



# Standard Specification for Rotary Positive Displacement Pumps, Ships Use<sup>1</sup>

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## 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:<sup>2</sup>

- A216 Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
- A27/A27M Specification for Steel Castings, Carbon, for General Application
- A36/A36M Specification for Carbon Structural Steel
- A48/A48M Specification for Gray Iron Castings
- 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)<sup>3</sup>
- B584 Specification for Copper Alloy Sand Castings for General Applications
- D1418 Practice for Rubber and Rubber Latices—Nomenclature
- 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

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

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

2.2 *ASME Standard*:<sup>4</sup>

**ASME B16.5** Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

2.3 *SAE Standards*:<sup>5</sup>

**SAE AS 568A** Aerospace Size Standard for O-Rings

**SAE J 429** Mechanical and Material Requirements for Externally Threaded Fasteners

2.4 *AMS Standard*:<sup>5</sup>

**AMS 3215** Acrylonitrile Butadiene (NBR) Rubber Aromatic Fuel Resistant 65-75

2.5 *ABMA Standards*:<sup>6</sup>

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

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

2.6 *AGMA Standard*:<sup>7</sup>

**AGMA 390.03** Gear Classification, Materials and Measuring Methods for Unassembled Gears

2.7 *API Standard*:<sup>8</sup>

**API 676** Positive Displacement Pumps—Rotary

2.8 *Military Standards*:<sup>9</sup>

**MIL-S-901**

**MIL-STD-167**

**MIL-STD-740**

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

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

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

3.1.9 *net positive inlet pressure available (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), 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.

3.1.11 *pressure, 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, n*—the difference between discharge pressure and inlet pressure.

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

3.1.14 *pressure, 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, 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  $\frac{2}{3}$  of the hydrostatic test pressure of the pressure containing parts.

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

3.1.17 *rotary 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, 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), n*—the highest speed at which the manufacturers' design will permit continuous operation.

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

### 3. Terminology

3.1 *Definitions*:

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

3.1.3 *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, 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.

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

<sup>5</sup> Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

<sup>6</sup> Available from American Bearing Manufacturers Association (ABMA), 1001 N. Fairfax Street, Suite 500, Alexandria, VA 22314, <https://www.americanbearings.org>.

<sup>7</sup> Available from American Gear Manufacturers Association (AGMA), 1001 N. Fairfax St., Suite 500, Alexandria, VA 22314-1587, <http://www.agma.org>.

<sup>8</sup> Available from American Petroleum Institute (API), 200 Massachusetts Avenue, NW Suite 1100 Washington, DC 20001-5571, <http://www.api.org>.

<sup>9</sup> Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

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

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

3.1.23 *temperature, maximum 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.

**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 <b>A395/A395M</b> or <b>A536</b> , Gr. 60-40-18
	ductile iron	ductile iron			ASTM <b>A536</b> , Br. 80-55-06
	lead tin bronze	lead tin bronze	lead tin bronze	lead tin bronze	ASTM <b>A27/A27M</b> , Gr. 65-35
	carbon steel	carbon steel	carbon steel		ASTM <b>B584</b> (C93700) ASTM <b>A216</b> , Gr. WCB
Shafts	steel	steel			ASTM <b>A434</b> , Gr. 4140, Cl.BC
	carbon steel	carbon steel			AISI 1141
	stainless steel	stainless steel	stainless steel	stainless steel	ASTM <b>A582/A582M</b> (S41600) and <b>A564/A564M</b> , Gr. 630 (S17400)
	alloy steel	alloy steel			ASTM <b>A322</b>
Rotors	cast gray iron	cast gray iron	cast gray iron		ASTM <b>A159</b> , Gr. G3500 or <b>A48/A48M</b> , Cl. 35-50 or 25-50
	ductile iron (80-55-06 only)	ductile iron			ASTM <b>A536</b> , Gr. 60-40-18, 80-55-06, or 120-90-02
		alloy steel			AISI 4150 RS, H.T.
	lead tin bronze	lead tin bronze	lead tin bronze	lead tin bronze	ASTM <b>A582/A582M</b> (S41600) ASTM <b>B584</b> (C93700)
Rotor housings, liners, and disks	cast gray iron	cast gray iron	cast gray iron		ASTM <b>A159</b> , Gr. G3500
	ductile iron	ductile iron	ductile iron		ASTM <b>A536</b> , Gr. 60-40-18
	stainless steel	stainless steel	stainless steel	stainless steel	ASTM <b>A564/A564M</b> , Gr. 630 (S17400)
	lead tin bronze	lead tin bronze	lead tin bronze	lead tin bronze	ASTM <b>B584</b> (C93700)
Glands	tin bronze	tin bronze	tin bronze		ASTM <b>B584</b> (C90300)
	stainless steel	stainless steel	stainless steel	stainless steel	ASTM <b>A743/A743M</b> , Gr. CF8M (J92900)
Bedplates and brackets	structural steel	structural steel	structural steel	structural steel	ASTM <b>A36/A36M</b>
	ductile iron	ductile iron			ASTM <b>A395/A395M</b> , Gr. 60-40-18 ASTM <b>A515/A515M</b>
Timing gears	nitrided steel	nitrided steel	nitrided steel	nitrided steel <sup>4</sup>	ASTM <b>A434</b> , Gr. 4140, Cl.BC
		aluminum bronze	stainless steel	stainless steel	ASTM <b>B150M</b> (C63000) ASTM <b>A582/A582M</b> (S41600)

THE FOLLOWING MATERIALS ARE APPLICABLE TO ALL CLASSES

Fasteners (studs, bolts, screws, nuts)	medium carbon alloy steel bolts				ASTM <b>A193/A193M</b> , Gr. B7
	medium carbon alloy steel nuts				ASTM <b>A194/A194M</b> , Gr. 7
	austenitic stainless steel (304/316)				ASTM <b>A193/A193M</b> , Gr. B8/B8M
	austenitic stainless steel (304/316)				ASTM <b>A194/A194M</b> , Gr. 8/8M
	medium carbon steel bolts and studs				ASTM <b>A449</b> , Gr 1 (equivalent to SAE Gr 5)
	medium carbon steel nuts				ASTM <b>A563</b> , Gr B (equivalent to SAE Gr 5)
	high-strength alloy steel bolts and studs				ASTM <b>A354</b> , Gr. BD (equivalent to SAE Gr 8)
	high-strength alloy steel nuts				ASTM <b>A563</b> , Gr. DH (equivalent to SAE Gr 8)
	alloy steel socket-head cap screws				ASTM <b>A574</b>
	alloy steel socket set screws				ASTM <b>F912</b> SAE J 429, Gr. 5, 5.1, 8, or 8.1
O-rings and other elastomers	fluorocarbon (viton, fluorel, or equal)				ASTM <b>D1418</b> Class: FKM, AS 568A, <b>D2000</b> Type and Class: HK
Gaskets	plant and animal fiber				ASTM <b>F104</b> , I.D. No. P 3313B
	fluorocarbon				ASTM <b>D2000</b> Type and Class: HK, <b>D1418</b> Class: FKM
Vaness and shoes	nitrile (Buna-N or equal)				AMS 3215
	lead tin bronze				ASTM <b>B584</b> (C93700)
	thermoset plastic				None

<sup>4</sup> Outside of pumpage when separately lubricated.

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.

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 ASME B16.5 raised face. Cast gray iron and nonferrous material cases shall be in accordance with ASME B16.5 flat face, unless otherwise stated in the ordering data. Flanged connections shall meet the requirements in API 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 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:

$$Q_{\max} = Q \left[ 1 + \frac{1}{1 + Q^{0.4}} \right] \quad (1)$$

where:

$Q$  = rated capacity and

$Q_{\max}$  = maximum allowable capacity, at minimum viscosity.

$Q_{\max}$  shall be rounded to the nearest whole number.

9.3 Capacity of all classes (except DH) pumps shall not be less than the value stated in 5.1.3 at the rated conditions, with minimum viscosity.

9.4 Class DH pumps shall meet the capacity requirements at 4000 SSU (863 centistokes) and shall not be damaged by continuous operation at 32 SSU (2 centistokes).

9.5 Class LM & LA pumps shall meet the capacity requirements at 130 SSU (27 centistokes) and driver horsepower shall be determined based on 4000 SSU (863 centistokes).

## 10. Painting and Coatings

10.1 *Painting*—External unmachined and nonmating machined surfaces shall be thoroughly cleaned and painted.

10.2 Painting external surfaces of nonferrous parts and components is not required but is permissible to avoid excessive masking. Identification and information plates shall not be painted or oversprayed.

## 11. Equipment Identification and Instruction Plates

11.1 Identification plates shall be made of brass or stainless steel and furnished on each pump unit.