SECTION 11214 - VERTICAL TURBINE PUMPS

City of San Diego, CWP Guidelines

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NTS: This specification is written for pumps lubricated by the pumped fluid (except the suction case bearing is grease lubricated), and with vertical solid shaft motors. It is necessary to start the water flush flow before the pumps start in order to flush and lubricate the bearings before shaft rotation. The water flush should be supplied from the common discharge manifold. Coordinate the required time delay with electrical and instrumentation.

Operational strains on shafts, bearings, shaft seals, etc., on variable speed pumps differ greatly from that experienced by pumps operating at constant speed at or near the best efficiency point. A much more rugged pump is required for variable speed applications. Options are indicated for both constant and variable speed pumping applications.

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PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

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NTS: Select "suction bell" for self-cleaning wet well installations. Select "inlet well" if a barrel or can inlet is required. Select the "custom engineered" pumps clause if variable speed drive pumps with suction bell inlets are specified.

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A. **General:** The WORK of this Section includes providing vertical turbine pumps for pumping [reclaimed water (tertiary effluent), which may contain mildly abrasive small diameter solids] [potable water]. Each pump shall consist of a bowl assembly with [suction bell] [inlet well], discharge column assembly, vertical electric motor, [flywheel, variable frequency drive controller,] above grade discharge head, supports, and all appurtenances required to provide a complete pumping system. Equipment furnished under this Section shall comply with the requirements of this Section and Section 11175. [The "custom engineered" pumps requirements specified in Section 11175 apply to the WORK of this Section.]

B. **Type:** Pumps furnished under this Section shall be single or multi-stage vertical turbine diffuser pumps designed for pumping water which may contain incidental quantities of soft solids. The pump shall be designed to support the entire weight of the pump bowl assembly, column, discharge head, [flywheel,] and motor on a baseplate designed to span an opening in the foundation slab of sufficient size to allow removal of the complete pumping element without disassembly.

C. **Unit Responsibility:** The CONTRACTOR shall cause the equipment specified under this Section, including [the engine drives and right-angle gears] [the variable speed drives specified under Section

11033 and] [the motors], to be furnished by the pump manufacturer, as provided in Section 11000. The CONTRACTOR shall furnish a Certificate of Unit Responsibility Assignment as provided in Section 11175.

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 11000 Equipment, General Requirements
2. Section 11002 Equipment Supports, Grouting and Installation
[3. Section 11030 Variable Speed Drives, General]
[4. Section 11033 Variable Frequency Drives]
5. Section 11175 Pumps, General

1.3 SPECIFICATIONS AND STANDARDS

A. Specifications and standards shall comply with Sections 11000 and 11175. Where this Section is silent on any subject, item or equipment, the requirements of Section 11175 shall govern.

1.4 SERVICES OF MANUFACTURER

A. Services of the manufacturer shall be provided in accordance with Section 11175 and as follows:

1. **Inspection, Startup, and Field Adjustment**: An authorized representative of the manufacturer shall visit the site for not less than [ ] day to check the installation, supervise start-up, and supervise testing and adjustment of pumps.

2. **Instruction of OWNER'S Personnel**: The authorized service representative shall instruct the OWNER'S personnel in the skills required for each Trade Group indicated and the duration indicated. This includes all aspects of pump operation and maintenance, including step-by-step troubleshooting procedures with necessary test equipment. Instruction shall include, but not be limited to, review of operation and maintenance manual; installation and removal of pumps, motors and shafts; service and replacement of bearings; service and flushing of seal water system; replacement and service of seals; daily maintenance requirements; and long-term maintenance provisions. Instruction of the OWNER'S personnel shall be conducted separate from the start-up and testing activities. Each of the OWNER'S Trade Groups will be instructed individually, and no more than six hours will be scheduled in one day. Durations of instruction are:

Trade Group	Class Hours	Field Hours
Electricians	[3]	[3]
Electronics Technicians	[3]	[3]
Operations	[3]	[3]
Plant Maint. Technicians	[3]	[3]

1.5 SHOP DRAWINGS AND SAMPLES

A. Submittal requirements shall be as set forth in Sections 11000 and 11175.

1.6 OWNER'S MANUAL

A. OWNER'S MANUAL requirements shall be as set forth in Sections 11000 and 11175.

1.7 FACTORY TESTS

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NTS: Select witnessed factory tests for pumps with variable speed drives.

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A. Each pump shall be factory tested in accordance with the requirements established in Section 11175 and shall be a [witnessed] [non-witnessed] test.

1.8 PUMPED FLUID AND OPERATING CONDITIONS:

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NTS: Provide a concise, but complete, description of the application, describing the pumped fluid, the installation environment, and the method of starting and stopping and operating the pumps in separate paragraphs.

The CITY desires that the pump suction/inlet piping practices recommended in ANSI/HI 9.8, a nationally recognized consensus standard, be incorporated in the design of its projects. Exceptions to this requirement must be submitted in writing to the CITY's project manager, and must be approved in writing by the CITY's project manager in advance of incorporating any exceptions into the design. The performance characteristics of installations that do not conform to the standard are to be confirmed by physical modeling as established in the standard. Physical modeling is expensive and requires months to complete.

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A. **PumpedFluid:** The fluid to be pumped is [reclaimed water (tertiary effluent)] [potable water]. The fluid is anticipated to range between [64] degrees F and [78] degrees F [and contain up to [10] mg/L of settleable solids consisting of organic and inorganic materials, and petroleum products, including grease]. Dissolved substances will include minor mineral constituents and chlorinated compounds

B. **Installation Environment:** [The pumps will be installed in an intake structure conforming to the design criteria established in ANSI/HI 9.8, and assuming the intake bell velocity will not exceed 5.5 ft/second at the flow established under Operating Condition B. Pumps with intake velocities greater than this value at Operating Condition B shall be furnished with a bell extension fitting or 'umbrella' to achieve this limitation.] [The pump will be installed in an inlet well conforming to the requirements

of this Section and furnished by the pump manufacturer in accordance with the unit responsibility requirements prescribed in Section 11175.] [ ] [Pump discharge heads will be exposed to the weather.] Drive control equipment will be installed in a weather protected, conditioned space.

C. **System Operation:** The pumps will be operated at [constant] [variable] speed in response to the control system specified in Section [13300]. [The pumps will be started and stopped against a closed valve.] [When more than one pump is in service, all pumps will operate at the same speed, responding to a common control signal.] [ ]

[Equipment furnished under this Section shall be equipped with flywheel assemblies for the control of hydraulic transient forces resulting from pumping operations.]

1.9 PERFORMANCE CRITERIA:

Performance of pumps furnished under this Section shall be guaranteed under the terms of paragraph 11175-1.7C. Field vibration shall be measured in accordance with requirements specified in Section 11175. Non-conforming pumps will be rejected.

PART 2 -- PRODUCTS

2.1 PUMP NAME: [ ] (P-[ ] through P-[ ])

A. **General:** Vertical turbine pumps shall conform to the following requirements:

1.	Number of pumping units	-	[ ]
2.	Locations	-	[ ]
3.	Services	-	[ ]
4.	Drive	-	[[Constant] [Variable] speed motor] [Engine]

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NTS: For pumps discharging to long new pipelines (over 1,000 feet in length), two system curves shall be developed by the DESIGN CONSULTANT, as recommended in ANSI/HI 9.6.1.5.5.2: one for the system as it will be installed; and a second to represent the condition of the system after some increase in pipe roughness has occurred. Pump design operating condition points shall be specified for the entire range of new and aged pipe conditions, since the pumps will be required to perform satisfactorily for both conditions.

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B. **Operating Conditions:**

{[Variable Speed Applications]

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NTS: For the FULL SPEED operating conditions, ***do not state the speed***. Condition A flow should be the result of the targeted maximum flow for the installation divided by the number of pumps in service. Condition A head is the system head at the worst (lowest) assumed 'C' value at the rated flow, but does not include the value of the individual pump losses ('pump correction loss').

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1. Condition A: Full Speed - Maximum Head Operation (See Notes a and e):

Capacity, gpm	-	[ ]
Total head, feet	-	[ ]
NPSHA, feet	-	[ ]

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NTS: Condition B is the so-called 'runout condition'. Condition B head is the system head at the best (highest) assumed 'C' value at the indicated flow, but does not include the value of the individual pump losses ('pump correction loss'). The flow at condition B head is unique to the individual pump selection and occurs at full pump speed so do not list a flow except as provided in Note b.

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2. Condition B: Full Speed - Minimum Head Operation (See Notes b and e)

Capacity, gpm	-	from pump H/Q curve
Total head, feet	-	[ ]
NPSHA, feet	-	[ ]

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NTS: ***Never insert a speed in the reduced speed portion of the table.*** The speeds necessary to achieve the required operation are unique to each individual pump vendor's product.

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3. Condition C: Reduced Speed - Continuous Duty Operation (See Notes c and e)

Capacity, gpm	-	[ ]
Total head, feet	-	[ ]
Pump speed, rpm	-	Reduced
NPSHA, feet	-	[ ]

4. Condition D: Reduced Speed - Startup/Shutdown (See Notes d and e)

Capacity, gpm	-	Zero

Total head, feet	-	[ ]
Pump speed, rpm	-	Minimum
NPSHA, feet	-	[ ]

NOTES:

a. Condition A shall be taken as the rated, continuous-duty operating condition with the pump operating ***at maximum speed against maximum anticipated system head****. Performance at the rated condition shall be guaranteed in accordance with Section 11175. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this Section should be selected to achieve Condition A performance, but also operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*

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NTS: While the flow used to establish Condition B should not be listed in the Operating Conditions table, it should be inserted into the blank in Note b to indicate the basis for the NPSHA information.

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b. Condition B head is presented to indicate operating conditions when the pump is operating at ***maximum speed against minimum anticipated system head,*** *assuming a hypothetical head-capacity curve.* ***Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*** *Pumps with head-capacity curves steeper than that assumed will produce less flow at lower head. The reverse will occur with pumps having a shallower head-capacity curve.* ***Proposed pump selections meeting this discharge head requirement by operating the equipment at less than full speed will be rejected.*** *NPSHA, as listed for Condition B is calculated on a pumped flow of [ ] mgd.*

c. Condition C is the ***anticipated continuous duty minimum speed condition*** *when the pump is operating* ***against maximum anticipated system head.*** *Pumps furnished under this specification Section shall be capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 11175. Condition C shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*

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NTS: Condition D is intended to inform the manufacturer of the conditions imposed upon startup and shutdown. If the pumps are to be started and stopped against a closed valve, then so state.

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d. Condition D represents the expected momentary (startup/ shutdown) condition. Pumps furnished under this specification Section will operate for no more than 30 seconds at this condition when initiating or terminating a service cycle. The maximum anticipated number of service cycles is 12 per day.

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NTS: NPSHA data is dominated by considerations associated with the pump setting (elevation). Therefore, it is imperative that the drawings show the elevation of the housekeeping pad for the pump discharge head for use by the pump manufacturer in responding to NPSH margin requirements. To avoid the potential for conflict, do not list the pump discharge centerline or housekeeping pad elevation in the Specifications. Section 11175 places restrictions on NPSH margin (NPSHA/NPSHR). The design engineer, specifier and submittal reviewer should become completely familiar with these requirements and the procedures established in ANSI/HI 9.6.1 to make certain that the design incorporates a setting that will allow all reasonable candidate pump designs to comply with these restrictions and rule out those designs that do not. ***Bear in mind: NPSHA must exceed NPSHR by a wide margin at all specified operating conditions and that this margin requirement will vary depending on several considerations. The bottom line with respect to installation costs is that the greater the NPSHR for a given pump, the lower a pump inlet must be below the inlet hydraulic gradient.*** The specifications, under Section 11175, require the pump manufacturer to demonstrate by calculation and supporting documentation that the proposed pump meets the NPSHA/NPSHR margin limitations established in the specification and in ANSI/HI 9.6.1.

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e. Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 2.1 – 2.6. ***The performance requirements listed above do not include pump inlet, bowl, discharge column, discharge head and lineshaft losses.*** *A separate curve for these values shall be submitted with the pump performance curve as part of the documentation required under Section 11175. Net positive suction head available (NPSHA) in the above tabulation is referred to the housekeeping pad supporting the pump discharge head shown, and is calculated in accordance with ANSI/HI 2.3 for average barometric pressure and maximum temperature conditions. NPSHA at the pump impeller eye can be determined by adjusting the given value by proposed pump dimensions and the indicated requirements for pump installation details. The performance requirements listed above include static lift, velocity head losses at the point of discharge, and dynamic losses associated with connected valving, fittings, and piping, but not internal pump losses. An allowance of five feet (negative) has been included as a margin of safety. This margin shall be exclusive of the required NPSHA margin specified in Section 11175.*

f. The pumps will be operated at variable speed in response to the control system specified in Section [13300]. To permit the pump to operate at or near best efficiency during reduced-speed operation, it is preferred that the rated condition lie to the right of the best efficiency point on the pump's head capacity curve.

g. Maximum expected surge pressure is [ ] psig. **}**

{[Constant Speed Applications]

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NTS: Condition A flow should be the result of the targeted maximum flow for the installation divided by the number of pumps in service. Condition A head is the system head at the worst (lowest) assumed 'C' value at the rated flow, but does not include the value of the individual pump losses ('pump correction loss').

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5. Condition A: Maximum Head Operation (See Notes a and d):

Capacity, gpm	-	[ ]
Total head, feet	-	[ ]
NPSHA, feet	-	[ ]

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NTS: Condition B is the so-called 'runout condition'. Condition B head is the system head at the best (highest) assumed 'C' value at the flow indicated, but does not include the value of the individual pump losses ('pump correction loss'). The flow at condition B head is unique to the individual pump selection so do not list a flow except as provided in Note b.

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6. Condition B: Minimum Head Operation (See Notes b and d):

Capacity, gpm	-	from pump H/Q curve
Total head, feet	-	[ ]
NPSHA, feet	-	[ ]

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NTS: Condition C is the anticipated continuous duty maximum head condition. Condition C head is the system head at the worst (lowest) assumed 'C' value plus the value of the individual pump losses ('pump correction loss') at the flow indicated. The flow at condition C head is unique to the individual pump selection so do not list a flow. Condition C is optional and is provided to describe a head condition that is not adequately described by Conditions A and B.

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7. Condition C: Continuous Duty Maximum Head Operation (See Notes c and d):

Capacity, gpm	-	from pump H/Q curve
Total head, feet	-	[ ]
NPSHA, feet	-	[ ]

NOTES:

a. Condition A shall be taken as the rated, continuous-duty operating condition with the pump operating ***against maximum anticipated system head.*** *Performance at the rated condition shall be guaranteed in accordance with Section 11175. Condition A has been selected to obtain the rated pumping capacity for the installation. It is not intended that the pumps be selected for maximum efficiency at Condition A. Pumps furnished under this Section should be selected to achieve Condition A performance, but also operate continuously without objectionable vibration or cavitation at the head specified under Condition B. Condition A may be located in the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*

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NTS: While the flow used to establish Condition B should not be listed in the Operating Conditions table, it should be inserted into the blank in Note b to indicate the basis for the NPSHA information.

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b. Condition B head is presented to indicate operating conditions when the pump is operating ***at minimum anticipated system head****, assuming a hypothetical head-capacity curve.* ***Condition B shall be used for pump selection. Condition B shall be located within the Preferred Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*** *Pumps with head-capacity curves steeper than that assumed will produce less flow at lower head. The reverse will occur with pumps having a shallower head-capacity curve. NPSHA, as listed for Condition B is calculated on a pumped flow of [ ] mgd.*

c. Condition C is the ***anticipated continuous duty maximum head condition.*** *Pumps furnished under this specification shall be capable of sustained (24 hours per day) operation at this condition within the requirements set forth in Section 11175. Condition C shall be located within the Allowable Operating Region as established by the pump manufacturer in accordance with ANSI/HI 9.6.3 and listed in the manufacturer's published application data for the specific model proposed for this application.*

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NTS: NPSHA data is dominated by considerations associated with the pump setting (elevation). Therefore, it is imperative that the drawings show the elevation of the housekeeping pad for the pump discharge head for use by the pump manufacturer in responding to NPSH margin requirements. To avoid the potential for conflict, do not list the pump discharge centerline or housekeeping pad elevation in the Specifications. Section 11175 places restrictions on NPSH margin (NPSHA/NPSHR). The design engineer, specifier and submittal reviewer should become completely familiar with these requirements and the procedures established in ANSI/HI 9.6.1 to make certain that the design incorporates a setting that will allow all reasonable candidate pump designs to comply with these restrictions and rule out those designs that do not. ***Bear in mind: NPSHA must exceed NPSHR by a wide margin at all specified operating conditions and that this margin requirement will vary depending on several considerations. The bottom line with respect to installation costs is that the greater the NPSHR for a given pump, the lower a pump inlet must be below the inlet hydraulic gradient.*** The specifications, under Section 11175, require the pump manufacturer to demonstrate by calculation and supporting documentation that the proposed pump meets the NPSHA/NPSHR margin limitations established in the specification and in ANSI/HI 9.6.1.

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d. Total head in the above tabulation is the algebraic difference between the discharge head and suction head as defined in ANSI/HI 2.1 – 2.6. ***The performance requirements listed above do not include pump inlet, bowl, discharge column, discharge head and lineshaft losses.*** *A separate curve for these values shall be submitted with the pump performance curve as part of the documentation required under Section 11175. Net positive suction head available (NPSHA) in the above tabulation is referred to the housekeeping pad supporting the pump discharge head shown, and is calculated in accordance*

with ANSI/HI 2.3 for average barometric pressure and maximum temperature conditions. NPSHA at the pump impeller eye can be determined by adjusting the given value by proposed pump dimensions and the indicated requirements for pump installation details. The performance requirements listed above include static lift, velocity head losses at the point of discharge, and dynamic losses associated with connected valving, fittings, and piping, but not internal pump losses. An allowance of five feet (negative) has been included as a margin of safety. This margin shall be exclusive of the required NPSHA margin specified in Section 11175.

e. The pumps will be operated at constant speed in response to the control system specified in Section [13300].

f. Maximum expected surge pressure is [ ] psig. **}**

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NTS: Note that all specified operating conditions require net positive suction head (NPSH) information. Provide NPSHA information for any added operating conditions.

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C. **Design Requirements**:

1. **General:** The pumps shall be specifically designed to pump the fluid described in paragraph 11214-1.8, and shall comply with the requirements specified in Section 11175.

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NTS: Discharge head anchor bolts for this type of pump can rarely be designed to withstand the hydraulic thrust developed at the elbow in larger sizes (>24-inch nozzle diameters). The arrangement of the discharge piping should provide for the nozzle to be restrained to a wall or other anchor on the discharge piping. See the NTS in Section 11175 under "Anchorage" for additional information.

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The rotor and critical speed analysis requirements specified in paragraph 11175-1.10, Rotor and Critical Speed Analysis and System Design, apply to the driven and drive equipment, including supports and appurtenances, for variable speed drive pumps furnished under this Section. This requirement does not apply to constant speed pumps furnished under this Section.

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NTS: Note that bowl efficiency is indicted as the maximum (minimum). This means the minimum acceptable efficiency at the peak of the efficiency/capacity curve, not the efficiency at the rated condition.

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2. Maximum bowl efficiency, minimum, [ ] (percent)

[3. Rotating moment of inertia (WK^2), ($lb\text{-}ft^2$) - [ ]]

[The rotating moment of inertia requirement applies to the sum of the moments of inertia of the motor rotor, flywheel, shafting, pump rotor, and water entrained in the pump rotor.]

4. Max pump speed (rpm) - [ ]

5. Max motor size (hp) - [ ]

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NTS: Depending on the method of driving the pump, another line may be needed to indicate motor speed or other considerations.

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[6. Max [motor] [engine] speed (rpm) - [ ]]

7. Duty - [continuous] [intermittent]

D. **Pump Dimensions:**

1. Min column diameter (in) - [ ]

2. Size of discharge flange (in) - [ ]

3. Discharge flange rating (psig) - [ ]

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NTS: The suction bell diameter should be based upon a maximum inlet velocity of 5.5 ft/sec., as stated in paragraph 11214-1.8B. Delete the next two requirements for barrel or can type pump installations.

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[4. Min suction bell diameter (inches) - [ ]]

[5. Elevation of suction bell inlet (feet) - [ ]]

2.2 PUMP REQUIREMENTS

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NTS: Pump construction is covered in Section 11175, which relies upon API 610 for basic requirements for materials and features. The DESIGN CONSULTANT should verify that the referenced API 610 requirements are suitable for the specific application, and list exceptions in the following paragraphs.

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A. **General:** Construction of vertical turbine pumps shall conform to the requirements set forth in Section 11175, except as described in the following paragraphs.

B. **Materials:**

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NTS: Consider specifying only bronze impellers for clean water. Bronze and aluminum bronze withstand cavitation better and cast iron withstands frictional wear better. Cast stainless steel has good frictional and cavitation resistance characteristics. Cast stainless steel impeller required for first stage of variable speed pumps.

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1.	Impeller	-	[Bronze] [Aluminum bronze] [Cast iron] [Cast stainless steel] [, except cast stainless steel for first stage], enclosed type
2.	Flanged column pipe and discharge head	-	Steel ASTM A 283, Grade D or ASTM A 53
3.	Lineshaft enclosing tube	-	Stainless steel, Type 316
4.	Shaft lubrication	-	Process water-lubricated
5.	Shaft seal	-	Breakdown bearing
[6.	Hydrocones	-	Stainless steel, Type 316L]

C. **Pump Drive:** [Direct drive] [Variable speed drive] [Engine drive.] [with vertical solid shaft, heavy-duty, high efficiency [ODP] [TEFC] [TENV], [inverter duty] [constant speed] electric motor capable of accepting the total, unbalanced thrust imposed by the pump and suitable for [480]-volt, [3]-phase, [60]-Hz ac power supply, in accordance with Section 16040.] [For variable speed drive see Sections 11030 to 11033.]

D. **Equipment Features:**

1. **Bell:** The bell shall provide a smooth transition from the diameter specified in paragraph 11214-2.1D to the suction case. Bolted connections shall be provided between the bell casting and the suction case. The bell may be larger than that listed, but shall not be less. At the manufacturer's option, a bell extension fitting or "umbrella" shall be provided to achieve this requirement.

2. **Suction Case:** The suction case shall be designed to provide conservative entrance velocities and evenly distribute the flow to the impeller. The inner surface of the case shall be smooth and free from projections or cavities. The pump shaft lower bearing shall be housed in a streamlined casing, centered and held in place by means of rigid cast vanes. The bearing housing and vanes shall be designed to conduct the flow efficiently into the impeller eye.

3. **Pump Bowl:** The pump bowl shall be flanged for registered fit. Bolted connections shall be provided between the suction case and the bowl and between the bowl and adjacent stages or the discharge case. Diffuser vanes shall not be a multiple of impeller vanes. Flow passages through the bowl and diffuser vanes shall be porcelain-lined for sizes 18-inch and smaller. [The pump bowl liner shall be stainless steel.] If required on multistage installations, the first-stage bowl may be designed to facilitate a low NPSH impeller arrangement.

   Replaceable wearing rings shall be provided on the pump bowl at the impeller inlet connection.

4. **Impeller:** Impellers shall be constructed free from projections, cavities, or abrupt transitions. The impeller surfaces shall be either polished or porcelain-lined.

   Impellers shall be of the enclosed type with shroud fitted with wearing rings. Impellers shall be secured to the pump shaft using tapered collets or keyways.

5. **Shafts:** Shafts shall be sized to prevent excessive elongation and transmit the required torque without distortion in both the forward and reverse direction. Shafts shall have a first critical speed not less than 20 percent above maximum operating speed. The pumping units shall utilize a two-piece headshaft, solid intermediate lineshafts supplied in maximum 10-foot lengths, and a single pump shaft shall be provided extending from the suction case through a discharge case or upper bowl case containing an upper pump shaft bearing.

   A lineshaft enclosing tube shall be provided to conduct lubricating fluid from the specified seal assembly, around the lineshaft and upper bowl bearings, to be vented through the discharge case bearing struts into the sump.

6. **Bearings:** Suction case, bowl, and lower tube bearings shall be close tolerance, sleeve type. The suction case bearing shall be grease lubricated. Bowl sleeve bearings shall be lubricated by the pumped fluid.

   Enclosed lineshaft bearings shall be externally threaded into the enclosing tube. The bearings shall be extra length spiral grooved sleeve type, spaced at not more than 5 feet apart. The lineshaft bearings shall be lubricated by gravity flow lubricant from the specified shaft seal through the lineshaft enclosing tube.

7. **Discharge Column:** Discharge columns shall be fabricated with interchangeable pipe sections with flanged joints. The column interior shall be free from offsets, burrs, discontinuities, or irregularities. The column shall be supplied in sections not exceeding 10 feet in length. Intermediate spider bushings shall be provided which align and support the lineshaft enclosure. Flanged connections shall be provided at all column, bowl and discharge head connections.

8. **Discharge Head and Drive Unit Support:** The discharge elbow shall be of the above grade type as shown and/ or specified, mitered or formed to provide a smooth transition from the discharge column to the discharge nozzle. The pump discharge nozzle shall be flanged. The discharge head shall be fitted with the specified shaft seal, located to afford convenient access for maintenance. The elbow shall be supported by a fabricated steel baseplate reinforced with

ribs designed to carry the weight of the complete pump [, flywheel] and drive unit without distortion when spanning an opening sufficient to permit withdrawal of the complete pump including the bowl and inlet bell. The drive unit support shall be cast or fabricated of steel and shall be designed to accommodate the equipment specified. Brackets, cartridges and drilled ports as required shall be provided for all monitoring devices specified in Section [ ]. Minimum 1-1/4-inch, 3,000 lb forged steel connections shall be provided for air valve, pressure switch and drain. The drive unit support shall be designed in accordance with Sections 11175 and 11000.

The pump head shall be provided with a soleplate conforming to Section 11002, manufactured expressly for the discharge head provided.

9. **Seal:** The lineshaft enclosing tube shall terminate in a breakdown bearing conforming to the pump manufacturer's recommendations and located in the discharge head. Drilled and tapped connections shall be provided for connection to the external source of lubricating fluid.

10. **Couplings:** The shaft coupling between the motor shaft and the headshaft above the tension nut assembly shall be the adjustable three-piece spacer type to permit positioning of the rotor and shall conform to the requirements specified in paragraph 11000-2.6.

Lineshaft couplings shall be a perfect butt-fit. They shall be designed with a safety factor of 1-1/2 times the shaft safety factor and shall have a left-hand thread to tighten during pump operation. Lineshaft couplings shall be pinned to prevent loosening on reverse rotation.

[11. **Flywheel:** The flywheel shall consist of cast weight in the form of a torus, keyed and locked on a shaft supported by bearings at each end of the shaft. The size of the weight and the distance of the torus centroid from the center of the shaft shall be sufficient to achieve the overall rotating moment of inertia (WK^2) specified for the pump rotating system under paragraph 11214-2.1C. Cantilevered designs employing only one set of bearings will not be permitted. Bearings shall be selected in accordance with ABMA 9 or 11 for an L-10 life of not less than 100,000 hours. Input and output bearings shall be held in place by rigid fabricated steel struts. The entire assembly shall be balanced in accordance with paragraph 11175-2.7 and shall be furnished with a fabricated steel enclosure designed to provide protection against accidental entry of tools or other objects and to provide enclosure protection in accordance with OSHA requirements. Top and bottom end plates shall be finished flat and shall have registered alignment fits in accordance with the requirements of API 610. The flywheel shaft shall be direct coupled to the motor output shaft and the pump input shaft by flexible couplings conforming to the requirements of paragraph 11000-2.6.]

[12. **Inlet Well:** The pump shall be installed in a fabricated steel inlet well designed in accordance with ANSI/HI 9.8. The inlet well shall contain anti-rotation baffles and anti-vortex baffles in accordance with the requirements of that standard. The CONTRACTOR shall cause the pump manufacturer to be fully responsible for the design and fabrication of the inlet well as a part of the manufacturer's Unit Responsibility duties.]

2.3 PAINTING

A. All external surfaces of the pump, [flywheel] and motor shall be coated as specified in Section 09800. All interior wetted ferrous surfaces of the pump shall be coated [with fusion bond epoxy] as specified

in Section 09800. [Interior epoxy coating shall be applied in three coats and have a total thickness of 25 mils.]

2.4 SPARE PARTS

A. The WORK includes the following spare parts per pump:

1. Suction bell manifold bearing assembly.
2. One set of bowl bearings.
3. One lineshaft bearing assembly.
4. One mechanical seal, complete.
5. One set of wear rings.
6. 2 sets special tools required for maintenance.
7. One packing gland follower.

B. Spare parts shall be stored in tool boxes, and identified with the equipment number by means of solid plastic or stainless steel name tags attached to the box.

2.5 MANUFACTURERS

A. Pursuant to the limitations described in paragraph 11000-2.1D, candidate pump manufacturers include [Byron Jackson, Fairbanks Morse, IDP, and Peerless], or equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. Pumping equipment shall be installed in accordance with approved procedures submitted with the shop drawings and as indicated.

B. General installation requirements shall be as indicated in Section 11175.

** END OF SECTION **