PIP RESP003H
Specification for High Power
Horizontal 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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PUBLISHING HISTORY

October 1997  Issued  October 2010  Editorial Revision  September 2018  Technical Revision
February 2004  Complete Revision  December 2010  Editorial Revision
February 2010  Complete Revision  October 2013  Complete Revision

Not printed with State funds
PIP RESP003H
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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 Accessories .................................. 15
   4.3 Inspection and Testing ...................... 17
   4.4 Preparation for Shipment ................. 17
   4.5 Documentation ................................ 19

Table 1. Recommended Spare Parts .......... 19
Table 2. Bearing Selection .................. 20

Appendix A – Selection of Pump
Materials of Construction .......... 21
Table A. Application of Material Classes
to Water Services ......................... 21

Appendix B – Pump Material Classes
Designations ................................. 23
Table B. Material Classes ................. 23
Table B. Material Classes (Continued) .... 24

Data Forms
RESP003H-D – Horizontal Centrifugal Pumps
for Water Service (U.S. Customary Units)
RESP003H-DM – Horizontal Centrifugal Pumps
for Water Service (SI Units)
1. **Scope**

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

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

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 RESP73H.

Pump types covered by this Practice are broadly classified as overhung or between-bearings.

The following pump types are not included in the scope of this Practice:

a. Close coupled (i.e., impeller mounted on the motor shaft)

b. Two-stage overhung

c. Double suction overhung

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 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*
- PIP RESP73H - *Application of ASME B73.1 – 2012, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process*

### 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)
  – OSHA 1910.219 - Mechanical Power Transmission Apparatus
  – ANSI B11.19 - Performance Criteria for Safe Guarding

• 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 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
    Section IX - Welding and Brazing Qualifications

• 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 281-1 - Rolling Bearings - Dynamic Load Ratings and Rating Life - Part 1: Calculation Methods
  – ISO 21940-11 - Balance Quality Requirements of Rigid Rotors
  – ISO 7005-1 - Metallic Flanges - Part 1: Steel Flanges
  – ISO 7005-2 - Metallic Flanges - Part 2: Cast Iron Flanges
  – 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

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

*allowable operating region:* See preferred operating region

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

*best efficiency point (BEP):* Flow rate 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

*drive train components:* Items of equipment (e.g., such as motor, gear, turbine, engine, fluid drive, and clutch) used in series to drive the pump

*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:* Highest speed (in revolutions per minute) at which the manufacturer’s design permits continuous operation

*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 rate at which the pump can operate continuously without exceeding vibration limits set by various standard development organizations (SDOs)

*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 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. This is typically measured at the suction flange to the pump however some pump configurations such as double case/can pumps may have this corrected to a reference such as top of foundation.

*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.

*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 horizontal centrifugal pump 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 can limit the operating range

**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 specified in this Practice

**relative density:** Ratio of the liquid’s density to that of water at standard temperature and pressure, normally 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:

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

where:

- \( n_{qs} \) = suction specific speed, metric
- \( N_{ss} \) = suction specific speed, US Customary
- \( n \) = 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
\[ NPSH_3 = \text{net positive suction head required in meters (feet) at the BEP for the maximum diameter impeller} \]

**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 horizontal 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 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 Horizontal centrifugal pumps shall be provided in accordance with this Practice and the purchaser’s PIP RESP003H-DM or PIP RESP003H-D 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 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 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 Pressure casing shall be designed to permit removal of the rotor or inner element without disconnecting the suction or discharge piping or moving the driver.

4.1.1.11 Pumps shall have a preferred operating region as described in PIP REEP006, Figures “Preferred Operating Ranges (metric)” and “Preferred Operating Ranges (US Customary)”

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.

4.1.1.15 BEP for the impeller should 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 stated in the proposal and requires approval by the owner. 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 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.

4.1.1.18 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 the purchaser’s PIP RESP003H-DM or PIP RESP003H-D Data Sheet.

4.1.1.19 Acceptable margins between NPSHA and NPSH3 shall be in accordance with PIP REEP006.

4.1.1.20 Spare parts, replacement parts, and auxiliaries shall 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 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 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 DN 32, 65, 90, 175, and 225 (1-1/4, 2-1/2, 3-1/2, 5, 7, and 9 NPS) shall not be used.

2. Casing connections shall be DN 15 (1/2 NPS) minimum.

4.1.3.2 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 conform to the dimensional requirements of ISO 7005-1 (ASME B16.5 or ASME B16.47).

4. Flat-face flanges with full raised face thickness may 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 may be used.

6. Flanges 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. Unless otherwise specified on the purchaser’s PIP RESP003H-DM or PIP RESP003H-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.

4.1.4 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 the purchaser, impellers shall have solid hubs and keyed to the shaft.

4.1.5.2 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 Wear Rings and Running Clearances

4.1.6.1 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.

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

4.1.7 Shafts

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

4.1.7.2 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 \( \mu \text{m} \) (32 \( \mu \text{in} \)) maximum.

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

4.1.8 Shaft-Sealing Systems

4.1.8.1 Shaft-sealing system, seal piping, and appurtenances shall be in accordance with the purchaser’s PIP RESP003H-DM or PIP RESP003H-D Data Sheet.

4.1.8.2 If specified on the purchaser’s PIP RESP003H-DM or PIP RESP003H-D 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 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.

4.1.8.8 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.

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

4.1.8.10 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.

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

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

4.1.8.14 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 controlled-compression type (e.g., O-ring or spiral-wound gasket) with metal-to-metal joint contact.

4.1.8.16 If controlled compression gaskets impractical, an alternate seal gland design shall be submitted to and approved by the purchaser.
4.1.9 Dynamics

4.1.9.1 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.

4.1.9.2 Vibration

1. 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.

2. 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

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

5. 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.

4.1.10 Bearings and Bearing Housings

4.1.10.1 Bearings

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

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. Bearing shall be designed to run without ball skidding.

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

4.1.10.2 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 PIP RESP003H-DM or PIP RESP003H-D Data Sheet, bearings and bearing housings shall be in accordance with the following:

   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.

4.1.11 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 RESP003H-DM or PIP RESP003H-D Data Sheet.

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 the purchaser’s approval on the purchaser’s PIP RESP003H-DM or PIP RESP003H-D Data Sheet.

3. Pump parts designated as “ASTM Full Compliance Materials” in the table 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 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 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 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.

4.1.12.2 Castings

1. 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 mm$^2$ (10 in$^2$).

4) Crack length exceeding 2 inches in length

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 the 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 the 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 shall be reviewed by supplier and purchaser to ensure that the welds are properly heat treated and non-destructively examined for soundness and compliance with the applicable qualified procedures.

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

4. If approved by the 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 barg (psig)
e. Speed, in revolutions per minute
f. Bearing manufacturer’s identity numbers
g. MAWP
h. 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.

4.2 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 RESP003H-DM or RESP003H-D 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 The motor shall be sized to cover the end-of-curve power or 110% of rated power, whichever is greater.

4.2.1.5 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.

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

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

4.2.2 Coupling and Guard

4.2.2.1 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.

4.2.2.2 Coupling shall be spacer-type flexible element in accordance with PIP REEEE003 Guidelines for General Purpose Non-Lubricated Flexible Couplings. Spacer shall be retained if the flexible element ruptures.

4.2.2.3 Coupling hubs shall be steel.

4.2.2.4 Spacer shall have a nominal length of 125 mm (5 inch) minimum, and shall permit removal of the coupling, bearings, seal, and rotor as applicable, without disturbing the driver or the suction and discharge piping.

4.2.2.5 Flexible couplings shall be keyed to the shaft. Keys, keyways, and fits shall be in accordance with AGMA 9002, Commercial Class (ISO R773).

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

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

4.2.2.8 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.
4.2.3 Baseplates

If a PIP baseplate is specified on the purchaser’s PIP RESP003H-DM or PIP RESP003H-D Data Sheet, baseplate shall be permitted in accordance with PIP RESP002.

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 DN 15 (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. Piping components shall have a pressure/temperature rating as a minimum equal to the MAWP 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 should be avoided, otherwise approved by purchaser. If a design requires a special tool, the tool shall be provided by the vendor.

4.3 Inspection and Testing

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

4.3.2 Witness of a test or inspection may be specified on the data sheet.

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

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

c. 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.

d. All exterior surfaces except machined and stainless steel surfaces shall be per the data sheet. If unspecified, the supplier’s standard paint system should be used. Paint shall not contain lead or chromates.

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

f. Internal areas of cast iron and carbon steel bearing housings and oil system components shall be coated with a suitable oil-soluble rust preventative that is compatible with the specified lube oil.

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

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

h. 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.

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

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

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

m. 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 bags shall be attached in an accessible area for easy removal. 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 the purchaser’s PIP REDP003-R Documentation Requirements Sheet.

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Number of Identical Pumps (N)</th>
<th>Number of Spare Parts Recommended for Startup</th>
<th>Number of Spare Parts Recommended for Normal Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-3</td>
<td>4-6</td>
<td>7+</td>
</tr>
<tr>
<td>Rotor (Note 4)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Case</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Head (Case Cover and Stuffing Box/Seal Chamber)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing Bracket / Housing</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Shaft (w/Key)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Impeller (Note 6)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wear Rings (Set) (Note 5)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bearings Complete (Antifriction, Radial) (Note 6)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bearings Complete (Antifriction, Thrust) (Note 6)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bearings Complete (Hydrodynamic, Radial) (Note 6)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bearing Pads Only (Hydrodynamic, Radial) (Note 6)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bearing Complete (Hydrodynamic, Thrust) (Note 6)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bearing Pads only (Hydrodynamic, Thrust) (Note 6)</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mechanical Seal / Packing (Notes 1 &amp; 6)</td>
<td>1</td>
<td>2</td>
<td>N/3</td>
</tr>
<tr>
<td>Shaft Sleeve</td>
<td>1</td>
<td>2</td>
<td>N/3</td>
</tr>
<tr>
<td>Gaskets, Shims, O-Rings (Set)</td>
<td>1</td>
<td>2</td>
<td>N/3</td>
</tr>
<tr>
<td>Diffusers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Cartridge-type mechanical seals shall include sleeve and gland.
4. Rotor consists of all rotating parts attached to the shaft.
5. Normal wear parts for 3 years
6. For each pump set
### Table 2. 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)</td>
<td>Rolling element radial and thrust</td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>Pump energy density below limit (Note 3)</td>
<td></td>
</tr>
<tr>
<td>Radial bearing speed or life outside limits (Notes 1 &amp; 2)</td>
<td>Hydrodynamic radial and rolling element thrust</td>
</tr>
<tr>
<td>and</td>
<td>Hydrodynamic radial and thrust</td>
</tr>
<tr>
<td>Thrust bearing speed and life within limits (Notes 1 &amp; 2)</td>
<td></td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>Pump energy density below limit (Note 3)</td>
<td></td>
</tr>
<tr>
<td>Radial and thrust bearing speed or life outside limits (Notes 1 &amp; 2)</td>
<td>Hydrodynamic radial and thrust</td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td>Pump energy density above limit (Note 3)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. Rolling element bearing speed limit: \( \text{nd}_{\text{m}} \) is less than or equal to 500,000
   
   \[ d_{\text{m}} = \frac{d + D}{2}, \text{ millimeters} \] (i.e., cage diameter)
   
   \[ d = \text{diameter of the inner race, mm} \]
   
   \[ D = \text{diameter of the outer race, mm} \]
   
   \[ n = \text{speed of rotation, rpm} \]

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</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 Barg (500 psig)</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 Barg (500 psig)</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 Barg (500 psig)</td>
<td>A-2</td>
</tr>
<tr>
<td>Treated</td>
<td>Note 4</td>
<td>&lt;100°C (212°F)</td>
<td>&lt;35 Barg (500 psig)</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/ reflux Streams (May Contain Hydrocarbons)</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 Water</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>C-4, C-5</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 the purchaser’s PIP RESP003H-DM or RESP003H-D Data Sheet whether water is considered sour. Also, 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 in Table A are not typically encountered in refineries or process plants. 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 A-2 offers extended life for increased initial cost.

2. 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.

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.
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</td>
<td>S. Duplex</td>
<td>6 Moly</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** | ASTM Full Comp Matl

| Casing         | Yes | A278 | A278 | A439 D2 | A743 CF3 | A743 CF3M | Duplex | S. Duplex | 6 Moly |
| Impeller       | Yes | A48  Cast Iron 40 | B61 922 | A743 CA6NM | A743 CF3M | A743 CF3 | Duplex | S. Duplex | 6 Moly |
| Case Wear Rings (Note 1) | No | A48  Cast Iron 30 | 548 937 | A276 420 | A439 D2-C | HF A276 304L (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Imp. Wear Rings (Note 1) | No | NA | 548 937 | A276 420 | HF 316L (Note 2) | HF A276 304L (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Shaft (Note 8) | Yes | A276 1020 A322 4140HT | A276 420 | A322 4140 HT | A276 316L or A276 XM19 | A276 304L or A276 XM19 | A276 316L or A276 XM19 | Duplex | S. Duplex | 6 Moly |
| Shaft Sleeve (Packed Pumps) | No | 12% Chrome Hardened | A276 420 | NA | HF 316L (Note 2) | HF A276 316L (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Shaft Sleeve (Mechanical Seal) | No | SS 316L (Note 2) | HF 316L (Note 2) | HF 316L (Note 2) | HF A276 316L (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Throat Bushing | No | A48  Cast Iron 30 | 584 937 | A276 420 | A439 D2-C | A276 304 | A276 316L | Duplex | S. Duplex | 6 Moly |
| Inner stage Sleeve | No | A276 420 | 148 954 | A276 420 | HF A276 316L (Note 2) | HF A276 304 (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Inerstage Inner stage Bushing | No | A48  Cast Iron 30 | 584 937 | A276 420 | A439 D2-C | A276 304 (Note 2) | HF A276 316L (Note 2) | Duplex | S. Duplex | 6 Moly |
| Lantern Ring (Note 9) | Yes | A48  Cast Iron 30 | 584 937 | NA | A439 D2-C | A276 304 | A276 316 | Duplex | S. Duplex | 6 Moly |
### Table B. Material Classes (Continued)

<table>
<thead>
<tr>
<th>Gland Plate (Mechanical Seal)</th>
<th>Yes</th>
<th>A276 316L</th>
<th>A276 316</th>
<th>A276 316</th>
<th>A276 316</th>
<th>A276 304</th>
<th>A276 316</th>
<th>Duplex</th>
<th>S. Duplex</th>
<th>6 Moly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Bracket</td>
<td>Yes</td>
<td>A278 or A48</td>
<td>A278 or A48</td>
<td>A216 WCB</td>
<td>A216 WCB</td>
<td>A216 WCB</td>
<td>A216 WCB</td>
<td>A216 WCB</td>
<td>A216 WCB</td>
<td>A216 WCB</td>
</tr>
<tr>
<td>Seal &amp; Vent Piping</td>
<td>Yes</td>
<td>(Note 6)</td>
<td>(Note 6)</td>
<td>(Note 6)</td>
<td>(Note 6)</td>
<td>(Note 6)</td>
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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 the 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. For dry shaft designs, alternate metallurgies may be considered.
9. For lantern rings, suitable nonmetallic materials may be considered.
**PUMPS AND DRIVER INFORMATION**

- **No. Pumps Required:**
- **No. Motor Driven:**
- **No. Turbine Driven:**

**Motor Data Sheet No.:**

**Turbine Data Sheet No.:**

**Gearbox Data Sheet No.:**

**Other:**

**Pump and Driver Information**

- **Pump and Driver Information**
- **Liquid**
  - **Name:**
  - **Pumping Temperature:**
    - **Normal:** °F
    - **Max.:** °F
    - **Min.:** °F
  - **Relative Density:**
    - **At:** °F
  - **Vapor Press.:** PSI
  - **Viscosity:**
    - **Cp At:** °F
  - **Initial Boiling Point:** °F
  - **Corrosion/Erosion Caused By:**
    - **Hazardous:**
    - **Non-Hazardous:**
  - **Remarks:**

- **Performance**
  - **Curve No.:**
  - **Efficiency:** %
  - **Speed:** RPM
  - **NPSH Required:** FT
  - **Maximum Head at Rated Impeller:** FT
  - **Minimum Continuous Flow:** GPM
  - **Thermal:**
  - **Stable:**

- **Operating Conditions**
  - **Capacity:**
    - **Normal:** GPM
    - **Rated:** GPM
  - **Discharge Press.:** PSI
  - **Suct. Press.:**
    - **Max.:** PSI
    - **Rated:** PSI
  - **Diff. Press.:** FT
  - **Diff. Head:** FT
  - **NPSH Available:** FT
  - **Hyd. Power:** HP

- **Site Conditions**
  - **Temperature:**
    - **Max.:** °F
    - **Min.:** °F
  - **Altitude:** FT
  - **Electrical Classification:**
    - **Class:**
    - **Group:**
    - **Div.:**
  - **Maximum Allowable Working Pressure:** PSIG

- **Materials of Construction**
  - **Class:**
  - **Case:**
  - **Impeller:**
    - **Shaft:**
  - **Sleeve:**

- **Impeller Type**
  - **Closed:**
  - **Ring Oil Flinger:**

- **Casing Mouting**
  - **Shaft:**
    - **Type:**
  - **Foot:**

- **Allowable Nozzle Loads**

- **Connections**
  - **Suction:**
  - **Discharge:**
    - **Size:**
    - **Rating:**
    - **Facing:**

- **Bearings**
  - **Radial Type:**
  - **Thrust:**

- **Lubrication**
  - **Grease:**
  - **Pressure:**
  - **Flinger:**
  - **Purge Mist:**
  - **Ring Oil:**
  - **Flood:**
  - **Pure Mist:**
  - **Other:**

**Notes:**

- **No.:**
- **Date:**
- **Revision Description:**
- **By:**
- **APVD.:**
## SEALING SYSTEM

**Mechanical Seal**

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<th>Cooling Water Piping Plan:</th>
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<td>Sight Flow Indicator</td>
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<td>Packing Cooling Injection</td>
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**COUPLING**

MANUFACTURER: 
TYPE: 
SIZE: 
MODEL: 
COUPLING GUARD: 
OTHER: 

**BASEPLATE**

MANUFACTURER'S STANDARD 
PIP STANDARD (GROUTED) 
PIP STANDARD (FREE-STANDING) 
INSTRUMENTATION

VIBRATION PROBES: YES NO 
TYPE: 

**SURFACE PREPARATION AND PAINT**

PUMP:

SURFACE PREPARATION: 
PRIMER: 
FINISH COAT: 
BASEPLATE: 
PRIMER: 
FINISH COAT: 
GROUTING REQUIRED YES NO 

**WEIGHTS**

| WEIGHT OF PUMP: | LB |
| WEIGHT OF BASEPLATE: | LB |
| WEIGHT OF MOTOR: | LB |
| WEIGHT OF TURBINE: | LB |
| TOTAL WEIGHT: | LB |

**DIMENSIONS**

BASEPLATE FOR MOTOR-DRIVEN PUMP  
(L x W x H): INCHES 
BASEPLATE FOR TURBINE-DRIVEN PUMP  
(L x W x H): INCHES

**ADDITIONAL INFORMATION**

## PIPING

**Primary Flush Plan:**

**Piping Assembly:**

**Type Tubing Fittings:**

**Secondary Flush Plan:**

**Piping Assembly:**

**Type Tubing Fittings:**

**Barrier Flush Fluid:**

**Relative Density:**

**Specific Heat:**

**Flow Rate - Max/Min:**

**Pressure - Max/Min:**

**Temperature - Max/Min:**

**DIMENSIONS**

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**horizontal centrifugal pumps for water service (si units)**

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

---

### Pump and Driver Information

- No. Pumps Required:
- No. Motor Driven:
- No. Turbine Driven:
- Motor Data Sheet No.:
- Motor No.:
- Turbine Data Sheet No.:
- Turbine No.:
- Gearbox Data Sheet No.:
- Motor Provided By:
- Turbine Provided By:
- Other:
- Motor Mounted By:
- Turbine Mounted By:

---

### Primary Pump Data

**Liquid**

- Pumping Temperature: Normal:
- Pumping Temperature: Max.:
- Pumping Temperature: Min.:
- Relative Density:
- Vapour Press.:
- Viscosity:
- Initial boiling point:
- Corrosion/erosion caused by:
- Remarks:

**Performance**

- Curve No.:
- Efficiency:
- Speed:
- NPSH Required:
- Maximum head at rated impeller:
- Maximum head at maximum impeller:
- Minimum continuous flow:
- Thermal:
- Stable:
- Suction specific speed:
- Impeller diameter:
- Rated:
- Maximum:
- Minimum:
- Maximum power at rated impeller:

**Operating Conditions**

- Capacity: Normal:
- Capacity: Rated:
- Discharge Press.:
- Suct. Press.:
- Diff. Press.:
- Diff. Head:
- NPSH Available:
- Hyd. Power:

**Connections**

- Size:
- Rating:
- Facing:

**Site Conditions**

- Temperature: Max.:
- Temperature: Min.:
- Altitude:
- Indoor/Outdoor:
- Heated/Unheated:
- Electrical Classification:
- Class:
- Group:
- Div.:

**Materials of Construction**

- Class:
- Case:
- Radial Type:
- Thrust:

**Bearings**

- Class:
- Impeller:
- Shaft:
- Sleeve:

**Lubrication**

- Grease:
- Pressure:
- Flinger:
- Purge Mist:
- Ring Oil:
- Flood:
- Pure Mist:
- Other:

**Impeller Design**

- Closed:
- Ring Oil:
- Flinger:

**Casing Mounting**

- Shaft (L3/D4):
- Foot:
- Centerline:
- Shaft Type:
- Other:

---

### Notes

- No.
- Date
- Revision Description
- By
- APVD.
### Sealing System

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#### Piping

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