Positive Displacement Pumps—Controlled Volume

API STANDARD 675
SECOND EDITION, OCTOBER 1994

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

Positive Displacement Pumps—Controlled Volume

Manufacturing, Distribution and Marketing Department

API STANDARD 675
SECOND EDITION, OCTOBER 1994

American
Petroleum
Institute

SPECIAL NOTES

1. API PUBLICATIONS NECESSARILY ADDRESS PROBLEMS OF A GENERAL NATURE. WITH RESPECT TO PARTICULAR CIRCUMSTANCES, LOCAL, STATE, AND FEDERAL LAWS AND REGULATIONS SHOULD BE REVIEWED.

2. API IS NOT UNDERTAKING TO MEET THE DUTIES OF EMPLOYERS, MANUFACTURERS, OR SUPPLIERS TO WARN AND PROPERLY TRAIN AND EQUIP THEIR EMPLOYEES, AND OTHERS EXPOSED, CONCERNING HEALTH AND SAFETY RISKS AND PRECAUTIONS, NOR UNDERTAKING THEIR OBLIGATIONS UNDER LOCAL, STATE, OR FEDERAL LAWS.

3. INFORMATION CONCERNING SAFETY AND HEALTH RISKS AND PROPER PRECAUTIONS WITH RESPECT TO PARTICULAR MATERIALS AND CONDITIONS SHOULD BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT MATERIAL, OR THE MATERIAL SAFETY DATA SHEET.

4. NOTHING CONTAINED IN ANY API PUBLICATION IS TO BE CONSTRUED AS GRANTING ANY RIGHT, BY IMPLICATION OR OTHERWISE, FOR THE MANUFACTURE, SALE, OR USE OF ANY METHOD, APPARATUS, OR PRODUCT COVERED BY LETTERS PATENT. NEITHER SHOULD ANYTHING CONTAINED IN THE PUBLICATION BE CONSTRUED AS INSURING ANYONE AGAINST LIABILITY FOR INFRINGEMENT OF LETTERS PATENT.

5. GENERALLY, API STANDARDS ARE REVIEWED AND REVISED, REAFFIRMED, OR WITHDRAWN AT LEAST EVERY FIVE YEARS. SOMETIMES A ONE-TIME EXTENSION OF UP TO TWO YEARS WILL BE ADDED TO THIS REVIEW CYCLE. THIS PUBLICATION WILL NO LONGER BE IN EFFECT FIVE YEARS AFTER ITS PUBLICATION DATE AS AN OPERATIVE API STANDARD OR, WHERE AN EXTENSION HAS BEEN GRANTED, UPON REPUBLICATION. STATUS OF THE PUBLICATION CAN BE ASCERTAINED FROM THE API AUTHORING DEPARTMENT [TELEPHONE (202) 682-8000]. A CATALOG OF API PUBLICATIONS AND MATERIALS IS PUBLISHED ANNUALLY AND UPDATED QUARTERLY BY API, 1220 L STREET, N.W., WASHINGTON, D.C. 20005.

FOREWORD

This standard is based on the accumulated knowledge and experience of manufacturers and users of displacement pumps. The objective of this publication is to provide a purchase specification to facilitate the manufacture and procurement of controlled volume pumps for use in the petroleum, chemical, and gas industries.

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 all modifications, deletions, and amplifications be made by supplementing this standard, rather than by rewriting or by incorporating sections thereof into another complete standard.

API standards are published as an aid to procurement of standardized equipment and materials. These standards are not intended to inhibit purchasers or producers from purchasing or producing products made to other standards.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

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.

CONTENTS

Positive Displacement Pumps—Controlled Volume

SECTION 1—GENERAL

1.1 Scope

This standard covers the minimum requirements for controlled volume positive displacement pumps for use in service in the petroleum, chemical, and gas industries. Both packed-plunger and diaphragm types are included. Diaphragm pumps that use direct mechanical actuation are excluded. See API Standard 674 for reciprocating pumps and Standard 676 for rotary 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 1.4.28.

1.4.1 The *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 A *controlled volume pump* is a reciprocating pump in which precise volume control is provided by varying effective stroke length. Such pumps are also known as proportioning, chemical injection, dosing, or metering pumps.

1.4.2.1 In a *packed-plunger pump*, the process fluid is in direct contact with the plunger.

1.4.2.2 In a *diaphragm pump*, the process fluid is isolated from the plunger by means of a hydraulically actuated flat or shaped diaphragm.

1.4.3 *Differential pressure* is the difference between discharge pressure and suction pressure.

1.4.4 *Flow repeatability*, expressed as a percent of rated capacity, describes the reproducibility of pump flow rate under a given set of conditions when capacity setting is varied and then returned to the set point being tested.

1.4.5 A *gauge board* is an unenclosed bracket or plate used to support and display gauges, switches, and other instruments.

1.4.6 *Linearity* is the relationship between the actual volume of liquid discharged at a given capacity setting and a best fit straight line drawn through the plotted points of volume and capacity setting determined during calibration tests of a pump. The deviation from this line is expressed as percent of the rated capacity of the pump.

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

1.4.8 *Lost motion* is a means of changing displacement of a constant stroke pump by altering the effective stroke length during each cycle. This may be accomplished mechanically or hydraulically.

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

1.4.10 *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.

1.4.11 *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.

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

1.4.13 *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).

1.4.14 *Multiple feed* (multiplexing) is the combination of two or more pumping elements with a common driver.

1.4.15 *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).

1.4.16 *Net positive suction head available* (NPSHA) is the NPSH, in meters (feet), deducting preliminary anticipated system acceleration head, determined by the purchaser for

the pumping system with the fluid at the rated capacity and normal pumping temperature.

Note: Selected equipment and final piping acoustic layout will dictate final acceleration head and resulting NPSHA.

1.4.17 *Net positive suction head required* (NPSHR) is the NPSH in meters (feet), including acceleration head, determined by vendor testing, usually with water. NPSHR is measured at the suction flange. NPSHR is the minimum NPSH at rated capacity required to prevent more than 3 percent capacity drop due to cavitation within the pump.

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

1.4.19 *Preliminary anticipated system acceleration head* is the estimated pressure change due to changes in velocity in the piping system. It is an important factor in the application of reciprocating pumps because of the pulsating nature of the flow in the pump suction line, in addition to NPSHR, vapor pressure, and head required to overcome suction line losses.

Note: For additional information on acceleration head, refer to Hydraulic Institute standards.

1.4.20 *Rated capacity* is the quantity of fluid actually delivered per unit of time at the stated operating conditions. Rated capacity includes liquid and any dissolved or entrained gases or solids, and is based on suction conditions.

1.4.21 *Rated discharge pressure* is the required discharge pressure of the pump at rated capacity, speed, suction pressure, specific gravity, and viscosity.

1.4.22 *Remote* refers to a device located away from the equipment or console, typically in a control house.

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

1.4.24 *Steady state accuracy* is the flow variation expressed as a percentage of mean delivered flow under fixed-system conditions. Steady state accuracy applies over the turndown ratio.

1.4.25 *Turndown ratio* is the rated capacity divided by the minimum capacity that can be obtained while maintaining specified steady state accuracy and linearity.

1.4.26 *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, noise, lubrication, material test reports, instrumentation, piping, and testing of components.

1.4.27 *Volumetric efficiency* is the ratio of the pump capacity to pump displacement and is expressed as a percentage.

1.4.28 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]

341.02	*Design of General Industrial Coarse - Pitch Cylindrical Wormgearing*
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*
RP 550	*Manual on Installation of Refinery Instruments and Control Systems* (Out of Print)
Std 614	*Lubrication, Shaft-Sealing, and Control-Oil Systems for Special-Purpose Applications*

[1]Anti-Friction Bearing Manufacturers Association, 1235 Jefferson Davis Highway, Arlington, Virginia 22202.
[2]American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, Virginia 22314-2730.

Std 615 *Sound Control of Mechanical Equipment for Refinery Services* (Out of Print)
Std 618 *Reciprocating Compressors for General Refinery Services*
RP 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)*
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, Socket-Welding and Threaded*
B16.42 *Ductile Iron Pipe Flanges and Flanged Fittings, Class 150 and 300*
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 192 *Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service*
A 193 *Specification for Alloy-Steel and Stainless Steel Bolting*
A194 *Specification for Carbon and Alloy Steel Nuts or 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 (345 °C)*
A 296 *Specification for Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base Alloy Castings for General Application*
A 312 *Specification for Seamless and Welded Austenitic Stainless Steel Pipe*
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 395 *Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*
A 436 *Specification for Austenitic Gray 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 575 *Specification for Merchant Quality Hot-Rolled Carbon Steel Bars*
A 744 *Specification for Castings, Iron-Chromium-Nickel, Corrosion-Resistant, for Severe Service*
B 124 *Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes*
B 139 *Specification for Phosphor Bronze Rod, Bar, and Shapes*
B 164 *Specification for Nickel-Copper Alloy Rod, Bar, and Wire*

[3]American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.
[4]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.

B 473 *Specification for UNS N08020, UNS N08026, and UNS N08024, Nickel Alloy Bar and Wire*
B 584 *Specification for Copper Alloy Sand Castings for Radiographic Testing*
D 1418 *Practice for Rubber and Rubber Latices - Nomenclature*
E 94 *Recommended Practice 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*

ISO[6]
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 I—"Steel Flanges" and Part II—"Cast Iron Flanges"

NACE[7]
Corrosion Engineer's Reference Book
MR-01-90 *Sulfide Stress Corrosion Cracking Resistant Metallic Material for Oil Field Equipment*

NEMA[8]
MG 1 *Motors and Generators*

NFPA[9]
70 *National Electrical Code*

1.5.3 The standards of the Hydraulic Institute[10] 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.

[5]American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33135.
[6]International Organization for Standardization. ISO publications are available from ANSI (American National Standards Institute, 11 West 42nd Street, New York, New York 10036).
[7]National Association of Corrosion Engineers, P.O. Box 218340, Houston, Texas 77218.
[8]National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, D.C. 20037.
[9]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-9101.
[10]Hydraulic Institute, 14600 Detroit Avenue, Cleveland, Ohio 44107.

SECTION 2—BASIC DESIGN

2.1 General

2.1.1 The equipment (including auxiliaries) covered by this standard shall be designed and constructed for a minimum service life of 20 years and at least 3 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 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.

• **2.1.4** Control of the sound pressure level (SPL) of all equipment furnished shall be on 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 to the trip speed and relief valve settings without damage.

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 the National Fire Protection Association (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

valves. Major parts shall be designed and manufactured to ensure accurate alignment on reassembly.

2.1.10 The pump design shall allow access for adjustment or replacement of liquid end components including packing, seals, check valves, and other wetted parts that require maintenance.

2.1.11 The check valves shall be removable from the liquid end for servicing or replacement. If removable spool pieces are required in the purchaser's piping to accomplish this, the vendor shall so state in the proposal.

• **2.1.12** 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).

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

2.1.14 The pump flow rate shall be adjustable over the specified turndown ratio while the pump is running.

2.1.15 Rated capacity shall be at least 110 percent of the maximum capacity specified.

2.1.16 The steady state flow accuracy shall be within plus or minus 1 percent over a turndown ratio of at least 10:1.

Note: It should be recognized that this accuracy generally cannot be guaranteed below 10 percent of rated flow.

2.1.17 The flow repeatability shall be within plus or minus 3 percent of rated flow over the specified turndown ratio.

2.1.18 Deviation from linearity shall not exceed plus or minus 3 percent of rated flow over the specified turndown ratio.

2.1.19 Minimum differential pressure required to ensure the specified flow accuracy shall be stated by the vendor in the quotation.

• **2.1.20** When specified, liquid ends shall be supplied with jacketed housings for heating or cooling the fluid being pumped.

2.2 Pressure-Containing Parts

2.2.1 The hoop-stress values used in the design of pressure-containing parts 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 Pressure-containing parts shall be positively bolted together (wing bolts, set screws, and clamps shall not be used) and shall be designed to prevent injurious distortion caused by temperature, pressure, torque, and allowable external forces and moments.

2.2.3 The use of tapped holes in pressure parts shall be minimized. To prevent leakage in pressure sections of castings, 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 Studded connections shall be furnished with studs and nuts installed. The first 1½ threads at both ends of each stud shall be removed.

2.2.5 Bolting shall be furnished as specified in 2.2.5.1 through 2.2.5.5.

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

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

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

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

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

2.2.6 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 of the face. Guide rods shall be of sufficient length to prevent damage to the internals or studs by any component during disassembly and reassembly.

2.3 Liquid End Connections

• **2.3.1** Inlet and outlet connections shall be flanged or machined and studded, oriented as specified, and shall be suitable for the working pressure to which it is normally subjected as defined in 1.4.11.

2.3.2 Connections welded to the liquid end shall meet the material requirements of the liquid end, including impact values, rather than the requirements of the connected piping (see 2.13.4.5). All welding of connections shall be done before hydrostatic testing (see 4.3.2).

2.3.3 Openings for piping connections shall be at least nominal pipe size (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 millimeters (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 sizes NPS 1 and smaller and a minimum of Schedule 80 for a size of NPS 1½.

2.3.3.3 The pipe nipple shall be provided with a welding-neck or socket-weld 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 liquid end. 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 2.3.6.2.

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

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

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

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

• 2.4 Pump Check Valves

The suction and discharge check-valve cartridges or seats and elements shall be field replaceable. Proper guiding of the check-valve element shall be provided for quick seating action and maximum seat life. When specified, double check valves (both suction and discharge) shall be furnished.

2.5 Diaphragms

2.5.1 Diaphragms provide isolation and transmit hydraulic motion from one fluid to another. Diaphragm materials shall be compatible with the fluids they contact at all specified temperatures. They shall be designed to withstand maximum flexing regardless of stroke-length setting and shall be of sufficient thickness and density to prevent permeation.

2.5.2 Single or double diaphragms (direct or remote mounted) may be used.

2.5.3 Single diaphragms and primary diaphragms on double diaphragm pumps shall have provisions to prevent excess flexure.

2.5.4 Double diaphragm designs intended to prevent overextension of the secondary diaphragm (e.g., tubular diaphragms) shall provide for a fluid filled intermediate chamber to transmit the motion from the primary diaphragm to the secondary diaphragm. The intermediate fluid shall be compatible with both the process fluid and the hydraulic fluid.

2.5.5 Unless otherwise specified, double diaphragm designs intended to provide means for detecting diaphragm failure shall provide a tapped hole for either a conductivity probe in the intermediate fluid or a pressure type detector between diaphragms in a dry design. If the probe/detector is not specified, a threaded plug shall be factory installed in the tapped hole.

2.6 Packed Plungers

2.6.1 Packed-plunger liquid ends shall provide for proper guiding of the plunger through the complete stroke cycle with minimum side loading against the packing. A lantern ring shall be provided in the stuffing box for flushing or adding lubricant to the packing. The pump body shall have a minimum NPS ¼ drilled and tapped hole on the top and bottom, in line with the lantern ring to provide inlet and outlet for flushing. When a packing lubricant is used, the bottom hole shall have a threaded plug installed.

2.6.2 Provision shall be made between the drive mechanism and the plunger liquid end to contain stuffing box leakage or to provide special liquid-end conditioning.

Note: The purchaser and the vendor should review any potential leakage collection system to ensure that all applicable environmental regulations are met.

2.7 Relief Valve Application

2.7.1 Diaphragm pumps shall have an integral, adjustable hydraulic relief valve to provide full protection of the pump drive mechanism from excessive discharge pressure. The relief valve setting shall be at least 10 percent or 175 kPa (25 psi) over the rated discharge pressure. The relief valve

shall be self-seating and shall be easily accessible for adjustment, repair, or replacement.

2.7.2 Packed-plunger pumps require external relief valves for mounting in the purchaser's piping. (3.4.4.5)

2.8 Gears

All gears used in the pump drive assembly shall be metal. They shall be designed with AGMA criteria as a guide and with a minimum service factor of 1.5 per AGMA 341.02 or 6010 as applicable. The gear lubrication system shall be self-contained.

2.9 Enclosure

2.9.1 The drive enclosure shall use materials of sufficient strength and thickness to provide stable, accurate alignment of drive parts.

2.9.2 The drive enclosure shall be provided with an oil drain at the low point of the housing and with fill provisions so that oil may be changed without disturbing the pump installation.

2.9.3 The enclosure shall be suitable for mounting on concrete slabs or masonry and shall be weatherproof and dust-tight.

2.9.4 All static seals and gaskets on the drive enclosure shall be leakage free for at least 3 years. Dynamic seals shall be easily replaceable.

2.10 Drive Bearings

2.10.1 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.

2.10.2 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.

12.10.3 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).

2.11 Lubrication

2.11.1 The lubrication system shall be of a forced-feed, splash, or submerged type and shall lubricate the reduction gears, bearings, and all other required points except the driver.

2.11.2 The vendor shall state in the operating manual the amount of and specifications for the lubricating and hydraulic oil required.

2.12 Capacity Adjustment

2.12.1 Pump capacity shall be adjusted by changing the actual or the effective stroke length or the pump stroking speed.

2.12.2 The pump shall be capable of accepting manual or automatic capacity stroke control, either factory mounted or by field conversion.

2.12.3 Integral pump devices used to vary capacity either manually or automatically shall be provided with visual indication of capacity setting, shown as a percentage of the nameplate rated flow. Manual control shall include a locking device to positively retain the capacity setting.

2.12.4 The direction of movement to increase or decrease pump flow shall be clearly marked. All adjustment means and indicators shall be easily accessible with the pump installed.

2.13 Materials

2.13.1 GENERAL

2.13.1.1 Materials of construction shall be manufacturer's standard for the specified operating conditions, except as required or prohibited by the data sheets or text of this standard. (See 3.5 for auxiliary piping material requirements.) The metallurgy of all major components shall be clearly stated in the vendor's proposal.

2.13.1.2 Materials shall be identified in the proposal with the applicable ASTM, AISI[11], ASME, or SAE[12] 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.

2.13.1.3 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.

2.13.1.4 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.

2.13.1.5 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.

[11]American Iron and Steel Institute, 1000 16th Street, NW, Washington, D.C. 20036.
[12]Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

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

2.13.1.7 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 attack is applied.

2.13.1.8 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 fluid.

Note: Torque loading values will differ considerably with and without an antiseizure compound.

• **2.13.1.9** 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 on the data sheets the presence of such agents in the media. Exceptions to this requirement may be (1) the surface of piston rods or plungers in the packing area and (2) the valve components where greater hardness has proven necessary.

2.13.1.10 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.*

2.13.1.11 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.

2.13.1.12 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.

2.13.1.13 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-temparature bolting material in accordance with ASTM A 320 shall be used.

2.13.2 CASTINGS

2.13.2.1 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.

2.13.2.2 The use of chaplets in pressure castings shall be held to a minimum. The chaplets shall be clean and corrosion free (plating permitted) and of a composition compatible with the casting.

2.13.2.3 Ferrous castings for pressure containing parts shall not be repaired by welding, peening, plugging, burning in, or impregnating, except as specified in 2.13.2.3.1 and 2.13.2.3.2.

2.13.2.3.1 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.

2.13.2.3.2 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.

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

2.13.2.5 Gray 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 14 bar gauge (200 psig) and 50°C (125°F).

2.13.2.6 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 2.13.2.6.1 through 2.13.2.6.5.

2.13.2.6.1 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.

2.13.2.6.2 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.

2.13.2.6.3 Integrally cast test bosses, preferably at least 25 millimeters (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, 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.

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

2.13.2.6.5 Brinell hardness readings shall be made on the actual casting at feasible locations on section changes, flanges, 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.

2.13.3 FORGINGS

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

2.13.4 WELDING

2.13.4.1 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 manufacturer's data report forms as specified in the code are not required.

2.13.4.2 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 (2.13.1.11). Repair welds shall be nondestructively tested by the same method used to detect the original flaw. As a minimum, this shall be in accordance with 4.2.2.4 for magnetic material and by the liquid penetrant method in accordance with 4.2.2.5 for nonmagnetic material.

2.13.4.3 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, nonpressure ducting, lagging, and control panels, shall be performed in accordance with AWS D1.1.

2.13.4.4 Pressure-containing components made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified in 2.13.4.4.1 through 2.13.4.4.3.

2.13.4.4.1 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.

2.13.4.4.2 Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after backchipping or gouging and again after postweld heat treatment.

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

2.13.4.5 Connections welded to pressure-containing components shall be installed as specified in 2.13.4.5.1 through 2.13.4.5.5.

• **2.13.4.5.1** In addition to the requirements of 2.13.4.1, the purchaser may specify that 100 percent radiography, magnetic particle inspection, or liquid penetrant inspection of welds is required.

2.13.4.5.2 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.

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

• **2.13.4.5.4** 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.

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

2.13.5 IMPACT TEST REQUIREMENTS

2.13.5.1 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).

2.13.5.2 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.

• **2.13.5.3** 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.

2.14 Nameplates and Rotation Arrows

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

2.14.2 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.

• **2.14.3** 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, and hydrostatic test pressures, shall appear on the machine's nameplate. The purchaser will specify on the data sheet whether customary or SI units are to be shown.

2.15 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 start-up 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 For motor-driven units, the motor nameplate rating (exclusive of the service factor) shall be at least 110 percent of the greatest power required (including gear and coupling losses) 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.

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

a. Electrical characteristics.
b. Type of enclosure.
c. Sound pressure level.
d. Area classification, based on API Recommended Practice 500.
e. Type of insulation.
f. Required service factor.
g. Ambient temperature and elevation above sea level.

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

3.2 Couplings and Guards

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

3.2.2 Unless otherwise specified, couplings shall be manufacturer's standard.

3.2.3 Guards shall be supplied by the vendor for exposed shafts or couplings. They shall be manufactured in accordance with any specified codes.

3.3 Baseplates

3.3.1 The pump shall be provided with a baseplate or equivalent arrangement suitable for permanent mounting. Baseplates, or pump frames, shall have provisions for bolting the complete unit rigidly to a foundation.

3.3.2 Pumps with separate drivers shall be provided with continuous baseplates under both the pump and the driver.

3.3.3 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.

• **3.3.4** 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 catalyzed epoxy primer applied to degreased white metal. 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.

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

3.3.6 The vendor of the mounting plates shall furnish stainless steel shim packs of at least 3 millimeters (⅛-inch) thickness between the equipment feet and the mounting plates. All shim packs shall straddle the hold-down bolts.

3.3.7 Anchor bolts will be furnished by the purchaser.

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

3.3.9 Jackscrews shall be provided for vertical adjustment of baseplates on units exceeding 450 kilograms (1000 pounds) in overall weight.

3.3.10 Mounting pads shall be provided for the pump and all drive train components. The pads shall be larger than the foot of the mounted equipment to allow leveling of the baseplate without removal of the equipment. The pads shall be fully machined flat and parallel. Corresponding surfaces shall be in the same plane within 1:6000 of distance between the pads. This requirement shall be met by supporting and clamping the baseplate at the foundation bolt holes only. Provision for shims between such surfaces shall not eliminate this requirement.

3.4 Controls and Instrumentation

3.4.1 GENERAL

3.4.1.1 Unless otherwise specified, instrumentation and installation shall conform to the requirements of API Standard 614.

3.4.1.2 Unless otherwise specified, controls and instrumentation shall be suitable for outdoor installation.

3.4.1.3 Where applicable, controls and instrumentation shall conform to API Recommended Practice 550.

3.4.2 CONTROL SYSTEMS

• **3.4.2.1** The control system may be mechanical, pneumatic, hydraulic, electric, or any combination thereof. The system may be manual, or it may be automatic with a manual override. The purchaser will specify the source of the control signal, its sensitivity and range, and the equipment to be furnished by the vendor.

3.4.2.2 The full range of the specified control signal will correspond to the required operating range of the driven equipment. Unless otherwise specified, the maximum control signal shall correspond to the maximum continuous speed or the maximum flow.

3.4.3 INSTRUMENT AND CONTROL PANELS

• **3.4.3.1** When specified, a panel shall be provided and shall include all panel-mounted instruments for the driven equipment and the driver. Such panels shall be designed and fabricated in accordance with the purchaser's description. The purchaser will specify whether the panel is to be free-standing, located on the base of the unit, or in another location. The instruments on the panel shall be clearly visible to the operator from the driver control point. A lamp test push button shall be provided. The instruments to be mounted on the panel will be specified.

3.4.3.2 Panels shall be completely assembled, requiring only connection to the purchaser's external piping and wiring circuits. When more than one wiring point is required on a unit for control or instrumentation, the wiring to each switch or instrument shall be provided from a single terminal box with terminal posts mounted on the unit (or its base, if any). Wiring shall be installed in metal conduits or enclosures. All leads and posts on terminal strips, switches, and instruments shall be tagged for identification.

3.4.4 INSTRUMENTATION

3.4.4.1 Temperature Gauges

3.4.4.1.1 Dial-type temperature gauges shall be heavy duty and corrosion resistant. They shall be at least 125 mil-

limeters (5 inches) in diameter and bimetallic or liquid filled. Black printing on a white background is standard for gauges.

3.4.4.1.2 The sensing elements of thermometers and temperature gauges shall be in the flowing fluid. This is particularly important for lines that may run partially full.

3.4.4.2 Thermowells

Temperature gauges that are in contact with flammable or toxic fluids or that are located in pressurized or flooded lines shall be furnished with NPS ¾ AISI Standard Type 300 stainless steel separable solid-bar thermowells.

• 3.4.4.3 Pressure Gauges

Pressure gauges (not including built-in instrument air gauges) shall be furnished with AISI Standard Type 316 stainless steel bourdon tubes and stainless steel movements, 115 millimeters (4 ½-inch) dials [150 millimeters (6-inch) dials for the range over 55 bar (800 psi)] and NPS ½ male alloy steel connections. Black printing on a white background is standard for gauges. When specified, oil-filled gauges shall be furnished in locations subject to vibration. Gauge ranges shall preferably be selected so that the normal operating pressure is at the middle of the gauge's range. In no case, however, shall the maximum reading on the dial be less than the applicable relief valve setting plus 10 percent. Each pressure gauge shall be provided with a device, such as a disk insert or blowout back, designed to relieve excess case pressure.

3.4.4.4 Solenoid Valves

Solenoid-operated valves shall have Class F insulation or better and shall have a continuous service rating.

3.4.4.5 Relief Valves

• **3.4.4.5.1** The vendor shall furnish the relief valves that are to be installed on equipment or in piping that the vendor is supplying for protection of the pump. When specified, the vendor shall furnish external relief valves to be installed in the purchaser's piping.

3.4.4.5.2 Relief valve bodies shall be of materials consistent with those specified for pressure-containing parts (2.2).

3.4.4.6 Backpressure Valves

The vendor's proposal shall state whether a backpressure valve is required. When a backpressure valve is required, any internal type will be supplied by the vendor, and any external type will be supplied by the purchaser. Backpressure valves shall be of materials consistent with those specified for pressure-containing parts (2.2). The valves shall operate in a manner that ensures proper pump check valve operation.

3.4.5 ELECTRICAL SYSTEMS

• **3.4.5.1** The characteristics of electrical power supplies for motors, heaters, and instrumentation will be specified. A pilot light shall be provided on the incoming side of each supply circuit to indicate that the circuit is energized. The pilot lights shall be installed on the control panels.

3.4.5.2 Electrical equipment located on the unit or on any separate panel shall be suitable for the hazard classification specified. Electrical starting and supervisory controls may be either AC or DC.

3.4.5.3 Power and control wiring within the confines of the baseplate shall be resistant to oil, heat, moisture, and abrasion. Stranded conductors shall be used within the confines of the baseplate and in other areas subject to vibration. Measurement and remote-control panel wiring may be solid conductor. Thermoplastic insulation shall be used and shall be covered by a Neoprene or equal sheath for abrasion protection. Wiring shall be suitable for environmental temperatures.

3.4.5.4 Unless otherwise specified, all leads on terminal strips, switches, and instruments shall be permanently tagged for identification. All terminal boards in junction boxes and control panels shall have at least 20 percent spare terminal points.

3.4.5.5 To facilitate maintenance, liberal clearances shall be provided for all energized parts (such as terminal blocks and relays) on equipment. The clearances required for 600-volt service shall also be provided for lower voltages. Enclosures shall be provided for all energized parts to guard against accidental contact.

• **3.4.5.6** Electrical materials, including insulation, shall be corrosion resistant and nonhygroscopic insofar as is possible. When specified for tropical location, materials shall be given the treatments specified in 3.4.5.6.1 and 3.4.5.6.2.

3.4.5.6.1 Parts (such as coils and windings) shall be protected from fungus attack.

3.4.5.6.2 Unpainted surfaces shall be protected from corrosion by plating or another suitable coating.

3.4.5.7 Control, instrumentation, and power wiring (including temperature element leads) within the limits of the baseplate shall be installed in rigid metallic conduits and boxes, properly bracketed to minimize vibration and isolated or shielded to prevent interference between voltage levels. Conduits may terminate (and in the case of temperature element heads, shall terminate) with a flexible metallic conduit long enough to permit access to the unit for maintenance without removal of the conduit. If temperature element heads will be exposed to temperatures above 60°C (140°F), a 20 millimeter (¾-inch) bronze hose with four-wall interlocking construction and joints with packed-on (heatproof) couplings shall be used.

3.4.5.8 For Division 2 locations, flexible metallic conduits shall have a liquid-tight thermosetting or thermoplastic outer jacket and approved fittings. For Division 1 locations, an NFPA-approved connector shall be provided.

3.4.5.9 AC and DC circuits shall be clearly labeled, connected to separate terminal blocks, and isolated from each other.

3.5 Piping

3.5.1 GENERAL

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

3.5.1.2 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. Steam heating.
   2. Instrument and control air.
   3. 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.

3.5.1.3 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.

3.5.1.4 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. The purchaser will furnish only interconnecting piping between equipment groupings and off-base facilities.

3.5.1.5 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 adapted 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.

3.5.1.6 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.

3.5.1.7 Pipe threads shall be taper threads in accordance with ASME B1.20.1. Alternately, pipe threads in accordance with ISO 228 Part I 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 millimeter (1/16-inch) gap shall be left between the pipe end and the bottom of the socket.

3.5.1.8 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.

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

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

3.5.1.11 Piping systems furnished by the vendor shall be fabricated, installed in the shop, and properly supported. Bolted holes for flanged connections shall straddle lines parallel to the main horizontal or vertical centerline of the equipment.

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

3.5.1.13 Pipe plugs shall be in accordance with 2.3.5.

3.5.2 INSTRUMENT PIPING

3.5.2.1 The vendor shall supply all necessary piping, valves, and fittings for instruments and instrument panels (3.4.3.2).

3.5.2.2 Connections on equipment and piping for pressure instruments and test points shall conform to 3.5.1.4. Beyond the initial NPS ¾ isolating valve, NPS ½ piping, valves, and fittings may be used. Where convenient, a common connection may be used for remotely mounted instruments that measure the same pressure. Separate secondary NPS ½ iso-

Table 1 — Minimum Requirements for Piping Materials

System	Group I (Auxilliary Process Fluid)		Group II (Steam)		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 (<1 inch)	Optional	<1 inch	>1 1/2 inches
Pipe (schedule)	Seamless[a]	Seamless[ab]	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 or ASTM A 192 steel (see 3.6.2.3)	—
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 53	ASTM A 338 and A 197, Class 150 malleable iron, galvanized to ASTM A 53	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 <1 1/2 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 53, Grade B; 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 312.

[a]Schedule 160 carbon steel for diameters of ¼ inch and smaller; Schedule 80 for diameters from 1 inch to 1½ inches; Schedule 40 for diameters of 2 inches and larger.
[b]Schedule 80S stainless steel for diameters 1 inch and smaller; Schedule 40S for diameters of 1½ and 3 inches; Schedule 10S for diameter 4 inches and larger.
[c]½-inch diameter x 0.065-inch wall, ¼-inch diameter x 0.095-inch wall, or 1-inch diameter x 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.

lating valves are required for each instrument on a common connection. Where a pressure gauge is to be used for testing pressure alarm or shutdown switches, common connections are required for the pressure gauge and switches.

3.5.3 PROCESS PIPING

• **3.5.3.1** The extent of and requirements for process piping to be supplied by the vendor will be specified.

3.5.3.2 The requirements of 3.5.1 shall apply to process piping supplied by the vendor.

• **3.5.3.3** When specified, the vendor shall review all piping, appurtenances (pulsation suppression devices, separators, and expansion joints), and vessels immediately upstream and downstream of the equipment and supports. The purchaser and the vendor shall mutually agree on the scope of this review.

3.6 Pulsation Suppression Devices

• **3.6.1** When specified, the vendor shall furnish pulsation suppression devices to be located at the pump suction and/or discharge connections. The following are three basic types of pulsation suppression devices:

a. Volume bottles without internals.
b. Pulsation dampeners using a gas-filled chamber isolated from the pumped fluid by a piston or elastomeric diaphragm.
c. Pulsation filters and attenuators, including proprietary commercial designs based on acoustical suppression techniques.

Note: These in-line devices are designed so that all pumped fluid flows through them.

3.6.2 The purchaser and the vendor shall mutually agree on the type and arrangement of pulsation suppression devices to be used for each pumping system. The following factors should be considered:

a. Pump power.
b. Discharge and suction pressure.
c. Number of cylinders per pump.
d. Number of pumps operating in parallel and any potential pulsation interaction.
e. Pump and bottle nozzle loading.
f. Bottle support arrangement.
g. Critical nature of the installation.
h. Residual pulsation level(s).

Note: Additional information on pulsation suppression devices may be obtained from API Standard 618.

3.7 Special Tools

3.7.1 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.

3.7.2 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 and/or vendor's representative 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 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 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 at least 20 years for examination or reproduction by the purchaser or 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 have been 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 2.13.4.1, 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.

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 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 GENERAL

4.3.1.1 Equipment shall be tested in accordance with 4.3.2 and 4.3.3.

4.3.1.2 At least 6 weeks before the first scheduled test, or at some mutually agreed upon time, the vendor shall submit to the purchaser, for review and comment, detailed procedures for all running tests, including acceptance criteria for all monitored parameters.

4.3.1.3 The vendor shall notify the purchaser not less than 5 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 5 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 1.5 bar gauge (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 pressure-containing components 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 PERFORMANCE TEST

4.3.3.1 Unless otherwise specified, the test fluid shall be water, and the suction port shall be flooded.

4.3.3.2 Pumps shall meet rated flow and pressure and shall demonstrate steady state accuracy at rated flow and discharge pressure between two consecutive capacity tests. The pressure variation shall not exceed plus or minus 1 percent of the value at rated capacity. Individual test-run periods need not exceed 5 minutes.

4.3.3.3 Automatically controlled pumps shall be operated using the job controls.

• **4.3.3.4** When flow repeatability and linearity tests are specified, they shall be run by using 100, 75, 50, 25, and 10 percent of rated capacity points in descending and ascending order. The flow variations shall not exceed plus or minus 3 percent of the value at rated capacity.

4.3.3.5 If replacement or modification of parts is required for improvement of mechanical operation or remediating performance deficiencies, the initial test will not be acceptable, and the final shop tests shall be run after such replacements or corrections are made.

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 6 months of outdoor storage from the time of shipment, with no disassembly required before operation. 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 start-up.

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 the purchaser. The preparation shall include that specified in 4.4.3.1 through 4.4.3.7.

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 Flanged openings shall be provided with metal closures at least 5 millimeter (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.

4.4.3.4 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: These are shipping plugs. Permanent plugs are covered in 2.3.5.

4.4.3.5 Lifting points and lifting lugs shall be clearly identified on the equipment or the equipment package. Recommended lifting arrangement shall be identified on boxed equipment.

4.4.3.6 The equipment shall be identified with item and serial numbers. Material shipped separately shall be 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.

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

4.4.5 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

5.2.2.1 The drawings described on the VDDR form shall be included. As a minimum, the following data shall be furnished:

a. 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.
b. Cross-sectional drawing(s) showing details of the proposed equipment.
c. Schematics of all auxiliary systems, including lube, control, and electrical. Bills of Material (B/Ms) shall be included.
d. Sketches indicating methods of lifting the assembled machine(s) and major components. (This can be part of Item a).

5.2.2.2 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 the weeks after receipt of the order.
e. A list of major wearing components showing interchangeability with other purchase units.
f. A list of spare parts recommended for start-up and normal maintenance purposes.
g. A list of special tools furnished for maintenance. The vendor shall identify any metric items included in the offering.
h. A statement of any special weather protection and winterization required for start-up, 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. A complete tabulation of utility requirements, such as electricity, air, and lube products. Approximate data shall be defined and clearly identified as such.
j. A description of the tests and inspection procedures for materials as required by 2.13.1.3.
k. A description of special requirements, as outlined in paragraphs 2.1.19, 2.12.2, 2.13.1.2, 2.13.1.9, 2.13.2.5, 2.13.4.2, 3.4.4.5.1, 3.4.4.6, 4.4.2, and any others in purchaser's inquiry.
l. A list of similar machines installed and operating under analogous conditions to those proposed.
m. Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment.

5.2.4 CURVES

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

• 5.2.5 OPTIONS

When specified, the vendor shall furnish procedures for any special 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 the date of certification, a reference to all identification data specified in 5.1.2, the revision number and date, and the 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 have 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 drawing(s) furnished shall contain sufficient information that, when combined with the manuals covered in 5.3.6, will enable the purchaser to properly install, operate, and maintain the ordered equipment.

Drawings shall be clearly legible, identified as in 5.3.1.1, and in accordance with ASME Y14.2M. As a minimum, each drawing shall include details for that drawing listed in Appendix D.

5.3.3 TECHNICAL DATA

Data shall be submitted per Appendix D and identified per 5.3.1.1. Any drawing comments or specification revisions necessitating a change in the data shall be noted by the vendor and will result in reissue of the completed, corrected data sheets by the purchaser 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 LIST 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 finished to satisfy specific performance requirements shall be uniquely identified by part number for interchangeablilty 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 start-up 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 start-up. 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 the complete equipment ordered. This information shall be compiled in a manual or manuals with a cover sheet containing all reference-identifying data required in 5.1.2, an index sheet containing 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 and shall not be typical.

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 separate from operating and maintenance instructions. This manual shall be forwarded at a time 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 quantity), and all installation design data, including any pertinent drawings/data specified in 5.3.2 and 5.3.3. Unless otherwise included, sketches showing the location of center of gravity and rigging provisions to permit removal of any subassemblies that weigh more than 135 kilograms (300 pounds) shall be furnished.

5.3.6.3 Operating and Maintenance Manual

The manual containing operating and maintenance data shall be forwarded no later than 2 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—CONTROLLED VOLUME PUMP DATA SHEETS

CONTROLLED VOLUME PUMP DATA SHEET CUSTOMARY UNITS

PAGE _____ OF _____
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 _____ MODEL _____ 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 (GPH/GPM):
MAXIMUM _____ MINIMUM _____ RATED _____
O DISCHARGE PRESSURE (PSIG):
MAXIMUM _____ MINIMUM _____
O SUCTION PRESSURE (PSIG):
MAXIMUM _____ MINIMUM _____
O DIFFERENTIAL PRESSURE (PSI):
MAXIMUM _____ MINIMUM _____
O NPSH AVAILABLE (FT.) _____
WITHOUT ACCELERATION HEAD _____ ACTUAL _____
O TURNDOWN RATIO _____

☐ PERFORMANCE

☐ NUMBER OF FEEDS _____ RATED CAPACITY (GPH/GPM) _____
☐ NPSH REQUIRED (FT.) _____
☐ BHP RATED _____ AT RELIEF SETTING _____
☐ PLUNGER SPEED (strokes/min) _____ DESIGN MAX _____
☐ DIAMETER (IN) _____ LENGTH OF STROKE (IN) _____
PUMP HEAD: _____
MAXIMUM PRESSURE (PSIG) _____
☐ HYDRO TEST PRESSURE (PSIG) _____
☐ MAX DISCH PRESS. W/ JOB DRIVER (PSIG) _____
☐ MAX BHP BASIS GEAR STRENGTH _____

☐ CONSTRUCTION

CONNECTIONS	SIZE	ANSI RATING	FACING	POSITION
SUCTION				
DISCHARGE				
FLUSH				

LIQUID END O JACKET REQ'D
TYPE O DIAPHRAGM O PLUNGER
☐ DIAPHRAGM DIA (IN) _____ NO REQ. _____
☐ VALVES/FEED SUCTION DISCHARGE
TYPE _____ _____
NUMBER _____ _____

O LIQUID

O TYPE OR NAME OF LIQUID _____
O PUMPING TEMPERATURE (°F):
NORMAL _____ MAX _____ MIN _____
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:

O API 675 POSITIVE DISPLACEMENT PUMPS - CONTROLLED VOLUME
O GOVERNING SPECIFICATION (IF DIFFERENT) _____

REMARKS _____

PRINTED IN U.S.A. DS-675-1 5/93

CONTROLLED VOLUME PUMP DATA SHEET CUSTOMARY UNITS

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

☐ MATERIALS

LIQUID END _____
CONTOUR PLATE _____
HYDRAULIC DIAPHRAGM _____
PROCESS DIAPHRAGM _____
PLUNGER _____
LANTERN RING _____
PACKING GLAND _____
PACKING _____
VALVE _____
VALVE SEAT _____
VALVE GUIDE _____
VALVE BODY _____
VALVE GASKET _____
FRAME _____
SPECIAL MATERIAL TESTS **(2.13.1.3)** _____

O LOW AMBIENT TEMPERATURE MATERIALS TESTS **(2.13.5)**

QA INSPECTION AND TEST

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

TESTS	REQ'D	WIT	OBS
HYDROSTATIC	●	O	O
STEADY STATE ACCURACY	●	O	O
REPEATABILITY	O	O	O
LINEARITY	O	O	O
_____	O	O	O
_____	O	O	O

LUBRICATION FLUID

☐ CRANKCASE ☐ INTERMEDIATE
☐ HYDRAULIC FLUID

ACCESSORIES

☐ SPEED REDUCER MANUFACTURER _____
O INTEGRAL O SEPARATE
MODEL _____
RATIO _____
☐ BASEPLATE UNDER _____
☐ COUPLING MANUFACTURER _____
☐ TYPE _____

CONTROLS

TYPE:
O MANUAL O REMOTE
O AUTOMATIC O LOCAL

SIGNAL:
O PNEUMATIC
O ELECTRONIC

STROKE CONTROL:
PNEUMATIC (PSIG):
MINIMUM _____ MAXIMUM _____
ELECTRONIC(mA):
MINIMUM _____ MAXIMUM _____

OTHER PURCHASE REQUIREMENTS

NAMEPLATE UNITS O CUSTOMARY O SI
O VENDOR FURNISHED PROCESS PIPING _____
O VENDOR REVIEW PIPING DRAWINGS
O VENDOR FURNISHED PULSATION SUPPRESSION DEVICES
O VENDOR FURNISHED RELIEF VALVE
O INTERNAL O EXTERNAL
☐ RELIEF VALVE SETTING (PSIG) _____
O VENDOR FURNISHED BACK-PRESSURE VALVE
O DOUBLE CHECK VALVES REQUIRED
O OIL-FILLED PRESSURE GAUGES REQUIRED
O VENDOR FURNISHED CONTROL PANEL
O BASEPLATE PREPARED FOR EPOXY GROUT
O PROVIDE TECHNICAL DATA MANUAL
O _____
O _____

PREPARATION FOR SHIPMENT

O DOMESTIC O EXPORT O EXPORT BOXING
O OUTDOOR STORAGE MORE THAN 6 MONTHS

WEIGHTS (LBS)

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

DRIVERS

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

REMARKS _____

PRINTED IN U.S.A. DS-675-2

5/93

O:\PS\111\206\00580SI.PM4

CONTROLLED VOLUME PUMP DATA SHEET SI UNITS

PAGE _____ OF _____

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 _____ MODEL _____ 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 (m³/h):
MAXIMUM _____ MINIMUM _____ RATED _____
O DISCHARGE PRESSURE (kPa)(BARG):
MAXIMUM _____ MINIMUM _____
O SUCTION PRESSURE (kPa)(BARG):
MAXIMUM _____ MINIMUM _____
O DIFFERENTIAL PRESSURE (kPa)(BARG):
MAXIMUM _____ MINIMUM _____
O NPSH AVAILABLE (m) _____
WITHOUT ACCELERATION HEAD _____ ACTUAL _____
O TURNDOWN RATIO _____

O LIQUID

O TYPE OR NAME OF LIQUID _____
O PUMPING TEMPERATURE (°C):
NORMAL _____ MAX _____ MIN _____
O SPECIFIC GRAVITY _____ MAXIMUM _____ MINIMUM
O SPECIFIC HEAT _____ Cp (kJ/kg°C)
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 _____

☐ PERFORMANCE

☐ NUMBER OF FEEDS _____ RATED CAPACITY (m³/h) _____
☐ NPSH REQUIRED (m) _____
☐ kW RATED _____ AT RELIEF SETTING _____
☐ PLUNGER SPEED (strokes/min) _____ DESIGN MAX _____
☐ DIAMETER (mm) _____ LENGTH OF STROKE (mm) _____
PUMP HEAD: _____
MAXIMUM PRESSURE (kPa)(BARG) _____
☐ HYDRO TEST PRESSURE (kPa)(BARG) _____
☐ MAX DISCH PRESS. W/ JOB DRIVER (kPa)(BARG) _____
☐ MAX kW BASIS GEAR STRENGTH _____

☐ CONSTRUCTION

CONNECTIONS	SIZE	ANSI RATING	FACING	POSITION
SUCTION				
DISCHARGE				
FLUSH				

LIQUID END O JACKET REQ'D
TYPE O DIAPHRAGM O PLUNGER
☐ DIAPHRAGM DIA (mm) _____ NO REQ. _____
☐ VALVES/FEED SUCTION DISCHARGE
TYPE _____ _____
NUMBER _____ _____

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 ___/___ °C
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 °C		MAX		
PRESS. (PSIG)		MIN		
SOURCE				

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

APPLICABLE SPECIFICATIONS:

O API 675 POSITIVE DISPLACEMENT PUMPS - CONTROLLED VOLUME
O GOVERNING SPECIFICATION (IF DIFFERENT) _____

REMARKS _____

PRINTED IN U.S.A. DS-675-1SI 5/93

O:\PS\111\206\00580.PM4

CONTROLLED VOLUME PUMP DATA SHEET SI UNITS

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

☐ MATERIALS

LIQUID END _____
CONTOUR PLATE _____
HYDRAULIC DIAPHRAGM _____
PROCESS DIAPHRAGM _____
PLUNGER _____
LANTERN RING _____
PACKING GLAND _____
PACKING _____
VALVE _____
VALVE SEAT _____
VALVE GUIDE _____
VALVE BODY _____
VALVE GASKET _____
FRAME _____
SPECIAL MATERIAL TESTS (2.13.1.3) _____

O LOW AMBIENT TEMPERATURE MATERIALS TESTS (2.13.5)

QA INSPECTION AND TEST

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

TESTS	REQ'D	WIT	OBS
HYDROSTATIC	●	O	O
STEADY STATE ACCURACY	●	O	O
REPEATABILITY	O	O	O
LINEARITY	O	O	O
_____	O	O	O
_____	O	O	O

LUBRICATION FLUID

☐ CRANKCASE ☐ INTERMEDIATE
☐ HYDRAULIC FLUID

ACCESSORIES

☐ SPEED REDUCER MANUFACTURER _____
O INTEGRAL O SEPARATE
MODEL _____
RATIO _____
☐ BASEPLATE UNDER _____
☐ COUPLING MANUFACTURER _____
☐ TYPE _____

CONTROLS

TYPE: **SIGNAL:**
O MANUAL O REMOTE O PNEUMATIC
O AUTOMATIC O LOCAL O ELECTRONIC

STROKE CONTROL:
PNEUMATIC (kPa)(BARG):
MINIMUM _____ MAXIMUM _____
ELECTRONIC(mA):
MINIMUM _____ MAXIMUM _____

OTHER PURCHASE REQUIREMENTS

NAMEPLATE UNITS O CUSTOMARY O SI
O VENDOR FURNISHED PROCESS PIPING _____
O VENDOR REVIEW PIPING DRAWINGS
O VENDOR FURNISHED PULSATION SUPPRESSION DEVICES
O VENDOR FURNISHED RELIEF VALVE
O INTERNAL O EXTERNAL
☐ RELIEF VALVE SETTING (kPa)(BARG) _____
O VENDOR FURNISHED BACK-PRESSURE VALVE
O DOUBLE CHECK VALVES REQUIRED
O OIL-FILLED PRESSURE GAUGES REQUIRED
O VENDOR FURNISHED CONTROL PANEL
O BASEPLATE PREPARED FOR EPOXY GROUT
O PROVIDE TECHNICAL DATA MANUAL
O _____
O _____

PREPARATION FOR SHIPMENT

O DOMESTIC O EXPORT O EXPORT BOXING
O OUTDOOR STORAGE MORE THAN 6 MONTHS

WEIGHTS (LBS)

☐ PUMP_____ ☐ BASE_____ ☐ GEAR_____ ☐ DRIVER_____

DRIVERS

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

REMARKS _____

PRINTED IN U.S.A. DS-675-2SI 5/93

O:\PS\111\206\00580SI.PM4

APPENDIX B—MISCELLANEOUS MATERIALS

Material	Typical Description
FFKM elastomer	ASTM D 1418 FFKM elastomer such as Du Pont Kalrez
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 0.030-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 0.03 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

Note: Table B-1 is to be used as a guide for material specifications.

Table B-1—Material Specifications for Metering Pump Parts

Material	Pressure-Containing Castings	Bar Stock	Bolts and Studs
Cast iron	ASTM A 48 or 278	—	—
Ductile iron	ASTM A 395	ASTM A 108 or A 575	—
Bronze	ASTM B 584, UNS C87200 (silicon bronze) or C92200 (tin bronze); ASTM B 148, UNS C95200 (aluminum bronze) or C95800 (nickel aluminum bronze)	ASTM B 139	ASTM B 124, Alloy 655
Carbon steel	ASTM A 216, GR WCA or WCB	ASTM A 108 or A 575	—
AISI 4140	—	ASTM A 322, GR 4140	ASTM A 193, GR B7
NI resist	ASTM A 436, Type 1, 2, or 3	—	—
12 percent chrome	ASTM A 296, GR CA-6NM or CA-15	ASTM A 276, Type 410 or ASTM A 582, Type 416	ASTM A 193, GR B6
5 percent chrome	ASTM A 217, GR C5	—	—
18-8 stainless steel	ASTM A 296, GR CF-20	ASTM A 276, Type 304	ASTM A 193, GR B8
316 stainless steel	ASTM A 296, GR CF-8M	ASTM A 276, Type 316	ASTM A 193, GR B8M
Alloy 20	ASTM B 473, UNS 8020 (wrought) ASTM A 744, Grade CN7M (cast)		

APPENDIX C—INSPECTOR'S CHECKLIST

	Item	Date Insp'd	Insp'd By	Status
1	Capacity adjustment (2.1.14) (2.12.4)			
2	Material certification (2.13.1.2) (4.2.1.1.a)			
3	Nondestructive examination (components) (2.13.1.3)			
4	Welding operators and procedures qualified (2.13.4.1, 2.13.4.3)			
5	Rotation arrow [2.14.2.(*)]			
6	Equipment nameplate data (2.14.3)			
7	Overall dimensions and connection locations (*)			
8	Nozzle flange dimensions (*)			
9	Anchor bolt layout and size (*)			
10	Mounting plate precoat for epoxy grout (3.3.4)			
11	Control panel wiring (3.4.3.2)			
12	Electrical wiring (3.4.5.7)			
13	Piping inspection (3.5.1.1)			
14	Pulsation suppression (3.6)			
15	Special tools (3.7)			
16	Maintenance and clearance data (4.2.1.1.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	Performance tests (4.3.3)			
21	Preparation for shipment (4.4.1)			
22	Painting (4.4.3.1)			
23	Shipping documents and tags (4.4.3.6)			
24	Match marked removed piping (4.4.5)			

(*) Check against certified dimensional outline drawing.

APPENDIX D—CONTROLLED VOLUME PUMP VENDOR DRAWING AND DATA REQUIREMENTS

CONTROLLED VOLUME PUMP VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. _____ ITEM NO. _____
PURCHASE ORDER NO. _____ DATE _____
REQUISITION NO. _____ DATE _____
INQUIRY NO. _____ DATE _____
PAGE 1 OF 1 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. Auxiliary systems.						
			4. Electrical and instrumentation schematics and bills of materials.						
			5. Electrical and instrumentation assembly drawings and lists of connections.						
			6. Tabulation of utility requirements.						
			7. Curve showing output-power shaft speed versus torque.						
			8. Allowable flange loadings.						
			9. Welding procedures.						
			10. Certified hydrostatic test logs.						
			11. Performance test logs.						
			12. Nondestructive test procedures.						
			13. Certified mill test reports.						
			14. As-built data sheets.						
			15. As-built dimensions.						
			16. Instruction manual.						
			17. Operating and maintenance manuals.						
			18. Spare-parts recommendations.						
			19. Engineering, fabrication, and delivery schedule (progress reports).						
			20. List of drawings.						
			21. Shipping list.						
			22. List of special tools furnished for maintenance.						
			23. Technical data manual.						
			24. 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.

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 baseplates (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 journal-bearing clearances and tolerances.

3. Auxiliary system schematics and bills of materials, including the following:
   a. Control, alarm, and trip settings (pressures and recommended temperatures).
   b. Utility requirements, including electricity, water, and air.
   c. Pipe and valve sizes.
   d. Instrumentation, safety devices, and control schemes.

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

5. Electrical and instrumentation arrangement drawing and lists of connections.

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

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

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

9. Welding procedures for fabrication and repair (see 2.13.2.3.1, 2.13.4.1, 2.13.4.3, 2.13.4.5.4, 3.5.1.12, and 4.2.2.1).

10. Certified hydrostatic test logs.

11. Performance test logs.

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

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

14. As-built data sheets.

15. As-built dimensions (including nominal dimensions with design tolerances) and data for the following listed parts:
   a. Shaft or sleeve diameters at each journal bearing.
   b. Each journal bearing inside diameter.
   c. Thrust-bearing concentricity (axial runout).

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

17. 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.
        2. Disassembly and reassembly of thrust bearing.
    g. Performance data, including curve showing certified flow versus turndown setting.
    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 above.
        4. Performance test logs, per item above.
    i. Drawings and data, including —
        1. Certified dimensional outline drawing and list of connections.
        2. Cross-sectional drawing and bill of materials.
        3. Thrust-bearing assembly drawing and bill of materials.
        4. Journal-bearing assembly drawings and bill of materials.
        5. Electrical and instrumentation schematics and bill of materials.
        6. Electrical and instrumentation assembly drawings and list of connections.

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

19. Progress reports and delivery schedule, including vendor buy-outs and milestones.

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

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

22. List of special tools furnished for maintenance (see 3.7).

23. Technical data manual, including the following:
    a. As-built purchaser data sheets, per item 14 above.
    b. Certified performance curves, per item 7 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 6 above.
    g. Reports, per items 10, 11, 12, and 13 above.

24. 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 positive displacement pump does not generate pressure solely by increasing fluid velocity. Instead these pumps convert rotating motion and torque into linear fluid motion and force, generating variable flow 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 prevent 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 an 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 positive displacement pump, flow is a function of pump stroke length and/or rpm.

Either type of pump requires sufficient fluid pressure at the inlet to prevent release of dissolved gasses 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 reciprocating pumps, as well as the latest editions of the Hydraulic Institute Standards, refer to the total suction head as NPSH rather than NPIP. Although the Hydraulic Institute indicates that NPSH is normally expressed in either kilopascals (pounds per square inch) or meters (feet), the latest API Standards refer to NPSH in meters (feet), the preferred terminology for both pump types, to avoid confusion. Positive displacement 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:

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

Where:

P_a = Absolute pressure at surface of liquid in kPa absolute (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 absolute (psia).

P_{amax} = Pressure loss due to acceleration head (see below) in kPa (psi).

NPIPA calculation for a controlled volume pump must include the effects of system acceleration head. From the Hydraulics Institute Standards, Fourteenth Edition, liquid in the suction and discharge lines of controlled volume pumps has to be accelerated because flow varies with time. This produces alternate pressure drops and surges. The instantaneous pressure drop required to accelerate the mass of fluid in the suction line, or the instantaneous pressure rise required to accelerate the mass of fluid in the discharge, is referred to as acceleration head. When computing this value for a controlled volume pump, the equation below defines the maximum instantaneous value of h_{amax}:

$$h_{amax} = \frac{LVnC}{Kg} \text{ or } P_{amax} \frac{LVnC\ (Sp\ Gr)}{2.31\ Kg}$$

Where:

h_{amax} = Maximum instantaneous acceleration head in meters (feet)

P_{amax} = Maximum instantaneous acceleration head in kPa (psi)

L = Length of pipe in meters (feet)

C = 0.628 for simplex single-acting

K = 1.4

V = Average velocity in meter/sec (feet/sec)

n = Pump speed in rpm

g = Gravitational constant, 9.82 m/s^2 (32.2 ft/sec^2)

Note that it is the responsibility of the purchaser to define acceleration head (see 1.4.19), yet the value is dependent on the characteristics of the pump selected. Consequently, the value should be reviewed by both the purchaser and the vendor before a final selection is made.

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.

1-01400--10/94--1M (5A)

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

Order No. 822-67502