PIP RESP003V
Specification for High Power Vertical 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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4. Requirements.................................................................6
  4.1 Basic Design...............................................................6
  4.2 Accessories..............................................................19
  4.3 Inspection and Testing .............................................21
  4.4 Preparation for Shipment .........................................21
  4.5 Documentation.........................................................23
  Table 1. Recommended Spare Parts.....................................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
RESP003V-D – Vertical Centrifugal Pumps for Water Service (U.S. Customary Units)
RESP003V-DM – Vertical Centrifugal Pumps for Water Service (SI Units)
1. Introduction

1.1 Purpose

This Practice provides requirements for design and manufacture of vertical 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.

1.2 Scope

This Practice describes manufacturing and performance requirements for vertical 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 outside these conditions and those that fall within the capabilities of ANSI/ASME pumps, it is recommended that PIP RESP73V be used for purchase of pumps.

Pumps covered by this Practice are broadly classified as diffuser-and-volute, separate discharge cantilevered, and vertical can.

Vertical in-line and submersible pumps have special design characteristics and are not included in the scope of this Practice.

Fire water pumps are covered by NFPA 20 and are not covered by this Practice.

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 REEP006 - Pump Selection Guidelines
- PIP RESP073V - Application of ASME B73.2 - 2003 Specification for Vertical In-Line Centrifugal Pumps for Chemical Process
2.2 Industry Codes and Standards

- 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 - 2011 – Forged Steel Fittings, Socket-Welding and Threaded
  - ASME B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 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
  - Boiler and Pressure Vessel Code (ASME Code)
    - Section VIII, Division 1 - Pressure Vessels
    - Section IX - Welding and Brazing Qualifications

- American National Standards Institute (ANSI)
  - ANSI B15.1 - Coupling Guards

- 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

- 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 7005-1 - Metallic Flanges - Part 1: Steel Flanges
  - ISO 7005-2 - Metallic Flanges - Part 2: Cast Iron Flanges
  - ISO 1940-1 - Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State

- 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 Electric Code
3. Definitions

allowable operating region: see preferred operating region

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. This critical speed is for the rotor immersed in water, also called the wet critical speed.

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

maximum suction pressure: Highest suction pressure to which the pump is subjected during operation

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 vertical pumps is top of the foundation.

net positive suction head available (NPSHA): NPSH determined by 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 the best efficiency point 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 are wear rings, interstage bushings, balancing devices, throat bushings, seal faces, bearings, and all gaskets.
operating region: Portion of a pump’s hydraulic coverage over which a pump operates

owner: The party who owns the facility wherein the vertical 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.

rated operating point: Point at which the supplier certifies that pump performance is within the tolerances specified 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:

\[
nqs = \frac{N(Q)^{0.5}/(NPSH3)^{0.75}}{}
\]

where:

- \(nqs\) = 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
  - = total flow for single suction impellers
  - = one-half total flow for double suction impellers
- \(NPSH3\) = 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 (\(nqs = 51.6 \times N_{ss}\)). The usual symbol for suction specific speed in U.S. units is \(N_{ss}\).
supplier: The party responsible for providing the vertical 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 a prime mover

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. The purchaser usually assigns unit responsibility to the pump vendor.

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 centrifugal pumps shall be provided in accordance with this Practice and purchaser’s PIP RESP003V-D or PIP RESP003V-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.

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 2 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 shall be capable of operating continuously up to a minimum of 105% of rated speed and shall be capable of operating briefly, under emergency conditions, up to the driver trip speed.

4.1.1.8 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%. Discharge orifices shall not be used as a means of providing a continuous rise to shutoff.

4.1.1.9 For wet pit pumps, the total dynamic head required to provide the specified discharge pressure at the discharge flange shall be determined in accordance with the minimum specified liquid level.

4.1.1.10 Acceptable margins between NPSHA and NPSH3 shall be in accordance with PIP REEP006, Section 5.1.4.8.7.

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

4.1.1.12 Allowable operating region shall be stated in the proposal.

4.1.1.13 If the allowable operating region is limited by a factor other than vibration, that factor shall be stated in the proposal.

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 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 purchaser. For pumps with flow rates greater than 450 m.³/hr. (2,000 gpm) suction specific speeds less than 175 (9,000) are preferred.

4.1.1.17 Pump and seal chamber shall be continuously vented with a high point connection in either the seal chamber or seal flush piping. Systems needing manual venting shall be approved by purchaser.

Comment: If venting to atmosphere is not permitted, the vent should be connected to the process piping at an elevation above the seal chamber.

4.1.1.18 Motors, electrical components, and electrical installations shall be suitable for the area classification (i.e., class, group, division, or zone) specified by the purchaser and shall be in accordance with NFPA 70, Articles 500, 501, and 502, and local codes specified and furnished by the purchaser.
4.1.1.19 Mechanical and hydraulic conditions in the seal chamber required to maintain a stable film at the seal faces, including temperature, pressure, and flow, shall be jointly established by the supplier and the seal manufacturer and shall be noted on purchaser’s PIP RESP003H-D or PIP RESP003H-DM Data Sheet.

4.1.1.20 Oil reservoirs and housings that enclose moving lubricated parts (e.g., bearings, shaft seals, highly polished parts, instruments, and control elements) shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation and idleness.

4.1.1.21 Arrangement of equipment, piping, and auxiliaries shall provide adequate clearance areas and safe access for operation and maintenance.

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

4.1.2 Pressure Casing

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

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

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

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

4.1.2.5 Inter-stage sealing of threaded bowls of diameters greater than 300 mm (12 inches) shall be by o-rings in the partition grooves.

4.1.3 Nozzle and Pressure Casing Connections

4.1.3.1 Casing Opening Sizes

1. 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.

2. Casing connections shall be 13 mm (1/2 NPS) minimum.

4.1.3.2 Suction and Discharge Nozzles

1. Suction nozzles, if provided, 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 fully machined or spot faced on the back and shall be designed for through bolting.

7. Flanges greater than 60 cm (24 inches) shall be in accordance with the dimensional requirements of ASME B16.42 or ASME B16.47.

4.1.3.3 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 inches) 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. All connections shall be suitable for the hydrostatic test pressure of the region of the casing to which they are attached.

8. Casing shall have vent connections for suction barrel and mechanical seals.

4.1.4 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.

4.1.5 Impellers

4.1.5.1 Unless otherwise approved by purchaser, impellers shall have solid hubs.

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

Comment: Impellers with solid hubs are preferred. The preference for solid hubs is intended to 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.

4.1.5.3 Impellers shall be keyed to the shaft.

4.1.5.4 If approved by the owner, collets may be used on pumps with shaft diameters of 1 inch or less.

4.1.6 Wear Rings and Running Clearances

4.1.6.1 If fully enclosed impellers are provided, renewable wear rings shall be provided on both the casing and the impeller. If clearances can be restored by adding wear rings in the future, impeller wear rings may be omitted. Renewable wear rings, if used, shall be secured by a press fit with locking pins or by tack welding.

4.1.6.2 Renewable casing bushings shall be provided at all interstage and steady-bearing points.

4.1.6.3 If required because of interstage pressure differential and the character of the liquid handled (e.g., dirty or nonlubricating), shaft sleeves shall be provided at interstage and steady-bearing points.

4.1.7 Shafts

4.1.7.1 Unless otherwise approved by purchaser, the pump shaft shall be one piece.

Comment: Total shaft length or shipping restrictions may preclude a one piece shaft.

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

4.1.7.3 Surface finish of the shaft or sleeve through the seal chamber shall be 0.8 µm (32 µin) maximum.

4.1.7.4 Total indicated run-out shall be 6 mm/m (0.0005 in/ft) length maximum.

4.1.7.5 Total run-out shall be 250 µm (0.010 in) maximum over the entire shaft length.

4.1.8 Shaft-Sealing Systems

4.1.8.1 Shaft-sealing system, seal piping, and appurtenances shall
be in accordance with purchaser’s PIP RESP003V-D or PIP RESP003V-DM Data Sheet.

4.1.8.2 If specified on purchaser’s PIP RESP003V-D or PIP RESP003V-DM Data Sheet, mechanical shaft seals shall be provided on pumps.

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

4.1.8.4 Cartridge seals shall be removable without disturbing the driver.

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

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

4.1.8.7 MAWP shall apply to all parts of the pressure casing. If pressure ratings of seals do not meet this requirement, purchaser shall be notified and 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.

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

4.1.8.9 Seal chamber shall be provided with an internal passage or external connection to permit complete venting of the chamber before startup.

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

4.1.8.11 During operation, the temperature of the seal chamber shall be maintained at a minimum of 10°C (50°F) less than local saturation vapor temperature.

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

4.1.8.13 Mechanical seals and glands shall be installed in the pump before shipment and shall be clean and ready for initial service.

4.1.8.14 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.

4.1.8.15 The mating joint between the seal gland and the seal chamber face shall incorporate a confined gasket. Gasket shall be of the controlled compression type (e.g., O-ring or spiral-wound gasket) with metal-to-metal joint contact.

4.1.8.16 If space, pump design, or size make controlled compression gaskets impractical, an alternate seal gland design shall be submitted to and approved by purchaser.

4.1.9 Dynamics

4.1.9.1 Critical Speed

The pump rotor shall be designed such that its first wet lateral critical speed is 20% greater than its maximum allowable continuous speed calculated with twice the normal wear and internal bushing clearances.

4.1.9.2 Vibration and Balance

1. Pumps 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. Rotating components shall be balanced in accordance with ISO 1940-1 grade 2.5.

3. If a performance test is specified on purchaser’s PIP RESP003-T Inspection and Testing Requirements Sheet, unfiltered vibration measurements shall be made at each test point except shutoff.

4. If specified on purchaser’s PIP RESP003-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 multistage pumps with different impellers, Z is the highest number of impeller vanes in any 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 \textit{ASME B73.1}, paragraph 5.1.4.

5. 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.

6. Variable speed pumps shall operate over their specified speed range without exceeding the vibration limits in purchaser’s \textit{PIP REDP003-T, Inspection and Testing Requirements Sheet}, Table T3.

7. Structural resonances (i.e., reed frequencies) of a vertical pump assembly shall be separated from the pump operating speed by a minimum of 20\%.

8. If the driver power is greater than 400 kW (500 hp), an analysis of the pump assembly shall be provided to verify preconstruction design. Purchaser and supplier shall agree on the extent, method, and acceptance criteria of this analysis.

\textit{Comment:} Vertically suspended pumps are generally flexible structures with running speed between natural frequencies. As such, they are susceptible to resonant vibration if the separation margins between running speeds and natural frequencies are not verified during design.

\textit{Comment:} Basic structural elements typically include the foundation, pump structures, and motor frame. Typically the deflection of the foundation represents less than 5\% of the total deflection of the structural elements. If foundation data are not available when the analysis is being conducted, the purchaser and supplier shall agree on a foundation deflection value.

9. 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 per ASME.

\textbf{4.1.10 Bearings and Bearing Housings}

\textbf{4.1.10.1 Bearings}

1. If provided in the pump, bearings shall be one of the following:
a. Rolling element radial and thrust
b. Hydrodynamic radial and rolling element thrust
c. Hydrodynamic radial and thrust

2. 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. Unloaded bearings shall be capable of running without ball skidding.

3. Thrust bearing design loads shall include an allowance for loads transmitted or generated by the coupling.

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

5. Single or double row ball bearings shall be Conrad type (i.e., no filling slots).

6. Guide bearings shall be corrosion- and abrasion-resistant for the specified pressure and temperature.

7. Thrust bearing shall be mounted with an interference fit on a slide-fit, key-driven sleeve to permit axial rotor adjustment and oil lubrication.

8. Line shaft bearings shall be spaced at intervals of 1.5 m (5 ft) or less.

4.1.10.2 Bearing Housings

1. Housings for oil-lubricated, non-pressure-fed bearings shall have tapped and plugged fill and drain openings of 12 mm (1/2 NPS) minimum.

2. Housings for oil lubricated, non-pressure fed bearings shall have constant-level, sight-feed 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.

3. 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.

4. For pressurized systems operating at an ambient temperature of 50°C (122°F) or less, oil temperature at
the outlet shall be less than 71°C (160°F), and bearing metal temperatures (if bearing temperature sensors are provided) shall be less than 93°C (200°F).

5. 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 are not permitted.

4.1.11 Lubrication

4.1.11.1 Unless pumped liquid is not suitable, internal bearings shall be lubricated by the pumped liquid.

4.1.11.2 Alternate methods of lubrication shall be proposed and approved by purchaser if the pumped liquid is not suitable.

4.1.11.3 Pump bearings located above the mounting plate shall be oil lubricated as specified in Section 4.1.10.2, or grease lubricated in accordance with the manufacturer’s guidelines.

Comment: This requirement does not apply to throat bushings or any product-lubricated bearing.

4.1.12 Materials

4.1.12.1 General

1. The table 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 may be listed for purchaser’s approval on the purchaser’s PIP RESP003V-D or PIP RESP003V-DM Data Sheet.

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

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

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

6. If an industry standard designation is not available, 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 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 be used if using austenitic stainless steel.

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

### 4.1.12.2 Castings

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

2. 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.

3. 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.

4. 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 and Section IX. 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.

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

4.1.12.3 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 and Section IX.

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 to originally qualify the part.

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

4.1.13 Nameplates and Rotation Arrows

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

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

4.1.13.3 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.

4.1.13.4 Nameplate 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. Rated flow
   f. Rated head
g. Speed, in revolutions per minute
h. Bearing manufacturer’s identity numbers
i. MAWP
j. Temperature (basis for MAWP)

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

4.1.14 Special Pump Considerations

4.1.14.1 Diffuser-and-Volute Pumps

1. Discharge head mounting surface shall be suitable for grouting or mounting on a machined sole plate.

2. Product-lubricated column sections shall have integral bearing spiders and rabbeted fits for columns with inside diameter of 300 mm (12 inches) or greater.

4.1.14.2 Separate Discharge Cantilevered Pumps

1. Rotor shall be cantilevered from its bearing assembly.

2. Submerged bottom bearings and/or bushings shall not be used to guide the shaft.

3. Shaft stiffness shall limit total deflection, without the use of a casing bushing, so that the impeller does not contact the pump casing under the most severe dynamic conditions over the complete head capacity curve with a maximum diameter impeller and at the maximum speed and fluid density.

Comment: For open-system sump-pump service, the pressure-containing components are the volute casing, suction cover, and discharge line. For closed-system pressurized or vacuum tank service, the outer stuffing box or seal housing, pump cover plate, and tank cover are also pressure components.

4. For services with temperatures above 120°C (250°F), pumps shall be designed to accommodate differences in thermal expansion between the pipe column and discharge pipe and between the casing and support plate.

5. Cover plate shall have lifting lugs for lifting the pump assembly including the driver.

6. Discharge nozzle shall be flanged.

7. Pump-out vanes shall be used to reduce leakage back into the sump. Reduction in axial thrust caused by the
pump-out vanes shall not be considered in sizing axial thrust bearings.

8. Coupling hubs shall be provided with a slip fit to the shafts. Keys shall be secured to the shaft with set screws.

_Comment:_ The slip fit facilitates final coupling adjustment for variations in spacing between shaft ends. Spacer couplings are not typically required for separate discharge cantilever-type pumps.

### 4.1.14.3 Vertical Can Pumps

1. Complete venting of the outer case shall be ensured by a high-point vent connection.

2. Inner assembly within the seal chamber or associated auxiliary process piping shall have a feature that ensures complete venting.

3. The suction shall have a low-point drain piped to the surface.

4. Column sections shall have bearing spiders and rabbeted fits for all column sizes.

### 4.2 Accessories

#### 4.2.1 Drivers

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

4.2.1.2 Driver shall be in accordance with the applicable inquiry specifications and purchaser’s _PIP RESP003V-D_ or _PIP RESP003V-DM_ Data Sheet and order.

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

4.2.1.4 If the end-of-curve power is less than 4 kW (5 hp), the next standard size larger motor shall be used.

_Comment:_ The purpose of this requirement is to compensate for startup problems caused by slow acceleration of small motors due to inertia and drag of seals. Seal drag increases as suction pressures increase. Failure to consider these factors can result in tripping the driver before operating speed is reached.

4.2.1.5 If the end-of-curve power is between 5 kW (7.5 hp) and 75 kW (100 hp), the motor shall be sized to cover the full operating range of the rated impeller from shutoff to the
end-of-curve without the use of a service factor. End-of-curve power is defined as 120% of BEP.

4.2.1.6 If the end-of-curve power is greater than 75 kW (100 hp), the motor shall be sized to cover the end-of-curve power or 110% of rated power, whichever is less.

4.2.1.7 For applications such as cooling water circulating pumps that are expected to operate at the end-of-curve during transient conditions, the motor shall be sized for operation throughout the range of the head-capacity curve.

4.2.1.8 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.

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

4.2.1.10 Pump and motor assemblies that can be damaged by reverse rotation shall have a nonreverse ratchet or another purchaser-approved device to prevent reverse rotation.

4.2.1.11 All vertical drive components shall be shop-fitted to the pump, and shall be aligned and matchmarked before being shipped.

4.2.2 Coupling and Guard

4.2.2.1 Coupling and guard between driver and driven equipment shall be provided.

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

4.2.2.3 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.

4.2.2.4 Removable coupling guard shall be in accordance with all applicable national, industrial, and statutory regulations, and ANSI B15.1.

4.2.3 Mounting Plate

4.2.3.1 Mounting plates for vertical can pumps shall be separate from the main body flange and shall be located sufficiently below the main body flange to permit through-bolting on the body flange.
4.2.3.2 Pump-to-motor mounting surface shall have a rabbeted fit.

4.2.3.3 If specified on purchaser’s PIP RESP003V-D or PIP RESP003V-DM Data Sheet, pumps shall have separate soleplates for bolting and grouting to the foundation. The soleplates shall be machined on its top surface for mounting the discharge head, can, or motor support.

### 4.2.4 Piping and Appurtenances

#### 4.2.4.1 General

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.

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

3. Minimum size of any connection or piping shall be NPS 1/2.

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

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

6. If mechanical seals and drivers are not installed before shipment, the seal piping system shall not be fully assembled.

#### 4.2.4.2 Auxiliary Process Fluid Piping

1. Auxiliary piping shall include vent and drain lines, balance lines, flushing lines, and injection lines.

2. Piping components shall have a pressure/temperature rating as a minimum equal to the maximum discharge pressure and temperature of the pump casing.

### 4.2.5 Special Tools

Pumps shall be designed to be assembled, disassembled, and maintained with standard hand tools. Designs requiring special tools shall not be permitted.

### 4.3 Inspection and Testing

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

### 4.4 Preparation for Shipment

4.4.1 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.
4.4.2 Restrained rotors shall be identified by using corrosion-resistant tags attached with stainless steel wire.

4.4.3 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.

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

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

4.4.6 Shipment preparation shall include the following activities:
   a. Packing used in tests shall be removed from the stuffing boxes before shipment.
   b. 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.
   c. All exterior surfaces except 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.
   d. Exterior machined surfaces of cast iron and carbon steel parts shall be coated with a suitable rust preventative.
   e. Internal areas of cast iron and carbon steel bearing housings and oil system components shall be coated with a suitable oil-soluble rust preventative.
   f. Flanged openings shall be protected with molded plastic flange closures or metal closures with elastomeric gaskets fastened with at least 4 full diameter bolts.
   g. 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.

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

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

j. 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.

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

l. 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.

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

4.4.8 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 easy 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.

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

4.5 Documentation

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

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Spares Recommended for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Identical Pumps</td>
</tr>
<tr>
<td></td>
<td>1-3</td>
</tr>
<tr>
<td>Cartridge (Note 2)</td>
<td>1</td>
</tr>
<tr>
<td>Element (Note 3)</td>
<td>1</td>
</tr>
<tr>
<td>Rotor (Note 4)</td>
<td>1</td>
</tr>
<tr>
<td>Head (Case Cover and Stuffing Box/Seal Clamber)</td>
<td></td>
</tr>
<tr>
<td>Shaft (w/Key)</td>
<td></td>
</tr>
<tr>
<td>Impeller</td>
<td>1</td>
</tr>
<tr>
<td>Wear Rings (Set) (Note 5)</td>
<td>1</td>
</tr>
<tr>
<td>Bearings Complete (Antifriction, Radial) (Notes 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Bearings Complete (Antifriction, Thrust) (Notes 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Bearings Complete (Hydrodynamic, Radial) (Notes 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Bearing Pads Only (Hydrodynamic, Radial) (Notes 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Bearing Complete (Hydrodynamic, Thrust) (Notes 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Bearing Pads only (Hydrodynamic, Thrust) (Notes 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Mechanical Seal / Packing (Notes 1, 5 &amp; 6)</td>
<td>1</td>
</tr>
<tr>
<td>Shaft Sleeve (Note 5)</td>
<td>1</td>
</tr>
<tr>
<td>Gaskets, Shims, O-Rings (Set) (Note 5)</td>
<td>1</td>
</tr>
<tr>
<td>Bowls</td>
<td></td>
</tr>
<tr>
<td>Spiders (Set)</td>
<td>1</td>
</tr>
<tr>
<td>Bearings, Bushings (Set) (Note 5)</td>
<td>1</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
7. N = Number of identical pumps
### Appendix A – Selection of Pump Materials of Construction

#### Table A. Application of Material Classes to Water Services

<table>
<thead>
<tr>
<th>Water Service</th>
<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>Note 1</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>A-1 or A-2</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>Note 2</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>A-2 or A-3</td>
</tr>
<tr>
<td>Condensate</td>
<td>Note 3</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>A-2</td>
</tr>
<tr>
<td>Treated</td>
<td>Note 4</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>A-1</td>
</tr>
<tr>
<td>Demineralized</td>
<td>Note 5</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>C-1 or C-2</td>
</tr>
<tr>
<td>Seawater</td>
<td>Note 6</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>B-1 or C-2</td>
</tr>
<tr>
<td>Foul/Water / Water Draw/</td>
<td>Note 7</td>
<td>&lt;150°C (300°F)</td>
<td>&lt;35 Bar (500 psi)</td>
<td>A-2 Only for Noncorrosive Water B-1 Is Minimum for Corrosive Waters</td>
</tr>
<tr>
<td>Reflux Streams</td>
<td>(May Contain Hydrocarbons)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produced Water</td>
<td>Note 8</td>
<td>Note 8</td>
<td>&lt;35 Bar (500 psi)</td>
<td>C-3, C-4, C-5</td>
</tr>
<tr>
<td>Injection Water</td>
<td>Note 9</td>
<td>Note 9</td>
<td>&lt;35 Bar (500 psi)</td>
<td></td>
</tr>
<tr>
<td>Formation Water</td>
<td>Note 10</td>
<td>Note 10</td>
<td>&lt;35 Bar (500 psi)</td>
<td>C-4, C-5</td>
</tr>
</tbody>
</table>

**General Notes:**

a. For waters that may be in contact with hydrocarbons, purchaser shall specify on purchaser’s PIP RESPo03H-D or RESPo03H-DM Data Sheet whether water is considered sour. Also, the purchaser shall specify whether H₂S is present (even in trace amounts).

b. If ammonia is present from chemical-treating reactions or other sources, bronze internals shall not be permitted.

c. Some types of waters described 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. Class A-1 is the lowest cost class, while class A-2 offers extended life for increased initial cost.

2. Cooling tower water is assumed to be recirculating. Build-up 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.

3. 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):

4. 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.

5. 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.

6. 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.

7. 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.

8. 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.

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-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.

10. 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>A-2</th>
<th>A-3</th>
<th>B-1</th>
<th>C-1</th>
<th>C-2</th>
<th>C-3 (Note 3)</th>
<th>C-4 (Note 4)</th>
<th>C-5 (Note 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td>Cast Iron</td>
<td>Cast Iron</td>
<td>Cast Iron</td>
<td>Ni-Resist</td>
<td>AUS SS</td>
<td>316L</td>
<td>Duplex (3)</td>
<td>S. Duplex (4)</td>
<td>6 Moly (5)</td>
</tr>
<tr>
<td>Impeller</td>
<td>Cast Iron</td>
<td>Bronze</td>
<td>13 Chrome</td>
<td>316L</td>
<td>AUS SS</td>
<td>316L</td>
<td>Duplex</td>
<td>S. Duplex</td>
<td>6 Moly</td>
</tr>
<tr>
<td>Trim</td>
<td>Cast Iron</td>
<td>Bronze</td>
<td>13 Chrome</td>
<td>Ni-Resist &amp; 316L</td>
<td>AUS SS</td>
<td>316L</td>
<td>Duplex</td>
<td>S. Duplex</td>
<td>6 Moly</td>
</tr>
</tbody>
</table>

**PUMP PART**<br>ASTM Full Comp Matl

| Casing          | Yes | A278 | A278 | A439 D2 | A743 CF3 | A743 CF3M | Duplex (A890 Gr 4a) | S. Duplex (A890 Gr 5a) | 6 Moly |
| Casing (Cast Iron 40) | Yes | A48 | B61 922 | A743 CA6NM | A743 CF3M | A743 CF3M | Duplex | S. Duplex | 6 Moly |
| Impeller (Note 1) | No | A48 | B148 954 | A276 420 | A439 D2-C | HF A276 304L (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Shaft (Note 8)  | Yes | A276 1020 | A276 420 | A276 316L or A276 XM19 | A276 304L or A276 XM19 | Duplex | S. Duplex | 6 Moly |
| Shaft Sleeve (Note 8) | No | 12% Chrome | A276 420 | NA | HF A276 316L (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Shaft Sleeve (Mechanical Seal) | No | SS 316L | HF 316L (Note 2) | HF 316L (Note 2) | HF 316L (Note 2) | HF 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Throat Bushing  | No | A48 | B584 937 | A276 420 | A439 D2-C | A276 304 | A276 316L | Duplex | S. Duplex | 6 Moly |
| Interstage Sleeve | No | A276 420 | B148 954 | A276 420 | HF A276 316L (Note 2) | HF A276 304 | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Interstage Bushing | No | A48 | B584 937 | A276 420 | A439 D2-C | HF A276 304 | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Lantern Ring (Note 9) | Yes | A48 | B584 937 | NA | A439 D2-C | A276 304 | A276 316 | Duplex | S. Duplex | 6 Moly |
| Gland Plate (Mechanical Seal) | Yes | A276 316L | A276 316 | A276 316 | A276 316 | A276 304 | A276 316 | Duplex | S. Duplex | 6 Moly |
| Bearing Bracket | Yes | A278 or A48 | A278 or A48 | A216 WCB | A216 WCB | A216 WCB | A216 WCB | A216 WCB | A216 WCB |
| Seal & Vent Piping | Yes | (Note 6) | (Note 6) | (Note 6) | (Note 6) | (Note 6) | (Note 6) | (Note 6) | (Note 6) |
| Wetted Fasteners | Yes | (Note 7) | (Note 7) | (Note 7) | (Note 7) | (Note 7) | (Note 7) | (Note 7) | (Note 7) |
Notes:
1. Mating wear surfaces of hardenable materials shall have a difference in Brinell hardness numbers (BHN) of 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 RESP003H-D or PIP RESP003H-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 nongalling 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 their increased amounts of chromium (25% nominal) and other alloys, typically nickel, molybdenum, and nitrogen. They 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 based on purchaser preference, mutual agreement between purchaser and supplier, and/or specific corrosive conditions.
6. Seal and vent piping shall be compatible with metallurgy of pump components. For classes A-1, A-2, and A-3, pipe shall be in accordance with ASTM A106 Gr. B, and fittings shall be in accordance with ASTM A105. For classes B-1, C-1, C-2, C-3, C-4, and C-5, pipe and fittings shall be made of an appropriate stainless steel for the corrosivity of the system.
7. Wetted fasteners shall be compatible with the pump metallurgy and corrosivity of the pumped water. Some materials, especially austenitic stainless steels, are prone to galling. Precautions should be made to avoid this problem.
8. Meehanite is an acceptable alternate for cast iron.
9. Fluted synthetic cutless rubber or Thordon (or equivalent) shall be used in abrasive service.
### Vertical Centrifugal Pumps for Water Service (U.S. Customary Units)

**Issue Details:**
- **Issued For:** Proposal
- **Facility Name/Location:**
- **Item Name:** Purchaser/Location:
- **Item Tag No.:**
- **Job No.:**
- **Unit:**
- **Paid No.:**

**Data Provided By:**
- Purchaser
- Supplier
- Supplier if not by Purchaser

**Purchasers References**
- Pump Mfr:
- Size & Type:
- Serial No.:
- Driver Type:
- This Data Sheet Covers:
- Pump Item No(s):
- Pumps of identical type and size in operation:
- Driver Data Sheet:
- Gear Unit Data Sheet:
- Lube Oil System Data Sheet:

**Design Operating Data**

**Service**
- Continuous
- Intermittent
- Standby
- Attended
- Unattended

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

**Upstream of Pump No(s):**
- Downstream of Pump No(s):

**Liquid Characteristics**
- Liquid Pumped:
- TDS:
- PPM
- Normal Flow Temperature:
- Max Flow Temperature:
- Relative Density at Normal Flow Temp:
- Viscosity at Flow Temperature:
- Vapor Pressure at Normal Flow Temp:
- Vapor Pressure at Maximum Flow Temp:
- TSS:
- Vol %:
- Character of Solids:
- Gas in Fluid:
- Principal Corrosives:
- pH:

**Rated Operating Conditions**
- Rated Capacity:
- USGPM
- Total Differential Head:
- FT
- Viscosity Correction Factors $C_d$, $C_r$, $C_v$:

**Suction System**
- Closed
- Open

**For Closed Suction Systems:**
- Enter data on Fig. 1
- NPSH available at suction flg:
  - At Rated Capacity:
  - At 120% of Rated Capacity:
- Rated suction pressure:
- PSIA
- Max. Suct. Pr. at Rated Cap:
- PSIA
- Max. Suct. Pr. at Shut Off:
- PSIA
- Rated discharge pressure:
- PSIA
- Max. Disch. Pr. at Rated Cap:
- PSIA

**For Open Suction Systems:**
- Enter data on Fig. 2
- Rated discharge pressure:
- PSIA

**Site Conditions**
- Indoor
- Outdoor
- Under roof
- Onshore
- Coastal
- Offshore
- Electrical area class:
- Div
- Group

**Data Sheet**

**Figure 1: Closed Suction System**
- Total Suction Head:
- FT
- Total Diff. Head:
- FT
- Total Disch. Head:
- FT
- Nozzle Cl Above:
- Datum:
- FT
- NPSHA at Datum:
- FT
- Barrel Wall Thick:
- IN
- Barrel Od:
- IN
- Barrel Length:
- IN
- Cl 1st Stage Impeller to Cl Suction Nozzle:
- FT

**Figure 2: Open Suction System**
- Type:
- Concentric Riser Column
- Side Discharge Pipe
- Nozzle Cl Above:
- Datum:
- FT
- Datum Elevation:
- FT
- Static Level:
- FT
- Pumping Level:
- FT
- Min. Liquid Level:
- FT
- Cl 1st Stage:
- FT
- Bottom of Sump/Tank:
- FT

**Notes**
- Mounted on:
- Concrete
- Structural Steel

---

**Page 1 of 4**

**October 2013**
### PERFORMANCE DATA

- **Driver Nameplate Power Rating:** HP
- **Rated Speed of Driver:** RPM

<table>
<thead>
<tr>
<th>MIN. CONT.</th>
<th>100%</th>
<th>120%</th>
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<tbody>
<tr>
<td>Stable Flow</td>
<td>Of Rated</td>
<td>Capacity</td>
</tr>
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</table>

- **Bowl Assembly Head:** FT
- **Column Loss:** FT
- **Efficiency:** %
- **Required Power:** HP
- **Vel In Column:** FT/SEC

#### FORCES AND MOMENTS

- **Rated Speed of Driver:** RPM
- **Allowable Forces and Moments:**
  - Suction: LB
  - Discharge: LB
  - Each Nozzle: FT-LB
  - FY: LB
  - FZ: LB
  - MX: FT-LB
  - MY: FT-LB
  - MZ: FT-LB
  - Bowl Assembly Head: FT
  - Column Loss: FT
  - Efficiency: %
  - Misc. Connections:
  - Required Power: HP
  - Barrel Vent:
  - Seal Liquid Inlet:
  - Seal Liquid Drain:
  - Stuffing Box Vent:
  - Pressure In Column:
  - Pressure At °F
  - Pressure At Maximum Impeller Diameter:
  - Pressure At End of Curve:
  - Capacity At End of Curve:
  - Minimum Continuous Stable Flow:
  - Minimum Continuous Thermal Flow:
  - Maximum OPR. Time at Shut-Off:
  - First Crit. Speed Dry:
  - First Crit. Speed Wet:
  - Max. Allowable Speed:
  - Max. Thrust:
  - Max. Down Thrust:
  - Max. Power Full Curve Actual Imp. Diam.:
  - Power at Shut Off Head:

### PUMP CONSTRUCTION DATA

- **Pump Bowl Type:**
  - Single Volute
  - Double Volute
  - Quadrant Volute
  - Diffuser
  - Threaded Bowls
  - Bolted Bowls

- **Line Shaft:**
  - Open
  - Enclosed
  - Flanged
  - Through Bearing

- **Suction Strainer:**
  - Pump
  - Driver

- **Barrel Insulation:**
  - Basket
  - Cone
  - None

- **Intermediate Transmission:**
  - Right Angle Gearbox
  - Ratio:

- **Direction of Rotation:**
  - CW
  - CCW

- **Nozzles:**
  - Size
  - Rating
  - Facing
  - Location
  - Suction: IN
  - Discharge: IN

- **Shaft Sealing:**
  - Packing Material: Packed Stuffing Box
  - Packing Material: Packing Material

- **Shaft Data:**
  - Shaft Diameter at Mechanical Seal Sleeve:
  - Shaft Diameter at Bearings:
  - Total Rotor Lift:
  - Shaft Coupling:
  - Keyed
  - Other:

- **Piping for Primary Seal Plan:**
  - Buffer Liquid System:
  - Req'd Press.:
  - Cooling Water Piping Plan:
  - Cyclone Separator:
  - Flow Orifice in Seal Flush Supply Line:
  - Seal Leakage Piping With Orifice:
  - Buffer Liquid System:
  - Req'd Press.:
  - Cartridge Design:
  - Yes
  - No
### PUMP CONSTRUCTION DATA (CONT) - SEAL CHAMBER
- **Flush Flow Rate - Max.**: GPM
- **Pressure - Max.**: PSI
- **Temperature - Max.**: °F

### STUFFING BOX DATA
- **Inside Diameter**: IN
- **Depth**: IN
- **Distance Face of Stuffing Box**: IN
- **Flange to Nearest Obstruction**: IN

### IMPPELLER DATA
- **Number of Stages**: N
- **Number of Vanes**: N
- **Actual Peripheral Speed**: FT/SEC
- **Pattern Number**: N
- **Precision Cast**: YES/NO
- **Cut Water Diameter**: IN
- **Specific Speed**: N
- **Suction Specific Speed at 3% ΔH**: N
- **Width Impeller Disch.**: IN
- **WEAR RINGS**: YES/NO
- **CLEARANCES INBOARD**: N
- **Design Outboard**: N

### LINE SHAFT BEARINGS AND LUBRICATION
- **GUIDE BEARING SPAN**: IN
- **OPEN LINESHAFT BEARINGS, LUBR'D BY MED. PUMPED**: N
- **ENCLOSED LINESHAFT BEARINGS**: N
- **LUBRICATED BY**: WATER (EXTERNAL SUPPLY) OR OIL (EXTERNAL SUPPLY)
- **OIL RESERVOIR CAPACITY**: USG
- **MIN. L. O. SUPPLY**: USG/WK
- **INDIVIDUAL BEARING L.O. SUPPLY**: YES/NO

### LUBRICANTS
- **LINE SHAFT BEARINGS**: LIQUID PUMPED WATER OR OIL
- **MOTOR BEARINGS**: OIL OR GREASE

### COUPLING
- **RIGID ADJUSTABLE SPACER TYPE**: N
- **SPACER LENGTH**: IN
- **HOLLOW SHAFT DRIVER**: N
### UTILITIES

<table>
<thead>
<tr>
<th>Electric Power:</th>
<th>AC/DC</th>
<th>Available Volts</th>
<th>Phase/HZ</th>
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<th>Controls and Protection:</th>
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<th>Other:</th>
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### MISCELLANEOUS

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<th>Purchaser's Paint Specification:</th>
<th>Supplier's Standard Paint:</th>
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<th>Remarks:</th>
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### AIR

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<th>Controls and Protection:</th>
<th>Available PSIG</th>
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<th>Other:</th>
<th>Available PSIG</th>
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### AVAILABLE COOLING

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<tr>
<th>Available Cooling</th>
<th>Press.</th>
<th>Inlet</th>
<th>Outlet</th>
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<table>
<thead>
<tr>
<th>Water:</th>
<th>Press.</th>
<th>°F</th>
<th>°F</th>
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</thead>
</table>

- [ ] Well Water
- [ ] Treated Water
- [ ] Sea Water
- [ ] Once Through System
- [ ] Closed Loop System

### INSTRUMENTATION & CONTROLS

<table>
<thead>
<tr>
<th>Shaft Seal Leakage Detection:</th>
<th>YES</th>
<th>NO</th>
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- [ ] Electrical
- [ ] Pneumatic

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<thead>
<tr>
<th>Pres. Switch Make:</th>
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<tbody>
<tr>
<td>Model:</td>
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<thead>
<tr>
<th>Pressure Setting &quot;Shutdown&quot;:</th>
<th>Press.</th>
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<tr>
<td>&quot;1900&quot;</td>
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<tr>
<th>Time Delay Setting:</th>
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<td>Contr. Orifice:</td>
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### MASSES

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<tr>
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<tr>
<td>BARREL:</td>
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<tr>
<td>COUPLING:</td>
<td></td>
</tr>
<tr>
<td>DRIVER ROTATING ASSEMBLY:</td>
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</tr>
<tr>
<td>TOTAL MASS PUMP, DRIVER, COUPLING, BARREL, BASE:</td>
<td></td>
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PUMPS OF IDENTICAL TYPE AND SIZE IN OPERATION:

SERVICE DATA SHEET:

GEAR UNIT DATA SHEET:

LUBE OIL SYSTEM DATA SHEET:

PUMPS OF IDENTICAL TYPE AND SIZE IN OPERATION:

DRIVER DATA SHEET:

GERMANY INTEGRITY DATA:

LIQUID CHARACTERISTICS DATA:

RATED OPERATING CONDITIONS DATA:

WATER SERVICE (SI UNITS)
### Performance Data

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<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Driver Nameplate Power Rating:</td>
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</tr>
<tr>
<td>Rated Speed of Driver:</td>
<td>RPM</td>
</tr>
<tr>
<td>Bowl Assembly Head:</td>
<td>M</td>
</tr>
<tr>
<td>Column Loss:</td>
<td>M</td>
</tr>
<tr>
<td>Efficiency:</td>
<td>%</td>
</tr>
<tr>
<td>Required Power:</td>
<td>KW</td>
</tr>
<tr>
<td>VEI in Column:</td>
<td>M/S</td>
</tr>
<tr>
<td>NPSHR for Closed Suct. System at CL 1st St. Impeller:</td>
<td>3%</td>
</tr>
<tr>
<td>NPSHR for Open Suct. System at CL 1st St. Impeller:</td>
<td>3%</td>
</tr>
<tr>
<td>Min. Subm. Req'd:</td>
<td>M</td>
</tr>
<tr>
<td>Shut-off Head at Actual Impeller Diameter:</td>
<td>M</td>
</tr>
<tr>
<td>At Maximum Impeller Diameter:</td>
<td>M</td>
</tr>
<tr>
<td>Capacity at End of Curve:</td>
<td>M^3/HR</td>
</tr>
<tr>
<td>Total Diff. Head at End of Curve:</td>
<td>M</td>
</tr>
<tr>
<td>Ratio-Shut-off Head/Rated Head:</td>
<td></td>
</tr>
<tr>
<td>Ratio-End of Curve Capacity Rated Cap:</td>
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</tr>
<tr>
<td>Minimum Continuous Stable Flow:</td>
<td>M^3/HR</td>
</tr>
<tr>
<td>Minimum Continuous Thermal Flow:</td>
<td>M^3/HR</td>
</tr>
<tr>
<td>Maximum OPR. Time at Shut-off:</td>
<td>S</td>
</tr>
<tr>
<td>First Crit. Speed Dry:</td>
<td>RPM</td>
</tr>
<tr>
<td>First Crit. Speed Wet:</td>
<td>RPM</td>
</tr>
<tr>
<td>Max. Allowable Speed:</td>
<td>RPM</td>
</tr>
<tr>
<td>Max. Upthrust:</td>
<td>N</td>
</tr>
<tr>
<td>Max. Downthrust:</td>
<td>N</td>
</tr>
<tr>
<td>Max. Power Full Curve Actual Imp. Diam.:</td>
<td>KW</td>
</tr>
<tr>
<td>Power at Shut Off Head:</td>
<td>KW</td>
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### Pump Construction Data

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<thead>
<tr>
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<td>Pumps Bowl Type:</td>
<td></td>
</tr>
<tr>
<td>Lineshaft:</td>
<td></td>
</tr>
<tr>
<td>Thrust Bearing in:</td>
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<tr>
<td>Suction Strainer:</td>
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<tr>
<td>Barrel Insulation:</td>
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<tr>
<td>Intermediate Transmission:</td>
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<tr>
<td>Direction of Rotation:</td>
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<tr>
<td>Nozzles:</td>
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<tr>
<td>Suction:</td>
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<tr>
<td>Discharge:</td>
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<td>Separate Soleplate:</td>
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### Pump Construction Data (Cont'd)

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<td>Bowls Assembly Head:</td>
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<td>Column Loss:</td>
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<td>Efficiency:</td>
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<tr>
<td>Required Power:</td>
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</tr>
<tr>
<td>VEI in Column:</td>
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</tr>
<tr>
<td>NPSHR for Closed Suct. System at CL 1st St. Impeller:</td>
<td>3%</td>
</tr>
<tr>
<td>NPSHR for Open Suct. System at CL 1st St. Impeller:</td>
<td>3%</td>
</tr>
<tr>
<td>Min. Subm. Req'd:</td>
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</tr>
<tr>
<td>Shut-off Head at Actual Impeller Diameter:</td>
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<tr>
<td>At Maximum Impeller Diameter:</td>
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<tr>
<td>Capacity at End of Curve:</td>
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<tr>
<td>Total Diff. Head at End of Curve:</td>
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<tr>
<td>Ratio-Shut-off Head/Rated Head:</td>
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<td>Ratio-End of Curve Capacity Rated Cap:</td>
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<tr>
<td>Minimum Continuous Stable Flow:</td>
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<td>Minimum Continuous Thermal Flow:</td>
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<td>Maximum OPR. Time at Shut-off:</td>
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<td>First Crit. Speed Dry:</td>
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<td>First Crit. Speed Wet:</td>
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<td>Max. Allowable Speed:</td>
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<td>Max. Upthrust:</td>
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<tr>
<td>Max. Downthrust:</td>
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<tr>
<td>Max. Power Full Curve Actual Imp. Diam.:</td>
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<tr>
<td>Power at Shut Off Head:</td>
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### Forces and Moments

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<tr>
<td>Suction:</td>
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<tr>
<td>Discharge:</td>
<td></td>
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<tr>
<td>Each Nozzle:</td>
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<tr>
<td>Misc. Connections:</td>
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<tr>
<td>Barrel Vent:</td>
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<td>Barrel Drain:</td>
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<tr>
<td>Seal Liquid Inlet:</td>
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<td>Seal Liquid Drain:</td>
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<tr>
<td>Stuffing Box Vent:</td>
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### Pressures

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<tr>
<td>Max. Allow Work Pressure:</td>
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<tr>
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<td>Column Assembly:</td>
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<td>Head Assy'Disch':</td>
<td>KPA(GA)</td>
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<tr>
<td>Head Assy'Suct':</td>
<td>KPA(GA)</td>
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<tr>
<td>Suction Barrel:</td>
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<tr>
<td>Mechanical Seal:</td>
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### Shaft Data

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<td>Shaft Diameter at Mechanical Seal Sleeve:</td>
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<td>Shaft Diameter at Bearings:</td>
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<tr>
<td>Total Rotor Lift:</td>
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<td>Shaft Coupling:</td>
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### Shaft Sealing

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<td>Packing Material:</td>
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<td>Provided with Lantern Ring:</td>
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<td>Sealing Arrangement:</td>
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<td>Through Sealing:</td>
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<td>Dead Ended Seal:</td>
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<td>4th Letter:</td>
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<td>Piping for Primary Seal Plan:</td>
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<td>Piping for Throttle Bushing or Auxiliary Seal Plan:</td>
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### Cooling Water Piping Plan

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<td>Cyclone Separator:</td>
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<td>Flow Orifice in Seal Flush Supply Line:</td>
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<td>Seal Leakage Piping with Orifice:</td>
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<tr>
<td>Buffer Liquid System:</td>
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</tbody>
</table>

### Other

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Req'd Press:</td>
<td>KPA(GA)</td>
</tr>
<tr>
<td>Cartridge Design:</td>
<td></td>
</tr>
<tr>
<td>YES, NO</td>
<td></td>
</tr>
</tbody>
</table>
### PUMP CONSTRUCTION DATA (CON'T)

<table>
<thead>
<tr>
<th>SEAL CHAMBER</th>
<th>MATERIALS OF CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLUSH FLOW RATE - MAX:</td>
<td>BOWLS:</td>
</tr>
<tr>
<td>PRESSURE - MAX:</td>
<td>IMPPELLERS:</td>
</tr>
<tr>
<td>TEMPERATURE - MAX:</td>
<td>WEAR RING BOWL:</td>
</tr>
<tr>
<td></td>
<td>WEAR RING IMPELLER:</td>
</tr>
<tr>
<td></td>
<td>BEARING BOWL ASSEMBLY:</td>
</tr>
<tr>
<td></td>
<td>SHAFT, BOWL ASSEMBLY:</td>
</tr>
<tr>
<td></td>
<td>LINE SHAFT (OIL LUB):</td>
</tr>
<tr>
<td></td>
<td>LINE SHAFT (SELF LUB):</td>
</tr>
<tr>
<td>STUFFING BOX DATA</td>
<td>BEARINGS, LINE SHAFT:</td>
</tr>
<tr>
<td>STUFFING BOX:</td>
<td>SHAFT SLEEVE:</td>
</tr>
<tr>
<td>INTERNAL</td>
<td>ASTM</td>
</tr>
<tr>
<td>EXTERNAL</td>
<td>ASTM</td>
</tr>
<tr>
<td>INSIDE DIAMETER:</td>
<td>ASTM</td>
</tr>
<tr>
<td>DEPTH:</td>
<td>ASTM</td>
</tr>
<tr>
<td>DISTANCE FACE OF STUFFING BOX:</td>
<td>ASTM</td>
</tr>
<tr>
<td>FLANGE TO NEAREST OBSTRUCTION:</td>
<td>ASTM</td>
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### IMPELLER DATA

<table>
<thead>
<tr>
<th>NUMBER OF STAGES:</th>
<th>FIRST STAGE</th>
<th>FOLLOW STAGES</th>
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</thead>
<tbody>
<tr>
<td>ACTUAL DIAMETER:</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>MAXIMUM DIAMETER:</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>MINIMUM DIAMETER:</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>SINGLE/DOUBLE SUCTION:</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>TOTAL EYE AREA IMPELLER:</td>
<td>cm²</td>
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<tr>
<td>VANE ANGLE AT IMPELLER EXIT:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NUMBER OF VANES:</td>
<td></td>
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<tr>
<td>ACTUAL PERIPHERAL SPEED:</td>
<td>m/s</td>
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<tr>
<td>PATTERN NUMBER:</td>
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<tr>
<td>PRECISION CAST:</td>
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<tr>
<td>CUT WATER DIAMETER:</td>
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<tr>
<td>SPECIFIC SPEED:</td>
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<tr>
<td>SUCTION SPECIFIC SPEED AT 3% ΔH:</td>
<td>mm</td>
<td></td>
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<tr>
<td>WIDTH IMPELLER DISCH.:</td>
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<td></td>
</tr>
<tr>
<td>WEAR RINGS:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMPELLER:</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>CLEARANCES INBOARD:</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>DESIGN OUTBOARD:</td>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>

### NOISE SPECIFICATION

| MAXIMUM ALLOWABLE SOUND LEVEL |
| AT 1 M DISTANCE: | DBA |
| GUARANTEED MINIMUM: | DBA |
| PUMP: | DBA |
| DRIVER: | DBA |
| COMPLETE TRAIN: | DBA |

### LINE SHAFT BEARINGS AND LUBRICATION

| GUIDE BEARING SPAN: | M |
| OPEN LINESHAFT BEARINGS, LUBR'D BY MED. PUMPED |
| ENCLOSED LINESHAFT BEARINGS |
| LUBRICATED BY: | WATER (EXTERNAL SUPPLY) |
| | OIL (EXTERNAL SUPPLY) |
| OIL RESERVOIR CAPACITY: | M³ |
| MIN. L. O. SUPPLY: | M³/WEEK |
| INDIVIDUAL BEARING L.O. SUPPLY: | YES | NO |

### LUBRICANTS

| LINESHAFT BEARINGS: | LIQUID PUMPED |
| | WATER |
| | OIL |
| MOTOR BEARINGS: | OIL |
| | GREASE |

### COUPLING

| RIGID ADJUSTABLE SPACER TYPE |
| SPACER LENGTH: | mm |
| HOLLOW SHAFT DRIVER |

### ASSOC. PIP

| DATA SHEET | OCTOBER 2013 |
| RESPO03V-DM | |
UTILITIES

ELECTRIC POWER:

MAIN ELECTRIC DRIVER:

CONTROLS AND PROTECTION:

OTHER:

AIR:

CONTROLS AND PROTECTION:

OTHER:

AVAILABLE COOLING

WATER:

INSTRUMENTATION & CONTROLS

SHAFT SEAL LEAKAGE DETECTION:

PRES. SWITCH MAKE:

PRESSURE SETTING "SHUTDOWN":

LEVEL SWITCH MAKE:

TIME DELAY SETTING:

ELECTRICAL

PNEUMATIC

PRES. SWITCH MAKE:

LEVEL SWITCH MAKE:

TIME DELAY SETTING:

☑ YES ☐ NO

☑ ELECTRICAL ☐ PNEUMATIC

PRES. SWITCH MAKE:

LEVEL SWITCH MAKE:

☑ YES ☐ NO

MASSES

PUMP:

PUMP ROTATING ASSEMBLY:

BARREL:

COUPLING:

DRIVER ROTATING ASSEMBLY:

TOTAL Mass PUMP, DRIVER, COUPLING, BARREL, BASE: