PIP RESP003S
Specification for High Power Vertical Submerged Motor Centrifugal Pumps for Water Service
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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Table of Contents

1. Scope ............................................. 2

2. References .................................... 2
   2.1 Process Industry Practices .............. 2
   2.2 Industry Codes and Standards ......... 2

3. Definitions ..................................... 4

4. Requirements ................................... 6
   4.1 Basic Design.................................. 6
   4.2 Motor Design .................................. 18
   4.3 Accessories ................................... 19
   4.4 Inspection and Testing ................. 20
   4.5 Preparation for Shipment ............. 21
   4.6 Documentation ............................... 22
   Table 1. Recommended Spare Parts .......... 23
   Table 2. Minimum Uninterrupted Operation
   for Pumps and Auxiliaries ................. 23
   Table 3. Bearing Selection ................. 24

Appendix A – Selection of Pump
Materials of Construction ................. 25
   Table A. Application of Material Classes to
   Water Services ............................... 25

Appendix B – Pump Material Classes
Designations ................................. 27
   Table B – Material Classes ................. 27

Data Sheets
RESP003S-D – Vertical Submerged Motor
Centrifugal Pumps for Water Service (U.S.
Customary Units)
RESP003S-DM – Vertical Submerged Motor
Centrifugal Pumps for Water Service (SI Units)
1. **Scope**

This Practice provides requirements for design and manufacture of vertical submerged motor centrifugal pumps of 150 kW (200 HP) or greater used for water services.

*Comment:* Water services include condensate, cooling water, demineralized water, utility water, produced water, treated water, etc.

*Comment:* General water services include condensate, cooling water, demineralized water, utility water, produced water, treated water, etc.

This Practice describes manufacturing and performance requirements for vertical submerged motor centrifugal pumps and their accessories.

This Practice covers pumps with service conditions within the following limits:

a. Maximum discharge pressure 35 Barg (500 psig)
b. Minimum pumping temperature 0°C (32°F)
c. Maximum pumping temperature 150°C (300°F)
d. Maximum rotational speed 3,600 rpm

*Comment:* For services within the capabilities of ANSI/ASME pumps, use PIP RESP73S.

2. **References**

Applicable parts of the following Practices and industry codes and standards shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Process Industry Practices (PIP)**

- PIP REDP003 - *Documentation Requirements for Centrifugal Pumps for Water Service*
- PIP REEE003 - *Guidelines for General Purpose Non-Lubricated Flexible Couplings*
- PIP REEP006 - *Pump Selection Guidelines*
- PIP REIE686A - *Machinery Installation and Installation Design Annex*
- PIP RESP002 - *Design of ASME B73.1 and General Purpose Pump Baseplates*

2.2 **Industry Codes and Standards**

- American Gear Manufacturers Association (AGMA)
  - AGMA 9002 - *Bores and Keyways for Flexible Couplings (Inch Series)*
- American National Standards Institute (ANSI)
  - ANSI B11.19 - *Performance Criteria for Safe Guarding*
  - ANSI S2.19 - *Mechanical Vibration - Balance Quality Requirement of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance*
• American Society of Mechanical Engineers (ASME)
  – ASME B1.20.1 - Pipe Threads, General Purpose (Inch)
  – ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings
  – ASME B16.11 - Forged Steel Fittings, Socket-Welding and Threaded
  – ASME B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings, Class 125 and Class 250
  – ASME B16.47 - Large Diameter Steel Flanges
  – ASME B16.5 - Pipe Flanges and Flanged Fittings
  – ASME B31.3 - Chemical Plant and Petroleum Refinery Piping
  – ASME Std 9 - Rolling Bearings - Dynamic Load Ratings and Rating Life - Part 1: Calculation Methods
  – ASME Boiler and Pressure Vessel Code (ASME Code), Section VIII, Division 1 - Pressure Vessels

• American Society for Testing and Materials (ASTM)
  – ASTM A105 - Specification for Forgings, Carbon Steel, for Piping Components
  – ASTM A106 - Specification for Seamless Carbon Steel Pipe for High-Temperature Service

• German National Standard
  – DIN 910 - Hexagon head screw plugs with collar-cylindrical threads

• International Organization for Standardization (ISO)
  – ISO 228-1 - Pipe Threads Where Pressure-Tight Joints Are Not Made on the Threads - Part 1: Designation, Dimensions, and Tolerances
  – ISO 281-1 - Rolling Bearings - Dynamic Load Ratings and Rating Life - Part 1: Calculation Methods
  – ISO 21940-11 - Balance Quality Requirements of Rigid Rotors
  – ISO 1940-1 - Mechanical vibration - Balance quality requirements for rotors in a constant (rigid) state
  – ISO R773 - Rectangular or Square Parallel Keys and Their Corresponding Keyways

• Manufacturers Standardization Society (MSS)
  – MSS SP-55 - Quality Standard for Steel Casings for Valves, Flanges, and Other Piping Components - Visual Method

• National Fire Protection Association (NFPA)
  – NFPA 70 - National Electrical Code

• United States Department of Labor
  – OSHA 1910.219 - Mechanical Power Transmission Apparatus
3. Definitions

For the purposes of this Practice, the following definitions apply:

**allowable operating region:** See preferred operating region.

**axially split:** Casing or housing joint that is parallel to the shaft centerline

**best efficiency point (BEP):** Point or capacity at which a pump achieves its highest efficiency with the rated impeller

**cartridge mechanical seal:** A mechanical seal unit, including sleeve, gland, primary seals, and secondary seals, that can be tested as a unit and installed as a unit

**critical speed:** Speed corresponding to a lateral natural frequency of a rotor

**maximum allowable temperature:** Maximum continuous temperature for which the equipment has been designed when handling the specified liquid at the specified pressure

**maximum allowable working pressure (MAWP):** Maximum continuous pressure for which the equipment has been designed when the equipment is operating at the maximum allowable temperature

**maximum continuous speed:** Speed (in revolutions per minute) that is a minimum of 105% of the highest speed required by any of the specified operating conditions

**maximum discharge pressure:** Maximum suction pressure plus the maximum differential pressure that the pump is able to develop when operating with the maximum impeller diameter at maximum continuous speed and maximum specified relative density

**minimum continuous stable flow:** Lowest flow at which the pump can operate without exceeding the vibration limits imposed by this Practice

**net positive suction head (NPSH):** Total absolute suction head, in meters (feet) of liquid, determined at the suction nozzle and referred to the datum elevation, minus the vapor pressure of the liquid, in meters (feet) absolute. Datum elevation for horizontal pumps is the shaft centerline.

**net positive suction head available (NPSHA):** NPSH determined by the purchaser for the pumping system with the liquid at the rated flow and normal pumping temperature

**net positive suction head 3 (NPSH3):** NPSH determined by supplier testing with water. NPSH3 is measured at the suction flange and corrected to the top of the foundation. NPSH3 is the minimum NPSH at rated capacity required to prevent a head drop of more than 3% (first-stage head in multistage pumps) caused by cavitation within the pump.

**normal wear parts:** Parts normally restored or replaced at each pump overhaul. Typically these parts are wear rings, interstage bushings, balancing devices, throat bushings, seal faces, bearings, and all gaskets.

**oil mist lubrication:** A lubrication system that uses oil mist produced by atomization in a central supply unit and transported to the bearing housing by compressed air

**operating region:** Portion of a pump’s hydraulic coverage over which a pump operates
**overhung pump:** Pump for which the impeller is cantilevered from the pump bearing assembly

**owner:** The party who owns the facility wherein the vertical submerged motor centrifugal pumps for water service will be used

**preferred operating region:** Portion of a pump’s hydraulic coverage over which a pump’s vibration is within the base limit specified in this Practice, temperature rise, or other limitations specified by the supplier

**pressure casing:** Composite of all stationary pressure-containing parts of a pump, including all nozzles, seal glands, and other attached parts, but excluding the stationary and rotating members of mechanical seals

**purchaser:** The party who awards the contract to the supplier. The purchaser may be the owner or the owner’s authorized agent.

**pure oil mist lubrication:** An oil mist lubrication system in which the mist both lubricates the bearing and purges the housing. Also called dry sump oil mist lubrication.

**purge oil mist lubrication:** An oil mist lubrication system in which the mist purges only the bearing housing. Bearing lubrication is by conventional oil bath, flinger, or oil ring. Also called wet sump oil mist lubrication.

**rated operating point:** Point at which the supplier certifies that pump performance is within the tolerances stated in this Practice

**relative density:** Ratio of the liquid’s density to that of water at 4°C (39.2°F); also called specific gravity.

**rotor:** Assembly of all the rotating parts of a centrifugal pump excluding the seals and bearings. If purchased as a spare, a rotor typically does not include the pump half coupling hub.

**suction specific speed:** An index of pump suction operating characteristics determined at the BEP with the maximum diameter impeller. Suction specific speed is an indicator of the NPSH3 (defined in the following equation) for given values of capacity and rotating speed and provides an assessment of the pump’s susceptibility to internal recirculation. Suction specific speed is calculated by the following equation:

\[
 n_{qs} = N(Q)^{0.5}/(NPSH3)^{0.75}
\]

where:

- \( n_{qs} \) = suction specific speed, metric
- \( N \) = rotating speed in revolutions per minute
- \( Q \) = flow per impeller eye, in cubic meters per second (gallons per minute) at the BEP with the maximum diameter impeller
- \( NPSH3 \) = net positive suction head required in meters (feet) at the BEP for the maximum diameter impeller

**Note:** Suction specific speed derived using cubic meters per second and meters, multiplied by a factor of 51.6, is equal to suction specific speed derived using U.S. gallons per minute and feet. The usual symbol for suction specific speed in U.S. units is \( \text{Nss} \).

\[
 n_{qs} = n(q)^{0.5}/(NPSH3)^{0.75}
\]

\[
 (N_{ss})
\]
where:

\[ n_{qs} = \text{suction specific speed, metric} \]
\[ N_{ss} = \text{suction specific speed, US Customary} \]
\[ n = \text{rotating speed in revolutions per minute} \]
\[ q = \text{flow per impeller eye, in cubic meters per second (gallons per minute) at the BEP with the maximum diameter impeller} \]
\[ = \text{total flow for single suction impellers} \]
\[ = \text{one-half total flow for double suction impellers} \]
\[ NPSH3 = \text{net positive suction head required in meters (feet) at the BEP for the maximum diameter impeller} \]

Note: Suction specific speed derived using cubic meters per second and meters multiplied by a factor of 51.6 is equal to suction specific speed derived using U.S. gallons per minute and feet, \( n_{qs} \times 51.6 = N_{ss} \). The usual symbol for suction specific speed in U.S. units is \( N_{ss} \).

supplier: The party responsible for providing the vertical submerged motor centrifugal pump

throat bushing: A device that forms a restrictive close clearance around the sleeve (or shaft) between the seal (or packing) and the impeller

trip speed: Speed (in revolutions per minute) at which the independent emergency overspeed device operates to shut down the driver

unit responsibility: Responsibility for the complete unit, including all equipment provided by themselves and sub suppliers. This includes responsibility for coordinating the technical aspects of the equipment and all auxiliary systems included in the scope of order. As a minimum, the power requirements, speed, direction of rotation, couplings, dynamics, lubrication, material test reports, instrumentation, piping, and testing of components are included.

witnessed test or inspection: A test or inspection that requires a hold be applied to the production schedule and that the inspection or test be carried out with the purchaser or the purchaser’s representative in attendance

4. Requirements

4.1 Basic Design

4.1.1 General

4.1.1.1 Vertical submerged motor centrifugal pumps shall be provided in accordance with this Practice and purchaser’s PIP RESP003S-D or PIP RESP003S-DM Data Sheet.

4.1.1.2 Supplier shall assume unit responsibility.

4.1.1.3 After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the supplier.
4.1.1.4 Purchaser shall specify the pump’s normal and rated operating points. Purchaser shall also specify any other anticipated operating conditions.

4.1.1.5 Design criteria for pumps and auxiliaries shall be consistent with a minimum service life of 20 years (excluding normal wear parts as identified in Table 1) and a minimum of 3 years of uninterrupted operation.

4.1.1.6 Except for seal flush, pumps shall be designed to operate without need for cooling to the design limit of 150°C (300°F).

4.1.1.7 Pumps maximum continuous speed shall be a minimum of 105% of the highest speed required by any of the specified operating conditions.

4.1.1.8 Pumps shall be capable of operating briefly, under emergency conditions, up to the driver trip speed.

4.1.1.9 The guaranteed pump performance curve, included with the proposal, shall be continuously rising to shutoff. For single operating pumps, percentage head rise from rated head to shutoff shall be a minimum of 10%.

4.1.1.10 If the pump fails to meet the specified performance during on site commissioning while handling the specified liquid at the conditions stated on the purchaser’s PIP RESP003S-D or PIP RESP003S-DM Data Sheet, the supplier shall be responsible for performing any corrective action required.

4.1.1.11 The total dynamic head required to provide the specified discharge pressure at the discharge flange based shall be determined in accordance with the minimum specified liquid level.

4.1.1.12 Unless specifically approved by the purchaser, design modifications to the pump bowls or internals that may affect the hydraulic or mechanical performance shall not be permitted after order placement.

4.1.1.13 Pumps shall have a preferred operating region as described in PIP REEP006, Figures 16 and 17.

4.1.1.14 Pumps shall be capable of a 5% minimum head increase at rated conditions by replacement of the impeller with an impeller of larger diameter or different hydraulic design.

   Comment: Purchaser may consider the use of a variable speed driver or blank stages for multistage pumps to meet this requirement.

4.1.1.15 BEP for the furnished impeller shall preferably be between the rated point and the normal point.

4.1.1.16 Pumps with suction specific speeds greater than 215 (11,000) shall be approved by the purchaser.

4.1.1.17 Spare parts, replacement parts, and auxiliaries shall, as a minimum, be in accordance with the requirements of this Practice.

4.1.1.18 Pumps and auxiliaries should be designed to run in uninterrupted service in accordance with Table 2.
4.1.2 Pressure Casing

4.1.2.1 MAWP of the pressure casing and flanges shall be greater than the maximum discharge pressure at the pumping temperatures.

4.1.2.2 MAWP shall apply to all parts of the pressure casing.

4.1.2.3 MAWP of the pressure casing and flanges shall be greater than the maximum discharge pressure at the pumping temperatures.

4.1.2.4 Pressure casing shall be designed with a corrosion allowance to meet the requirements of Section 4.1.1.5.

4.1.2.5 For between-bearings pumps with axially split casings, lifting lugs or tapped holes for eyebolts shall be provided for lifting the top half of the casing separately.

4.1.3 Bowls

4.1.3.1 Thickness of cast bowls shall be suitable for the following pressures with a 3.2-mm (1/8-in) minimum corrosion allowance:
   a. Maximum discharge pressure and allowances for head increases at pumping temperature
   b. Hydrostatic test pressure at ambient temperature

4.1.3.2 Bowls with diameters of 300 mm (12 in) and greater shall have flanged joints.

4.1.3.3 If threaded bowls are used for diameters less than 300 mm (12 in), sealing shall be achieved by means of O-rings in the partition grooves.

4.1.4 Nozzle and Pressure Casing Connections

4.1.4.1 Casing Opening Sizes

Openings for nozzles and other pressure casing connections shall be standard nominal pipe sizes (DN or NPS). Openings of 1-1/4, 2-1/2, 3-1/2, 5, 7, and 9 NPS shall not be used.

4.1.4.2 Suction and Discharge Nozzles

1. Suction and discharge nozzles shall be flanged and of equal rating.

2. Cast iron flanges shall be flat-faced and shall be in accordance with the dimensional requirements of ISO 7005-2 (ASME B16.1).

3. Flanges other than cast iron shall be in accordance with the dimensional requirements of ISO 7005-1 (ASME B16.5 or ASME B16.47).

4. Flat-face flanges with full raised face thickness can be used on casings.

5. Flanges in all materials that are thicker or have a larger outside diameter than that required by ISO (ASME) standards can be used.

6. Flanges shall be designed for through bolting.

7. Flanges greater than 60 cm (24 in) shall be in accordance with conform to the dimensional requirements of ASME B16.42 or ASME B16.47.
4.1.4.3 Pressure Casing Connections

1. Auxiliary connections to the pressure casing may be threaded. Threads shall be in accordance with ISO 228-1 (ASME B1.20.1).

2. Tapped openings and bosses for pipe threads shall be in accordance with ISO 7005-1 (ASME B16.5).

3. Connections welded to the casing shall be in accordance with the material requirements of the casing.

4. Pipe nipples welded to the casing shall be a maximum of 150 mm (6 in) in length and shall terminate in a flange.

5. Valves shall not be welded to the pump casing.

6. Tapped openings shall be plugged. Plug material shall have a corrosion resistance equal to, or greater than, the part in which the plug is installed.

7. Unless otherwise specified on the purchaser’s PIP RESP003S-DM or PIP RESP003S-D Data Sheet, the casing shall have vent and drain connections.

   Comment: Vent connections may be omitted if the pump is self-venting by the arrangement of the nozzles. A pump is considered self-venting if the nozzle arrangement and casing configuration permit adequate venting of gases from the first-stage impeller and volute area to prevent loss of suction during the starting sequence.

4.1.5 External Nozzle Forces and Moments

Allowable nozzle loads and a figure that defines the coordinate system in which the loads are applied shall be submitted with the proposal.

4.1.6 Impellers

4.1.6.1 Unless otherwise approved by the purchaser, impellers shall have solid hubs and keyed to the shaft.

4.1.6.2 An impeller made from a cored pattern may be provided if approved by the purchaser.

   Comment: Impellers with solid hubs are preferred. Solid hubs minimize the danger to personnel when impellers are removed by heating. The concern is that trapped water might vaporize and overpressure the void creating a potential for injury to personnel. If some other feature, such as a vent hole, is supplied, a cored impeller might be acceptable to some users.

4.1.6.3 Impellers shall have solid hubs.

4.1.6.4 Impellers made from a cored pattern shall be acceptable if the core is completely filled with a suitable metal that has a minimum melting point of 260°C (500°F).
Comment: The requirement to fill cored impeller hubs is intended to minimize the danger to personnel when impellers are removed by heating.

4.1.6.5 Collet-mounted impellers shall be acceptable if the absorbed power per stage is not greater than 50 kW (75 hp).

4.1.6.6 For power levels greater than 50 kW (75 hp) per stage, keyed impellers shall be provided.

4.1.6.7 Use of snap rings as a means of preventing axial movement of impellers shall be approved by purchaser.

4.1.7 Wear Rings and Running Clearances

4.1.7.1 Unless both wear surfaces have Brinell hardness numbers of 400 minimum, the mating wear surfaces of hardenable materials shall have a difference in Brinell hardness numbers of 50 minimum.

4.1.7.2 If fully enclosed impellers are provided, renewable wear rings shall be provided on the casing and the impeller shall have either integral wear surfaces or renewable wear rings. Renewable wear rings, if used, shall be secured by a press fit with locking pins (not recommended), axial set screws, or by tack welding.

4.1.7.3 If fully enclosed impellers are provided, renewable wear rings shall be provided on the casing and the impeller shall have either integral wear surfaces or renewable wear rings. Renewable wear rings, if used, shall be secured by a press fit with a minimum of two locking pins or by two tack welds.

4.1.7.4 Multistage between bearing pumps shall have renewable casing bushings and interstage sleeves or the equivalent at all interstage points.

4.1.8 Shafts

4.1.8.1 Shafts shall be machined or ground and finished for the entire length.

4.1.8.2 Where a non-contacting vibration system is installed the surface finish of the shaft or sleeve in the area of the non-contacting vibration probes shall be 0.8 µm (32 µin) maximum.

4.1.8.3 Total indicated run-out shall be 0.05 mm (0.002 in) maximum.

4.1.9 Running Clearances

4.1.9.1 When establishing running clearances between wear rings or between other rotating and stationary parts, consideration shall be given to pumping temperature, suction conditions, characteristics of the water, expansion and galling characteristics of the materials, and hydraulic efficiency.

4.1.9.2 Clearances shall be sufficient to ensure dependability of operation and freedom from seizure under all operating conditions.
4.1.10 Shaft-Sealing Systems

4.1.10.1 Shaft-sealing system, seal piping, and appurtenances shall be in accordance with the purchaser’s PIP RESP003S-DM or PIP RESP003S-D Data Sheet.

4.1.10.2 If specified on the purchaser’s PIP RESP003S-DM or PIP RESP003S-D Data Sheet, mechanical shaft seals shall be provided on pumps.

4.1.10.3 All standard mechanical seals, regardless of type or arrangement, shall be of the cartridge design. Hook sleeve cartridges shall not be permitted.

4.1.10.4 Cartridge seals shall be removable without disturbing the driver.

4.1.10.5 Mechanical seals shall be single (i.e., one rotating face per seal chamber), inside-balanced type.

4.1.10.6 Design and materials of seal components shall be suitable for the specified service conditions.

4.1.10.7 If pressure ratings of seals does not meet the MAWP of the pressure casing, the purchaser shall be notified and shall be advised of the maximum sealing pressure and the seal’s maximum dynamic and static pressure ratings.

Comment: This Practice does not cover design of mechanical seal components.

4.1.10.8 Specified seal and pump connections shall be identified by symbols permanently marked into the component (e.g., stamped, cast, or chemically etched) and shown on the seal drawing. Suffix letters shall be used in conjunction with these markings if appropriate.

4.1.10.9 Seal chamber shall be provided with an internal passage or external connection to permit complete venting of the chamber before start-up.

4.1.10.10 Throat bushings shall be provided if the infusion of the flush medium into the process needs to be restricted or the seal chamber pressure needs to be raised.

4.1.10.11 During operation, the pressure at the seal faces shall be maintained at or above atmospheric pressure.

4.1.10.12 For vacuum service such as condensate pumps, the seal shall seal against atmospheric pressure when the pump is not operating.

4.1.10.13 Unless otherwise specified Mechanical seals and glands shall be installed in the pump before shipment and shall be clean and ready for initial service.

4.1.10.14 For pump seals that require final adjustment or installation in the field, a metal tag warning of this requirement shall be attached to the seal chamber area.

4.1.10.15 The mating joint between the seal gland and the seal chamber face shall incorporate a confined gasket. Gasket shall be controlled-compression type (e.g., O-ring or spiral-wound gasket) with metal-to-metal joint contact.
4.1.10.16 If controlled compression gaskets impractical, an alternate seal gland design shall be submitted to and approved by the purchaser.

4.1.11 Dynamics

4.1.11.1 General

1. Actual critical speeds shall not encroach upon operating speeds.
2. Amplification factors shall not be greater than 8 while accelerating through critical speeds.
3. First critical speed in the pumped liquid shall not be in the range of 85% to 125% of the specified operating speed.
4. Rotating elements shall be dynamically balanced if possible.
5. Impellers with diameters of 152 mm (6 in) and larger shall be balanced in accordance with ANSI/ASA S2.19 grade G2.5, or better.

4.1.11.2 Critical Speed

Operational speed of the pump shall be a minimum of 20% less than the first wet critical speed calculated with twice the normal wear and internal bushing clearances.

4.1.11.3 Vibration

1. Pump shall perform on the test stand (if performance testing is required) and on its permanent foundation within the vibration criteria specified in this section.
2. If a performance test is specified on the purchaser’s PIP REDP003-T Inspection and Testing Requirements Sheet, unfiltered vibration measurements shall be made at each test point except shutoff.
3. At any speed greater than the maximum continuous speed, up to and including the trip speed of the driver, the vibration shall not exceed 150% of the maximum value recorded at the maximum continuous speed.
4. If specified on the purchaser’s PIP REDP003-T Inspection and Testing Requirements Sheet, vibration measurements shall include a Fast Fourier Transfer (FFT) spectrum in accordance with the following:
   a. Measurements shall be taken on the bearing housings in the X, Y, and Z planes.
   b. FFT spectra shall include the range of frequencies from 5 Hz to 2Z times running speed, where Z is the number of impeller vanes.
      
      Comment: In two-stage pumps with different impellers, Z is the highest number of impeller vanes in either stage.
   c. Plotted spectra shall be included with the pump test results.
      
      Comment: Discrete frequencies such as 1.0, 2.0, and Z times running speed are associated with various pump phenomena.
   d. Vibration levels shall meet the specifications of ASME B73.1
5. Variable speed pumps shall operate over their specified speed range without exceeding the vibration limits in purchaser’s PIP REDP003-T, Inspection and Testing Requirements Sheet, Table 3.

6. At any speed greater than the maximum continuous speed, up to and including the trip speed of the driver, the vibration shall not exceed 150% of the maximum value recorded at the maximum continuous speed.

7. Minimum continuous stable flow is the lowest flow rate at which the pump can operate continuously without exceeding vibration values set by various standard development organizations such as API or by a specified percentage of BEP in accordance with ASME.

8. Variable speed pumps shall operate throughout their specified speed range without exceeding the vibration limits in the purchaser’s PIP REDP003-T Table T3.

9. Components shall be balanced to ISO 21940-11 grade 1.0 and the rotor assembly shall be balanced to ISO 21940-11 grade 2.5 or better.

4.1.12 Bearings and Bearing Housings

4.1.12.1 Bearings

1. Motor thrust bearings shall be designed as follows:
   a. Sized for continuous operation under all specified conditions, including maximum differential pressure.
   b. All loads shall be determined at design internal clearances and also at two times design internal clearances.
   c. Bearings shall be capable of running with the maximum expected transient up thrust.

2. Bearing type and arrangement shall be selected in accordance with Table 3.

3. Thrust bearings shall be designed as follows:
   a. Sized for continuous operation under all specified conditions, including maximum differential pressure.
   b. All loads shall be determined at design internal clearances and also at two times design internal clearances.
   c. Bearing shall be designed to run without ball skidding.

4.1.12.2 Thrust bearings shall provide full load capabilities if the pump’s normal direction of rotation is reversed.

4.1.12.3 Radial bearings shall be of the sleeve-type.

4.1.12.4 Pumps that have thrust bearings shall be approved by purchaser.

4.1.12.5 Bearing Housings

1. Bearing housings shall be arranged so that bearings can be replaced without disturbing pump driver or mountings.
2. Housings for oil-lubricated, non-pressure-fed bearings shall have tapped and plugged fill and drain openings of DN 15 (1/2 NPS) minimum.

3. Housings shall have constant level oilers 100 cc (4 oz) minimum in size. Oilers shall have positive-level positioners (i.e., not an external screw), heat-resistant glass containers, and protective wire cages.

4. Oil level indication shall be provided for detection of over or under filling of the sump. Permanent indication of the proper static and operating oil levels shall be accurately located and clearly marked on the outside of the bearing housing with permanent metal tags, marks inscribed in the castings, or other durable means.

5. For ambient temperatures of 50°C (122°F) or less, oil and bearing temperatures shall be as follows: For ambient temperatures greater than this, contact a specialist.
   a. For pressurized systems, oil outlet temperature shall be less than 70°C (160°F), and bearing metal temperatures (if bearing temperature sensors are provided) shall be less than 93°C (200°F).
   b. For ring-oiled or splash systems, oil sump temperature shall be less than 82°C (180°F).

6. Bearing housings shall have replaceable, labyrinth-type end seals and deflectors where the shaft passes through the housing. Seals and deflectors shall be designed to retain oil in the housing and prevent entry of foreign material into the housing. Lip seals shall not be permitted.

7. If oil mist lubrication is specified on the purchaser’s
   a. A DN 8 (1/4-NPS) oil mist inlet connection shall be provided in the top half of the bearing housing. Pure oil or purge oil mist fitting connections shall be located so that oil mist flows through rolling element bearings.
   b. A DN 8 (1/4-NPS) vent connection shall be provided on the housing or end cover for each of the spaces between the rolling element bearings and the housing shaft seals. Alternatively, if oil mist connections are between each housing shaft seals and the bearings, one vent central to the housing shall be supplied. For housings with only sleeve-type bearings, the vent shall be located near the end of the housing.
   c. Shielded or sealed bearings shall not be permitted.
   d. If pure oil mist lubrication is specified, oil rings or flingers and constant-level oilers shall not be provided, and a mark indicating the oil level is not required.
   e. If purge oil mist lubrication is specified, oil rings or flingers and constant-level oilers shall be provided, and the oiler shall be piped so that it is maintained at the internal pressure of the bearing housing.
f. Oil mist supply and drain fittings shall be provided by the purchaser.

4.1.13 Lubrication

Bearings and bearing housings shall be arranged for hydrocarbon oil lubrication in accordance with the type of lubrication specified on the purchaser’s PIP RESP003S-DM or PIP RESP003S-D Data Sheet.

4.1.14 Materials

4.1.14.1 General

1. Table A in Appendix A shall be used as a guide for applying the material classes provided in Appendix B that may be appropriate for various services.

2. Materials for pump parts shall be in accordance with Appendix B, except that superior or alternate materials recommended for the service shall be listed on the purchaser’s PIP RESP003S-D or PIP RESP003S-DM Data Sheet.

3. Pump parts designated as “ASTM Full Compliance Materials” in Table B in Appendix B shall be in accordance with all of the requirements of the industry specifications listed for materials in the table.

4. Pump parts not designated as “ASTM Compliance Materials” in Table B shall be made from materials with the applicable chemical composition but need not be in accordance with all the other requirements of the listed industry specifications.

5. Materials shall be clearly identified in the proposal with their applicable industry standard numbers, including the material grade (see Appendix B).

6. The supplier’s material specification, giving physical properties, chemical composition, and test requirements, shall be included in the proposal.

7. Materials, casting factors, and the quality of any welding shall be in accordance with ASME Code Section VIII, Division 1. Supplier’s data report forms, as specified in the ASME Code, are not required.

8. Purchaser shall specify any corrosive agents present in the motive and process fluids and in the environment, including constituents that can cause stress corrosion cracking.

Comment: Typical agents of concern are amines, hydrogen sulfide, cyanide, ammonia, chlorides, fluorides, and acids.

9. Purchaser shall specify whether chlorides are present in concentrations greater than 50 parts per million (ppm). Caution shall then be used if using austenitic stainless steel.

Comment: Chlorides can cause stress corrosion cracking in austenitic stainless steel.
4.1.14.2 Castings

1. Castings shall be sound and generally free from porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar defects.

2. Castings shall be sound and generally free from porosity. The casting shall be free from hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar defects. Any major repairs of castings require the approval of the purchaser.

Note: Major weld repairs are:
   1) Those that cause the casting to leak during hydrostatic or pneumatic testing.
   2) Those that result in repair cavities that exceed 20% of the casting wall thickness or 25 mm (1 in.), whichever is less.
   3) Those that result in a repair area that exceeds 6500 mm² (10 in²).
   4) Crack length exceeding 2 inches in length

3. Surfaces of castings shall be cleaned by sandblasting, shot blasting, chemical cleaning, or any other standard method to meet the visual requirements of MSS SP-55. Mold-parting fins and remains of gates and riser shall be chipped, filed, or ground flush.

4. Use of chaplets in pressure castings shall be minimized. Chaplets shall be clean, corrosion free (plating permitted), and of a composition compatible with the casting. Chaplets shall not be used in impeller castings.

5. Ferrous pressure boundary and impeller castings shall not be repaired by welding, peening, plugging, burning-in, or impregnating, except as described as follows:
   a. Weldable steel castings may be repaired by welding, with a qualified welding procedure based on the requirements of ASME Code Section VIII, Division 1. Weld repairs shall be inspected according to the same quality standard used to inspect the casting. All repairs shall be approved by purchaser.
   b. Iron castings may be repaired by plugging within the limits of the applicable ISO (ASTM) standards. Holes drilled for plugs shall be carefully examined, using liquid penetrant, to ensure that all defective material has been removed. All repairs that are not covered by ISO (ASTM) standards shall be approved by purchaser.

6. Fully enclosed cored voids, including voids closed by plugging, shall not be permitted.

7. Fully enclosed cored voids, including voids closed by plugging, shall not be permitted, except for impellers made from a cored pattern.

4.1.14.3 Welding

1. Welding and weld repairs of piping, pressure-containing parts, and wetted parts shall be performed and inspected by operators and procedures qualified in accordance with ASME Code Section VIII, Division 1.
2. All weld repairs and repair welds shall be reviewed by supplier and purchaser to ensure that the welds are properly heat treated and nondestructively examined for soundness and compliance with the applicable qualified procedures.

3. Repair welds shall be nondestructively tested by the same method used originally to qualify the part. If approved by purchaser, weld repairs may be made to nodular iron casings using supplier’s qualified weld procedures.

4. Repair welds shall be non-destructively tested by the same method used to originally qualify the part.

5. If approved by the purchaser, weld repairs may be made to nodular iron casings using supplier’s qualified weld procedures.

### 4.1.15 Nameplates and Rotation Arrows

4.1.15.1 Pump and motor nameplates made of 18 Cr - 8 Ni, stainless steel shall be securely attached to the surface plate assembly by fasteners made of the same material as the nameplates.

4.1.15.2 A nameplate shall be securely attached at a readily visible location on the pump and on any other major piece of auxiliary equipment.

4.1.15.3 Rotation arrows shall be cast or attached to each major item of rotating equipment at a readily visible location.

4.1.15.4 Nameplates and rotation arrows (if attached) shall be made of austenitic stainless steel or of nickel-copper alloy (monel or its equivalent). Attachment pins shall be of the same material as the nameplate or rotation arrow. Welding of nameplates and rotation arrows shall not be permitted.

4.1.15.5 Nameplates shall be stamped with the following information:
   a. Purchaser’s item number
   b. Supplier’s size and model number
   c. Pump serial number
   d. Casing hydrostatic test pressure, in kilopascals (psi gauge)
   e. Casing hydrostatic test pressure, in barg (psig)
   f. Rated flow
   g. Rated head
   h. Speed, in revolutions per minute
   i. Bearing manufacturer’s identity numbers
   j. MAWP
   k. Temperature (basis for MAWP)

4.1.15.6 In addition to being stamped on the nameplate, the pump serial number shall be plainly and permanently marked on the pump casing.
4.2 Motor Design

4.2.1 General

4.2.1.1 For services in which the temperature of the pumped liquid does not exceed 40°C (104°F), either oil-filled or water-filled motors may be provided.

4.2.1.2 For pumped liquid temperatures greater than 40°C (104°F), oil-filled motors shall be provided.

4.2.1.3 Submersible motors shall have a pressure-equalizing system or an external oil/water-circulating system.

4.2.1.4 Oil-filled motors shall have forced oil circulation. Circulation by thermosyphon shall be permitted for water-filled motors.

4.2.1.5 For open sump applications, submersible motors shall have a shroud to ensure a minimum cooling flow velocity of 0.5 m/s (1.65 ft/s) over the motor outer casing.

4.2.1.6 Submersible motor windings shall be adequately braced to permit the reapplication of the rated voltage across the windings with a minimum of 33% residual voltage.

4.2.1.7 Winding insulation shall be in accordance with the following:
   a. For water-filled motors, Class Y
   b. For oil-filled motors, equivalent to Class F minimum

4.2.1.8 Motor shall be shop-installed on the pump, aligned, and match-marked before being shipped.

4.2.2 Motor Bearings

4.2.2.1 Radial bearings shall be sleeve-type. Use of antifriction bearings shall be approved by purchaser.

4.2.2.2 Thrust bearings shall be tilting-pad or solid-shoe type. Bearings shall be rated to permit 200% of the maximum downthrust developed over the pump operating range from minimum continuous flow to end-of-curve flow.

4.2.2.3 Pump-starting upthrust, if any, may be absorbed by a thrust button in the motor.

4.2.2.4 Thrust-bearing rating shall be based on the sum of the following loads:
   a. Pump and motor rotors masses
   b. Coupling mass
   c. Maximum pump hydraulic thrust

4.2.2.5 Maximum pump hydraulic thrust shall be determined from calculations that include thrusts developed during starting, stopping, and while operating at any capacity, including zero flow.
4.2.3 **Seals**

Motors shall be provided with mechanical seals. Lip seals shall not be permitted as a primary means of sealing. Mercury seals shall not be permitted.

4.2.4 **Dynamics**

Motor rotors shall be dynamically balanced in accordance with ISO 1940-1 grade 2.5.

4.2.5 **Couplings**

Couplings shall be of a rigid design and may be spline, claw, or axially split type.

4.3 **Accessories**

4.3.1 **Drivers**

4.3.1.1 Driver shall be sized in accordance with all specified operating conditions, including bearing, mechanical seal, external gear, and coupling losses, as applicable.

4.3.1.2 Driver shall be in accordance with the applicable inquiry specifications and purchaser’s PIP RESP003S-DM or RESP003S-D Data Sheet and order.

4.3.1.3 Driver shall be suitable for satisfactory operation under the utility and site conditions specified.

4.3.1.4 The motor shall be sized to cover the end-of-curve power or 110% of rated power, whichever is greater.

4.3.1.5 Motor shall be capable of accelerating the load to rated speed at 80% of the normal voltage.

*Comment:* For most applications, the starting voltage is typically greater than 80% of the normal voltage, and the time required to accelerate to full speed is generally less than 15 seconds.

4.3.1.6 Steam turbine power rating shall be 110% of the greatest calculated power requirement of the pump at any operating condition with specified steam condition.

4.3.1.7 Horizontal and vertical jackscrews shall be provided for the feet of drive train components.

4.3.2 **Coupling and Guard**

4.3.2.1 Coupling guard between driver and driven equipment shall be provided in accordance with applicable national, industrial, and statutory regulations, including ANSI B11.19 and OSHA 119.219.

4.3.2.2 Coupling shall be spacer-type flexible element in accordance with PIP REEE003. Spacer shall be retained if the flexible element ruptures.

4.3.2.3 Coupling hubs shall be steel.

4.3.2.4 Spacer shall have a nominal length of 125 mm (5 in) minimum, and shall permit removal of the coupling, bearings, seal, and rotor as applicable, without disturbing the driver or the suction and discharge piping.
4.3.2.5 Flexible couplings shall be keyed to the shaft. Keys, keyways, and fits shall be in accordance with AGMA 9002, Commercial Class (ISO R773).

4.3.2.6 If servicing the mechanical seal requires removal of the coupling hub, and the shaft diameter is greater than 100 mm (4 in), the hub shall be mounted with a taper fit. Diametral taper shall be 1 in 16 (1 mm/16 mm [0.75 in/ft]).

4.3.2.7 Coupling and coupling-to-shaft junctures shall as a minimum be rated for the maximum driver power, including any service factor.

4.3.2.8 If mounting the driver is not required, the fully machined half coupling shall be delivered to the driver manufacturer’s plant or to any other designated location, together with the necessary instructions for mounting the half coupling on the driver shaft.

4.3.3 Baseplates

If a PIP baseplate is specified on the purchaser’s PIP RESP003S-DM or PIP RESP003S-D Data Sheet, baseplate shall be permitted in accordance with PIP RESP002.

4.3.4 Piping and Appurtenances - General

4.3.4.1 Piping and components in contact with the process fluid shall have a corrosion/erosion resistance equal to, or better than, that of the casing.

4.3.4.2 Piping design, materials, joint fabrication, examination, and inspection shall be in accordance with ASME B31.3.

4.3.4.3 Minimum size of any connection or piping shall be DN 15 (NPS 1/2).

4.3.4.4 Connections, piping, valves, and fittings shall be common standard sizes.

4.3.4.5 Plastic plugs shall not be permitted in the pressure casing.

4.3.4.6 Piping components shall have a pressure/temperature rating as a minimum equal to the MAWP and temperature of the pump casing.

4.3.5 Special Tools

Pumps shall be designed to be assembled, disassembled, and maintained with standard hand tools. Designs requiring special tools should be avoided, otherwise approved by purchaser. If a design requires a special tool, the tool shall be provided by the vendor.

4.4 Inspection and Testing

Pumps shall be inspected and tested in accordance with purchaser’s PIP REDP003-T Inspection and Testing Requirements Sheet. Witnessed or observed testing and inspection will be specified by the owner.

4.4.1 Pumps shall be inspected and tested in accordance with the purchaser’s PIP REDP003-T Inspection and Testing Requirements Sheet.

4.4.2 Witness of a test or inspection may be specified on the data sheet.
4.5 Preparation for Shipment

4.5.1 Equipment shall be prepared for the type of shipment specified in the contract documents, including restraint of the rotor if necessary, to ensure the equipment reaches the shipping destination without damage.

4.5.2 Restrained rotors shall be identified using corrosion-resistant tags attached with stainless steel wire.

4.5.3 Preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment, and equipment disassembly shall not be required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser and supplier shall mutually agree upon the procedures to be followed.

4.5.4 Instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before startup shall be provided.

4.5.5 Equipment shall be prepared for shipment after all testing and inspection has been completed and the equipment has been released by the purchaser.

4.5.6 Shipment preparation shall include the following activities:

a. Packing used in tests shall be removed from the stuffing boxes before shipment.

b. If multiple pumps are being shipped, the components for each pump shall be packaged, identified, and shipped with the individual pump.

c. Seal chambers or stuffing box shall be plugged to prevent foreign objects entering the pump during shipping.

d. Unless otherwise specified in the contract documents, pumps shall not be disassembled after the performance test. The pump, including the seal chamber, shall be completely drained and dried, and all internal parts shall be coated with a suitable rust preventative.

e. All exterior surfaces except for machined and stainless steel surfaces shall be given a minimum of one coat of the supplier’s standard paint. Paint shall not contain lead or chromates.

f. Exterior machined surfaces of cast iron and carbon steel parts shall be coated with a suitable rust preventative.

g. Internal areas of cast iron and carbon steel bearing housings and oil system components shall be coated with a suitable oil-soluble rust preventative.

Comment: The owner is encouraged to insure the pump is adequately protected during the storage period.

h. Flanged openings shall be protected with either molded plastic flange closures, or with metal closures with elastomeric gaskets and fastened with at least 4 full diameter bolts.

i. Flanged openings shall be protected with appropriate flange closures to prevent debris and moisture intrusion.

j. Threaded Openings

1) Threaded openings shall be protected with plugs of material compatible with the case.
2) Taper-threaded plugs shall be long-shank solid round-head, or long-shank hexagon-head bar stock plugs in accordance with ASME B16.11.

3) Cylindrical threaded plugs shall be solid hexagon-head plugs in accordance with DIN 910.

4) A lubricant/sealant that is suitable for high temperature duty shall be used to ensure that the threads are vapor-tight.

5) Plastic plugs shall not be permitted.

6) Temporary plugged ports intended for service connections in the field shall be clearly tagged and labeled.

k. Lifting points and lifting lugs shall be clearly identified.

l. Equipment shall be identified with item and serial numbers.

m. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which the material is intended.

n. Crated equipment shall be shipped with duplicate packing lists, one inside and one outside of the shipping container.

o. Exposed shafts and shaft couplings shall be wrapped with waterproof, moldable waxed cloth or volatile corrosion-inhibiting paper. Seams shall be sealed with oil-proof adhesive tape.

4.5.7 Bearing assemblies shall be fully protected from entry of moisture and dirt.

4.5.8 If vapor-phase-inhibitor crystals or desiccant bags are installed in large cavities to absorb moisture, the desiccant bags shall be attached in an accessible area for ease of removal. Bags shall be installed in wire cages attached to flanged covers. Bag locations shall be indicated by corrosion-resistant tags attached with stainless steel wire.

4.5.9 One copy of standard installation instructions shall be packed and shipped with the equipment.

4.6 Documentation

Pump drawings, technical data, curves, parts lists, manuals, and other documentation shall be provided in accordance with purchaser’s PIP REDP003-R.
Table 1. Recommended Spare Parts

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Spares Recommended for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Startup</td>
</tr>
<tr>
<td></td>
<td>1-3 4-6 7+</td>
</tr>
<tr>
<td>Cartridge (Note 2)</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Element (Note 3)</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Rotor (Note 4)</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Head (Case Cover and Stuffing Box)</td>
<td></td>
</tr>
<tr>
<td>Shaft (w/Key)</td>
<td>1 1 2 N/3</td>
</tr>
<tr>
<td>Impeller</td>
<td>1 1 2 N/3</td>
</tr>
<tr>
<td>Wear Rings (Set) (Note 5)</td>
<td>1 1 1 2 1 1</td>
</tr>
<tr>
<td>Bearings Complete (Antifriction, Radial) (Note 6)</td>
<td>1 1 2 1 2 N/3</td>
</tr>
<tr>
<td>Bearings Complete (Antifriction, Thrust) (Note 6)</td>
<td>1 1 2 1 2 N/3</td>
</tr>
<tr>
<td>Bearings Complete (Hydrodynamic, Radial) (Note 6)</td>
<td>1 1 2 1 2 N/3</td>
</tr>
<tr>
<td>Bearing Pads Only (Hydrodynamic, Radial) (Note 6)</td>
<td>1 1 2 1 2 N/3</td>
</tr>
<tr>
<td>Bearing Complete (Hydrodynamic, Thrust) (Note 6)</td>
<td>1 1 2 1 2 N/3</td>
</tr>
<tr>
<td>Bearing Pads Only (Hydrodynamic, Thrust) (Note 6)</td>
<td>1 1 2 1 2 N/3</td>
</tr>
<tr>
<td>Mechanical Seal / Packing (Note 1, 5 &amp; 6)</td>
<td>1 2 N/3 1 2 N/3</td>
</tr>
<tr>
<td>Shaft Sleeve (Note 5)</td>
<td>1 2 N/3 1 2 N/3</td>
</tr>
<tr>
<td>Gaskets, Shims, O-Rings (Set) (Note 5)</td>
<td>1 2 N/3 1 2 N/3</td>
</tr>
<tr>
<td>Bowls</td>
<td></td>
</tr>
<tr>
<td>Spiders (Set)</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Bearings, Bushings (Set) (Note 5)</td>
<td>1 1 2 1 1 N/3</td>
</tr>
</tbody>
</table>

Notes:
1. Cartridge-type mechanical seals shall include sleeve and gland.
2. Cartridge consists of assembled element plus discharge head, seals, and bearing housings.
3. Element consists of assembled rotor plus stationary hydraulic parts (i.e., diffusers or volutes).
4. Rotor consists of all rotating parts attached to the shaft.
5. Normal wear parts for 3 years
6. For each pump set, including the motor
7. \( N \) = Number of identical pumps

Table 2. Minimum Uninterrupted Operation for Pumps and Auxiliaries

<table>
<thead>
<tr>
<th>Water Temperature</th>
<th>Minimum Uninterrupted Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50°C (120°F)</td>
<td>5 years</td>
</tr>
<tr>
<td>Between 50°C (120°F) and 60°C (135°F)</td>
<td>3 years</td>
</tr>
<tr>
<td>Between 60°C (135°F) and 65°C (150°F)</td>
<td>2 years</td>
</tr>
<tr>
<td>Greater than 65°C (150°F)</td>
<td>1 year</td>
</tr>
</tbody>
</table>
### Table 3. Bearing Selection

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Bearing Type and Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial and thrust bearing speed and life within limits (Notes 1 &amp; 2) for rolling element bearings and Pump energy density below limit (Note 3)</td>
<td>Rolling element radial and thrust</td>
</tr>
<tr>
<td>Radial bearing speed or life outside limits (Notes 1 &amp; 2) for rolling element bearings and Thrust bearing speed and life within limits (Notes 1 &amp; 2) for rolling element bearings and Pump energy density below limit (Note 3)</td>
<td>Hydrodynamic radial and rolling element thrust or Hydrodynamic radial and thrust</td>
</tr>
<tr>
<td>Radial and thrust bearing speed or life outside limits (Notes 1 &amp; 2) for rolling element bearings or Pump energy density above limit (Note 3)</td>
<td>Hydrodynamic radial and thrust</td>
</tr>
</tbody>
</table>

Notes:
1. Rolling element bearing speed limit: \( nd_m \) is less than or equal to 500,000
   where: \( d_m = \frac{d + D}{2} \), millimeters (i.e., cage diameter)
   \( d = \) diameter of the inner race, mm
   \( D = \) diameter of the outer race, mm
   \( n = \) speed of rotation, rpm
2. Rolling element bearing life limit: Basic rating \( L_{10h} \) per ISO 281-1 (ASME/ABMA Std 9) is 25,000 hours minimum with continuous operation at rated conditions and 16,000 hours minimum at maximum radial and axial loads and rated speed
3. Energy density limit: Product of pump-rated power, kW (hp), and rated speed (rpm) is less than or equal to 4.0 million (5.4 million)
Appendix A – Selection of Pump Materials of Construction

Table A. Application of Material Classes to Water Services

<table>
<thead>
<tr>
<th>Water Service Description Notes</th>
<th>Temperature</th>
<th>Pressure Range</th>
<th>Material Class (See Appendix B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh (Potable)</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>A-1 or C-1</td>
</tr>
<tr>
<td>Seawater</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>B-1; C-2, or C-3</td>
</tr>
<tr>
<td>Oily Water/ Surface Foul Water/ Water Draw/ Reflux Streams (May Contain Hydrocarbons)</td>
<td>Note 3</td>
<td>&lt;150°C (300°F)</td>
<td>&lt;35 Bar (500 psi)</td>
</tr>
<tr>
<td>Produced Water</td>
<td>Note 4</td>
<td>&lt;35 Bar (500 psi)</td>
<td>C-2, C-3, C-4</td>
</tr>
<tr>
<td>Injection Water</td>
<td>Note 5</td>
<td>&lt;35 Bar (500 psi)</td>
<td>C-3, C-4</td>
</tr>
<tr>
<td>Formation Water</td>
<td>Note 6</td>
<td>&lt;35 Bar (500 psi)</td>
<td>C-3, C-4</td>
</tr>
</tbody>
</table>

General Notes:

- For waters that may be in contact with hydrocarbons, purchaser shall specify on purchaser’s PIP RESP003S-D or RESP003S-DM Data Sheet whether water is considered sour. Also, purchaser shall specify whether H2S is present (even in trace amounts).
- If ammonia is present from chemical-treating reactions or from other sources, bronze internals shall not be permitted.
- Some types of waters described in Table A are not typically encountered in the refinery or process plant. However, these waters or waters with similar corrosive elements may be pumped in auxiliary or related plant systems.

Water Service Description Notes:

1. Fresh potable water is assumed to be saturated or nearly saturated with oxygen and at temperatures less than 100°C (212°F). At temperatures greater than 100°C (212°F), water may become aggressive and unstable, requiring a special material class based on water chemistry.
2. Fresh potable water is assumed to be saturated or nearly saturated with oxygen and at temperatures less than 100°C (212°F). At temperatures greater than 100°C (212°F), water may become aggressive and unstable, requiring a special material class based on water chemistry. Class A-1 is the lowest cost class, while A-2 offers extended life for increased initial cost.
3. Seawater is assumed to be fully oxygenated, free flowing, clean seawater (i.e., seawater does not contain hydrocarbons and is not brackish bay water with excessively high chlorides and other contaminants). Seawater outside this definition requires special material recommendations. Additionally, if flow rate is less than 1 m/s (3 ft/s) or frequently stagnant, pitting can occur and special material recommendations are required.
4. Cooling tower water is assumed to be recirculating. Buildup or concentration of chlorides and other contaminants is anticipated, especially for temperatures greater than approximately 93°C (200°F). Class A-3 shall be considered for longer service life if sulfur compounds or free chlorine is present.
5. Oily water, surface foul water, water draw, and reflux streams vary widely in corrosivity. Class A-1 or more corrosion-resistant classes may be required. Special material recommendations shall be obtained on the basis of expected contaminants.
6. Condensate is assumed to be at temperatures less than 100°C (212°F). At temperatures greater than 100°C (212°F), corrosiveness of water may vary widely and material class shall be based on water stability, pH, dissolved solids, and other water chemistry parameters.

(NOTES CONTINUED ON NEXT PAGE)
Water Service Description Notes (Continued):

7. Produced water is corrosive and defined as seawater or similar high-chloride water from an aquifer that has been injected into an oil field and subsequently risen to the surface as an oil-water mixture from which water is removed and reinjected. Typical produced water is assumed to have H2S, possibly CO2, a minimum pH of 6.0, and maximum chlorides of 60,000 ppm. Class C-2 is typically a minimum, but class shall be based on purchaser-furnished water chemistry, temperature, and other parameters defined by purchaser and supplier. Classes C-3 or C-4 may be required. Material temperature limits are dependent on specific corrosive conditions.

8. Treated water is assumed to be noncorrosive, i.e., treated to control scaling, pH, and fouling (use of biocide or other additions). Caution shall be exercised in water chemistry control to avoid excessive amounts of free chlorine.

9. Injection water is water injected into an oil-bearing formation to maintain formation pressure and enhance oil recovery. Corrosiveness of injection water can vary widely because the water may be seawater, produced water, freshwater, or aquifer water with varying corrosivity. Typical injection water is high in chlorides and can contain H2S and CO2. Class C-2 is typically a minimum, but class shall be based on purchaser-furnished water chemistry, temperature, and other parameters defined by purchaser and supplier. Classes C-3 or C-4 may be required. Material temperature limits are dependent on specific corrosive conditions.

10. Demineralized water is assumed to be low in chlorides and should be considered corrosive. Classes C-1 and C-2 are based on considerations of minimizing corrosion and maintaining water purity. Class C-1 is a cost-effective alternative, whereas C-2 may be readily available and offered as pump manufacturer standard.

11. Formation water is similar to produced water and considered a highly saline water (brine). Formation water comes from aquifers and other sources. Typically, formation water has very high concentrations of chlorides (i.e., 150,000 ppm or greater), possibly H2S, and nearly neutral pH. Class shall be based on purchaser-furnished water chemistry, temperature, and other parameters defined by purchaser and supplier. Classes C-3, C-4, or other special materials beyond the scope of this Practice may be required. Material temperature limits are dependent on specific corrosive conditions.

12. Seawater is assumed to be fully oxygenated, free-flowing, clean seawater (i.e., seawater does not contain hydrocarbons and is not brackish bay water with excessively high chlorides and other contaminants). Seawater outside this definition requires special materials recommendations. Additionally, if flow rate is less than 1 m/s (3 ft/s) or frequently stagnant, pitting can occur and special material recommendations are required.

13. Foul water, water draw, and reflux streams vary widely in corrosivity. Class B-1 or more corrosion-resistant classes may be required. Special material recommendations shall be obtained on the basis of expected contaminants.

14. Produced water is corrosive and defined as seawater or similar high-chloride water from an aquifer that has been injected into an oil field and subsequently risen to the surface as an oil-water mixture from which water is removed and reinjected. Typical produced water is assumed to have H2S, possibly CO2, a minimum pH of 6.0, and maximum chlorides of 60,000 ppm. Class C-3 is typically a minimum, but class shall be based on purchaser-furnished water chemistry, temperature, and other parameters defined by purchaser and supplier. Classes C-4 or C-5 may be required. Material temperature limits depend on specific corrosive conditions.

15. Injection water is water injected into an oil-bearing formation to maintain formation pressure and enhance oil recovery. Corrosiveness of injection water can vary widely because the water may be seawater, produced water, freshwater, or aquifer water with varying corrosivity. Typical injection water is high in chlorides and can contain H2S and CO2. Class C-3 is typically a minimum, but class shall be based on purchaser-furnished water chemistry, temperature, and other parameters defined by purchaser and supplier. Classes C-4 or C-5 may be required. Material temperature limits depend on specific corrosive conditions.

16. Formation water is similar to produced water and is considered a highly saline water (brine). Formation water comes from aquifers and other sources. Typically, formation water has high concentration of chlorides (i.e., 150,000 ppm or greater), possibly H2S, and nearly neutral pH. Material class shall be based on purchaser-furnished water chemistry, temperature, and other parameters defined by purchaser and supplier. Classes C-4, C-5, or other special materials beyond the scope of this Practice may be required. Material temperature limits depend on specific corrosive conditions.
### Appendix B – Pump Material Classes Designations

#### Table B – Material Classes

<table>
<thead>
<tr>
<th>MATERIAL CLASS</th>
<th>A-1</th>
<th>B-1 (Note 7)</th>
<th>C-1</th>
<th>C-2 (Note 3)</th>
<th>C-3 (Note 4)</th>
<th>C-4 (Note 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing/Bowls</td>
<td>Ni-Resist</td>
<td>Nickel-Aluminum-Bronze</td>
<td>316L</td>
<td>Duplex</td>
<td>S. Duplex</td>
<td>6 Moly</td>
</tr>
<tr>
<td>Impeller</td>
<td>316L</td>
<td>Nickel-Aluminum-Bronze</td>
<td>316L</td>
<td>Duplex</td>
<td>S. Duplex</td>
<td>6 Moly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PUMP PART (Notes 1 &amp; 2)</th>
<th>ASTM Full Comp Matl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowls</td>
<td>Yes</td>
</tr>
<tr>
<td>Impeller</td>
<td>Yes</td>
</tr>
<tr>
<td>Pump Shafts</td>
<td>Yes</td>
</tr>
<tr>
<td>Bowl Bearings (Note 6)</td>
<td>No</td>
</tr>
<tr>
<td>Bolting: Studs</td>
<td>Yes</td>
</tr>
<tr>
<td>Nuts</td>
<td>Yes</td>
</tr>
<tr>
<td>Lock Collets</td>
<td>No</td>
</tr>
<tr>
<td>Coupling</td>
<td>No</td>
</tr>
<tr>
<td>Motor Housing</td>
<td>Yes</td>
</tr>
<tr>
<td>Riser Column</td>
<td>Yes</td>
</tr>
<tr>
<td>Strainer</td>
<td>No</td>
</tr>
</tbody>
</table>

- **Notes:**
  1. Mating wear surfaces of hardenable materials shall have a difference in Brinell hardness numbers (BHN) of 50 BHN minimum, unless both wear surfaces have BHN of 400 or greater.
  2. Requirement for hard-facing and specific hard-facing material may be specified by the purchaser on purchaser’s PIP RESP003S-D or PIP RESP003S-DM data sheets. Method of hard-facing application may also be specified by purchaser, or both material and method of application may be specified by mutual agreement between purchaser and supplier. Alternatives to hard-facing may include opening of running clearances and/or use of nongalloing materials.
  3. Duplex (i.e., austenitic-ferritic) stainless steels are typically identified by trade name and have slightly varying composition and corrosion-resistant properties. One of the most common wrought duplex steels, UNS 31803, has a nominal composition of 22% chromium, 5.5% nickel, 3% molybdenum, and 0.14% nitrogen.
  4. Super duplex stainless steels are distinguished from standard duplex steels (see Note 3) by increased amounts of chromium (25% nominal) and other alloys, typically nickel, molybdenum, and nitrogen. These stainless steels are most frequently designated by trade name with slightly varying compositions and specific corrosion resistance.
  5. 6-Moly (super austenitic) stainless steels are enhanced austenitic stainless steels that have maximum resistance to pitting and crevice corrosion. These steels are typically required for the most severe services with high-chloride concentrations. These steels are designated by trade name. Choice of a specific steel shall be according to purchaser preference, mutual agreement between purchaser and supplier, and/or specific corrosive conditions.
  6. For bowl bearings, synthetic cutless rubber or Thordon (or equivalent) are acceptable alternatives for sandy or abrasive water service.
  7. Nickel-aluminum-bronze shall be temper annealed.
### Design Operating Data

<table>
<thead>
<tr>
<th>Service</th>
<th>Continuous</th>
<th>Intermittent</th>
<th>Standby</th>
<th>Attended</th>
<th>Unattended</th>
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</thead>
<tbody>
<tr>
<td>PUMP Function</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUMP OPERATING MODE</td>
<td>INDIVIDUALLY</td>
<td>IN PARALLEL</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

### Liquid Characteristics

<table>
<thead>
<tr>
<th>Liquid Pumped</th>
<th>TDS:</th>
<th>PPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Temperature</td>
<td>°F</td>
<td></td>
</tr>
<tr>
<td>Relative Density at Flow Temp.</td>
<td>PPM</td>
<td></td>
</tr>
<tr>
<td>Vapor Pressure at Flow Temp.</td>
<td>PSIA</td>
<td></td>
</tr>
<tr>
<td>TSS:</td>
<td>NONE</td>
<td>PPM</td>
</tr>
<tr>
<td>Character of Solids:</td>
<td>ABRASIVE</td>
<td>NON ABRASIVE</td>
</tr>
</tbody>
</table>

### Description

- GAS IN LIQUID: NONE
- VOL.: % UNKOWN
- TYPE OF GAS: UNKOWN
- PRINCIPAL CORROSIVES: PH: | CL: | PPM |

### Equipment Data

- PUMP: MANUFACTURER |
- MODEL/TYPE/SIZE: |
- SERIAL NUMBER: |
- ELECTRIC MOTOR: |
- MANUFACTURER: |
- MODEL/TYPE/SIZE: |
- SERIAL NUMBER: |
- CABLE: |
- MAKE/TYPE/DIAM: |
- WEIGHTS: |
  - PUMP: LBS |
  - MOTOR: LBS |
  - CABLE: LBS |
- LUBRICANT: |
- LEVEL READ COUPLING GAGE: |
- SUPPLIER STOCK |
- NONE |

### Construction Data

- PUMP CONSTRUCTION
  - IMPPELLER(S) NO.: |
  - 1ST STAGE: |
  - FOLLOW STAGES: |
  - ACTUAL DIA: |
  - MAXIMUM DIA: |
  - MINIMUM DIA: |
  - IMPPELLER EYE AREA: |
  - EYE ENTRANCE VELOCITY: |
  - PERIPHERAL EYE VEL: |
  - PATTERN NUMBER: |
  - NUMBER OF VANES: |
  - IMPPELLERS: |
  - COLLET FITTED |
  - KEY FITTED |
  - BOLTED |

- PRESURES: |
  - MAWP AT °F |
  - HYDROTEST PRESS |

### Performance Data

- SHUT OFF HEAD BOWL ASSY AT ACT: |
- IMPPELLER DIAMETER: |
- CAPACITY AT END OF CURVE: |
- USGPM |
- RATIO: END CURVE FLOW/RATED FLOW: |
- RATIO: SHUT OFF HDRAWTED FLOW: |
- MAX BHP FULL CURVE (LIQ. PUMPED): |
- DRIVER NAMEPLATE RATING: |
- PERM MIN. CONTINUOUS FLOW: |
- USGPM |
- PERM OPER TIME AGAINST CLOSED VALVE: |
- S |
- FIRST WET CRITICAL SPEED: |
- RPM |
- MAX. UPTHRUST: |
- LBS |
- MAX DOWNTHRUST: |
- LBS |

<table>
<thead>
<tr>
<th>NO.</th>
<th>DATE</th>
<th>REVISION DESCRIPTION</th>
<th>BY</th>
<th>APVD.</th>
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<tr>
<td></td>
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CONSTRUCTION DATA (CONT’D)

PUMP CONSTRUCTION (CONT’D)

POWER CABLE RECESS
COLUMN ADAPTOR
(PUMP TO RISER COLUMN):

<table>
<thead>
<tr>
<th>SIZE</th>
<th>ANSI CLASS</th>
<th>FACING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</table>

SURFACE PLATE ASSEMBLY

<table>
<thead>
<tr>
<th>SIZE OD</th>
<th>THICKN.</th>
<th>B.C.Φ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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SURFACE PLATE FLANGE:

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<tr>
<th>SIZE</th>
<th>RATING</th>
<th>FACING</th>
</tr>
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<tr>
<td></td>
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BOLTING NUMBER/SIZE:

<table>
<thead>
<tr>
<th>SIZE</th>
<th>RATING</th>
<th>FACING</th>
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ELBOW DISCHARGE FLANGE:

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<th>SIZE</th>
<th>RATING</th>
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RISEN COLUMN TOP CONNECTION:

<table>
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<th>SIZE</th>
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SURFACE PLATE ASSEMBLY

<table>
<thead>
<tr>
<th>NO</th>
<th>YES</th>
</tr>
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<tbody>
<tr>
<td></td>
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CABLE ENTRY IN WELL:

<table>
<thead>
<tr>
<th>Packed Off</th>
<th>Through Discharge Elbow</th>
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<tbody>
<tr>
<td>Yes</td>
<td>No</td>
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</table>

INSULATOR THRU WELL HEAD HANGER

SPECIAL REQUIREMENTS

CHECK VALVE IN COLUMN PIPE:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td></td>
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GAS SEPARATOR:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
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<tbody>
<tr>
<td></td>
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</table>

PURCHASER’S REFERENCES

PUMPS OF THE SAME TYPE & SIZE IN OPERATION

<table>
<thead>
<tr>
<th>PUMP ITEM NO.</th>
<th>INQ./ORDER NO.</th>
<th>DATA SHEET NO.</th>
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UTILITY DATA

<table>
<thead>
<tr>
<th>MAIN POWER SUPPLY:</th>
<th>3 PHASE/60 CYCLE/ VOLTS</th>
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</thead>
<tbody>
<tr>
<td></td>
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WINDING TEMP. ACTUAL RISE (BY RESISTANCE METHOD): °F

<table>
<thead>
<tr>
<th>MAXIMUM PERMISSIBLE:</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

CLASS INSULATION:

<table>
<thead>
<tr>
<th>PRESSURE EQUALIZATION SYSTEM:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diaphragm</td>
</tr>
<tr>
<td></td>
</tr>
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</table>

MATERIALS OF CONSTRUCTION

BOWLS:

<table>
<thead>
<tr>
<th>NUTS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

SHAFT. BOWL ASSEMBLY:

<table>
<thead>
<tr>
<th>PIN COLETS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Bearing, Bowl Assembly:

<table>
<thead>
<tr>
<th>COUPLING:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
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BOLTING STUDS:

<table>
<thead>
<tr>
<th>LOCKING STUDS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

LOCK COLLETS:

<table>
<thead>
<tr>
<th>MOTOR HOUSING:</th>
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<tbody>
<tr>
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PUMP GUIDE BUSHINGS

<table>
<thead>
<tr>
<th>MOTOR RADIUS BEARINGS</th>
</tr>
</thead>
<tbody>
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</table>

Motor Thrust Bearings

<table>
<thead>
<tr>
<th>WEAR RINGS</th>
<th>BOWL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IMPELLER</td>
</tr>
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</table>

MECHANICAL SEAL CODE

SPECIAL REQUIREMENTS

PAINTING PUMP HEAD, COLUMN MOUNTING FLANGE:

<table>
<thead>
<tr>
<th>PURCHASER’S PAINT SPEC.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier's Standard Paint</td>
</tr>
</tbody>
</table>

MINIMUM DRY FILM THICKNESS: MLS

COPPER ANODE FOULING PREVENTION SYSTEM:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

PUMPS OF THE SAME TYPE & SIZE IN OPERATION

<table>
<thead>
<tr>
<th>PURCHASER’S REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUMP ITEM NO.</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

MOTOR DATA

SPEED AT FULL LOAD: RPM

<table>
<thead>
<tr>
<th>RATED POWER (NAMEPLATE RATING):</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VOLTAGE RATING AT MOTOR TERMINAL: V

LOCKS ROTOR CURRENT, STARTING METHOD:

<table>
<thead>
<tr>
<th>MINIMUM STARTING TORQUE:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

| MINIMUM BREAKDOWN TORQUE: |
|                           |

| EFFICIENCY AT FULL LOAD: |
|                          |

| POWER FACTOR AT FULL LOAD: |
|                           |

| CURRENT AT FULL LOAD: |
|                       |

WINDING TO BE BRACED FOR FULL VOLTAGE

<table>
<thead>
<tr>
<th>START WITH A RESIDUAL VOLTAGE OF:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

WINDING TEMP. ACTUAL RISE (BY RESISTANCE METHOD): °F

<table>
<thead>
<tr>
<th>MAXIMUM PERMISSIBLE:</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CLASS INSULATION:

| PRESSURE EQUALIZATION SYSTEM: |
| Diaphragm | Balancing Tube | Bladder | Ext. Circ. Syst. |
|           |               |        |                 |

MOTOR OIL:

<table>
<thead>
<tr>
<th>HEAT EXCHANGER COOLING:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

EXTERNAL CIRCULATION SYSTEM:

<table>
<thead>
<tr>
<th>SHAFT SEALING:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

THURST BEARING RATED: CONTINUOUS & TRANSIENT LBS

<table>
<thead>
<tr>
<th>RADIAL SLEEVE BEARING DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOTOR SHROUD DIAMETER</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tbody>
</table>

MOTOR DATA

SPEED AT FULL LOAD: RPM

<table>
<thead>
<tr>
<th>RATED POWER (NAMEPLATE RATING):</th>
<th>HP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

VOLTAGE RATING AT MOTOR TERMINAL: V

LOCKS ROTOR CURRENT, STARTING METHOD:

<table>
<thead>
<tr>
<th>MINIMUM STARTING TORQUE:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

| MINIMUM BREAKDOWN TORQUE: |
|                           |

| EFFICIENCY AT FULL LOAD: |
|                          |

| POWER FACTOR AT FULL LOAD: |
|                           |

| CURRENT AT FULL LOAD: |
|                       |

WINDING TO BE BRACED FOR FULL VOLTAGE

<table>
<thead>
<tr>
<th>START WITH A RESIDUAL VOLTAGE OF:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CLASS INSULATION:

| PRESSURE EQUALIZATION SYSTEM: |
| Diaphragm | Balancing Tube | Bladder | Ext. Circ. Syst. |
|           |               |        |                 |

MOTOR OIL:

<table>
<thead>
<tr>
<th>HEAT EXCHANGER COOLING:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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EXTERNAL CIRCULATION SYSTEM:

<table>
<thead>
<tr>
<th>SHAFT SEALING:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

THURST BEARING RATED: CONTINUOUS & TRANSIENT LBS

<table>
<thead>
<tr>
<th>RADIAL SLEEVE BEARING DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOTOR SHROUD DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
**Design Operating Data**

- **Service:**
  - Continuous
  - Intermittent
  - Standby

- **Pump Function:**
  - Individually
  - In parallel

**Liquid Characteristics**

- **Flow Temperature:** °C
- **TDS:** MGA
- **Relative Density at Flow Temp.:** KPA(ABS)
- **Character of Solids:** Abrasive
- **Description:**
  - Gas in Liquid: None
  - Vol.: %

**Equipment Data**

- **Type of Gas:**
- **Pump, Driver and Auxiliaries**
- **Principal Corrosives:**

**Operating Conditions**

- **Flowing, Press. at Datum:** KPA(ABS)
- **Non-Flooding Other:**

**Productivity Index:**

- **Rated Capacity:** L/S

**Installation**

- **Disch. Press.:** KPA(ABS)
- **Head Above Datum:** M
- **Bowl Assy. Differential Head:** M
- **Datum Elev.:** M
- **Disch. Elev.:** M
- **Datum Elev.:** M
- **Static Level:** M
- **Drawdown Lvl.:** M
- **Pumping Lvl.:** M
- **Min. Submergence Req’d Above First Stage:** M

**Construction Data**

- **Impeller(s) No.:**
- **1st Stage, Follow Stages**

**Performance Data**

- **Pump Characteristics:**
- **Shut off head bowl Assy at Act.:** M
- **Impeller Diameter:** M
- **Ratio: End Curve Flow/Rated Flow:** M³/HR
- **Pump Diff. Head at End of Curve:** M
- **Max BHP Full Curve (Liq. Pumped):** KW
- **Driver Nameplate Rating:** KW
- **Perm Min. Continuous Flow:** L/S
- **Perm Oper Time Against Closed Valve:** S
- **First Wet Critical Speed:** RPM
- **Max. Upthrust:** N
- **Max. Downthrust:** N

---

**Data Sheet RESP003S-DM**

**Vertical Submerged Motor Centrifugal Pumps for Water Service (SI Units)**

**January 2020**
### Construction Data (Cont’d)

**Pump Construction (Cont’d)**

- **Power Cable Recess Column Adaptor**
  - (Pump to Riser Column):
  - Size: [ ] Round
  - [ ] Flat
  - [ ] Hollow
  - Column Adapter
  - Size: [ ] Conductor: [ ] Each
  - Length: [ ] M
  - Diameter, OD: [ ] mm
  - Cross Section Each Conductor: [ ] mm²
  - Insulation Type: [ ]
  - Cable Entry in Well: [ ]
  - Insulator Thru Well Head Hanger

- **Surface Plate Assembly**
  - Size: [ ] Yes
  - Thickness: [ ] mm
  - B.C.Ø: [ ] mm
  - Surface Plate Flange: [ ] mm
  - Bolting Number/Size: [ ]

- **Surface Plate Flange**
  - Size: [ ] mm
  - Diameter: [ ] mm
  - Flanged: [ ] mm
  - Thread: [ ] mm

- **Surface Plate Through Discharge Elbow**
  - Size: [ ] mm
  - Flanged: [ ] mm
  - Thread: [ ] mm

### Cable Data

- **Type**: [ ] Round
  - [ ] Flat
  - [ ] Hollow
  - Power Cable Recess
  - Size: [ ]
  - Conductor: [ ] Each
  - Length: [ ] M
  - Diameter, OD: [ ] mm
  - Cross Section Each Conductor: [ ] mm²
  - Insulation Type: [ ]
  - Cable Entry in Well: [ ]
  - Insulator Thru Well Head Hanger

### Special Requirements

- **Check Valve in Column Pipe**
  - [ ] Yes, at Elevation: [ ] M
  - [ ] No
  - Gas Separator: [ ]
  - [ ] Yes
  - [ ] No

### Miscellaneous

- **Painting Pump Head, Column Mounting Flange**
  - [ ] Purchaser’s Paint Spec.: [ ]
  - Supplier’s Standard Paint
  - Minimum Dry Film Thickness: [ ] mm
  - Copper Anode Fouling Prevention System: [ ]
  - [ ] Yes
  - [ ] No

### Purchaser’s References

- **Pumps of the Same Type & Size in Operation**
  - Pump Item No.: [ ]
  - Inq./Order No.: [ ]
  - Data Sheet No.: [ ]

### Utility Data

- **Main Power Supply**
  - 3 Phase/60 Cycle/ [ ] Volts
  - Control & Protection: [ ]
  - 3 Phase/60 Cycle/ [ ] Volts

### Submersible Motor/Cable Data

#### Motor Data

- **Speed at Full Load**: [ ] RPM
- Rotation, Viewed From End Opposite Shaft Extension: [ ] CW [ ] CCW
- Rated Power (Nameplate Rating): [ ] KW
- Voltage Rating at Motor Terminal: [ ] V
- Locked Rotor Current, Starting Method:
  - Minimum Starting Torque: [ ] %
  - Minimum Breakdown Torque: [ ] %
  - Efficiency at Full Load: [ ] %
  - Power Factor at Full Load: [ ] %
  - Current at Full Load: [ ] A
- Winding to be Braced for Full Voltage
  - Start with a Residual Voltage of:
  - Winding Temp. Actual Rise (by Resistance Method): [ ] °C
  - Maximum Permissible: [ ] °C
- Class Insulation:
- Pressure Equalization System:
  - [ ] Diaphragm
  - [ ] Balancing Tube
  - [ ] Bladder
  - [ ] Ext. Circ. Syst.
- Motor Oil:
  - Heat Exchanger Cooling: [ ] Yes [ ] No
  - External Circulation System: [ ] Yes [ ] No
- Shaft Sealing: [ ] Mechanical Seal
- Thrust Bearing Rated: Continuous [ ] N Transient [ ] N
- Radial Sleeve Bearing Diameter: [ ] mm
- Motor Shroud Diameter: [ ] mm

This data sheet covers pumps of the same type & size in operation.