall comply with NEMA MG-1 standards and shall be NEMA WP1 rated. The motor shall operate below motor nameplate full-load amps, for all three phases, over the entire range of the pump curve. The following motor characteristics shall be indicated in the project plans and specifications and shall be stamped on a permanently affixed, engraved stainless steel motor nameplate. The motor shall meet the following requirements:

Table 1201-2
Motor Requirements

Characteristic	Requirement
Horsepower	As specified in project plans and specifications
Speed	Rated motor speed shall be as specified and greater than 96% synchronous speed at rated horsepower
Voltage	460
Phase	3
Hertz	60
Service Factor	1.15
NEMA Design	B
Minimum Insulation	Class F
Ambient Temperature	40° C at maximum altitude of 3,000 feet
Enclosure	WP1
Efficiency	(Minimum at full load)
Full Voltage Start	As shown on plans
Duty Cycle	Continuous
Type	Vertical solid shaft squirrel cage induction motor

The temperature rise of motor shall be in accordance with the requirements for Class B at a service factor of 1.15.

The motor conduit box shall be provided with grounding terminal. The conduit box shall be sized to handle required conduit and wire, as shown on the plans.

Motor windings shall be copper with not less than 98 percent conductivity.

The motor shall be capable of continuous operation at full load and at a voltage 10 percent above or below the rated voltage, provided that the sum of voltage and the frequency variation does not exceed 10 percent with the frequency variation not exceeding 5 percent.

Motor bearings to be lubricated with grease shall be equipped with grease nipples and grease relief plugs. Thrust and guide bearings shall be oil lubricated, with accessible drain and fill plugs on the oil reservoir. The oil level on the reservoir shall be indicated by a sight gauge. The thrust bearing shall have a minimum of (L-10) 88,000 life hours at 7,950 pounds down thrust and be capable of withstanding any momentary up thrust produced by the pump.

The motor shall be supplied with non-reverse ratchet, ball bearing type. The ratchet

assembly shall be capable of being quickly fitted at any time or removed for servicing without disturbing the coupling or pump setting.

The motor shall have short commercial tests performed that include:

- No-load current
- Locked-rotor current
- Winding resistance
- High potential
- Vibration and bearing inspection

Copies of a test report on the short commercial test performed on the provided motor model shall be submitted for review as part of the shop drawing submittal. Complete initial test data for a comparable motor shall also be submitted for review as part of the shop drawing submittal, and shall include, but not be limited to:

- Full-load heat rise
- Percent slip
- Breakdown torque
- Locked-rotor torque
- Efficiency
- Power factor at full, 3/4, and 1/2 load, running light current
- Power factor at no load, running current at rated voltage

The following information shall be stamped on a permanently affixed, engraved stainless steel motor nameplate:

- Motor insulation class
- Temperature rise class
- Ambient temperature rating
- Design class
- Service factor
- Horsepower
- Number of phases
- Voltage
- Frequency
- Frame size
- Type
- Full-load current
- Full-load RPM
- NEMA nominal efficiency
- Motor power factor
- Motor duty cycle (continuous)

(2) Motor Data. Detailed motor data shall be submitted prior to shipment. The detailed data on the proposed electric motors shall include sufficient information to verify it meets all electric motor requirements of the project plans and specifications.

(3) Testing. Prior to field performance testing of the pump and motor, the Contractor shall furnish operating and maintenance instruction manuals for the motor, as well as copies of a test report for a short commercial test on the exact motor being provided.

Test data shall include:

- No-load current
- Locked-rotor current
- Winding resistance
- High potential
- Vibration and bearing visual inspection

1201.0300 EXECUTION

1201.0302 Installation. Installation shall be in strict accordance with the manufacturer's instructions and recommendations, and in accordance with the approved submittals.

Qualified supervisory services—including manufacturer's engineering representatives—shall be provided to ensure the work is done in a manner fully approved by the respective equipment manufacturer. The pump manufacturer's representative shall specifically supervise the installation and alignment of the pump with the driver, grouting, alignment of the connecting piping, and installation of the mechanical seal. Services of the manufacturer's representatives and training shall be provided when the first pump is started, with follow-up visits upon startup of each subsequent pump.

Connection of piping to pumps shall be done in the Engineer's presence. All piping connections to the pump shall be done without bending and/or twisting the piping to mate with the pump flange connections.

A certificate from the equipment manufacturer shall be submitted stating that installation of their equipment is satisfactory, that the equipment is ready for operation, and that the Owner's operating personnel have been suitably instructed in the operation, lubrication, and care of each unit.

1201.0303 Pumping Unit Requirements. Pumping unit performance criteria shall meet the requirements provided by the project plans and specifications. Each pump shall have a rising head capacity curve for stable pump operation from the minimum head operating point to the shutoff head.

Where total discharge head (TDH) is referred to in conjunction with the specified discharge requirements, it shall be understood to consist of the sum, in feet, of the static head plus the velocity head at the discharge nozzle of the pump, minus the static head and velocity head at the suction nozzle of the can. Bowl efficiency shall be understood to be based upon total head as just defined.

The pumps shall operate throughout the entire operating range, within the vibration limitations specified in Subsection 1201.0304.

The pump's horsepower requirements shall be non-overloading everywhere on the curve. Not meeting this requirement—both at the factory and in the field—will be cause for rejection.

The vertical turbine pump suction bell shall be located below the inlet suction lateral per current Hydraulic Institute Standards.

1201.0304 Quality Assurance. Quality assurance requirements for pumping unit assemblies are as follows:

(1) Pumping unit assemblies shall be provided by the pump manufacturer.

(2) Units specified herein shall be furnished by a single manufacturer. The equipment furnished shall be designed, constructed, and installed to operate satisfactorily when installed as shown on the plans.

(3) Pumping unit assemblies shall be manufactured in accordance with the Hydraulic Institute Standards, and as specified herein.

(4) The pump manufacturer shall be fully responsible for the design, arrangement, and operation of all connected rotating components, of the assembled pumping unit, mounted on a manufacturer supplied booster can, to ensure that neither harmful nor damaging vibrations occur at any speed within the specified operating range.

(5) The pump manufacturer shall perform both lateral and torsional critical speed analyses for all pumps greater than 100 horsepower to identify and ensure that:

   (a) The first lateral critical speed shall be at least 25 percent above the maximum pump speed.

   (b) No torsional natural frequencies occur within a range extending from 25 percent below to 25 percent above the specified operating speed range.

   (c) Any blade-excited resonant frequency shall be no closer than ±25 percent of the natural frequency of any part of the installed assembled pumping unit.

Prior to manufacture, a statement must be forwarded to the Engineer indicating that the required analyses have been made and that the specified limitations will be met.

(6) Vibration, when measured in the direction of maximum amplitude at the top motor bearing, shall not exceed the allowable values established by the Hydraulic Institute ANSI/HI 9.6.4-2000. In all instances, peak-to-peak displacement (vibration) shall not exceed a maximum peak velocity of 0.26 inch per second RMS (6.60 millimeters per second RMS) at any speed within the specified operating speed range.

1201.0305 Testing.

(A) Shop Testing. Each pumping unit shall be factory tested with a Standard Performance Test as described in the American National Standard/Hydraulic Institute Test Standards for Vertical Turbine Pumps ANSI/HI 2.6—Latest Edition. This non-witnessed, certified pump performance test shall be conducted at an RPM equal to that specified in the project plans and specifications. All tests shall be conducted in accordance with the latest requirements of the Hydraulic Institute Standards. All test data shall be submitted for the Engineer's approval prior to shipment. Certified copies of the pump performance curves shall be submitted including:

- Pumping capacity (GPM) vs. pumping lift (feet) curve
- Horsepower requirement curve
- Efficiency curve
- Thrust factor (K) curve; data from previous tests of duplicate model acceptable
- NPSHR curve; data from previous tests of duplicate model acceptable
- Required submergence; data from previous tests of duplicate model acceptable

Each pumping unit shall have the linings and coatings factory tested for conformance to the required dry film thickness as specified in the project plans and specifications. All linings and coatings that are in contact with water shall be NSF approved.

The motor shall have short commercial tests performed as specified in Subsection 1201.0201(E).

(B) Field Testing. Field tests shall be as necessary to indicate that the pumping unit assemblies conform to the specified head vs. capacity and horsepower requirements; these tests shall be performed in the Engineer's presence. The Contractor shall provide all manpower, facilities, power, equipment, and expertise to conduct field testing. Requirements are as follows:

(1) Calibration and Installation. The Contractor shall provide, calibrate, and install all temporary gauges and meters. He/she shall also make the necessary tapped holes in the pipes, and install all temporary piping, layflat, valves, hoses, and wiring required for the field acceptance tests.

(2) Service Representative, Pump Manufacturer. The Contractor shall provide the

service of a fully qualified, factory-trained service representative of the pump manufacturer to inspect the installation, witness the initial startup and testing of the pump, and make adjustments as necessary for proper operation. Provisions will be made for the services of the manufacturer's representative for such periods of time as may be necessary to place the unit in satisfactory operating condition.

(3) Vibration Measurements. The pump manufacturer's factory-trained service representative shall field test and measure the pumping unit for vibration in accordance with the latest requirements of the Hydraulic Institute Standards. Vibration shall be measured and recorded with an electronic velocity meter or accelerometer. An electronic vibration analyzer that provides vibration amplitude and velocity for a wide range of frequencies is desirable. Both vertical and horizontal vibration tests shall be made.

(4) Vibration Limits. The vibration limits of the pumping unit shall be as described in the Hydraulic Institute Standards. It shall be the pump manufacturer's responsibility to dynamically balance the pump and motor, as well as reinforce, stiffen, or support the pump casing, frame, pedestal, or shafting in order to provide vibration levels within the limits described.

(5) Inspection. Prior to testing, all required inspection and adjustments shall be made for the proper operation of the pumps.

(6) Test Data. After all testing is complete, the pump manufacturer's factory-trained service representative shall submit in bound booklet form all pertinent data relating to the pumping unit's installation and operation, including but not limited to:

- Pump I.D. and location, technician's name, and date and time tests were performed
- Pump serial number, pump make, pump model, head model, impeller diameter, number of stages, capacity and head at design point, and motor horsepower rating
- Measured line shaft runout at the top of motor, as well as inside stuffing box, along with a note identifying the maximum acceptable runout
- Impeller lateral in inches and number of nut turns, in addition to actual impeller setting in inches and number of nut turns
- Vibration measurement readings at design point, with sketches showing location of readings

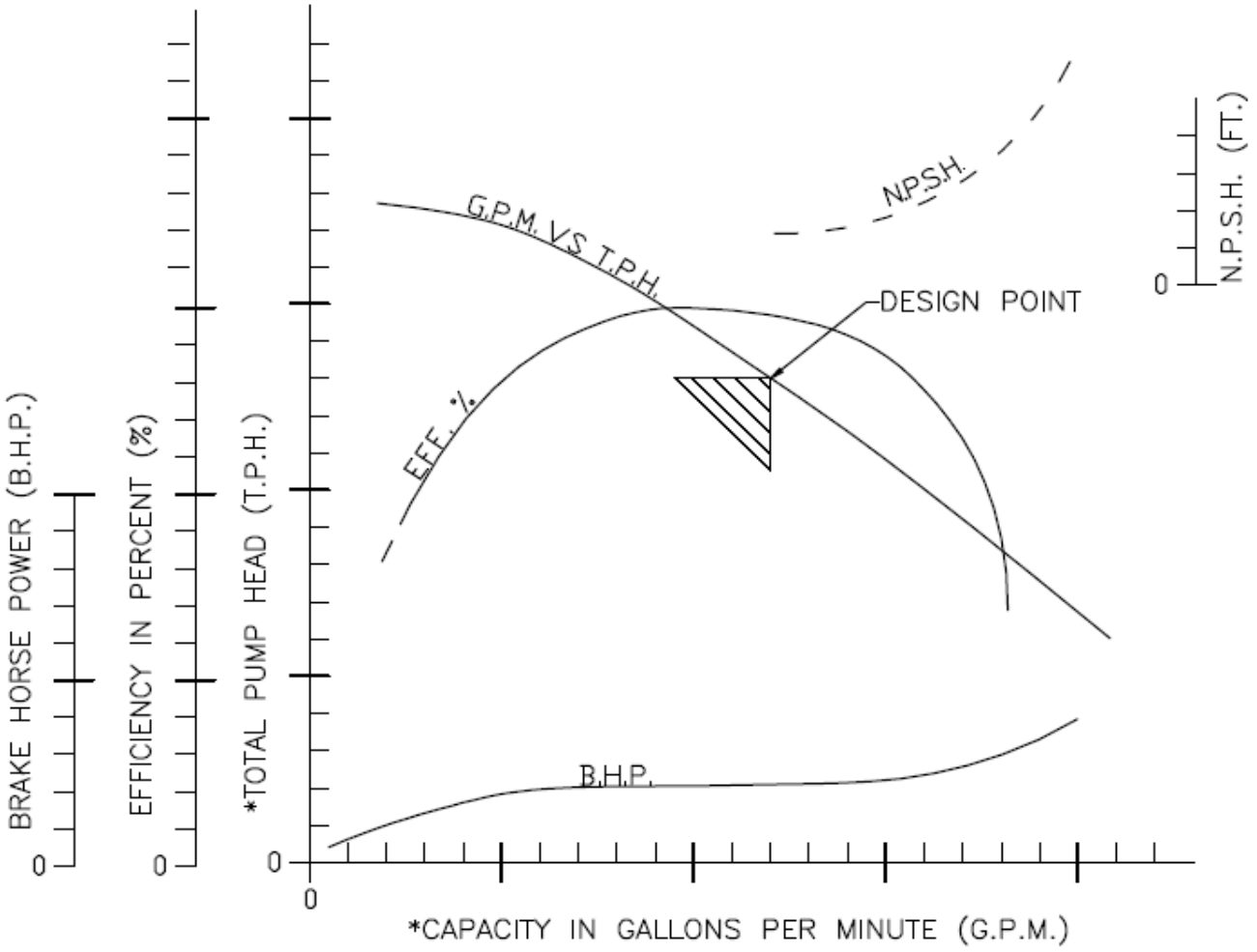
SECTION 1201

This information shall be included as part of the Operations and Maintenance Manual submittals, and shall be provided prior to final project acceptance.

See Table and graph on the next page.

SAMPLE PUMP CURVE

1. Manufacturer _____
2. Impeller Diameter _____
3. Design Head _____
4. H.P. _____
5. Pump Model No. _____
6. Design GPM _____
7. RPM _____
8. No. of Stages _____



*Range of capacity (GPM) and Total Pump Head (TPH) shall be of the size to properly demonstrate the pump operational characteristics throughout the entire pumping range of the pump. Failure to do so will result in rejection of the pump curve.