Designation: ~~F1510 – 07 (Reapproved 2013)~~ F1510 – 07 (Reapproved 2019)~~ε1~~ An American National Standard

Standard Specification for Rotary Positive Displacement Pumps, Ships Use[1]

This standard is issued under the fixed designation F1510; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification defines the requirements applicable to design and construction of rotary positive displacement pumps for shipboard use. The classes of service are shown in Section 4.

1.2 This specification will not include pumps for hydraulic service or cargo unloading applications.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A27/A27M Specification for Steel Castings, Carbon, for General Application
A36/A36M Specification for Carbon Structural Steel
A48/A48M Specification for Gray Iron Castings
A53/A53M Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A159 Specification for Automotive Gray Iron Castings
A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
A194/A194M Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
A322 Specification for Steel Bars, Alloy, Standard Grades
A354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
A395/A395M Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
A434 Specification for Steel Bars, Alloy, Hot-Wrought or Cold-Finished, Quenched and Tempered
A449 Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
A515/A515M Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
A536 Specification for Ductile Iron Castings
A563 Specification for Carbon and Alloy Steel Nuts
A564/A564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
A574 Specification for Alloy Steel Socket-Head Cap Screws
A582/A582M Specification for Free-Machining Stainless Steel Bars
A743/A743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
B150M Specification for Aluminum Bronze, Rod, Bar, and Shapes [Metric] (Withdrawn 2002)[3]
B584 Specification for Copper Alloy Sand Castings for General Applications
D1418 Practice for Rubber and Rubber Latices—Nomenclature

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.11 on Machinery and Piping Systems.

Current edition approved ~~Oct. 1, 2013~~Dec. 1, 2019. Published ~~October 2013~~January 2020. Originally approved in 1994. Last previous edition approved in ~~2007~~2013 as ~~F1510 – 07.~~F1510 – 07 (2013). DOI: ~~10.1520/F1510-07R13.~~10.1520/F1510-07R19.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

D2000 Classification System for Rubber Products in Automotive Applications
D3951 Practice for Commercial Packaging
F104 Classification System for Nonmetallic Gasket Materials
F912 Specification for Alloy Steel Socket Set Screws
F1511 Specification for Mechanical Seals for Shipboard Pump Applications

2.2 ~~*ANSI*~~*ASME Standard:*[4]
~~B 16.5~~ASME B16.5 Pipe Flanges and Flanged ~~Fittings~~ Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

2.3 *SAE Standards:*[5]
SAE AS 568A Aerospace Size Standard for O-Rings
SAE J 429 Mechanical and Material Requirements for Externally Threaded Fasteners

2.4 *AMS Standard:*[5]
AMS 3215 Acrylonitrile Butadiene (NBR) Rubber Aromatic Fuel Resistant 65-75

2.5 *ABMA Standards:*[6]
ABMA 9 Load Ratings and Fatigue Life for Ball Bearings
ABMA 11 Load Ratings and Fatigue Life for Roller Bearings

2.6 *AGMA Standard:*[7]
AGMA 390.03 Gear Classification, Materials and Measuring Methods for Unassembled Gears

2.7 *API Standard:*[8]
API 676 Positive Displacement Pumps—Rotary

2.8 *Military Standards:*[9]
MIL-S-901
MIL-STD-167
MIL-STD-740

3. Terminology

3.1 *Definitions:*

3.1.1 ~~*capacity—*~~*capacity, n—*the quantity of fluid actually delivered per unit of time at the rated speed, including both the liquid and dissolved or entrained gases, under stated operating conditions. In the absence of any gas or vapor entering or forming within the pump, the capacity is equal to the volume displaced per unit of time, less slip.

3.1.2 *capacity, ~~maximum—~~maximum, n—*the quantity of fluid delivered that does not exceed the limit determined by the formula in 9.2.

3.1.3 ~~*displacement—*~~*displacement, n—*the volume displaced per revolution of the rotor(s). In pumps incorporating two or more rotors operating at different speeds, the displacement is the volume displaced per revolution of the driving rotor. Displacement depends only on the physical dimensions of the pumping elements.

3.1.4 *dry ~~operation—~~operation, n—*a brief run during priming or stripping with suction and discharge lines unrestricted and pump chamber wet with liquid but pumping only air or vapor available from the suction.

3.1.5 *efficiency, ~~mechanical—~~mechanical, n—*the ratio of the pump power output (hydraulic horsepower) to the pump power input (brake horsepower) expressed in percent.

3.1.6 *efficiency, ~~volumetric—~~volumetric, n—*the ratio of the ~~pump's~~pump's capacity to the product of the displacement and the speed expressed in percent.

3.1.7 *fuel, ~~clean—~~clean, n—*fuel purified for direct use.

3.1.8 *fuel, ~~dirty—~~dirty, n—*fuel before purification which may contain water and some solids.

3.1.9 *net positive inlet pressure available ~~(NPIPA)—~~(NPIPA), n—*the total inlet pressure available from the system at the pump inlet connection at the rated flow, minus the vapor pressure of the liquid at the pumping temperature.

3.1.10 *net positive inlet pressure required ~~(NPIPR)—~~(NPIPR), n—*the net pressure above the liquid vapor pressure at rated flow and pumping temperature and at the pump inlet connection required to avoid performance impairment due to cavitation.

[4] Available from American ~~National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor,~~ Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY ~~10036, http://www.ansi.org.~~10016-5990, http://www.asme.org.
[5] Available from ~~Society of Automotive Engineers~~ SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA ~~15096-0001,~~15096, http://www.sae.org.
[6] Available from American Bearing Manufacturers Association (ABMA), ~~2025 M Street, NW Suite 800, Washington, DC 20036, http://www.abma-dc.org.~~1001 N. Fairfax Street, Suite 500, Alexandria, VA 22314, https://www.americanbearings.org.
[7] Available from American Gear ~~Manufacturer's~~Manufacturers Association (AGMA), ~~500 Montgomery~~ 1001 N. Fairfax St., Suite ~~350,~~500, Alexandria, VA ~~22314-1581,~~22314-1587, http://www.agma.org.
[8] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, ~~http://api-ec.api.org.~~http://www.api.org.
[9] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

3.1.11 *pressure, ~~cracking—~~cracking, n—*sometimes called set pressure, start-to-discharge pressure, or popping pressure—the pressure at which the relief valve just starts to open. This pressure cannot be determined readily if the relief valve is internal to the pump and it bypasses the liquid within the pump.

3.1.12 *pressure, ~~differential—~~differential, n—*the difference between discharge pressure and inlet pressure.

3.1.13 *pressure, ~~discharge—~~discharge, n—*the pressure at the outlet of the pump. Discharge pressure is sometimes called outlet pressure.

3.1.14 *pressure, ~~inlet—~~inlet, n—*the total pressure at the inlet of the pump. Inlet pressure is sometimes called suction pressure.

3.1.15 *pressure, maximum allowable ~~working—~~working, n—*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. This pressure should not be greater than ⅔ of the hydrostatic test pressure of the pressure containing parts.

3.1.16 *rated ~~condition—~~condition, n—*defined by discharge pressure, inlet pressure, capacity, and viscosity.

3.1.17 *rotary ~~pump—~~pump, n—*a positive displacement pump consisting of a casing containing gears, screws, lobes, cams, vanes, shoes, or similar elements actuated by relative rotation between the drive shaft and the casing. There are no inlet and outlet valves. These pumps are characterized by their close running clearances.

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

3.1.19 *speed, maximum allowable (in revolutions per ~~minute)—~~minute), n—*the highest speed at which the ~~manufacturers'~~manufacturers' design will permit continuous operation.

3.1.20 *speed, minimum allowable (in revolutions per ~~minute)—~~minute), n—*the lowest speed at which the ~~manufacturers'~~manufacturers' design will permit continuous operation.

3.1.21 *speed, ~~rated—~~rated, n—*the number of revolutions per minute of the driving rotor required to meet the rated conditions.

3.1.22 *suction ~~lift—~~lift, n—*a term used to define a ~~pump's~~pump's capability to induce a partial vacuum at the pump inlet.

3.1.23 *temperature, maximum ~~allowable—~~allowable, n—*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.

4. Classification

4.1 Pumps will be classified as follows:

4.1.1 *Types:*

4.1.1.1 *Type II*—Screws with timing gears.

4.1.1.2 *Type III*—Screws without timing gears.

4.1.1.3 *Type IV*—Impellers with timing gears.

4.1.1.4 *Type V*—External gear (spur, helical, herringbone, lobe).

4.1.1.5 *Type VIII*—Internal gear, internal rotary lobe.

4.1.1.6 *Type X*—Vane (sliding).

4.1.1.7 *Type XI*—Sliding shoe.

4.1.2 *Classes:*

4.1.2.1 *Class A*—Aqueous film forming foam, AFFF.

4.1.2.2 *Class B*—Bromine.

4.1.2.3 *Class CD*—Clean distillate fuel, viscosity 32 to 100 SSU (2 to 21 centistokes) (for example, jet fuel, JP-5, fuel).

4.1.2.4 *Class CH*—Clean heavy fuel, viscosity 100 to 1500 SSU (21 to 325 centistokes) (propulsion fuel).

4.1.2.5 *Class DD*—Dirty distillate fuel, viscosity 32 to 100 SSU (2 to 21 centistokes) (for example, transfer, stripping, purifier feed, leak-off).

4.1.2.6 *Class DH*—Dirty heavy oil, viscosity 32 to 4000 SSU (2 to 863 centistokes) (for example, waste oil, transfer, stripping, purifier feed, drains).

4.1.2.7 *Class G*—Gasoline, aviation gasoline, gasohol.

4.1.2.8 *Class LM*—Lube oil, viscosity 130 to 4000 SSU (27 to 863 centistokes) (for example, propulsion, SSTG, control, L.O. service).

4.1.2.9 *Class LA*—Auxiliary L.O. 130 to 4000 SSU (27 to 863 centistokes) service and L.O. transfer.

4.1.2.10 *Class M*—Miscellaneous.

4.1.2.11 *Class W*—Heavily contaminated seawater, viscosity 32 to 4000 SSU (2 to 863 centistokes) (bilge stripping, oily waste transfer).

5. Ordering Data

5.1 The ordering activity shall provide manufacturers with all of the following information:

5.1.1 Title, number, and date of specification,

5.1.2 Type and classification, see Section 4,
5.1.3 Capacity in gallons per minute or litres per minute at rated discharge pressure,
5.1.4 Discharge pressure in pound-force per square inch gauge (psig) or kilopascal (kPa) gauge.
5.1.5 Airborne noise levels (if different than 7.5),
5.1.6 Viscosity (only if different than Section 4),
5.1.7 Mounting configuration (vertical, horizontal),
5.1.8 Driver type (motor, turbine, engine, attached),
5.1.9 Driver characteristics or specifications, or both,
5.1.10 Relief valve cracking pressure and full-flow bypass pressure,
5.1.11 Packaging and boxing requirements (immediate use, domestic; storage, domestic; overseas),
5.1.12 Quantity of pumps,
5.1.13 Quantity of drawings,
5.1.14 Quantity of technical manuals,
5.1.15 Quantity of test reports,
5.1.16 Performance test, if required,
5.1.17 Certified data required, and
5.1.18 Instruction plates and locations, if required.

6. Materials

6.1 Pump component parts shall be constructed of the materials shown in Table 1.

6.2 Materials other than shown in Table 1 are considered exceptions and are subject to approval by the purchaser before usage.

7. General Requirements

7.1 Pumps shall be designed for a 20-year service life.

7.2 Pumps shall be capable of sustained operation during inclinations up to 45° in any direction.

7.3 The pumps shall be capable of withstanding environmental vibration induced by shipboard machinery and equipment in the frequency range from 4 to 25 Hz.

7.4 The internally excited vibration levels of the pump shall not exceed 0.003-in. (0.00762-mm) displacement peak to peak during rated operation when readings are measured on the pump case near the coupling perpendicular to the pump shaft.

7.5 At normal operating conditions, the airborne noise level of the pump shall not exceed 85 dBA.

7.6 The pump driver (electric motor, air motor, turbine, hydraulic motor, diesel engine, attached) shall be as specified in the ordering data. The driver shall be sized for maximum flow at the relief valve full-flow bypass pressure, at maximum viscosity. If a two-speed motor is specified for high-viscosity Class LM applications, the motor size shall be based on power required at low speed, which is used during cold startup.

7.7 If a reduction gear is required between the driver and the pump, it shall be provided by the pump manufacturer. Reduction gears shall meet the requirements of AGMA 390.03. Gears shall be AGMA Class 7 or better, pinions shall be AGMA Class 8 or better, and bearings shall be designed for a L10 life of 15 000 h.

7.8 Horizontal pumps may be mounted on a common horizontal bedplate with the driving unit or mounted directly to the driver. Vertical pumps may be mounted with a bracket to the driving unit or mounted directly to the driver.

7.9 All pump units shall incorporate guards over couplings, belts, and other external rotating parts.

7.10 The mounting arrangement shall be sufficiently rigid to assure alignment is maintained between the pump and the driver in accordance with the conditions in 7.2, 7.3, and 8.1.

7.11 Seating surfaces of mounting bedplates, bracket mounting plates, or other mounting arrangements shall be machined.

7.12 Mounting bedplates, brackets, and plates shall be provided with holes of sufficient size and quantity to assure adequate attachment to shipboard foundation or mounting structure.

7.13 Vertical units with face mounted motors shall be arranged so there are four (4) possible orientations of motor driver to pump. Other drivers are to be oriented in accordance with the ordering information.

7.14 Vertical units that are motor driven shall be assembled with the conduit box mounted over the pump inlet flange, unless otherwise specified.

7.15 Couplings between the pump and the driver shall be keyed to both shafts.

7.16 Alignment between the pump and the driver shall not exceed 0.005-in. (0.13-mm) offset and 0.0005-in./in. (0.01-mm/mm) angularity.

TABLE 1 Materials

Component	Class A, B, CD, G	Class CH, LM, LA	Class DD, DH	Class W	Specification (UNS)
Casings, heads, and covers	ductile iron	ductile iron	ductile iron		ASTM A395/A395M or A536, Gr. 60-40-18
	ductile iron	ductile iron			ASTM A536, Br. 80-55-06
		cast steel			ASTM A27/A27M, Gr. 65-35
	leaded tin bronze	leaded tin bronze	leaded tin bronze	leaded tin bronze	ASTM B584 (C93700)
	carbon steel	carbon steel	carbon steel		ASTM A53/A53M
Shafts	steel	steel			ASTM A434, Gr. 4140, Cl.BC
	carbon steel	carbon steel			AISI 1141
-	~~stainless steel~~	~~stainless steel~~	~~stainless steel~~	~~stainless steel~~	~~ASTM A582/A582M (S41600) and ASTM A564/A564M Gr. 630 (S17400)~~
-	stainless steel	stainless steel	stainless steel	stainless steel	ASTM A582/A582M (S41600) and A564/A564M Gr. 630 (S17400)
	alloy steel	alloy steel			ASTM A322
~~Rotors~~	~~cast gray iron~~	~~cast gray iron~~	~~cast gray iron~~	-	~~ASTM A159, Gr. G3500 or ASTM A48/A48M, Cl. 35-50 or 25-50~~
Rotors	cast gray iron	cast gray iron	cast gray iron	-	ASTM A159, Gr. G3500 or A48/A48M, Cl. 35-50 or 25-50
-	~~ductile iron (80-55-06 only)~~	~~ductile iron~~	-	-	~~ASTM A536, Gr. 60-40-18, 80-55-06, or 120-90-02~~
-	ductile iron (80-55-06 only)	ductile iron	-	-	ASTM A536, Gr. 60-40-18, 80-55-06, or 120-90-02
		alloy steel			AISI 4150 RS, H.T.
			stainless steel	stainless steel	ASTM A582/A582M (S41600)
	leaded tin bronze	leaded tin bronze	leaded tin bronze	leaded tin bronze	ASTM B584 (C93700)
~~Rotor housings,~~	~~cast gray iron~~	~~cast gray iron~~	~~cast gray iron~~	-	~~ASTM A159, Gr. G3500~~
Rotor housings, liners, and disks	cast gray iron	cast gray iron	cast gray iron	-	ASTM A159, Gr. G3500
	ductile iron	ductile iron	ductile iron		ASTM A536, Gr. 60-40-18
	stainless steel	stainless steel	stainless steel	stainless steel	ASTM A564/A564M, Gr. 630 (S17400)
	leaded tin bronze	leaded tin bronze	leaded tin bronze	leaded tin bronze	ASTM B584 (C93700)
Glands	tin bronze	tin bronze	tin bronze		ASTM B584 (C90300)
	stainless steel	stainless steel	stainless steel	stainless steel	ASTM A743/A743M, Gr. CF8M (J92900)
Bedplates and brackets	structural steel	structural steel	structural steel	structural steel	ASTM A36/A36M
	ductile iron	ductile iron			ASTM A395/A395M 5, Gr. 60-40-18
		carbon steel			ASTM A515/A515M
Timing gears	nitrided steel	nitrided steel	nitrided steel	nitrided steel[A]	ASTM A434, Gr. 4140, Cl.BC
		aluminum bronze			ASTM B150M (C63000)
			stainless steel	stainless steel	ASTM A582/A582M (S41600)

THE FOLLOWING MATERIALS ARE APPLICABLE TO ALL CLASSES

~~Fasteners (studs, bolts, screws, nuts)~~	~~medium carbon alloy steel bolts~~	~~ASTM A193/A193M, Gr. B7~~
Fasteners (studs, bolts, screws, nuts)	medium carbon alloy steel bolts	ASTM A193/A193M, Gr. B7
	medium carbon alloy steel nuts	ASTM A194/A194M, Gr. 7
	austenitic stainless steel (304/316)	ASTM A193/A193M, Gr. B8/B8M
	austenitic stainless steel (304/316)	ASTM A194/A194M, Gr. 8/8M
	medium carbon steel bolts and studs	ASTM A449, Gr 1 (equivalent to SAE Gr 5)
	medium carbon steel nuts	ASTM A563, Gr B (equivalent to SAE Gr 5)
	high-strength alloy steel bolts and studs	ASTM A354, Gr. BD (equivalent to SAE Gr 8)
	high-strength alloy steel nuts	ASTM A563, Gr. DH (equivalent to SAE Gr 8)
	alloy steel socket-head cap screws	ASTM A574
	alloy steel socket set screws	ASTM F912
		SAE J 429, Gr. 5, 5.1, 8, or 8.1
~~O-rings and other elastomers~~	~~fluorocarbon (viton, fluorel, or equal)~~	~~ASTM D1418 Class: FKM, AS 568A, ASTM D2000 Type and Class: HK~~
O-rings and other elastomers	fluorocarbon (viton, fluorel, or equal)	ASTM D1418 Class: FKM, AS 568A, D2000 Type and Class: HK
Gaskets	plant and animal fiber	ASTM F104, I.D. No. P 3313B
	~~fluorocarbon~~	~~ASTM D2000 Type and Class: HK, ASTM D1418 Class: FKM~~
	fluorocarbon	ASTM D2000 Type and Class: HK, D1418 Class: FKM

THE FOLLOWING MATERIALS ARE APPLICABLE TO ALL CLASSES		
Vanes and shoes	nitrile (Buna-N or equal)	AMS 3215
	leaded tin bronze	ASTM B584 (C93700)
	thermoset plastic	None

[A] Outside of pumpage when separately lubricated.

7.17 An external (separate) relief valve shall not be provided with the pump unless otherwise specified. The purchaser shall provide the cracking pressure and the fullflow bypass pressure of the system relief valve to the pump manufacturer.

7.18 Direction of rotation shall be indicated by an arrow cast into the pump or by a label plate attached to the pump.

7.19 Inlet and outlet connections shall be indicated by a label plate attached to each flange.

8. Pump Design

8.1 Pump inlet and outlet connections shall be flanged. Steel case pump flanges shall be in accordance with ~~ANSI~~ASME B16.5 raised face. Cast gray iron and nonferrous material cases shall be in accordance with ~~ANSI~~ASME B16.5 flat face, unless otherwise stated in the ordering data. Flanged connections shall meet the requirements in API ~~Standard~~ 676, Paragraph 2.4.7. Spool piece adapters (threaded and seal welded, or O-ring sealed to the pump case on one end and flanged on the other end) may be furnished to meet the flanged inlet and outlet requirement.

8.2 Pump cases shall be equipped with vent, drain, inlet, and outlet gauge connections. The connection shall be straight thread with an O-ring seal. Tapered pipe thread connections are prohibited. Small pumps do not require vent, drain, and gauge connections.

8.3 Materials for the pump shall be compatible with the fluid being pumped, and the operating parameters to be encountered including maximum pressure and temperature extremes stated in the ordering data.

8.4 Pumps shall be equipped with radial and thrust bearings as necessary to counteract any unbalanced forces in the pump and to ensure that the pump will operate satisfactorily in accordance with 7.2.

8.5 Bearings shall be securely fitted (by snap rings, shoulders, or other means) to prevent axial movement. Bearing housings shall be integral to the pump case or secured to the pump case in such a manner as to ensure alignment. Usage of bolts alone is not considered sufficient to ensure alignment.

8.6 Bearings may be sealed and self-lubricated or externally lubricated or may be lubricated by the liquid being pumped.

8.7 Rolling contact bearings shall be selected in accordance with AFBMA standards and shall have a minimum L10 life of 15 000 h as calculated in accordance with AFBMA ~~Standard~~ 9 or 11 as appropriate.

8.8 Pumps shall be equipped with mechanical shaft seals, in accordance with Specification F1511. The installation shall ensure that adequate circulation of liquid at the seal faces occurs to minimize deposit of foreign matter and provide adequate lubrication of the seal faces.

8.9 Mechanical seals shall be positioned or located on the shaft axially, by a positive means such as a stub, step, or shoulder positively located on the pump shaft. Set screws shall not be used to position seals or seal sleeves axially. An antirotation pin may be provided to prevent the mechanical seal-mating ring from rotating.

8.10 When required by the ordering data, the pump shall be equipped with a backup packing box. The design shall allow for installation of two or more rings of packing for use in the event of a mechanical seal failure. The packing rings shall be able to be inserted without having to remove the mechanical seal.

8.11 Pump head or end covers, or both, shall be located to the pump case by a means such as rabbet, dowels, or pilot to ensure proper alignment.

8.12 Rotors and timing gears shall be machined and positively secured in position to maintain required clearances and prevent undue wear.

8.13 Fasteners shall be selected from Table 1 taking into consideration temperature of operation, mechanical properties, and corrosion resistance.

9. Performance Requirements

9.1 Pumps shall deliver the rated capacity at 10-psia (69-kPa absolute) inlet pressure while operating at the parameters specified in the ordering data.

9.2 The maximum capacity of the pump shall not exceed the amount determined by the following formula: