Date of Issue: June 15, 1999
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ERRATA

The following formulae are replaced as shown:

Page 7, Section 2.4 External Forces and Moments (SI Units)

$F_x = 430D$	$M_x=2350D$
$F_y = 430D$	$M_y=2350D$
$F_z = 430D$	$M_z=2350D$

Replace with:

$F_x = 13D$	$M_x=7D$
$F_y = 13D$	$M_y=7D$
$F_z = 13D$	$M_z=7D$

Positive Displacement Pumps—Rotary

API STANDARD 676
SECOND EDITION, DECEMBER 1994

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

Positive Displacement Pumps—Rotary

Manufacturing, Distribution and Marketing Department

API STANDARD 676
SECOND EDITION, DECEMBER 1994

American
Petroleum
Institute

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FOREWORD

The primary purpose of this standard is to establish minimum electromechanical requirements. This limitation in scope is one of charter as opposed to interest and concern. Energy conservation is of concern and has become increasingly important in all aspects of equipment design, application, and operation. Thus, innovative energy-conserving approaches should be aggressively pursued by the manufacturer and the user during these steps. Alternative approaches that may result in improved energy utilization should be thoroughly investigated and brought forth. This is especially true of new equipment proposals, since the evaluation of purchase options will be based increasingly on total life costs as opposed to acquisition cost alone. Equipment manufacturers, in particular, are encouraged to suggest alternatives to those specified when such approaches achieve improved energy effectiveness and reduced total life costs without sacrifice of safety or reliability.

This standard requires the purchaser to specify certain details and features. Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of this standard, it is strongly recommended that such modifications, deletions, and amplifications be made by supplementing this standard, rather than by rewriting or incorporating sections thereof into another complete standard.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution and Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Positive Displacement Pumps—Rotary

SECTION 1—GENERAL

1.1 Scope

This standard covers the minimum requirements for rotary positive displacement pumps for use in the petroleum, chemical and gas industries. See API Standard 675 for controlled volume pumps and Standard 674 for reciprocating pumps.

Note: A bullet (•) at the beginning of a paragraph indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the data sheets (see Appendix A); otherwise, it should be stated in the quotation request or in the order.

1.2 Alternative Designs

The vendor may offer alternative designs. Equivalent metric dimensions, fasteners, and flanges may be substituted as mutually agreed upon by the purchaser and the vendor.

1.3 Conflicting Requirements

In case of conflict between this standard and the inquiry or order, the information included in the order shall govern.

1.4 Definition Of Terms

Terms used in this standard are defined in 1.4.1 through 1.4.25.

1.4.1 *Alarm point* is a preset value of a parameter at which an alarm is activated to warn of a condition that requires corrective action.

1.4.2 The *displacement* of a rotary pump is the volume displaced per revolution of the rotor(s). In pumps incorporating two or more rotors operating at different speeds, the displacement is the volume displaced per revolution of the driving rotor. Displacement depends only on the physical dimensions of the pumping elements.

1.4.3 *Gauge board* is an unenclosed bracket or plate used to support and display gauges, switches, and other instruments.

1.4.4 *Local* means mounted on, or in close proximity to, the equipment.

1.4.5 *Maximum allowable speed* (in revolutions per minute) is the highest speed at which the manufacturer's design will permit continuous operation.

1.4.6 *Maximum allowable temperature* is the maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified pressure.

1.4.7 *Minimum allowable temperature* is the minimum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred).

1.4.8 *Maximum allowable working pressure* is the maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified temperature and capacity.

1.4.9 *Minimum allowable speed* (in revolutions per minute) is the lowest speed at which the manufacturer's design will permit continuous operation.

1.4.10 *Net positive suction head* (NPSH) is the total inlet pressure, in meters (feet), determined at the pump suction connection, minus the vapor pressure of the liquid in meters (feet).

Note: See Appendix E for a discussion of NPSH and Net Positive Inlet Pressure (NPIP).

1.4.11 *Net positive suction head available* (NPSHA) is the NPSH, in meters (feet), determined by the purchaser for the pumping system with the fluid at the rated capacity and normal pumping temperature.

1.4.12 *Net positive suction head required* (NPSHR) is the NPSH, in meters (feet), determined by vendor testing.

NPSHR is measured at the suction flange. NPSHR is the minimum NPSH at rated capacity required to prevent more than three percent capacity drop due to cavitation within the pump.

1.4.13 *A panel* is an enclosure used to mount, display, and protect gauges, switches, and other instruments.

1.4.14 *Pump efficiency* (also called pump overall efficiency) is the ratio of the pump output (hydraulic power) to the pump power input.

1.4.15 *Rated capacity* of a rotary pump is the total volume of fluid actually delivered per unit of time at the stated operating conditions. Rated capacity includes liquid and any dissolved or entrained gases, and is based on suction conditions.

1.4.16 *Rated differential pressure* is the difference between rated suction pressure and rated discharge pressure.

1.4.17 *Rated discharge pressure* is the discharge pressure for the operating conditions specified.

1.4.18 The *rated speed* of a rotary pump is the number of revolutions per minute of the rotor(s) required to meet the specified operating conditions. In pumps incorporating two or more rotating elements operating at different speeds, the rated speed is the speed of the driving rotor.

1.4.19 *Rated suction pressure* is the suction pressure for the operating conditions specified.

1.4.20 *Remote* means located away from the equipment or console, typically in a control house.

1.4.21 A *rotary pump* is a positive displacement pump (including rotary plunger and axial position pumps) consisting of a casing containing gears, screws, lobes, cams, vanes, plungers or similar elements actuated by relative rotation between the drive shaft and the casing. There are no separate inlet and outlet valves. These pumps are characterized by their close running clearances.

1.4.22 *Slip* is the quantity of fluid per unit of time that leaks through the internal clearances of a rotary pump. Slip depends on the internal clearances, the differential pressure, the characteristics of the fluid handled, and in some cases, the speed.

1.4.23 *Shutdown point* is a preset value of a parameter at which automatic or manual shutdown of a system is required.

1.4.24 *Unit responsibility* refers to the responsibility for coordinating the technical aspects of the equipment and all auxiliary systems included in the scope of the order. It includes responsibility for reviewing such factors as the power requirements, speed, rotation, general arrangements, couplings, dynamics, noise, lubrication, sealing system, materials test reports, instrumentation, piping and testing of components.

1.4.25 *Volumetric efficiency* is the ratio of the pump's rated capacity to the product of the displacement times the rated speed. It is expressed as a percentage.

1.4.26 The use of the word *design* in any term (such as design power, design pressure, design temperature, or design speed) should be avoided in the purchaser's specifications. This terminology should be used only by the equipment designer and the manufacturer.

1.5 Referenced Publications

1.5.1 This standard makes reference to American standards. Other international or national standards may be used as mutually agreed between purchaser and vendor provided that it can be shown that these other standards meet or exceed the American standards referenced.

1.5.2 The editions of the following standards, codes, and specifications that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard. The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed upon by the purchaser and the vendor.

AFBMA[1]

Std 7 *Shaft and Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundary Plans*

Std 9 *Load Ratings and Fatigue Life for Ball Bearings*

Std 11 *Load Ratings and Fatigue Life for Roller Bearings*

Std 20 *Radial Bearings of Ball, Cylindrical Roller and Spherical Roller Types, Metric Design; Basic Plan for Boundary Dimensions, Tolerances and Identification Codes*

AGMA[2]

6010-E88 *Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives*

API

Spec 5L *Specification for Line Pipe*

RP 500 *Classification of Locations for Electrical Installations at Petroleum Refineries*

RP 520 *Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries, Part I*—"Sizing and Selection," and Part II—"Installation"

Std 526 *Flanged Steel Safety-Relief Valves*

Std 541 *Form-Wound Squirrel-Cage Induction Motors–250 Horsepower and Larger*

Std 546 *Form-Wound Brushless Synchronous Motors–500 Horsepower and Larger*

RP 550 *Manual on Installation of Refinery Instruments and Control Systems (out of print)*

Std 611 *General-Purpose Steam Turbines for Refinery Service*

Std 615 *Sound Control of Mechanical Equipment for Refinery Services (Out of Print)*

Std 677 *General-Purpose Gear Units for Refinery Service*

Std 683 *Quality Improvement Manual for Mechanical Equipment in Petroleum, Chemical and Gas Industries*

Manual of Petroleum Measurement Standards Chapter 15, "Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries"

ASME[3]

Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination"; Section VIII, "Pressure Vessels"; and Section IX, "Welding and Brazing Qualifications"

B1.1 *Unified Inch Screw Threads (UN and UNR Thread Form)*

[1]Anti-Friction Bearing Manufacturers Association, 1235 Jefferson Davis Highway, Arlington, VA 22202.

[2]American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314-2730.

[3]American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

B1.20.1 *Pipe Threads, General Purpose (Inch)*
B16.1 *Cast Iron Pipe Flanges and Flanged Fittings*
B16.5 *Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys*
B16.11 *Forged Fittings, Socketwelding and Threaded*
B16.42 *Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300*
B16.47 *Large-Diameter Carbon Steel Flanges (Nominal Pipe Sizes 26 Through 60; Classes 75, 150, 300, 400, 600, and 900)*
B31.3 *Chemical Plant and Petroleum Refinery Piping*
Y14.2M *Line Conventions and Lettering*

ASTM[4]

A 48 *Specification for Gray Iron Castings*
A 53 *Specification for Welded and Seamless Zinc-Coated Black and Hot-Dipped Steel Pipe*
A 105 *Specification for Carbon Steel Forgings for Piping Components*
A 106 *Specification for Seamless Carbon Steel Pipe for High- Temperature Service*
A 108 *Specification for Cold-Finished Carbon Steel Bars, Standard Quality*
A 181 *Specification for Carbon Steel Forgings for General Purpose Piping*
A 182 *Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*
A 192 *Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service*
A 193 *Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service*
A 193 *Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service*
A 194 *Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service*
A 197 *Specification for Cupola Malleable Iron*
A 216 *Specification for Carbon-Steel Castings Suitable for Fusion Welding for High-Temperature Service*
A 217 *Specification for Martensitic Stainless Steel and Alloy Steel Castings for Pressure-Containing Parts Suitable for High-Temperature Service*
A 247 *Method for Evaluating the Microstructure of Graphite in Iron Castings*
A 269 *Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
A 276 *Specification for Stainless and Heat-Resisting Steel Bars and Shapes*
A 278 *Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650°F*
A 296 *Specification for Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base Alloy Castings for General Application*
A 307 *Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile*
A 312 *Specification for Seamless and Welded Austenitic Stainless Steel Pipe*
A 320 *Specification for Alloy-Steel Bolting Materials for Low-Temperature Service*
A 322 *Specification for Hot-Rolled Alloy Steel Bars*
A 338 *Specification for Malleable Iron Flanges, Pipe Fittings and Valve Parts for Railroad, Marine, and Other Heavy Duty Service at Temperatures up to 650°F (345°C)*
A 351 *Specification for Castings, Austenitic, Austenitic-Ferretic (Duplex), for Pressure-Containing Parts*
A 352 *Specification for Ferretic Steel Castings for Pressure-Containing Parts Suitable for Low-Temperature Service*
A 358 *Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High-Temperature Service*
A 395 *Specification for Ferretic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*
A 436 *Specification for Austenitic Grey Iron Castings*
A 439 *Specification for Austenitic Ductile Iron Castings*
A 494 *Specification for Castings, Nickel and Nickel Alloy*
A 515 *Specification for Carbon Steel Pressure Vessel Plates for Intermediate and Higher Temperature Service*
A 524 *Specification for Seamless Carbon Steel Pipe for Atmospheric and Lower Temperatures*
A 536 *Specification for Ductile Iron Castings*
A 564 *Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless and Heat-Resisting Steel Bars, and Shapes*
A 576 *Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality*

[4]American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187

A 582 *Specification for Hot-Rolled or Cold-Finished Free Machining Stainless and Heat-Resisting Steel Bars*
A 744 *Specification for Castings, Iron-Chromium-Nickel, Corrosion-Resistant, for Severe Service*
A 747 *Specification for Steel Castings, Stainless Precipitation Hardening*
B23 *Specification for White Metal Bearing Alloys (known commercially as Babbit metal)*
B 124 *Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes*
B 127 *Specification for Nickel-Copper Alloy UNS N04400 Plate, Sheet, and Strip*
B 139 *Specification for Phosphor Bronze Rod, Bar, and Shapes*
B 148 *Specification for Aluminum-Bronze Castings*
B 164 *Specification for Nickel-Copper Alloy Rod, Bar and Wire*
B 473 *Specification for UNS N08020, UNS N08026, and UNS N08024, Nickel Alloy Bar and Wire*
B 564 *Specification for Nickel Alloy Forgings*
B 574 *Specification for Low-Carbon Nickel-Molybdenum-Chromium and Low-Carbon Nickel-Chromium-Molybdenum Alloy Rod.*
B 575 *Specification for Low-Carbon Nickel-Molybdenum-Chromium and Low-Carbon Nickel-Chromium-Molybdenum Alloy Plate, Sheet and Strip*
B 584 *Specification for Copper Alloy Sand Castings for Radiographic Testing*
B 637 *Specification for Precipitation Hardening Nickel Alloy Bars, Forgings and Forging Stock for High-Temperature Service*
B 670 *Specification for Precipitation Hardening Nickel Alloy (UNS N07718) Plate, Sheet and Strip for High-Temperature Service*
D 1418 *Practice for Rubber and Rubber Latices—Nomenclature*
E 94 *Guide for Radiographic Testing*
E 125 *Reference Photographs for Magnetic Particle Indications on Ferrous Castings*
E 142 *Method for Controlling Quality of Radiographic Testing*
E 709 *Practice for Magnetic Particle Examination*

AWS[5]

D1.1 *Structural Welding Code—Steel*

[5]American Welding Society, 550 NW LeJeune Road, Miami, FL 33135.

IEEE[6]

841 *Standard for Petroleum and Chemical Industry Severe Duty TEFC Squirrel-Cage Induction Motors—Up to and Including 500HP*

ISO[7]

228 *Pipe Threads Where Pressure Tight Joints Are Not Made on the Threads, Part 1—"Designation/Dimensions and Tolerances" and Part 2—"Verification by Means of Limit Gauges"*
7005 *Metallic Flanges, Part 1—"Steel Flanges" and Part 2—"Cast Iron Flanges"*

MSS[8]

SP-44 *Steel Pipe Line Flanges*

NACE[9]

Corrosion Engineer's Reference Book
MR-01-90 *Sulfide Stress Corrosion Cracking Resistant Metallic Material for Oil Field Equipment*

NEMA[10]

MG 1 *Motors and Generators*

NFPA[11]

70 *National Electrical Code*

1.5.3 The standards of the Hydraulic Institute[12] also form a part of this standard.

1.5.4 The purchaser and the vendor shall mutually determine the measures that must be taken to comply with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment.

1.5.5 It is the vendor's responsibility to invoke all applicable specifications to each subvendor.

1.6 Unit Conversion

The factors in Chapter 15 of the API *Manual of Petroleum Measurement Standards* were used to convert from customary to SI units. The resulting exact SI units were then rounded off.

[6]Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017-2394.
[7]International Organization for Standardization. ISO Publications are available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.
[8]Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street NE, Vienna, VA 22180
[9]National Association of Corrosion Engineers, P.O. Box 218340, Houston, TX 77218
[10]National Electrical Manufacturers Association, 2101 L Street NW, Washington, DC 20037.
[11]National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101.
[12]Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ 07054-3802

SECTION 2—BASIC DESIGN

2.1 General

2.1.1 The equipment (including auxiliaries) covered by this standard shall be designed and constructed for minimum service life of 20 years and at least three years of uninterrupted operation. It is recognized that this is a design criterion.

2.1.2 The vendor shall assume unit responsibility for all equipment, including pump, driver, power transmission, and all auxiliary systems included in the scope of the order.

● **2.1.3** The purchaser will specify the equipment's normal operating point on the data sheets. If a range of operating conditions is specified, the pump vendor shall advise the purchaser about the pump's minimum and maximum capacity at its rated differential pressure and its required brake horsepower. Anticipated process variations that may affect the sizing of the pump and the driver (such as changes in pressure, temperature, or properties of fluids handled, and special plant startup conditions) will be specified.

● **2.1.4** Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the purchaser and the vendor. The equipment furnished by the vendor shall conform to the maximum allowable sound pressure level specified by the purchaser.

2.1.5 Equipment shall be designed to run without damage to the trip speed and relief valve settings.

2.1.6 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

● **2.1.7** Motors, electrical components, and installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser on the data sheets and shall meet the requirements of NFPA 70, Articles 500, 501, 502 and 504, as well as local codes specified and furnished by the purchaser.

2.1.8 Oil reservoirs and housings that enclose moving lubricated parts (such as 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.

2.1.9 All equipment shall be designed to permit rapid and economical maintenance, particularly regarding packing and seals. Major parts shall be designed (shouldered or cylindrically doweled) and manufactured to ensure accurate alignment on reassembly.

2.1.10 The machine and its driver shall perform on the test stand and on their permanent foundation within the specified acceptance criteria. After installation, the combined performance of the units shall be the joint responsibility of the purchaser and the vendor having unit responsibility.

2.1.11 The purchaser will specify whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), as well as the weather and environmental conditions in which the equipment must operate (including maximum and minimum temperatures, unusual humidity, and dusty or corrosive conditions).

2.1.12 Spare parts for the machine and all furnished auxiliaries shall meet all the criteria of this standard.

2.1.13 Unless otherwise specified, the vendor shall recommend the pump speed for the specified service, considering such factors as NPSH, maximum fluid viscosity, solids and abrasives content, and wear allowance if required.

Note: It must be recognized that different rotary pump designs operate on different principles so that no one speed criterion can be applied

2.2 Pressure Casings

2.2.1 The hoop-stress values used in the design of the casing shall not exceed the maximum allowable stress values in tension specified in Section VIII, Division 1, of the ASME Code at the maximum operating temperature of the material used.

2.2.2 The maximum allowable working pressure of the casing shall be at least equal to the specified relief valve setting. The relief valve setting shall exceed the rated discharge pressure by at least 10 percent or 1.7 bar (25 psi), whichever is greater.

2.2.3 The use of tapped holes in pressure parts shall be minimized. To prevent leakage in pressure sections of casings, metal equal in thickness to at least half of the nominal bolt diameter, in addition to the allowance for corrosion, shall be left around and below the bottom of drilled and tapped holes. The depth of the tapped holes shall be at least 1½ times the stud diameter.

2.2.4 Bolting shall be furnished as specified in 2.2.4.1 through 2.2.4.5.

2.2.4.1 The details of threading shall conform to ASME B1.1.

2.2.4.2 Studs shall be supplied unless cap screws are specifically approved by the purchaser.

2.2.4.3 Adequate clearance shall be provided at bolting locations to permit the use of socket or box wrenches.

2.2.4.4 Internal socket-type, slotted-nut, or spanner-type bolting shall not be used unless specifically approved by the purchaser.

2.2.4.5 Stud ASTM grade marking shall be located on the nut end of the exposed stud end.

2.2.5 Jackscrews, lifting lugs, eyebolts, guide dowels, and alignment dowels shall be provided to facilitate disassembly and reassembly when required by pump design. When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counterbored or recessed) to prevent a leaking joint or improper fit caused by marring. Guide rods shall be of sufficient length to prevent damage to the internals or studs by any component during disassembly and reassembly. Lifting lugs or eyebolts shall be provided for lifting only the top half of the casing.

2.2.6 Pump cooling or heating jackets, if required, shall be designed to positively prevent process fluid from leaking into the coolant. When cooling of casings is necessary, separate, noninterconnecting chambers are required for casing and head.

2.2.7 Unless otherwise specified, jackets shall be designed for minimum of 5.2 bar gauge (75 psig) working pressure and shall be suitable for hydrostatic testing at a minimum of 8 bar gauge (115 psig).

2.2.8 The equipment feet shall be provided with vertical jackscrews and shall be drilled with pilot holes that are accessible for use in final doweling.

2.3 Casing Connections

● **2.3.1** Inlet and outlet connections shall be flanged or machined and studded, and oriented as specified. If threaded connections are standard, they may be used for NPS 1½ and smaller. The inlet connection shall be rated for the maximum allowable inlet working pressure. The outlet connection shall be rated for the maximum allowable outlet working pressure. (2.2.2) The purchaser will specify if higher inlet connection flange ratings are required or if threaded connections NPS 1½ and smaller are prohibited.

2.3.2 Connections welded to the casing shall meet the material requirements of the casing, including impact values, rather than the requirements of the connected piping (2.9.4.5).

2.3.3 Casing openings for piping connections shall be at least NPS ½ and shall be flanged or machined and studded. Where flanged or machined and studded openings are impractical, threaded openings in sizes NPS ½ through NPS 1½ are permissible. These threaded openings shall be installed as specified in 2.3.3.1 through 2.3.3.7.

2.3.3.1 A pipe nipple, preferably not more than 150 mm (6 inches) long, shall be screwed into the threaded opening.

2.3.3.2 Pipe nipples shall be a minimum of Schedule 160 seamless for NPS 1 and smaller, and a minimum of Schedule 80 for NPS 1¼.

2.3.3.3 The pipe nipple shall be provided with a welding-neck or socketweld flange.

2.3.3.4 The nipple and flange materials shall meet the requirements of 2.3.2.

2.3.3.5 The threaded connection shall be seal welded; however, seal welding is not permitted on cast iron equipment, for instrument connections, or where disassembly is required for maintenance. Seal-welded joints shall be in accordance with ASME B31.3.

2.3.3.6 Tapped openings and bosses for pipe threads shall conform to ASME B16.5.

2.3.3.7 Pipe threads shall be taper threads conforming to ASME B1.20.1.

2.3.4 Openings for NPS 1¼, 2½, 3½, 5, 7, and 9 shall not be used.

2.3.5 Tapped openings not connected to piping shall be plugged with solid round-head steel plugs furnished in accordance with ASME B16.11. As a minimum, these plugs shall meet the material requirements of the cylinder. Plugs that may later require removal shall be of corrosion-resistant material. Lubricant of the proper temperature specification shall be used on all threaded connections. Tape shall not be applied to threads of plugs inserted into oil passages. Plastic plugs are not permitted.

2.3.6 Flanges shall conform to ASME B16.1, B16.5, or B16.42 as applicable, except as specified in 2.3.6.1 through 2.3.6.4.

2.3.6.1 Cast iron flanges shall be flat faced and shall have a minimum thickness of Class 250 per ANSI B16.1 for sizes 8 inches and smaller.

2.3.6.2 Flat-faced flanges with full raised-face thickness, are acceptable on cases other than cast iron, with purchaser's approval.

2.3.6.3 Flanges that are thicker or have a larger outside diameter than that required by ASME B16.5, API Standard 605 or MSS-SP-44 are acceptable.

● **2.3.6.4** Connections other than those covered by ASME B16.5, API Standard 605 or MSS-SP-44 require the purchaser's approval. When specified, the mating parts shall be furnished by the vendor.

2.3.7 Machined and studded connections shall conform to the facing and drilling requirements of ASME B16.1, B16.5, or B16.42. Studs and nuts shall be furnished installed. The first 1½ threads at both ends of each stud shall be removed. Connections larger than those covered by ASME shall meet the requirements of 2.3.6.4.

2.3.8 All of the purchaser's connections shall be accessible for disassembly without the machine being moved.

2.4 External Forces and Moments

For pumps with steel or alloy-steel casings, inlet and outlet nozzles shall be capable of withstanding forces and moments from external piping determined by the following formulas (see Figure 1):

$$F_x = 430D \qquad M_x = 2350D$$

$$F_y = 430D \qquad M_y = 2350D$$

$$F_z = 430D \qquad M_z = 2350D$$

or in conventional units

$$F_x = 75D \qquad M_x = 125D$$

$$F_y = 75D \qquad M_y = 125D$$

$$F_z = 75D \qquad M_z = 125D$$

Where:

D = nominal pipe size of the pump nozzle connection in millimeters (inches).

F_x = force in Newtons (pounds) on the x-axis, which is parallel to the shaft axis.

F_y = horizontal force in Newtons (pounds) on the y-axis, which is mutually perpendicular to the x- and z-axis.

F_z = vertical force in Newtons (pounds) on the z-axis, which is mutually perpendicular to the y- and x-axes.

M_x = moments around the x-axis, in Newton-meters (pound-feet).

M_y = moments around the y-axis, in Newton-meters (pound-feet).

M_z = moments around the z-axis, in Newton-meters (pound-feet).

The vendor shall submit comparable criteria for pump casings constructed of other materials.

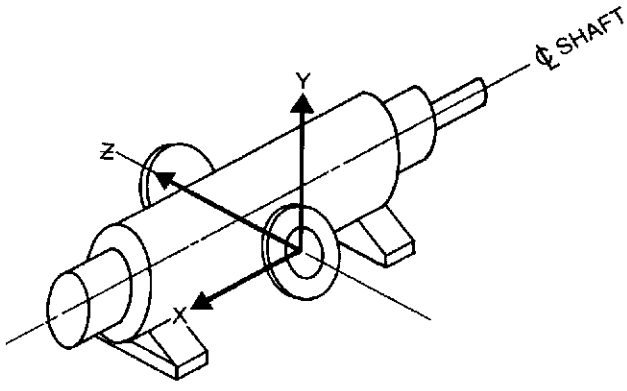

Figure 1—Coordinate System for Calculating Forces and Moments

2.5 Rotating Elements

2.5.1 Stationary and moving pumping elements shall be designed and fabricated of material to prevent galling. Rotating parts shall be properly aligned. Internal loads shall be fully supported by the use of such means as hydraulic balance, bearings, or bushings.

2.5.2 Rotors and shafts shall be of sufficient stiffness and material compatibility to prevent wear between the rotor bodies and the casing, and between gear-timed rotor bodies at the most unfavorable specified conditions, including 110 percent of the relief-valve set pressure. Rotor bodies not integral with the shaft shall be permanently fixed to the shaft to prevent unintended relative motion under any operating condition. Rotors and shafts shall be of materials that have corrosion and erosion resistance compatible with the application.

2.5.3 Timing gears, when furnished, may be spur, helical, or herringbone type. All gears shall be the coarse-pitch type, and the gear quality shall be at least 9, as defined by AGMA. The gears shall be designed in accordance with AGMA Standard 6010 with a minimum service factor of 1.5.

2.6 Mechanical Seals And Conventional Packing

2.6.1 MECHANICAL SEALS

2.6.1.1 Unless otherwise specified, mechanical seals shall be furnished.

● **2.6.1.2** Mechanical seals shall be of the single-balanced type (one rotating face per seal chamber) with either a sliding gasket or a bellows between the axially movable face and the shaft sleeve or housing. Unbalanced seals shall be furnished when specified or approved by the purchaser. Other special configurations may be specified, or they may be recommended by the vendor if required for the service. Double seals have two rotating faces per chamber, sealing in opposite directions. Tandem seals have two rotating faces per chamber, sealing in the same direction.

2.6.1.3 This standard does not cover the design of the component parts of mechanical seals; however, the design and materials of the component parts shall be suitable for the specified service conditions. The components shall also withstand the maximum discharge pressure except in high-discharge-pressure service where this requirement is impractical. For such applications, the vendor shall advise the purchaser of the maximum sealing pressure and the maximum dynamic and static pressure ratings of the seal.

2.6.1.4 Mechanical-seal materials shall be furnished in accordance with Appendix F. Seal faces and gaskets shall be coded in accordance with Tables F-1 and F-2.

2.6.1.5 When a seal gland is used, its component parts shall be satisfactory for the maximum seal-chamber design pressure and pumping temperature. It shall have sufficient rigidity to avoid any distortion that would impair seal operation, including distortion that may occur during tightening of the bolts to set gasketing.

2.6.1.6 The seal chamber shall be provided with an internal or external vent to permit complete venting of the chamber before startup.

2.6.1.7 If seal flushing and cooling is provided by the pumped fluid, the pump vendor shall ensure that sufficient flow reaches the primary seal faces to provide for cooling and maintenance of a stable film at the seal faces.

If the purchaser provides an external source of seal flushing, the pump vendor shall specify the flow, pressure, temperature, and required lubricating properties of the flushing medium. If a restriction orifice is used, it shall not be less than 3 mm (⅛ inch) in diameter.

● **2.6.1.8** Where leakage past the primary mechanical seal must be contained, additional shaft sealing devices may be specified. These devices typically include double or tandem mechanical seals, auxiliary stuffing boxes, or secondary seals. The purchaser and the vendor shall mutually agree on the manner of lubricating these devices.

2.6.1.9 Unless otherwise specified, mechanical seals shall be installed in the pump prior to shipment and shall be clean, lubricated, and ready for service.

2.6.2 STUFFING BOXES FOR CONVENTIONAL PACKING

2.6.2.1 Unless otherwise specified, the packing type and material shall be selected by the vendor for the specified service.

2.6.2.2 Stuffing boxes shall have not less than four rings of packing plus a lantern ring. The stuffing boxes shall preferably accommodate five rings of packing plus a lantern ring. The minimum packing size permitted shall be 6mm (¼ inch) square. The packing size shall preferably be a minimum of 9mm (⅜ inch) square.

● **2.6.2.3** When specified, or when recommended by the vendor, a lantern ring with a width at least 1½ times the packing size shall be provided for the introduction of cooling and/or lubricating media directly into the packing. Connections to the lantern ring shall be a minimum of NPS ¼.

2.6.2.4 Ample space shall be provided for packing replacement without removing or dismantling any part other than the gland.

2.6.2.5 Unless otherwise specified, packing shall be installed by the pump vendor before shipment.

2.6.2.6 Glands on all oil pumps shall be designed so that the bolts cannot slip if the packing becomes loose.

2.7 Bearings

2.7.1 Antifriction bearings shall have a minimum L-10 rated life (see AFBMA Standard 9) of either 25,000 hours with continuous operation at rated conditions, or 16,000 hours at maximum axial and radial loads and rated speed.

Note: The rated life is the number of hours at rated bearing load and speed that 90 percent of the group of identical bearings will complete or exceed before the first evidence of failure. It is recognized that this life may not be achieved where bearings are operated in fluids other than clean lubricating oil.

2.7.2 Antifriction bearings shall be retained on the shaft and fitted into housings in accordance with the requirements of AFBMA Standard 7; however, the device used to lock ball thrust bearings to the shaft shall be restricted by a nut with a tongue-type lock washer, for example, Series W.

2.7.3 Except for the angular contact type, antifriction bearings shall have a loose internal clearance fit equivalent to AFBMA Symbol 3, as defined in AFBMA Standard 20. Tapered roller bearings shall have a clearance fit as described in AFBMA 11. Single- or double-row bearings shall be of the Conrad type (no filling slots).

2.7.4 Housings for separately lubricated bearings shall be sealed against external contaminants. Such housings for oil-lubricated bearings shall contain a drain at the low point and shall be equipped with an oil-level gauge.

2.7.5 When regreaseable-type lubricated bearings are supplied, the manufacturer's design shall include a provision to protect against overgreasing.

2.8 Lubrication

2.8.1 Unless otherwise specified, bearings and bearing housings shall be arranged for hydrocarbon oil lubrication.

2.8.2 The vendor shall specify the type, amount, and frequency of lubrication for separately lubricated bearings and timing gears.

● **2.8.3** When specified, oil-lubricated bearings in separate housings shall be furnished with constant-level oilers.

2.8.4 Any points that require grease lubrication shall have suitable extension lines to permit access during operation.

2.9 Materials

2.9.1 GENERAL

2.9.1.1 Materials of construction shall be manufacturer's standard for the specified operating conditions, except as required or prohibited by the data sheets or this standard. (See 3.5 for auxiliary piping material requirements.) The metal-

lurgy of all major components shall be clearly stated in the vendor's proposal.

2.9.1.2 Materials shall be identified in the proposal with the applicable ASTM, AISI[13], ASME, or SAE[14] numbers, including material grade (See Appendix B). When no such designation is available, the vendor's material specification, giving physical properties, chemical composition, and test requirements, shall be included in the proposal.

2.9.1.3 The vendor shall specify the ASTM optional tests and inspection procedures that may be necessary to ensure that materials are satisfactory for the service. Such tests and inspections shall be listed in the proposal. The purchaser may consider specifying additional tests and inspections, especially for materials used in critical components.

2.9.1.4 External parts subject to rotary or sliding motions (such as control linkage joints and adjusting mechanisms) shall be of corrosion-resistant materials suitable for the site environment.

2.9.1.5 Minor parts that are not identified (such as nuts, springs, washers, gaskets, and keys) shall have corrosion resistance at least equal to that of specified parts in the same environment.

● **2.9.1.6** The purchaser will specify any corrosive agents in the motive and process fluid and in the environment, including constituents that may cause stress corrosion cracking.

2.9.1.7 If parts exposed to conditions that promote intergranular corrosion are to be fabricated, hard faced, overlaid, or repaired by welding, they shall be made of low-carbon or stabilized grades of austenitic stainless steel.

Note: Overlays or hard surfaces that contain more than 0.10 percent carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel unless a buffer layer that is not sensitive to intergranular corrosion is applied.

2.9.1.8 Where mating parts such as studs and nuts of AISI Standard Type 300 stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an antiseizure compound of the proper temperature specification and compatible with the specified fluids.

Note: It is preferable to use materials which do not have galling tendencies. Also, torque loading values will be considerably different with and without antiseizure compound.

2.9.1.9 Materials exposed to a sour environment (wet H_2S) as defined by NACE MR-01-90 shall be in accordance with the requirements of that standard. Ferrous materials not covered by NACE MR-01-90 shall be limited to a yield strength not exceeding 6200 bar (90,000 psi) and a hardness not exceeding Rockwell C22.

Note: It is the responsibility of the purchaser to determine the amount of H_2S that may be present, considering normal operation, startup, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration. In many applications, small amounts of H_2S are sufficient to require NACE materials. When there are trace quantities of H_2S known to be present or if there is any uncertainty about the amount of H_2S that may be present, the purchaser should automatically note on the data sheets that NACE materials are required.

Components that are fabricated by welding shall be stress relieved, if required, so that both the welds and the heat-affected zones meet the yield strength and hardness requirements. The purchaser will specify the presence of such agents in the media.

2.9.1.10 When dissimilar materials with significantly different electrical potentials are placed in contact with the presence of an electrolytic solution, galvanic couples that can result in serious corrosion of the less noble material may be created. If such conditions exist, the purchaser and the vendor should select materials in accordance with the NACE *Corrosion Engineer's Reference Book.*

2.9.1.11 Materials, casting factors, and the quality of any welding shall be equal to those required by Section VIII, Division 1, of the ASME Code. The manufacturer's data report forms, as specified in the code, are not required.

2.9.1.12 The use of ASTM A 515 steel is prohibited. Low-carbon steels can be notch-sensitive and susceptible to brittle fracture at ambient or low temperatures. Therefore, only fully killed, normalized steels made to fine-grain practice are acceptable.

2.9.1.13 The minimum quality bolting material for pressure joints for cast iron casings shall be carbon steel (ASTM A 307, Grade B); and for steel casings shall be high-temperature alloy steel (ASTM A 193, Grade B7). Nuts shall conform to ASTM A 194, Grade 2H (or ASTM A 307, Grade B, case hardened, where space is limited). For temperatures below -30°C (-20°F), low-temperature bolting material in accordance with ASTM A 320 shall be used.

2.9.2 CASTINGS

2.9.2.1 Castings shall be sound and free from hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects. Porosity shall not exceed the limits stated in the material inspection acceptance criteria (4.2.2).

Surfaces of castings shall be cleaned by sandblasting, shotblasting, chemical cleaning, or any other standard method. Mold-parting fins and remains of gates and risers shall be chipped, filed, or ground flush.

2.9.2.2 The use of chaplets in pressure castings shall be held to a minimum. The chaplets shall be clean and corro-

[13]American Iron and Steel Institute, 1000 16th Street NW, Washington, DC 20036
[14]Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096

sion free (plating permitted) and of a composition compatible with the casting.

2.9.2.3 Ferrous castings for pressure retaining parts shall not be repaired by welding, peening, plugging, burning in, or impregnating, except as specified in 2.9.2.3.1 and 2.9.2.3.2.

2.9.2.3.1 Weldable grades of steel castings may be repaired by welding, using a qualified welding procedure based on the requirements of Section VIII, Division 1, and Section IX of the ASME Code.

2.9.2.3.2 Cast gray iron or nodular iron may be repaired by plugging within the limits specified in ASTM A 278, A 395, or A 536. The 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 ASTM specifications shall be subject to the purchaser's approval.

2.9.2.4 Fully enclosed cored voids, including voids closed by plugging, are prohibited.

2.9.2.5 Grey cast iron (ASTM A278) shall not be used for pressure-containing parts that handle flammable or toxic fluids. With the purchaser's approval, nodular cast iron (ASTM A 395) may be used in such services.

Note: It is recommended that nodular cast iron only be used for services less than 200 psig (14 bar gauge) and 125°F (50°C)

2.9.2.6 Nodular iron castings shall be produced in accordance with ASTM A 395. The production of the castings shall also conform to the conditions specified in in 2.9.2.6.1 through 2.9.2.6.5.

2.9.2.6.1 A minimum of one set (three samples) of Charpy V-notch impact specimens at one-third the thickness of the test block shall be made from the material adjacent to the tensile specimen on each keel or Y block. These specimens shall have a minimum impact value of 14 joules (10 foot-pounds) at room temperature.

2.9.2.6.2 The keel or Y block cast at the end of the pour shall be at least as thick as the thickest section of the main casting.

2.9.2.6.3 Integrally cast test bosses, preferably at least 25 mm (1 inch) in height and diameter, shall be provided at critical areas of the casting for subsequent removal for the purposes of hardness testing and microscopic examination. Critical areas are typically heavy sections, section changes, high-stress points such as drilled lubrication points, the cylinder bore, valve ports, flanges, and other points agreed upon by the purchaser and the vendor. Classification of graphite nodules shall be in accordance with ASTM A 247.

2.9.2.6.4 An as-cast sample from each ladle shall be chemically analyzed.

2.9.2.6.5 Brinell hardness readings shall be made on the actual casting at feasible locations on section changes, flanges, the cylinder bore, and valve ports. Sufficient surface material shall be removed before hardness readings are made to eliminate any skin effect. Readings shall also be made at the extremities of the casting at locations that represent the sections poured first and last. These shall be made in addition to Brinell readings on the keel or Y blocks.

2.9.3 FORGINGS

Unless otherwise agreed upon by the purchaser and the vendor, the forging material shall be selected from those listed in Appendix B.

2.9.4 WELDING

2.9.4.1 Welding of piping and pressure-containing parts, as well as any dissimilar metal welds and weld repairs, shall be performed and inspected by operators and procedures qualified in accordance with Section VIII, Division 1, and Section IX of the ASME Code. The manufacturers data report forms as specified in the code are not required.

2.9.4.2 The vendor shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and nondestructively examined for soundness and compliance with the applicable qualified procedures (2.9.1.11). Repair welds shall be nondestructively tested by the same method used to detect the original flaw. As a minimum, the inspection shall be in accordance with 4.2.2.4 or 4.2.2.5 as applicable.

2.9.4.3 Unless otherwise specified, all welding other than that covered by Section VIII, Division 1, of the ASME Code and ASME B31.3, such as welding on baseplates, standard pump items, nonpressure ducting, lagging, and control panels, shall be performed in accordance with AWS D1.1.

2.9.4.4 Unless otherwise specified, pressure-containing components made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 2.9.4.4.1 through 2.9.4.4.4.

2.9.4.4.1 Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by Section VIII, Division 1, UG-93(d)(3), of the ASME Code.

2.9.4.4.2 Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examina-

tion after backchipping or gouging and again after postweld heat treatment.

2.9.4.4.3 Pressure-containing welds, including welds of the cylinder to horizontal- and vertical-joint flanges, shall be full-penetration welds.

2.9.4.4.4 Cylinders fabricated from materials that, according to Section VIII, Division 1, of the ASME Code, require post-weld heat treatment, shall be heat treated regardless of thickness.

2.9.4.5 Connections welded to pressure casings shall be installed as specified in 2.9.4.5.1 through 2.9.4.5.5.

● **2.9.4.5.1** In addition to the requirements of 2.9.4.1, the purchaser may specify that 100 percent radiography, magnetic particle inspection, or liquid penetrant inspection of welds is required.

2.9.4.5.2 Auxiliary piping welded to chromium-molybdenum alloy steel or 12 percent chrome steel components shall be of the same material, except that chromium-molybdenum alloy steel pipe may be substituted for 12 percent chrome steel pipe.

2.9.4.5.3 When heat treating is required, piping welds shall be made before the component is heat treated.

● **2.9.4.5.4** When specified, proposed connection designs shall be submitted to the purchaser for approval before fabrication. The drawing shall show weld designs, size, materials, and preweld and postweld heat treatments.

2.9.4.5.5 All welds shall be heat treated in accordance with Section VIII, Division 1, UW-40, of the ASME Code.

2.9.5 IMPACT TEST REQUIREMENTS

2.9.5.1 To avoid brittle fracture during operation, maintenance, transportation, erection and testing, good design practice shall be followed in the selection of fabrication methods, welding procedures and materials for vendor furnished steel pressure retaining parts that may be subject to a temperature below the ductile-brittle transition point.

Note: The published design-allowable stresses for many materials in the ASME Code and ANSI standards are based on minimum tensile properties. The ASME Code and ANSI standards do not differentiate between rimmed, semi-killed, fully-killed, hot-rolled and normalized material, nor do they take into account whether materials were produced under fine- or coarse-grain practices.

The vendor shall exercise caution in the selection of materials intended for service between -30°C (-20°F) and 40°C (100°F).

2.9.5.2 All pressure containing components including nozzles, flanges and weldments shall be impact tested in accordance with the requirements of Section VIII, Division 1, Sections USC-65 through 68, of the ASME Code. High-alloy steels shall be tested in accordance with Section VIII, Division 1, Section UHA-51, of the ASME Code.

Impact testing is not required if the requirements of Section VIII, Division 1, Section UG-20F, of the ASME Code are met.

Nominal thickness for castings as defined in Section VIII, Division 1, Paragraph UCS-66(2), of the ASME Code shall exclude structural support sections such as feet or lifting lugs.

The results of the impact testing shall meet the minimum impact energy requirements of Section VIII, Division 1, Section UG-84 of the ASME Code.

● **2.9.5.3** The purchaser will specify the minimum design metal temperature used to establish impact test requirements.

Note: Normally this will be the lower of the minimum surrounding ambient temperature or minimum fluid pumping temperature; however, the purchaser may specify a minimum metal temperature based on fluid pumped properties such as autorefrigeration at reduced pressures.

2.10 Nameplates And Rotation Arrows

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

2.10.2 Rotation arrows shall be cast in or attached to each major item of rotating equipment in a readily visible location. Nameplates and rotation arrows (if attached) shall be of ANSI Standard Type 300 stainless steel or of nickel-copper alloy (Monel or its equivalent). Attachment pins shall be of the same material. Welding is not permitted.

2.10.3 The purchaser's item number, the vendor's name, the machine's serial number, and the machine's size and type, as well as its minimum and maximum allowable design limits and rating data (including pressures, temperatures, speeds, and power), maximum allowable working pressures and temperatures, hydrostatic test pressures and critical speeds, shall appear on the machine's nameplate. The purchaser will specify on the data sheet whether customary or SI units are to be shown.

2.11 Quality

Refer to API Recommended Practice 683 for guidelines on improving the quality of equipment.

SECTION 3—ACCESSORIES

3.1 Drivers

● **3.1.1** The type of driver will be specified. The driver shall be sized to meet the maximum specified operating conditions, including external gear and/or coupling losses, and shall be in accordance with applicable specifications, as stated in the inquiry and order. The driver shall be suitable for satisfactory operation under the utility and site conditions specified.

● **3.1.2** Anticipated process variations that may affect the sizing of the driver (such as changes in the pressure, temperature, or properties of the fluid handled, as well as special plant startup conditions) will be specified.

● **3.1.3** The starting conditions for the driven equipment will be specified, and the starting method shall be mutually agreed upon by the purchaser and the vendor. The driver's starting- torque capabilities shall exceed the speed-torque requirements of the driven equipment.

● **3.1.4** When specified, motor drives shall conform to API standard 541 or 546, as applicable. Motors that are below the power scope of API standard 541 or 546 shall be in accordance with IEEE 841. The motor nameplate rating (exclusive of the service factor) shall be at least 110 percent of the maximum power required for any of the specified operating conditions. The motor nameplate rating including service factor shall be suitable for operation at 110 percent of the relief valve setting. Equipment driven by induction motors shall be rated at the actual motor speed for the rated load conditions.

● **3.1.5** The purchaser will specify the type of motor and its characteristics and accessories, including the following:

a. Electrical characteristics.
b. Starting conditions (including the expected voltage drop on starting).
c. The type of enclosure.
d. The sound pressure level.
e. The area classification, based on API Recommended Practice 500A.
f. The type of insulation.
g. The required service factor.
h. The ambient temperature and elevation above sea level.
i. Transmission losses.
j. Temperature detectors, vibration sensors, and heaters, if these are specified.
k. Auxiliaries (such as motor-generator sets, a ventilation blower, and instrumentation).
l. Vibration acceptance criteria

● **3.1.6** The motor's starting-torque requirements shall be met at a specified reduced voltage, and the motor shall accelerate to full speed within a period of time agreed upon by the purchaser and the vendor.

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

3.1.7 Unless otherwise specified, steam turbine drivers shall conform to API Standard 611. Steam turbine drivers shall be sized to deliver continuously 110 percent of the maximum power required for the purchaser's specified conditions while operating at a corresponding speed with the specified steam conditions.

3.1.8 Unless otherwise specified, gears shall conform to API Standard 677.

3.1.9 For drivers that weigh more than 250 kg (500 pounds), the equipment feet shall be provided with vertical jackscrews.

3.2 Couplings and Guards

3.2.1 Unless otherwise specified, flexible couplings and guards between drivers and driven equipment shall be supplied by the manufacturer of the driven equipment.

3.2.2 The make, type, and mounting arrangement of couplings shall be agreed upon by the purchaser and the vendors of the driver and driven equipment. A spacer coupling shall be supplied for all pumps equipped with mechanical seals. The spacer length shall be sufficient to permit seal replacement without moving either the pump or driver.

3.2.3 Information on shafts, keyway dimensions (if any), and shaft end movements due to end play and thermal effects shall be furnished to the vendor supplying the coupling.

3.2.4 The coupling-to-shaft juncture shall be designed and manufactured to be capable of transmitting power at least equal to the power rating of the coupling.

3.2.5 Removable coupling guards shall be supplied by the vendor. They shall be manufactured in accordance with all specified codes.

3.3 Mounting Plates

3.3.1 GENERAL

● **3.3.1.1** The equipment shall be furnished with R 19 soleplates or a baseplate, as specified.

3.3.1.2 In 3.3.1.2.1 through 3.3.1.2.12, the term *mounting plate* refers to both baseplates and soleplates.

3.3.1.2.1 All machinery mounting surfaces on the mounting plates shall be machined flat and parallel after fabrication, and shall extend at least 25 millimeters (1 inch) beyond the outer three sides of the equipment feet. To prevent a soft foot, all surfaces on which a piece of equipment mounts shall be in the same plane within 50 micrometers (0.002 inch) (see Figure 2). The maximum surface finish shall be 3 micrometers (125 microinches) R_a.

3.3.1.2.2 When the equipment supported weighs more than 250 kilograms (500 pounds), the mounting plates shall be furnished with axial and lateral jackscrews the same size as or larger than the vertical jackscrews. Vertical jackscrews in the equipment feet shall be arranged to prevent marring of shimming surfaces. The lugs holding these jackscrews shall be attached to the mounting plates so that the lugs do not interfere with the installation or removal of the equipment, jackscrews or shims If the equipment is too heavy to use jackscrews, other means shall be provided.

3.3.1.2.3 Machinery supports shall be designed to limit a change of alignment caused by the worst combination of pressure, torque, and allowable piping stress to 50 micrometers (0.002 inch) at the coupling flange. (See 2.4 for allowable piping forces).

3.3.1.2.4 When centerline supports are provided, they shall be designed and manufactured to permit the machine to be moved by using the horizontal jackscrews.

● **3.3.1.2.5** When epoxy grout is specified, the vendor shall commercially sandblast, in accordance with SSPC SP 6, all the grouting surfaces of the mounting plates and shall precoat these surfaces with a compatible epoxy primer. The epoxy primer shall be compatible with epoxy grout. The vendor shall submit to the purchaser instructions for field preparation of the epoxy primer.

Note: Epoxy primers have a limited life after application The grout manufacturer should be consulted to ensure proper field preparation of the mounting plate for satisfactory bonding of the grout.

3.3.1.2.6 Anchor bolts shall not be used to fasten machinery to the mounting plates.

3.3.1.2.7 Mounting plates shall not be drilled for equipment to be mounted by others. Mounting plates intended for grouting shall be supplied with leveling screws. Mounting plates that are to be grouted shall have 50 mm radiused (2-inch radiused) outside corners (in the plan view). Mounting plates that are not to be grouted shall be coated with a rust preventive immediately after machining

3.3.1.2.8 Mounting plates shall be designed to extend at least 25 mm (1 inch) beyond the outer three sides of equipment feet.

3.3.1.2.9 The vendor of the mounting plates shall furnish stainless steel (AISI standard type 300) shim packs of at least 3 mm (⅛-inch) total thickness between the equipment feet and the mounting plates. All shim packs shall straddle the hold-down bolts and vertical jackscrews.

3.3.1.2.10 Anchor bolts will be furnished by the purchaser.

3.3.1.2.11 Fasteners for attaching the components to the mounting plates and jackscrews for leveling the pedestal soleplates shall be supplied by the vendor.

3.3.2 BASEPLATES

● **3.3.2.1** When a baseplate is specified, the purchaser will indicate the major equipment to be mounted on it. A baseplate shall be a single iron casting or fabricated steel unit.

3.3.2.2 Unless otherwise specified, the baseplate or skid shall extend under the drive train components so that any leakage from these components is contained within the baseplate.

3.3.2.3 The baseplate shall be provided with lifting lugs for at least a four-point lift. Lifting the baseplate complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or machinery mounted on it. The vendor shall advise if a spreader bar is needed, and if equipment must be uncoupled before lifting.

3.3.2.4 The bottom of the baseplate between structural members shall be open. When the baseplate is to be grouted, it shall be provided with at least one grout hole having a clear area of at least 0.01 square meter (20 square inches) and no dimension less than 75 mm (3 inches) in each bulkhead section. These holes shall be located to permit grouting under all load-carrying structural members. Where practical, the holes shall be accessible for grouting with the equipment installed. The holes shall have 15 mm (½-inch) raised-lip edges, and if located in an area where liquids could impinge on the exposed grout, metallic covers with a minimum thickness of 16 gauge shall be provided. Vent holes at least 15 mm (½-inch) in size shall be provided at the highest point in each bulkhead section of the baseplate.

● **3.3.2.5** The mounting pads on the bottom of the baseplate shall be in one plane to permit use of a single-level foundation. When specified, subplates shall be provided by the vendor.

3.3.2.6 Unless otherwise specified, nonskid decking covering all walk and work areas shall be provided on the top of the baseplate.

3.3.2.7 The baseplate mounting pads shall be machined after the baseplate is fabricated.

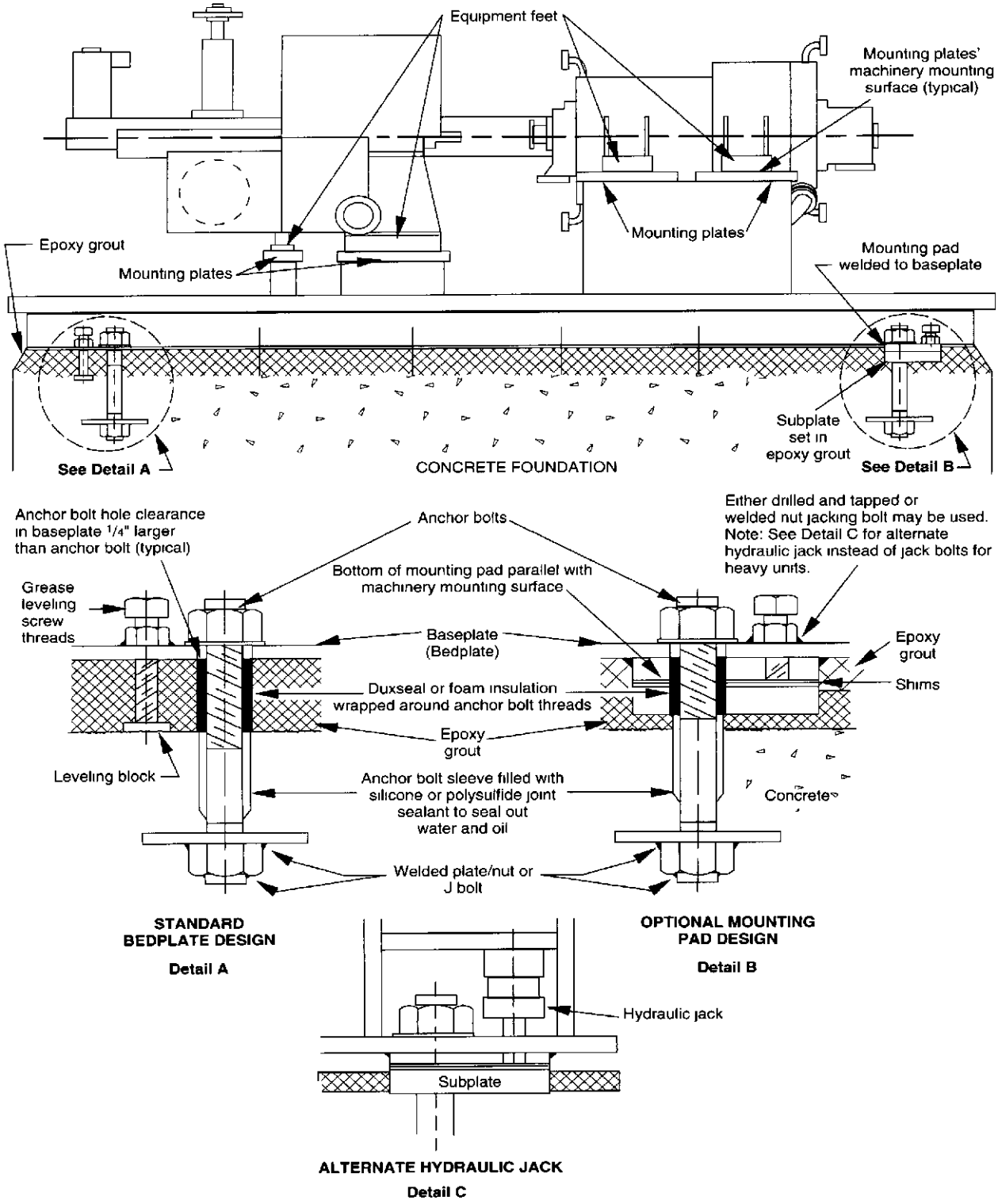

Figure 2 — Baseplate Mounting Pad Arrangement

● **3.3.2.8** When specified, baseplates shall be of the drain-rim or drain-pan type and shall have a raised lip. Connections for a drain shall be tapped (NPS ¼ minimum) in the raised lip at the pump end and shall be located for complete drainage. The pan or upper surface of the baseplate shall be sloped at a minimum ratio of 1:120 toward the drain end.

3.4 Relief Valves

● **3.4.1** When specified, the vendor shall furnish the relief valves that are to be installed on equipment or in piping that the vendor is supplying. Other relief valves will be furnished by the purchaser. Relief valves for all operating equipment shall meet the limiting relief valve requirements defined in API Recommended Practice 520, Parts I and II, and in API Standard 526. The vendor shall determine the size and set the pressure of all relief valves related to the equipment. The vendor's quotation shall list all relief valves and shall clearly indicate those to be furnished by the vendor. Relief valve settings, including accumulation, shall take into consideration all possible types of equipment failure and the protection of piping systems.

3.4.2 Relief valves that are integral with or internal to the pump are not acceptable.

3.4.3 Unless otherwise specified, relief valves shall have steel bodies.

3.5 Piping

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

3.5.2 Auxiliary systems are defined as piping systems that are in the following services.

a. Group I:
   1. Gland and flushing fluid
   2. Drains and vents
b. Group II:
   1. Instrument air
   2. Drains and vents
c. Group III:
   1. Cooling water
   2. Drains and vents
d. Group IV:
   1. Lubricating oil
   2. Drains and vents

Auxiliary systems shall comply with the requirements of Table 1.

Note: Casing connections are discussed in 2.3.

3.5.3 Piping systems shall include piping, isolating valves, control valves, relief valves, pressure reducers, orifices, temperature gauges and thermowells, pressure gauges, sight flow indicators, and all related vents and drains.

● **3.5.4** The vendor shall furnish all piping systems, including mounted appurtenances, located within the confines of the main unit's base area, any oil console base area, or any auxiliary base area. The piping shall terminate with flanged connections at the edge of the base. When soleplates are specified for the equipment train, the extent of the piping system at the equipment train will be defined by the purchaser. The purchaser will furnish only interconnecting piping between equipment groupings and off-base facilities.

3.5.5 The design of piping systems shall achieve the following:

a. Proper support and protection to prevent damage from vibration or from shipment, operation, and maintenance
b. Proper flexibility and normal accessibility for operation, maintenance, and thorough cleaning
c. Installation in a neat and orderly arrangement adopted to the contour of the machine without obstruction of access openings
d. Elimination of air pockets by the use of valved vents or nonaccumulating piping arrangements
e. Complete drainage through low points without disassembly of piping

3.5.6 Piping shall preferably be fabricated by bending and welding to minimize the use of flanges and fittings. Welded flanges are permitted only at equipment connections, at the edge of any base, and for ease of maintenance. The use of flanges at other points is permitted only with the purchaser's specified approval. Other than tees and reducers, welded fittings are permitted only to facilitate pipe layout in congested areas. Threaded connections shall be held to a minimum. Pipe bushings shall not be used.

3.5.7 Pipe threads shall be taper threads in accordance with ASME B1.20.1. Alternately, pipe threads in accordance with ISO 228 Part 1 are acceptable when required for compliance with local standards. Flanges shall be in accordance with ISO 7005 (ASME B16.5). Slip-on flanges are permitted only with the purchaser's specific approval. For socket-welded construction, a 1.5 mm (1/16-inch) gap shall be left between the pipe end and the bottom of the socket.

3.5.8 Connections, piping, valves, and fittings that are 30 mm (1¼ inches), 65 mm (2½ inches), 90 mm (3½ inches), 125 mm (5 inches), 175 mm (7 inches), or 225 mm (9 inches) in size shall not be used.

3.5.9 Where space does not permit the use of NPS ½, ¾, or 1 pipe, seamless tubing may be furnished in accordance with Table 1.

3.5.10 Unless otherwise approved by the purchaser, the minimum size of any connection shall be NPS ½.

3.5.11 Piping systems furnished by the vendor shall be fabricated, installed in the shop, and properly supported. Bolted

Table 1—Minimum Requirements for Piping Materials

System	Group I (Auxiliary Process Fluid)		Group II (Steam and Air)		Group III (Cooling Water)		Group IV (Lubricating and Control Oil)	
	Nonflammable/ Nontoxic	Flammable/Toxic	≤75 pounds per square inch gauge	>75 pounds per square inch gauge	Standard (≤ NPS 1)	Optional	≤ NPS 1	≥ NPS 1½
Pipe (schedule)	Seamless[a]	Seamless[a,b]	Seamless[a]	Seamless[a]	Seamless[a]	ASTM A 53, Schedule 40	ASTM A 312, Type 304 or 316 stainless steel (see 3.6.2.3)[b]	ASTM A 312, Type 304 or 316 stainless steel (see 3.6.2.3)[b]
Tubing[c]	Seamless ASTM A 269 stainless steel or ASTM A 192 steel	Seamless ASTM A 269 stainless steel or ASTM A 192 steel	Seamless ASTM A 269 stainless steel or ASTM A 192 steel	Seamless ASTM A 269 stainless steel or ASTM A 192 steel	Seamless ASTM A 269 stainless steel or ASTM A 192 steel	Seamless ASTM A 269 stainless steel or ASTM A 192 steel	Seamless ASTM A 269 stainless steel	—
All valves	Class 800	Class 800	Class 800	Class 800	Class 200, bronze	Class 200, bronze	Carbon steel, Class 800	Carbon steel, Class 800
Gate and globe valves[d]	Bolted bonnet and gland	Bolted bonnet and gland	Bolted bonnet and gland	Bolted bonnet and gland	—	—	Bolted bonnet and gland	Bolted bonnet and gland
Pipe fittings and unions	Forged, Class 3000	Forged, Class 3000	Forged, Class 3000	Forged, Class 3000	ASTM A 338 and A 197, Class 150 malleable iron, galvanized to ASTM A 153	ASTM A 338 and A 197, Class 150 malleable iron, galvanized to ASTM A 153	Stainless steel (see 3.6.2.2)	Stainless steel (see 3.6.2.2)
Tube fittings	Manufacturer's standard (with purchaser's approval)	Manufacturer's standard (with purchaser's approval)	Manufacturer's standard (with purchaser's approval)	Manufacturer's standard (with purchaser's approval)	Manufacturer's standard (with purchaser's approval)	Manufacturer's standard (with purchaser's approval)	Manufacturer's standard (with purchaser's approval)	—
Fabricated joints ≤1½ inches	Threaded	Socket welded Threaded[e]	Threaded	Socket welded Threaded[e]	Threaded	Threaded	—	Carbon steel slip-on flange
Fabricated joints ≥2 inches	—	—	—	—	Purchaser to specify	Purchaser to specify	—	Carbon steel slip-on flange
Gaskets	Type 304 or 316 stainless steel, spiral wound	Type 304 or 316 stainless steel, spiral wound	Type 304 or 316 stainless steel, spiral wound	Type 304 or 316 stainless steel, spiral wound	—	—	—	Type 304 or 316 stainless steel, spiral wound
Flange bolting[f]	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	—	—	ASTM A 193, Grade B7 ASTM A 194, Grade 2H	—

Note: Carbon steel piping shall conform to ASTM A 106, Grade B; ASTM A 524; or API Specification 5L, Grade A or B. Carbon steel fittings, valves, and flanged components shall conform to ASTM A 105 and A 181. Stainless steel piping shall be seamless in accordance with ASTM A 312.

[a]Schedule 160 carbon steel for NPS ¼ and smaller; Schedule 80 for NPS 1 to 1½; Schedule 40 for NPS 2 and larger.

[b]Schedule 80S stainless steel for NPS 1 and smaller; Schedule 40S for NPS 1½ and 3; Schedule 10S for NPS 4 and larger.

[c]½-inch diameter × 0.065-inch wall, ¾-inch diameter × 0.095-inch wall, or 1-inch diameter × 0.109-inch wall.

[d]For primary ANSI service pressure ratings above 900 pounds per square inch gauge (62 bar gauge), block valves may be of welded-bonnet or no-bonnet construction with a bolted gland. These valves shall be suitable for repacking under pressure.

[e]Threaded joints require seal welding; however, seal welding is not permitted on cast iron equipment, on instruments, or where disassembly is required for maintenance. Seal-welded joints shall be made in accordance with ASME B31.3.

[f]Bolting shall be in accordance with 2.2.8.

holes for flanged connections shall straddle lines parallel to the main horizontal or vertical centerline of the equipment.

3.5.12 Welding shall be performed by operators and procedures qualified in accordance with Section IX of the ASME Code.

3.5.13 Pipe plugs shall be in accordance with 2.3.5.

3.6 Special Tools

3.6.1 When special tools and fixtures are required to disassemble, assemble, or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the machine. For multiple unit installations, the requirements for quantities of special tools and fixtures shall be mutually agreed upon by the purchaser and the vendor. These or similar special tools shall be used during shop assembly and post-test disassembly of the equipment.

3.6.2 When special tools are provided, they shall be packaged in separate, rugged metal boxes and marked "special tools for (tag/item number)." Each tool shall be stamped or tagged to indicate its intended use.

SECTION 4—INSPECTION, TESTING, AND PREPARATION FOR SHIPMENT

4.1 General

4.1.1 The purchaser will specify the extent of participation in the inspection and testing and the amount of advanced notification required.

4.1.2 When specified, the purchaser's representative, the vendor's representative, or both shall indicate compliance in accordance with the inspector's checklist (Appendix C) by initialing, dating and submitting the completed checklist to the purchaser before shipment.

4.1.3 After advance notification of the vendor by the purchaser, the purchaser's representative shall have entry to all vendor and subvendor plants where manufacturing, testing, or inspection of the equipment is in progress.

4.1.4 The vendor shall notify subvendors of the purchaser's inspection and testing requirements.

4.1.5 The vendor shall provide sufficient advance notice to the purchaser before conducting any inspection or test that the purchaser desires to be witnessed or observed.

4.1.5.1 When shop inspection and testing have been specified by the purchaser, the purchaser and the vendor shall meet to coordinate manufacturing hold points and inspectors' visits.

4.1.5.2 *Witnessed* means that a hold shall be applied to the production schedule and that the inspection or test shall be carried out with the purchaser or his representative in attendance. For mechanical running or performance tests, this requires written notification of a successful preliminary test.

4.1.5.3 *Observed* means that the purchaser shall be notified of the timing of the inspection or test; however, the inspection or test shall be performed as scheduled, and if the purchaser or his representative is not present, the vendor shall proceed to the next step.

Note: The purchaser should expect to be in the factory longer than for a witnessed test.

4.1.6 Equipment for the specified inspection and Tests shall be provided by the vendor.

4.1.7 The purchaser's representative shall have access to the vendor's quality program for review.

4.2 Inspection

4.2.1 GENERAL

4.2.1.1 The vendor shall keep the following data available for for at least twenty years for examination or reproduction by the purchaser or his representative upon request.

- a. When specified, necessary certification of materials, such as mill test reports.
  b. Test data to verify that the requirements of the specification are being met.
  c. Results of documented tests and inspections, including fully identified records of all heat treatment and radiography.
- d. When specified, final-assembly maintenance and running clearances.

4.2.1.2 Pressure-containing parts shall not be painted until the specified inspection of the parts is completed.

- **4.2.1.3** In addition to the requirements of 2.9.4.1, the purchaser may specify the following:

  a. Parts that shall be subjected to surface and subsurface examination.
  b. The type of examination required, such as magnetic particle, liquid penetrant, radiographic, and ultrasonic examination.

4.2.2 MATERIAL INSPECTION

- **4.2.2.1 General**

When radiographic, ultrasonic, magnetic particle or liquid penetrant inspection of welds or materials is required or

specified, the criteria in 4.2.2.2 through 4.2.2.5 shall apply unless other criteria are specified by the purchaser. Cast iron may be inspected in accordance with 4.2.2.4 and 4.2.2.5. Welds, cast steel, and wrought material may be inspected in accordance with 4.2.2.2 through 4.2.2.5.

4.2.2.2 Radiography

4.2.2.2.1 Radiography shall be in accordance with ASTM E 94 and ASTM E 142.

4.2.2.2.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, UW-51 (100 percent) and UW-52 (spot), of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

4.2.2.3 Ultrasonic Inspection

4.2.2.3.1 Ultrasonic inspection shall be in accordance with Section V, Articles 5 and 23, of the ASME Code.

4.2.2.3.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 12, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendix 7, of the ASME Code.

4.2.2.4 Magnetic Particle Inspection

4.2.2.4.1 Both wet and dry methods of magnetic particle inspection shall be in accordance with ASTM E 709.

4.2.2.4.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 6 and Section V, Article 25, of the ASME Code. The acceptability of defects in castings shall be based on a comparison with the photographs in ASTM E 125. For each type of defect, the degree of severity shall not exceed the limits specified in Table 2.

Table 2—Maximum Severity of Defects in Castings

Type	Defect	Maximum Severity Level
I	Linear discontinuities	1
II	Shrinkage	2
III	Inclusions	2
IV	Chills and chaplets	1
V	Porosity	1
VI	Welds	1

4.2.2.5 Liquid Penetrant Inspection

4.2.2.5.1 Liquid penetrant inspection shall be in accordance with Section V, Article 6, of the ASME Code.

4.2.2.5.2 The acceptance standard used for welded fabrications shall be Section VIII, Division 1, Appendix 8 and Section V, Article 24, of the ASME Code. The acceptance standard used for castings shall be Section VIII, Division 1, Appendices 7 and 24, of the ASME Code.

Note: Regardless of the generalized limits in 4.2.2, it shall be the vendor's responsibility to review the design limits of the equipment in the event that more stringent requirements are necessary. Defects that exceed the limits imposed in 4.2.2 shall be removed to meet the quality standards cited, as determined by the inspection method specified.

4.2.3 MECHANICAL INSPECTION

4.2.3.1 During assembly of the equipment and before testing, each component (including cast-in passages of these components) and all piping and appurtenances shall be cleaned chemically or by another appropriate method to remove foreign materials, corrosion products, and mill scale.

4.2.3.2 Any portion of the oil system furnished shall meet the cleanliness requirements of API Standard 614.

● **4.2.3.3** When specified, the purchaser may inspect for cleanliness the equipment and all piping and appurtenances furnished by or through the vendor before heads are welded to vessels, openings in vessels or exchangers are closed, or piping is finally assembled.

● **4.2.3.4** When specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing of the parts, welds, or heat-affected zones. The method, extent, documentation, and witnessing of the testing shall be mutually agreed upon by the purchaser and the vendor.

4.3 Tests

4.3.1 TESTING

4.3.1.1 Equipment shall be tested in accordance with 4.3.2 and 4.3.3. Other tests that may be specified are described in 4.3.4.

4.3.1.2 At least six weeks before the first scheduled running test, or at some mutually agreed upon time, the vendor shall submit for the purchaser's review and comment detailed procedures for the mechanical running test and all specified running optional tests (4.3.4), including acceptance criteria for all monitored parameters.

4.3.1.3 The vendor shall notify the purchaser not less than five working days before the date the equipment will be ready for testing. If the testing is rescheduled, the vendor shall notify the purchaser not less than five working days before the new test date.

4.3.2 HYDROSTATIC TEST

4.3.2.1 Pressure-containing parts (including auxiliaries) shall be tested hydrostatically with liquid at a minimum of 1½ times the maximum allowable working pressure but not less than gauge pressure of 1.5 bar (20 psig). The test liquid shall be at a higher temperature than the nil- ductility transition temperature of the material being tested.

4.3.2.2 If the part tested is to operate at a temperature at which the strength of a material is below the strength of the material at room temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at room temperature by that at operating temperature. The stress values used shall conform to those given in ASME B31.3 for piping or in Section VIII, Division 1, of the ASME Code for vessels. The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed. The data sheet shall list actual hydrostatic test pressures.

4.3.2.3 Where applicable, tests shall be in accordance with the ASME Code. In the event that a discrepancy exists between the code test pressure and the test pressure in this standard, the higher pressure shall govern.

4.3.2.4 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 parts per million. To prevent deposition of chlorides as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

4.3.2.5 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the casing or casing joint is observed for a minimum of 30 minutes. Large, heavy castings may require a longer testing period to be agreed upon by the purchaser and the vendor. Seepage past internal closures required for testing of segmented cases and operation of a test pump to maintain pressure are acceptable.

4.3.3 MECHANICAL RUNNING TEST

The vendor shall conduct a standard mechanical running test on all pumps to ensure satisfactory operation at the specified operating conditions. Such tests need not be performed with the specified liquid nor at the specified conditions.

4.3.4 OPTIONAL TESTS

● 4.3.4.1 Performance Test

When specified, the vendor shall operate the complete pump in his shop for a sufficient period to obtain complete test data, including speed, discharge pressure, suction pressure, efficiency, capacity, and power.

Tests apply to the pump only, and the values of power and efficiency shall be taken as referring to the pump. The recorded data and final report may, however, include information on the complete unit, including the driver and auxiliary equipment.

Note: If dismantling is necessary to correct pump deficiencies, the pump characteristics affected by the correction shall be reestablished by test.

4.3.4.2 Test Tolerances

When operated on the test stand, pumps shall be within the following tolerances of the rated characteristics or the test equivalent:

Characteristic	Tolerance (Percent)
Capacity	
@ 100 % speed	+3.0, -0 of rated capacity
@ 90 % speed	+3.3, -0 of rated capacity
@ 60 % speed	+5.0, -0 of rated capacity
@ 30 % speed	+10.0, -0 of rated capacity
Rated power (at rated pressure and capacity)	+0
NPSHR (at rated capacity)	+0

● 4.3.4.3 NPSH Test

When specified, the pump shall be tested for NPSH. At rated speed and with NPSHA equal to quoted NPSHR, the pump capacity shall be within three percent of the noncavitating capacity.

4.3.5 TEST DATA

Immediately upon completion of each witnessed mechanical and performance test, copies of the data logged shall be given to the witness.

4.4 Preparation For Shipment

4.4.1 Equipment shall be suitably prepared for the type of shipment specified. The preparation shall make the equipment suitable for six months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser will consult with the vendor regarding the recommended procedures to be followed.

4.4.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before startup.

4.4.3 The equipment shall be prepared for shipment after all testing and inspection have been completed and the equipment has been released by purchaser. The preparation shall include that specified in 4.4.3.1 through 4.4.3.9.

4.4.3.1 Exterior surfaces, except for machined surfaces, shall be given at least one coat of the manufacturer's standard nonlead and nonchromate paint.

4.4.3.2 Exterior machined surfaces, except for corrosion-resistant material, shall be coated with a suitable rust preventive.

4.4.3.3 The interior of the equipment shall be clean; free from scale, welding spatter, and foreign objects; and sprayed or flushed with a suitable rust preventive that can be removed with solvent.

4.4.3.4 Internal steel areas of bearing housings and carbon steel oil systems' auxiliary equipment such as reservoirs, vessels, and piping shall be coated with a suitable oil-soluble rust preventive.

4.4.3.5 Flanged openings shall be provided with metal closures at least 5 mm (3⁄16-inch) thick, with elastomeric gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be used to secure closures Each opening shall be car sealed so that the protective cover cannot be removed without the seal being broken.

4.4.3.6 Threaded openings shall be provided with steel caps or round-head steel plugs. In no case shall nonmetallic (such as plastic) caps or plugs be used.

Note: There are shipping plugs. Permanent plugs are covered in 2.3.5.

4.4.3.7 Lifting points and lifting lugs shall be clearly identified on the equipment or the equipment package. The recommended lifting arrangement shall be identified on the boxed equipment.

4.4.3.8 The equipment shall be identified with item and serial numbers. Material shipped separately shall identified with securely affixed corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. In addition, crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

4.4.3.9 Exposed shafts and shaft couplings shall be wrapped with waterproof, moldable waxed cloth or volatile-corrosion-inhibitor paper. The seams shall be sealed with oil-proof adhesive tape.

4.4.4 Auxiliary piping connections furnished on the purchased equipment shall be impression-stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing. Service and connection designations shall be indicated.

4.4.5 Bearing assemblies shall be fully protected from the entry of moisture and dirt. If vapor-phase-inhibitor crystals in bags are installed in large cavities to absorb moisture, the bags must be attached in an accessible area for ease of removal. Where applicable, bags shall be installed in wire cages attached to flanged covers, and bag locations shall be indicated by corrosion-resistant tags attached with stainless steel wire.

4.4.6 One copy of the manufacturer's standard installation instructions shall be packed and shipped with the equipment.

4.4.7 Connections on auxiliary piping removed for shipment shall be match marked for ease of reassembly.

SECTION 5—VENDOR'S DATA

5.1 General

5.1.1 The information to be furnished by the vendor is specified in 5.2 and 5.3. The vendor shall complete and forward the Vendor Drawing and Data Requirements (VDDR) form (see Appendix D) to the address(es) noted on the inquiry or order. This form shall detail the schedule for transmission of drawings, curves, and data as agreed to at the time of the proposal or order as well as the number and type of copies required by the purchaser.

5.1.2 The data shall be identified on the transmittal (cover) letters and in the title blocks or title pages with the following information:

a. The purchaser/user's corporate name.

b. The job/project number.

c. The equipment item number and service name.

d. The inquiry or purchase order number.

e. Any other identification specified in the inquiry or purchase order.

f. The vendor's identifying proposal number, shop order number, serial number, or other reference required to completely identify return correspondence.

5.2 Proposals

5.2.1 GENERAL

The vendor shall forward the original and the specified number of copies of the proposal to the addressee stated on

the inquiry documents. This proposal shall contain as a minimum the data specified in 5.2.2 through 5.2.4, and a specific statement that the system and all its components are in strict accordance with this standard. If the system and components are not in strict accordance, the vendor shall include a specific list that details and explains each deviation. The vendor shall provide details to evaluate any alternative designs proposed. All correspondence shall be clearly identified per 5.1.2.

5.2.2 DRAWINGS

The drawings described on the VDDR form shall be included. As a minimum, the data shown in 5.2.2.1 through 5.2.2.4 shall be furnished.

5.2.2.1 A general arrangement or outline drawing for each major skid or system showing overall dimensions, maintenance clearance dimensions, overall weights, erection weights, and maximum maintenance weights (indicate piece). Direction of rotation and size and location of major purchaser connections shall also be indicated.

5.2.2.2 Cross-sectional drawing(s) showing details of the proposed equipment.

5.2.2.3 Schematics of all auxiliary systems. Include B/Ms.

5.2.2.4 Sketches indicating methods of lifting the assembled machine(s) and major components (can be part of 5.2.2.1).

Note: If "typical" drawings, schematics and B/Ms are used, they shall be marked up to show correct weight and dimension data, and to reflect the actual equipment and scope proposed.

5.2.3 TECHNICAL DATA

The data described below shall be included:

a. The purchaser's data sheets with complete vendor information entered thereon and literature to fully describe details of the offering.
b. The purchaser's noise data sheet or the form from the appendix of API Standard 615.
c. The VDDR form (see Appendix D) with a schedule for transmission of all data specified as part of the contract.
d. A schedule for shipment of the equipment in weeks after receipt of the order.
e. A list of major wearing components showing interchangeability with other purchase units.
f. Spare parts recommended for startup and normal maintenance purposes .
g. A list of special tools furnished for maintenance, with identification of any metric items included in the offering.
h. A statement of any special weather protection and winterization required for startup, operation, and periods of idleness under the various site conditions specified on the data sheets. (The list should show the protection required to be furnished by the purchaser, as well as that included in the vendor's scope of supply.)
i. Complete tabulation of utility requirements such as steam, water, electricity, air, gas, and lube oil. (Approximate data shall be defined and clearly identified as such.)
j. A description of the tests and inspection procedures for materials as required by 2.9.1.3.
k. A description of special requirements, as outlined in paragraphs 2.3.6.4, 2.9.1.2, 2.9.2.5, 2.9.4.2, 3.3.2.3, 3.4.1, 4.4.1, and any others in purchaser's inquiry.
l. A list of similar machines installed and operating under analogous conditions to that proposed.
m. Any startup, shutdown, or operating restrictions required to protect the integrity of the equipment.

5.2.4 CURVES

The vendor shall provide complete performance curves or tables to encompass the map of operations, with any limitations indicated thereon.

5.2.5 OPTIONS

The vendor shall furnish procedures for any special or optional tests.

5.3 Contract Data

5.3.1 GENERAL

5.3.1.1 The contract information to be furnished by the vendor is specified in Appendix D. Each drawing, B/M or data sheet shall have a title block in the lower right hand corner with date of certification, reference to all identification data specified in 5.1.2, revision number and date, and title.

5.3.1.2 The purchaser will promptly review the vendor's data when received; however, this review shall not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing. After the data has been reviewed, the vendor shall furnish certified copies in the quantity specified.

5.3.1.3 A complete list of all vendor data shall be included with the first issue of major drawings. This list will contain titles, drawing numbers, and a schedule for transmission of all data the vendor will furnish. See Appendix D.

5.3.2 DRAWINGS

The drawings furnished shall contain sufficient information so that with the drawings and the manuals specified in 5.3.6, the purchaser can properly install, operate, and maintain the ordered equipment. Drawings shall be clearly legible, shall be identified in accordance with 5.3.1.1, and shall be in accordance with ASME Y14.2M. As a minimum, the drawings shall include the details for that drawing listed in Appendix D.

5.3.3 TECHNICAL DATA

The data shall be submitted in accordance with Appendix D and identified in accordance with 5.3.1.1. Any comments on the drawings or revisions of specifications that necessitate a change in the data shall be noted by the vendor.

Note: These notations will result in the purchaser's reissue of completed, corrected data sheets as part of the order specifications.

5.3.4 PROGRESS REPORTS

The vendor shall submit progress reports to the purchaser at the interval specified on the VDDR form. (See Appendix D.)

5.3.5 PARTS LISTS AND RECOMMENDED SPARES

5.3.5.1 The vendor shall submit complete parts lists for all equipment and accessories supplied. The lists shall include manufacturer's unique part numbers, materials of construction and delivery times. Materials shall be identified as specified in 2.9.1.2. Each part shall be completely identified and shown on cross-sectional or assembly-type drawings so that the purchaser may determine the interchangeability of the part with other equipment. Parts that have been modified from standard dimensions and/or finish to satisfy specific performance requirements shall be uniquely identified by part number for interchangeability and future duplication purposes. Standard purchased items shall be identified by the original manufacturer's name and part number.

5.3.5.2 The vendor shall indicate on the above parts lists which parts are recommended spares for startup and which parts are recommended for normal maintenance (see Item f of 5.2.3). The vendor shall forward the lists to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of the parts before field startup. The transmittal letter shall be identified with the data specified in 5.1.2.

5.3.6 INSTALLATION, OPERATION, MAINTENANCE AND TECHNICAL DATA MANUALS

5.3.6.1 General

The vendor shall provide sufficient written instructions and a list of all drawings to enable the purchaser to correctly install, operate, and maintain all of the equipment ordered. This information shall be compiled in a manual or manuals with a cover sheet that contains all reference- identifying data specified in 5.1.2, an index sheet that contains section titles, and a complete list of referenced and enclosed drawings by title and drawing number. The manual shall be prepared for the specified installation; a typical manual is not acceptable.

5.3.6.2 Installation Manual

Any special information required for proper installation design that is not on the drawings shall be compiled in a manual that is separate from operating and maintenance instructions. This manual shall be forwarded at a time that is mutually agreed upon in the order, but not later than the final issue of prints. The manual shall contain information such as special alignment or grouting procedures, utility specifications (including quantities), and all other installation design data, including any pertinent drawings and data specified in 5.2.2 and 5.2.3. The manual shall also include sketches that show the location of center of gravity and rigging provisions to permit the removal of the top half of the casings, rotors, and any subassemblies that weigh more than 136 kilograms (300 pounds).

5.3.6.3 Operating and Maintenance Manual

The manual containing operating and maintenance data shall be forwarded no later than two weeks after the successful completion of all specified tests. The manual shall include a section to cover special instructions for operations at specified extreme environmental conditions, such as temperatures. In addition, as a minimum, it shall include all data shown in Appendix D.

5.3.7 TECHNICAL DATA MANUAL

When specified, the vendor shall provide a technical data manual to the purchaser within 30 days of completion of shop testing. See Appendix D for detail requirements.

APPENDIX A –ROTARY PUMP DATA SHEETS

ROTARY PUMP DATA SHEET
SI UNITS

PAGE _____ OF _____
JOB NO. _____ ITEM NO. _____
PURCH. ORDER NO. _____ DATE _____
INQUIRY NO. _____ BY _____
REVISION _____ DATE _____

APPLICABLE TO: ○ PROPOSAL ○ PURCHASE ○ AS BUILT
FOR _____ UNIT _____
SITE _____ NO. OF PUMPS REQUIRED _____
SERVICE _____ SIZE AND TYPE _____
MANUFACTURER _____ SERIAL NO. _____
NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER

GENERAL

NO. MOTOR DRIVEN		OTHER DRIVER TYPE			
PUMP ITEM NO'S		PUMP ITEM NO'S			
MOTOR ITEM NO'S		DRIVER ITEM NO'S		GEAR ITEM NO'S	
MOTOR PROVIDED BY		DRIVER PROVIDED BY		GEAR PROVIDED BY	
MOTOR MOUNTED BY		DRIVER MOUNTED BY		GEAR MOUNTED BY	
MOTOR DATA SHEET NO.		DRIVER DATA SHEET NO.		GEAR DATA SHEET NO.	

○ OPERATING CONDITIONS

○ CAPACITY @ PT (m³/h):
@ MAXIMUM VISCOSITY _____ @ MINIMUM VISCOSITY _____
○ DISCHARGE PRESSURE (kPa)(BARG):
MAXIMUM _____ MINIMUM _____
○ SUCTION PRESSURE (kPa)(BARG):
MAXIMUM _____ MINIMUM _____
○ DIFFERENTIAL PRESSURE (kPa)(BARG):
MAXIMUM _____ MINIMUM _____
○ NPSH AVAILABLE (m) _____
○ HYDRAULIC kW _____

☐ PERFORMANCE

☐ RATED CAPACITY (m³/h) _____
☐ NPSH REQUIRED (m) _____
☐ RATED SPEED (RPM) _____
☐ DISPLACEMENT (m³/h) _____
☐ VOLUMETRIC EFFICIENCY (%) _____
☐ MECHANICAL EFFICIENCY (%) _____
☐ kW @ MAXIMUM VISCOSITY _____
☐ kW @ RELIEF VALVE SETTING _____
☐ MAXIMUM ALLOWABLE SPEED (RPM) _____
☐ MINIMUM ALLOWABLE SPEED (RPM) _____

☐ CONSTRUCTION

CONNECTIONS	SIZE	ANSI RATING	FACING	POSITION
SUCTION				
DISCHARGE				
GLAND FLUSH				
DRAINS				
VENTS				
JACKET				

PUMP TYPE:
☐ INTERNAL GEAR ☐ TWIN-SCREW ☐ VANE
☐ EXTERNAL GEAR ☐ THREE-SCREW ☐ PROGRESSING CAVITY
GEAR TYPE
☐ SPUR ☐ HELICAL
☐ OTHER _____

○ LIQUID

○ TYPE OR NAME OF LIQUID _____
○ PUMPING TEMPERATURE (°C):
NORMAL _____ MAXIMUM _____ MINIMUM _____
○ SPECIFIC GRAVITY _____ MAXIMUM _____ MINIMUM _____
○ SPECIFIC HEAT _____ Cp (kJ/kg°C)
○ VISCOSITY (Cp) _____ MINIMUM _____ MAXIMUM
○ CORROSIVE/EROSIVE AGENTS _____
○ CHLORIDE CONCENTRATION (PPM) _____
○ H_2S CONCENTRATION (PPM) _____
LIQUID ○ TOXIC ○ FLAMMABLE ○ OTHER _____

○ SITE AND UTILITY DATA

LOCATION ○ INDOOR ○ OUTDOOR
○ HEATED ○ UNHEATED ○ UNDER ROOF
○ ELECTRICAL AREA CLASS _____ GROUP _____ DIV _____
○ WINTERIZATION REQD ○ TROPICALIZATION REQD
SITE DATA
○ RANGE OF AMBIENT TEMPS: MIN/MAX _____/_____ °C
UNUSUAL CONDITIONS
○ DUST ○ FUMES ○ SALT ATMOSPHERE
○ OTHER _____
○ UTILITY CONDITIONS

ELECTRICITY	DRIVERS	HEATING	CONTROL	SHUTDOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER	INLET	RETURN	DESIGN	MAX Δ
TEMP °C		MAX		
PRESS. (kPa)(BARG)		MIN		
SOURCE				

INSTRUMENT AIR MAX MIN
PRESSURE (kPa)(BARG) _____ _____

APPLICABLE SPECIFICATIONS:

API 676 POSITIVE DISPLACEMENT PUMPS - ROTARY
○ GOVERNING SPECIFICATION (IF DIFFERENT) _____
REMARKS: _____

PRINTED IN U.S.A. DS-676-1SI 5/93

PAGE _____ OF _____

ROTARY PUMP DATA SHEET
SI UNITS

JOB NO. _____ ITEM NO. _____
REVISION _____ DATE _____
BY _____

CONSTRUCTION (CONTINUED)

CASING
- ☐ MAXIMUM ALLOWABLE PRESSURE: _____ (kPa)(BARG) @ _____ °C
- ☐ HYDROSTATIC TEST PRESSURE: _____ (kPa)(BARG)
- ☐ STEAM JACKET PRESSURE: _____ (kPa)(BARG) @ _____ °C

ROTOR MOUNT ☐ BETWEEN BEARINGS ☐ OVERHUNG
TIMING GEARS ☐ YES ☐ NO
BEARING TYPE: ☐ RADIAL _____ ☐ THRUST _____
LUBRICATION TYPE: ○ CONSTANT LEVEL OILERS
☐ PUMPED FLUID ☐ RING OIL ☐ OIL MIST
☐ EXTERNAL ☐ OIL FLOOD ☐ GREASE
☐ LUBRICANT TYPE _____
○ MECHANICAL SEALS
- ☐ MANUFACTURER AND MODEL _____
- ☐ MANUFACTURER CODE _____

○ API 610 SEAL FLUSH PLAN _____
☐ API 610 SEAL CODE _____
○ PACKING: ○ LANTERN RING
☐ MANUFACTURER AND TYPE _____ ☐ NO. OF RINGS _____

DRIVE MECHANISM

○ DIRECT-COUPLED ○ V-BELT ☐ GEAR
☐ COUPLING MANUFACTURER _____

DRIVERS

○ MOTOR:
- ☐ MANUFACTURER _____
- ☐ TYPE _____
- ☐ FRAME NO. _____
- ○ CONSTANT SPEED _____
- ○ VARIABLE SPEED _____
- ☐ kW _____ RPM _____
- ○ VOLTS _____ PHASE _____
- ○ HERTZ _____ SERVICE FACTOR _____
- ○ ENCLOSURE _____
- ○ _____

○ STEAM TURBINE
○ OTHER (SEE SEPARATE DATA SHEETS) _____

OTHER PURCHASER REQUIREMENTS

NAMEPLATE UNITS ○ CUSTOMARY ○ SI
○ RELIEF VALVES BY PUMP MFGR ○ INTERNAL ○ EXTERNAL
PIPING FOR SEAL FLUSH FURNISHED BY:
○ PUMP VENDOR ○ OTHERS
PIPING FOR COOLING/HEATING FURNISHED BY:
○ PUMP VENDOR ○ OTHERS
○ PROVIDE TECHNICAL DATA MANUAL

MATERIALS

- ☐ CASING _____
- ☐ STATOR _____
- ☐ END PLATES _____
- ☐ ROTOR(S) _____
- ☐ VANES _____
- ☐ SHAFT _____
- ☐ SLEEVE(S) _____
- ☐ GLAND(S) _____
- ☐ BEARING HOUSING _____
- ☐ TIMING GEARS _____
- ○ SPECIAL MATERIAL TESTS (2.9.1.3) _____
- ○ LOW AMBIENT TEMP. MATERIALS TESTS (2.9.5)

QA INSPECTION AND TEST

- ○ COMPLIANCE WITH INSPECTORS CHECK LIST
- ○ CERTIFICATION OF MATERIALS
- ○ FINAL ASSEMBLY CLEARANCES
- ○ SURFACE AND SUBSURFACE EXAMINATIONS
  - ○ RADIOGRAPHY _____
  - ○ ULTRASONIC _____
  - ○ MAGNETIC PARTICLE _____
  - ○ LIQUID PENETRANT _____
- ○ CLEANLINESS PRIOR TO FINAL ASSEMBLY
- ○ HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES
- ○ FURNISH PROCEDURES FOR OPTIONAL TESTS

TESTS	REQ'D	WIT	OBS
HYDROSTATIC	●	○	○
MECHANICAL RUN	●	○	○
PERFORMANCE	○	○	○
NPSH	○	○	○

PREPARATION FOR SHIPMENT

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQD.
○ OUTDOOR STORAGE MORE THAN 6 MONTHS

WEIGHTS (LBS)

☐ PUMP _____ ☐ BASE _____ ☐ GEAR _____ ☐ DRIVER _____

BASEPLATE

○ BY PUMP MANUFACTURER ○ SUITABLE FOR EPOXY GROUT
○ EXTENDED FOR _____
○ SUBSOLE PLATES BY PUMP MANUFACTURER
○ DRAIN-RIM ○ DRAIN-PAN

REMARKS _____

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PAGE _____ OF _____

ROTARY PUMP DATA SHEET
CUSTOMARY UNITS

JOB NO. _____ ITEM NO. _____
PURCH. ORDER NO. _____ DATE _____
INQUIRY NO. _____ BY _____
REVISION _____ DATE _____

APPLICABLE TO: O PROPOSAL O PURCHASE O AS BUILT

FOR _____ UNIT _____
SITE _____ NO. OF PUMPS REQUIRED _____
SERVICE _____ SIZE AND TYPE _____
MANUFACTURER _____ SERIAL NO. _____

NOTE: O INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER

GENERAL

NO. MOTOR DRIVEN		OTHER DRIVER TYPE			
PUMP ITEM NO'S		PUMP ITEM NO'S			
MOTOR ITEM NO'S		DRIVER ITEM NO'S		GEAR ITEM NO'S	
MOTOR PROVIDED BY		DRIVER PROVIDED BY		GEAR PROVIDED BY	
MOTOR MOUNTED BY		DRIVER MOUNTED BY		GEAR MOUNTED BY	
MOTOR DATA SHEET NO.		DRIVER DATA SHEET NO.		GEAR DATA SHEET NO.	

O OPERATING CONDITIONS

O CAPACITY @ PT (GPM):
@ MAXIMUM VISCOSITY _____ @ MINIMUM VISCOSITY _____
O DISCHARGE PRESSURE (PSIG):
MAXIMUM _____ MINIMUM _____
O SUCTION PRESSURE (PSIG):
MAXIMUM _____ MINIMUM _____
O DIFFERENTIAL PRESSURE (PSI):
MAXIMUM _____ MINIMUM _____
O NPSH AVAILABLE (FT.) _____
O HYDRAULIC HP _____

☐ PERFORMANCE

☐ RATED CAPACITY (GPM) _____
☐ NPSH REQUIRED (FT.) _____
☐ RATED SPEED (RPM) _____
☐ DISPLACEMENT (GPM) _____
☐ VOLUMETRIC EFFICIENCY (%) _____
☐ MECHANICAL EFFICIENCY (%) _____
☐ BHP @ MAXIMUM VISCOSITY _____
☐ BHP @ RELIEF VALVE SETTING _____
☐ MAXIMUM ALLOWABLE SPEED (RPM) _____
☐ MINIMUM ALLOWABLE SPEED (RPM) _____

☐ CONSTRUCTION

CONNECTIONS	SIZE	ANSI RATING	FACING	POSITION
SUCTION				
DISCHARGE				
GLAND FLUSH				
DRAINS				
VENTS				
JACKET				

PUMP TYPE:
☐ INTERNAL GEAR ☐ TWIN-SCREW ☐ VANE
☐ EXTERNAL GEAR ☐ THREE-SCREW ☐ PROGRESSING CAVITY
GEAR TYPE
☐ SPUR ☐ HELICAL
☐ OTHER _____

O LIQUID

O TYPE OR NAME OF LIQUID _____
O PUMPING TEMPERATURE (°F):
NORMAL _____ MAXIMUM _____ MINIMUM _____
O SPECIFIC GRAVITY _____ MAXIMUM _____ MINIMUM _____
O SPECIFIC HEAT _____ Cp (BTU/lb °F)
O VISCOSITY (Cp) _____ MINIMUM _____ MAXIMUM
O CORROSIVE/EROSIVE AGENTS _____
O CHLORIDE CONCENTRATION (PPM) _____
O H_2S CONCENTRATION (PPM) _____
LIQUID O TOXIC O FLAMMABLE O OTHER _____

O SITE AND UTILITY DATA

LOCATION O INDOOR O OUTDOOR
O HEATED O UNHEATED O UNDER ROOF
O ELECTRICAL AREA CLASS ____ GROUP ____ DIV ____
O WINTERIZATION REQD O TROPICALIZATION REQD
SITE DATA
O RANGE OF AMBIENT TEMPS: MIN/MAX ____/____ °F
UNUSUAL CONDITIONS
O DUST O FUMES O SALT ATMOSPHERE
O OTHER _____
O UTILITY CONDITIONS

ELECTRICITY	DRIVERS	HEATING	CONTROL	SHUTDOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER	INLET	RETURN	DESIGN	MAX Δ
TEMP °F		MAX		
PRESS. (PSIG)		MIN		
SOURCE				

INSTRUMENT AIR	MAX	MIN
PRESSURE (PSIG)		

APPLICABLE SPECIFICATIONS:

API 676 POSITIVE DISPLACEMENT PUMPS - ROTARY
O GOVERNING SPECIFICATION (IF DIFFERENT) _____
REMARKS: _____

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ROTARY PUMP DATA SHEET
CUSTOMARY UNITS

PAGE _____ OF _____
JOB NO. _____ ITEM NO. _____
REVISION _____ DATE _____
BY _____

CONSTRUCTION (CONTINUED)

CASING
- ☐ MAXIMUM ALLOWABLE PRESSURE: _____ PSIG @ _____ °F
- ☐ HYDROSTATIC TEST PRESSURE: _____ PSIG
- ☐ STEAM JACKET PRESSURE: _____ PSIG @ _____ °F

ROTOR MOUNT ☐ BETWEEN BEARINGS ☐ OVERHUNG
TIMING GEARS ☐ YES ☐ NO
BEARING TYPE: ☐ RADIAL _____ ☐ THRUST _____
LUBRICATION TYPE: ○ CONSTANT LEVEL OILERS
☐ PUMPED FLUID ☐ RING OIL ☐ OIL MIST
☐ EXTERNAL ☐ OIL FLOOD ☐ GREASE

- ☐ LUBRICANT TYPE _____
- ○ MECHANICAL SEALS
  - ☐ MANUFACTURER AND MODEL _____
  - ☐ MANUFACTURER CODE _____
- ○ API 610 SEAL FLUSH PLAN _____
- ☐ API 610 SEAL CODE _____
- ○ PACKING: ○ LANTERN RING
  - ☐ MANUFACTURER AND TYPE _____ ☐ NO. OF RINGS _____

DRIVE MECHANISM

○ DIRECT-COUPLED ○ V-BELT ☐ GEAR
☐ COUPLING MANUFACTURER _____

DRIVERS

- ○ MOTOR:
- ☐ MANUFACTURER _____
- ☐ TYPE _____
- ☐ FRAME NO. _____
- ○ CONSTANT SPEED _____
- ○ VARIABLE SPEED _____
- ☐ kW _____ RPM _____
- ○ VOLTS _____ PHASE _____
- ○ HERTZ _____ SERVICE FACTOR _____
- ○ ENCLOSURE _____
- ○ _____
- ○ STEAM TURBINE
- ○ OTHER (SEE SEPARATE DATA SHEETS) _____

OTHER PURCHASER REQUIREMENTS

NAMEPLATE UNITS ○ CUSTOMARY ○ SI
○ RELIEF VALVES BY PUMP MFGR ○ INTERNAL ○ EXTERNAL
PIPING FOR SEAL FLUSH FURNISHED BY:
○ PUMP VENDOR ○ OTHERS
PIPING FOR COOLING/HEATING FURNISHED BY:
○ PUMP VENDOR ○ OTHERS
○ PROVIDE TECHNICAL DATA MANUAL

MATERIALS

- ☐ CASING _____
- ☐ STATOR _____
- ☐ END PLATES _____
- ☐ ROTOR(S) _____
- ☐ VANES _____
- ☐ SHAFT _____
- ☐ SLEEVE(S) _____
- ☐ GLAND(S) _____
- ☐ BEARING HOUSING _____
- ☐ TIMING GEARS _____
- ○ SPECIAL MATERIAL TESTS (2.9.1.3) _____
- ○ LOW AMBIENT TEMP. MATERIALS TESTS (2.9.5)

QA INSPECTION AND TEST

- ○ COMPLIANCE WITH INSPECTORS CHECK LIST
- ○ CERTIFICATION OF MATERIALS
- ○ FINAL ASSEMBLY CLEARANCES
- ○ SURFACE AND SUBSURFACE EXAMINATIONS
  - ○ RADIOGRAPHY _____
  - ○ ULTRASONIC _____
  - ○ MAGNETIC PARTICLE _____
  - ○ LIQUID PENETRANT _____
- ○ CLEANLINESS PRIOR TO FINAL ASSEMBLY
- ○ HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES
- ○ FURNISH PROCEDURES FOR OPTIONAL TESTS

TESTS	REQ'D	WIT	OBS
HYDROSTATIC	●	○	○
MECHANICAL RUN	●	○	○
PERFORMANCE	○	○	○
NPSH	○	○	○

PREPARATION FOR SHIPMENT

○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQD.
○ OUTDOOR STORAGE MORE THAN 6 MONTHS

WEIGHTS (LBS)

☐ PUMP _____ ☐ BASE _____ ☐ GEAR _____ ☐ DRIVER _____

BASEPLATE

○ BY PUMP MANUFACTURER ○ SUITABLE FOR EPOXY GROUT
○ EXTENDED FOR _____
○ SUBSOLE PLATES BY PUMP MANUFACTURER
○ DRAIN-RIM ○ DRAIN-PAN

REMARKS _____

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APPENDIX B—MATERIAL SPECIFICATIONS FOR MAJOR COMPONENT PARTS AND LIST OF MISCELLANEOUS MATERIALS

Table B-1 — Material Specifications for Rotary Pump Parts[a]

Material	Castings	Forgings	Bar Stock	Bolts and Studs
Cast iron	ASTM A 278 or A 48	—	—	—
Nodular iron	ASTM A 395 or	—	—	—
Carbon Steel	ASTM A 216, Grade WCA or WCB	ASTM A 105	ASTM A 576 or A 108	—
Bronze	ASTM B584	—	ASTM B 139	ASTM B 124
5% Chrome steel	ASTM A 217, Grade C5	ASTM A 182, Grade F5	—	—
12% Chrome steel	ASTM A 296, Grade CA6NM or CA15	ASTM A 182, Grade F6	ASTM A276, Type 410, or ASTM A 582, Type 416	ASTM A 193, Grade B6
18–8 Stainless steel	ASTM A 296, Grade CF20	ASTM A 182, Grade F304	ASTM A 276, Type 304	ASTM A 193, Grade B8
316 Stainless steel	ASTM A 296, Grade CF8M	ASTM A 182, Grade F316	ASTM A 276, Type 316	ASTM A 193, Grade B8M
AISI 4140 Steel	—	—	ASTM A 322, Grade 4140	ASTM A 193, Grade B7

[a]This table is not to be used as a guide.

Table B-2 — Miscellaneous Materials

Material	Typical Description
Alloy 20	ASTM B 473, UNS 8020 (wrought); ASTM A 744, Grade CN7M (cast)
Babbitt	ASTM B 23, Grades 1-9, as required by vendor for service conditions
Bronze	ASTM B 584, UNS C87200 (silicon bronze) or C92200 (tin bronze); ASTM B 148, UNS C95200 (aluminum bronze) or C95800 (nickel aluminum bronze)
Carbon	Suitable mechanical carbon as recommended for the service conditions
FFKM elastomer	ASTM D 1418 such as Du Pont Kalrez or equal
Fluoroelastomer	Du Pont Viton or equal
Graphite foil	Union Carbide Grafoil or similar material
Hard facing	Stellite (Cabot Corp.), Colomonoy (Wahl-Colomonoy Corp.), Type 3 tungsten carbide, etc.; overlay-weld deposit of 0.8 mm (0.030 inch) minimum finished thickness, or if available, a solid cast part of equal material may be substituted
Type 1 tungsten carbide	As required for service conditions, with cobalt binder (solid part, not overlay)
Type 2 tungsten carbide	As required for service conditions, with nickel binder (solid part, not overlay)
Type 3 tungsten carbide	Sprayed overlay as required for service conditions; minimum finished thickness of 0.8 mm (0.030 inch)
Monel (nickel-copper alloy)	ASTM A 494, Grade M-30C (weldable cast material); ASTM B 164, Class A (wrought material)
Ni-resist	ASTM A 436, Type 1, 2, or 3 (austenitic cast iron); ASTM A 439, Type D2 (austenitic ductile iron)
Nitrile	B.F. Goodrich HYCAR, Buna-N, or equal
Polytetrafluoroethylene (PTFE)	Du Pont Teflon or similar material
Glass-filled PTFE	25-percent glass-filled PTFE
Precipitation-hardening	ASTM A 564, Grade 630 or 631 (wrought); ASTM A 747, stainless steel, Grade CB7C (cast)
Sheet gasket	Long-fiber material with synthetic rubber binder suitable for service conditions or spiral-wound stainless steel and equal gasket material
Silicon carbide	Suitable mechanical silicon carbide as recommended for service conditions

APPENDIX C—INSPECTOR'S CHECKLIST

INSPECTOR'S CHECKLIST

Item	Date Inspected	Inspected By	Status
1. Material certification (2.9.1.2) (4.2.1.1.a)			
2. Nondestructive examination (components) (2.9.1.3)			
3. Welding operators and procedures qualified (2.9.4.1, 2.9.4.3)			
4. Rotation arrow (2.10.2(*))			
5. Equipment nameplate data (2.10.3)			
6. Overall dimensions and connection locations (*)			
7. Nozzle flange dimensions (*)			
8. Anchor bolt layout and size (*)			
9. Shaft and keyway dimensions (*)			
10. Mounting plate precoat for epoxy grout (3.3.1.2.5)			
11. Equipment feet pilot holes (2.2.8)			
12. Relief valve characteristics (3.4.1)			
13. Piping inspection (3.5.1)			
14. Special tools (3.6)			
15. Test documentation (4.2.1.1.c)			
16. Maintenance and clearance data (4.2.2.1.d)			
17. Components inspected for cleanliness (list each) (4.2.3.3)			
18. Hardness testing (4.2.3.4)			
19. Hydrostatic tests (4.3.2)			
20. Mechanical running test (4.3.3)			
21. Performance test (4.3.4.1)			
22. NPSH test (4.3.4.3)			
23. Preparation for shipment (4.4)			
24. Painting (4.4.3.1)			
25. Shipping documents and tags (4.4.3.8)			

(*)Check against certified dimensional outline drawing

APPENDIX D—ROTARY PUMP VENDOR DRAWING AND DATA REQUIREMENTS

ROTARY PUMP VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO _____ ITEM NO _____
PURCHASE ORDER NO _____ DATE _____
REQUISITION NO _____ DATE _____
INQUIRY NO _____ DATE _____
PAGE 1 OF 2 BY _____
FOR _____ REVISION _____
SITE _____ UNIT _____
SERVICE _____ NO REQUIRED _____

Proposal[a] Bidder shall furnish _____ copies of data for all items indicated by an X

Review[b] Vendor shall furnish _____ copies and _____ transparencies of drawings and data indicated.

Final[c] Vendor shall furnish _____ copies and _____ transparencies of drawings and data indicated.
Vendor shall furnish _____ operating and maintenance manuals

DISTRIBUTION RECORD

Final—Received from vendor
Final—Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

			DESCRIPTION					
			1. Certified dimensional outline drawing and list of connections.					
			2. Cross-sectional drawing and bill of materials.					
			3. Rotor assembly drawings and bills of materials.					
			4. Thrust-bearing assembly drawing and bill of materials.					
			5. Journal-bearing assembly drawings and bills of materials.					
			6. Shaft-coupling assembly drawings and bills of materials.					
			7. Lube-oil schematic and bills of materials.					
			8. Electrical and instrumentation schematics and bills of materials.					
			9. Electrical and instrumentation assembly drawings and lists of connections.					
			10. Tabulation of utility requirements.					
			11. Curve showing output-power shaft speed versus torque.					
			12. Allowable flange loadings.					
			13. Coupling alignment diagram.					
			14. Welding procedures.					
			15. Certified hydrostatic test logs.					
			16. Mechanical running test logs.					
			17. Performance test logs.					
			18. Nondestructive test procedures.					
			19. Procedures for special and optional tests (see 4.3.4).					
			20. Certified mill test reports.					
			21. As-built data sheets.					
			22. As-built dimensions and data.					
			23. Installation manual.					
			24. Operating and maintenance manuals.					
			25. Spare-parts recommendations.					
			26. Engineering, fabrication, and delivery schedule (progress reports)					
			27. List of drawings.					
			28. Shipping list.					
			29. List of special tools furnished for maintenance.					
			30. Technical data manual.					
			31. Material Safety Data Sheets.					

[a]Proposal drawings and data do not have to be certified or as built Typical data shall be clearly identified as such
[b]Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form
[c]Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal

ROTARY PUMP VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO _____ ITEM NO _____

PAGE 2 OF 2 BY _____

DATE _____ REVISION _____

Notes:

1. Send all drawings and data to _____

2. All drawings and data must show project, appropriation, purchase order, and item numbers in addition to the plant location and unit. In addition to the copies specified above, one set of the drawings/instructions necessary for field installation must be forwarded with the shipment.

Nomenclature:

_____ S—number of weeks prior to shipment.
_____ F—number of weeks after firm order.
_____ D—number of weeks after receipt of approved drawings.

Vendor _____
Date _____ Vendor Reference _____
Signature _____
(Signature acknowledges receipt of all instructions)

DESCRIPTION

1. Certified dimensional outline drawing and list of connections, including the following:
   a. Size, rating, and location of all customer connections.
   b. Approximate overall handling weights.
   c. Overall dimensions.
   d. Shaft centerline height.
   e. Dimensions of mounting plates (if furnished), complete with diameter, number, and locations of bolt holes and thickness of the metal through which the bolts must pass; centers of gravity; and details for foundation design.

2. Cross-sectional drawing and bill of materials, including the following:
   a. Journal-bearing clearances and tolerances.
   b. Shaft end clearances and tolerances.

3. Rotor assembly drawings and bills of materials, including the following:
   a. Axial position from the active thrust-collar face to
      1. Each journal-bearing centerline.
      2. Coupling face or end of shaft.
   b. Thrust-collar assembly details, including
      1. Collar-shaft, with tolerance.
      2. Concentricity (or axial runout) tolerance.
      3. Required torque for locknut.
      4. Surface finish requirements for collar faces.
      5. Preheat method and temperature requirements for shrunk-on collar installation.
   c. Thrust-bearing assembly drawing and bill of materials.

4. Thrust-bearing assembly drawing and bill of materials.

5. Journal-bearing assembly drawings and bills of materials for all field-maintainable rotors.

6. Shaft-coupling assembly drawings and bills of materials, including the following:
   a. Hydraulic mounting procedure.
   b. Shaft end gap and tolerance.
   c. Coupling guards.

7. Lube-oil schematic and bills of materials, including the following:
   a. Steady-state and transient oil flows and pressures at each use point.
   b. Control, alarm, and trip settings (pressures and recommended temperatures).
   c. Utility requirements, including electricity, water, and air.
   d. Pipe and valve sizes.
   e. Instrumentation, safety devices, and control schemes.

8. Electrical and instrumentation schematics and bills of materials for all systems. The schematics shall show all alarm and shutdown limits (set points).

9. Electrical and instrumentation assembly drawings and lists of connections.

10. Tabulation of utility requirements (may be on as-built purchaser data sheets).

11. Curve showing output-power shaft speed versus torque.

12. Allowable flange loadings for all customer connections, including anticipated thermal movements referenced to a defined point.

13. Coupling alignment diagram, including recommended coupling limits during operation. Note all shaft-end position changes and support growth from a reference ambient temperature of 15°C (59°F) or another temperature specified by the purchaser. Include the recommended alignment method and cold setting targets.

14. Welding procedures for fabrication and repair (see 2.9.1.11, 2.9.2.3.1, 2.9.4.4, 2.9.4.5.4, 3.5.12, and 4.2.2.1).

15. Certified hydrostatic test logs.

16. Mechanical running test logs.

17. Performance test logs and report.

18. Nondestructive test procedures as itemized on the purchase order data sheets or the Vendor Drawing and Data Requirements form.

19. Procedures for any special or optional tests (see 4.3.4).

20. Certified mill test reports of items as agreed upon in the precommitment or preinspection meetings.

21. As-built data sheets.

22. As-built dimensions (including nominal dimensions with design tolerances) and data for the following listed parts:
    a. Shaft or sleeve diameters at
        1. Thrust collar (for separate collars).
        2. Each seal component.
        3. Each journal bearing.
    b. Each labyrinth or seal-ring bore.
    c. Thrust-collar bore (for separate collars).
    d. Each journal-bearing inside diameter.
    e. Thrust-bearing concentricity (axial runout).
    f. Metallurgy and heat treatment for
        1. Shaft.
        2. Rotors.
        3. Thrust collar.

23. Installation manual describing the following (see 5.3.6.2):
    a. Storage procedures.
    b. Foundation plan.
    c. Grouting details.
    d. Setting equipment, rigging procedures, component weights, and lifting diagrams.
    e. Coupling alignment diagram (per item 13 above).

f. Piping recommendations, including allowable flange loads.
g. Composite outline drawings for the driver/driven-equipment train, including anchor-bolt locations.
h. Dismantling clearances.

24. Operating and maintenance manuals describing the following:
    a. Start-up.
    b. Normal shutdown.
    c. Emergency shutdown.
    d. Lube-oil recommendations.
    e. Routine operational procedures, including recommended inspection schedules and procedures.
    f. Instructions for
        1. Disassembly and reassembly of journal bearings (for tilting-pad bearings, the instructions shall include "go/no-go" dimensions with tolerances for three-step plug gauges).
        2. Disassembly and reassembly of thrust bearing.
        3. Disassembly and reassembly of seals (including maximum and minimum clearances).
        4. Disassembly and reassembly of thrust collar.
    g. Performance data, including
        1. Curve showing certified shaft speed versus site rated power.
        2. Curve showing output-power shaft speed versus torque.
    h. As-built data, including
        1. As-built data sheets.
        2. As-built dimensions or data, including assembly clearances.
        3. Hydrostatic test logs, per item 15 above.
        4. Mechanical running test logs, per item 16 above.
    i. Drawings and data, including
        1. Certified dimensional outline drawing and list of connections.
        2. Cross-sectional drawing and bill of materials.
        3. Rotor assembly drawings and bills of materials.
        4. Thrust-bearing assembly drawing and bill of materials.
        5. Journal-bearing assembly drawings and bills of materials.
        6. Seal-component drawing and bill of materials.
        7. Lube-oil schematics and bills of materials.
        8. Electrical and instrumentation schematics and bills of materials.
        9. Electrical and instrumentation assembly drawings and list of connections.

25. Spare parts list with stocking level recommendations, in accordance with 5.3.5.

26. Progress reports and delivery schedules, including vendor buy-outs and milestones.

27. List of drawings, including latest revision numbers and dates.

28. Shipping list, including all major components that will ship separately.

29. List of special tools furnished for maintenance (see 3.6).

30. Technical data manual, including the following:
    a. As-built purchaser data sheets, per item 21 above.
    b. Certified performance curves, per items 17 above.

c. Drawings, in accordance with 5.3.2.
d. As-built assembly clearances.
e. Spare parts list, in accordance with 5.3.5.
f. Utility data, per item 13 above.
g. Reports, per items 17 above.

31. Material Safety Data Sheets (OSHA Form 20).

APPENDIX E—NET POSITIVE SUCTION HEAD VERSUS NET POSITIVE INLET PRESSURE

Because centrifugal pumps and positive displacement pumps operate on entirely different principles, common usage has created two different ways to identify the pressures associated with them. In its simplest form, a centrifugal pump is a velocity machine. The liquid to be pumped is directed into the center of a rotating impeller where it is entrained in the impeller vanes and accelerated to a higher velocity. The casing surrounding the impeller then converts the high velocity to pressure. Because it is a velocity machine, if pressure is measured in units of liquid length, all units of measure become consistent. Velocity is measured in meters/second (feet/second) and pressure is measured in meters (feet); i.e., the pressure created by the height of a column of the liquid being pumped. This consistent use of units greatly simplifies pump calculations and allows the effects of certain liquid properties (specific gravity, for example) to be ignored.

By contrast, a rotary positive displacement pump does not generate pressure by increasing fluid velocity. Instead these pumps convert rotating motion and torque into fluid motion, overcoming system pressure at the discharge connection. Positive displacement pumps have no theoretical discharge pressure limitation. They respond solely to the pumping system, and require system discharge pressure control, usually in the form of a relief valve, to present damage to the pump mechanism and/or stalling of the driver. A centrifugal pump, however, responds quite differently in that the discharge pressure developed is a function of flow through the pump impeller. With decreasing flow (as in the case of increased system resistance) the centrifugal pump develops ever increasing pressure rise up to the point defined as shutoff head at zero flow. Shutoff head is the maximum pressure rise that a centrifugal pump can develop. For a rotary positive displacement pump, theoretically flow is constant per revolution.

Either type of pump requires sufficient fluid pressure at the inlet to prevent release of dissolved gases and/or change of state of the pumped fluid from liquid to gas. The term for pressure at the inlet is either Net Positive Suction Head (NPSH) or Net Positive Inlet Pressure (NPIP). To be consistent, the API Standards for both centrifugal and rotary pumps refer to the total suction head as NPSH rather than NPIP. The Hydraulic Institute Rotary Pump Standards use NPIP expressed in pounds per square inch (kilopascals) because this requires no conversion of units nor correction for specific gravity as does NPSH. Installation pressure readings are usually given in psi kPa (psi). The latest API Standards refer to NPSH in meters (feet), the preferred terminology for both pump types, to avoid confusion. Rotary pump manufacturers generally refer to NPIP, expressed in kPa (psi).

NPSH or NPIP is indicated as either Available or Required. The Net Positive Inlet Pressure Available is the absolute pressure above fluid vapor pressure at the pump inlet and is determined as follows:

$$\text{NPIP Available} = P_a + P_z - P_f - P_{vp}$$

Where:

P_a = Absolute pressure at surface of liquid in kPa abs (psia).
P_z = Static Head (+) or Static Lift (-) in kPa (psi) for level of fluid above or below inlet.
P_f = Inlet line, valve & fitting friction losses at maximum viscosity in kPa (psi).
P_{vp} = Fluid vapor pressure or gas dissolution pressure in kPa abs (psia).

NPIP Required is a function of pump type, speed and viscosity of fluid pumped. NPIP Available must always be greater than NPIP Required to prevent occurrence of cavitation. Typically, NPIP Required values published by positive displacement pump manufacturers are expressed in kPa (psi) units.

APPENDIX F—SEAL MATERIALS

Table F-1 — Typical Descriptions of Miscellaneous Materials for Mechanical Seal Parts

Material	Typical Description
Alloy 20	ASTM B 473, UNS N08020 (wrought) ASTM A 744,. Grade CN-7M, UNS J95150 (cast)
Fluoroelastomer (FKM)	DuPont Viton or equal
Flexible Graphite	Union Carbide Grafoil or equal
Gasket	Spiral wound stainless steel with graphite or equal filler
Low Carbon Nickel-Molybdenum-Chromium Alloy	Hastelloy (Cabot Corp.) Alloy C-276: ASTM B 564, UNS N10276 (forgings) ASTM B 574, UNS N10276 (bar and rod) ASTM B 575, UNS N10276 (plate, sheet and strip) ASTM A 494, Grade CW-12MW (weldable cast)
Nickel-Copper Alloy	Monel (Huntington Alloys) Alloy 400: ASTM B 564, UNS N04400 (forgings) ASTM B 164, Class A, UNS N04400 (bar & rod) ASTM B 127, UNS N04400 (plate, sheet & strip) ASTM A 494, Grade M30C (weldable cast)
Ni-resist	ASTM A 436, Type 1, 2, or 3, UNS F41000/F410021F41004 respectively (austenitic cast iron); ASTM A 439, Type D2, UNS F43000 (austenitic ductile iron)
Nitrile	B.F. Goodrich Hycar, Buna-N, or equal
Perfluoroelastomer (FFKM)	ASTM D 1418, such as DuPont Kalrez, or equal
Precipitation-Hardening Nickel Alloy	Inconel (Huntington Alloys) Alloy 718: ASTM B-637, UNS N07718 (forgings and bars) ASTM B 670, UNS N07718 (plate, sheet and strip)
Precipitation-hardening Stainless Steel	ASTM A 564, Grade 630, UNS S17400 or Grade 631, UNS 17700 (wrought) ASTM A 747, Grade CB7Cu-1, UNS J92180 (cast)

Table F-2—ASTM Material Specifications for Mechanical Seal Parts

Material	Pressure-Containing Castings	Wrought Forgings	Bar Stock	Bolts and Studs
Carbon Steel	ASTM A 216, Grade WCA, UNS J02502 or Grade WCB, UNS J03002	ASTM A 105, UNS K03505 or ASTM A 576	ASTM A 576, Grade 10515, UNS G10150	—
12% Chrome Steel	ASTM A 217, Grade CA15, UNS J91150 or ASTM A 487, Grade CA6NM, UNS J91540	ASTM A 182, Grade F6, UNS K91151 or Grade F6NM, UNS S41500	ASTM A 276, Type 410, UNS S41000 or Type 416, UNS S41610	ASTM A 193, Grade B6, UNS S41000
Austenitic Stainless Steel (Note 1)	ASTM A 351, Grade CF8, UNS J92600 or Grade CF3, UNS J92500	ASTM A 182	ASTM A 276	ASTM A 193
Type 316 Stainless Steel	ASTM A 351, Grade CF8M, UNS J92900 or Grade CF3M, UNS J92800	ASTM A 182, Grade F316, UNS S31600 or Grade F316L, UNS 31603	ASTM A 276, Type 316, UNS S31600 or Type 316L, UNS S31603	ASTM A 193, Grade B8M, UNS S31600

Note:
1. Austenitic stainless steels may include Standard Types 302, 303, 304, 316, 321, and 347. If a particular type is desired, the purchaser will so state.

Table F-3—Typical Temperature Limitations for Seal Materials in Hydrocarbon Service

Face Material	Maximum Temperature °C (°F)
Tungsten Carbide	400 (750)
Silicon Carbide (solid)	425 (800)
Carbon-graphite - Oxidizing -Non-oxidizing	 275 (525) 475 (800)

Table F-4—Typical Temperature Limitation Guidelines for Secondary Seal Materials in Hydrocarbon Service

Material	Ambient or Pumping Temperature °C (°F)	
	Minimum	Maximum
Fluoroelastomer (FKM): – Hydrocarbon Service – Water-based Service	 -7 (20) -7 (20)	 150 (300) 120 (250)
Perfluoroelastomer (FFKM)	-7 (20)	290 (550)
Nitrile (BUNA-N)	-40 (-40)	120 (250)
Flexible Graphite	-240 (400)	480 (900)

1-01400—12/94— 1M (1E)

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