



# Standard Specification for Centrifugal Pump, Shipboard Use<sup>1</sup>

This standard is issued under the fixed designation F998; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification covers the requirements applicable to the design and construction of centrifugal pumps for shipboard application. The three classes of service covered by this specification are as follows:

- 1.1.1 Class 1—Freshwater,
- 1.1.2 Class 2—Seawater, and
- 1.1.3 Class 3—Hydrocarbon pumps (less than 1500 SSU).

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

- A36/A36M Specification for Carbon Structural Steel
- A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications
- A194/A194M Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- A276 Specification for Stainless Steel Bars and Shapes
- A494/A494M Specification for Castings, Nickel and Nickel Alloy
- A582/A582M Specification for Free-Machining Stainless Steel Bars
- A743/A743M Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
- A747/A747M Specification for Steel Castings, Stainless, Precipitation Hardening
- A890/A890M Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
- B148 Specification for Aluminum-Bronze Sand Castings

- B164 Specification for Nickel-Copper Alloy Rod, Bar, and Wire
- B271 Specification for Copper-Base Alloy Centrifugal Castings
- B369 Specification for Copper-Nickel Alloy Castings
- B505/B505M Specification for Copper Alloy Continuous Castings
- B584 Specification for Copper Alloy Sand Castings for General Applications
- F468 Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use
- F1511 Specification for Mechanical Seals for Shipboard Pump Applications

2.2 *ANSI Standards*:

- B1 ISO Metric Screw Threads (ANSI-B1 Report)<sup>3</sup>
- B1.1 Unified Screw Threads<sup>3</sup>
- B16.1 Cast Iron Pipe Flanges and Flange Fittings<sup>3</sup>
- B16.5 Steel Pipe Flanges, Flanged Valves and Fittings, 150, 300, 400, 600, 900, 1500 and 2500 lb.<sup>3</sup>
- B16.11 Forged Steel Fittings, Socket Welding and Threaded<sup>3</sup>
- B16.24 Bronze Flanges and Flanged Fittings, 150, 300lb<sup>3</sup>

2.3 *Hydraulic Institute Standards*:

- ANSI/HI 1.1-1.5 American National Standard for Centrifugal Pumps for Nomenclature, Definitions, Applications and Operation<sup>3</sup>
- ANSI/HI 1.6 American National Standard for Centrifugal Pump Tests<sup>3</sup>
- ANSI/HI 9.1-9.6 American National Standard for Pumps—General Guidelines for Types, Definitions, Applications and Sound Measurements<sup>3</sup>

2.4 *AFBMA Standards*:

- 9 Load Ratings and Fatigue Life for Ball Bearings<sup>4</sup>
- 11 Load Ratings and Fatigue Life for Roller Bearings<sup>4</sup>

2.5 *ISO Standards*:

- ISO 9001 Quality Systems and Quality Assurance—Design/Development, Production, Installation and Service<sup>3</sup>

## 3. Terminology

3.1 *Definitions*:

<sup>3</sup> Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

<sup>4</sup> Anti-Friction Bearing Manufacturers Association, Inc., 1101 Connecticut Ave., N.W., Suite 700, Washington, DC 20036.

<sup>1</sup> This specification is under the jurisdiction of Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.11 on Machinery and Piping Systems.

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<sup>2</sup> 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.

3.1.1 *best efficiency point (BEP)*, *n*—the capacity and head in which the pump efficiency is the highest.

3.1.2 *BHP*, *n*—power delivered to the pump from the driver in brake horse power.

3.1.3 *capacity*, *n*—the total volume output per unit of time.

3.1.4 *centrifugal pump*, *n*—a kinetic machine converting mechanical energy into hydraulic energy through rotating motion.

3.1.5 *close coupled pumps*, *n*—in this arrangement, no coupling is provided between the pump and the motor shafts, and the pump housing is flange mounted to the motor. The pump impeller is directly mounted to the motor shaft.

3.1.6 *coupled pumps*, *n*—in this arrangement, the pump and the motor must use a coupling to transmit the power from the driver to the pump shaft.

3.1.7 *gallons per minute (GPM)*, *n*—U.S. customary unit for capacity.

3.1.8 *head*, *n*—the expression of the energy content of the liquid referred to in any arbitrary datum. It is expressed in units of energy per unit of weight liquid. The measuring unit for head is foot (metre) of liquid.

3.1.9 *head, total discharge*, *n*—the sum of the pump's discharge gauge head, the velocity head at the gauge connection, and the elevation difference between the pump centerline and the gauge centerline.

3.1.10 *head, total*, *n*—the measurement of energy increase per unit weight of the liquid, imparted to the liquid by the pump, and is the difference between the total discharge head and the total suction head.

3.1.11 *head, total suction*, *n*—the sum of the pumps suction gauge head, the velocity head at the gauge connection, and the elevation difference between the pump inlet centerline and the gauge centerline.

3.1.12 *head, maximum rated*, *n*—the most head a pump can generate with the correct impeller diameter for the service conditions.

3.1.13 *hydrostatic test*, *n*—applying static pressure to the assembled pump or pressure containing components to determine structural integrity of the unit.

3.1.14 *maximum allowable working pressure*, *n*—the maximum discharge pressure that could occur in the pump when it is operated at the rated speed and suction pressure for a given application.

3.1.15 *maximum BHP rated impeller*, *n*—the highest power required by a pump with the correct impeller diameter for the service condition.

3.1.16 *minimum continuous flow*, *n*—the lowest possible flow rate at which the pump can run without generating excessive heat within the unit or damage to the pump.

3.1.17 *net positive suction head available (NPSHA)*, *n*—the total suction head absolute, determined at the first stage impeller datum, less the absolute vapor pressure of the liquid at a specific capacity.

3.1.18 *net positive suction head required (NPSHR)*, *n*—the amount of suction head over vapor pressure required at the pump to prevent more than a 3 % loss in total head from the first stage of the pump at a specific capacity.

3.1.19 *nonmetallic materials*, *n*—any material that would not be recognized as a metal. Examples include plastics, fiberglass resins, carbon fiber, fiberglass-reinforced vinyl ester, polytetrafluoroethylene (PTFE), or any similar material.

3.1.20 *non-overloading power characteristics*, *n*—this characteristic requires that the driver be sized for the highest possible power requirement from the pump.

3.1.21 *OEM*, *n*—original equipment manufacturer of the pump unit.

3.1.22 *pounds per square inch absolute (PSIA)*, *n*—the U.S. customary measure of pressure with zero as a true absolute zero in pounds per square inch.

3.1.23 *pounds per square inch gauge (PSIG)*, *n*—the U.S. customary measure of pressure with zero being adjusted to atmospheric pressure in pounds per square inch.

3.1.24 *pump efficiency (Eff)*, *n*—the ratio of the energy imparted to the liquid by the pump to the energy supplied to the pump from the driver.

3.1.25 *pump unit*, *n*—a typical pump unit consists of a separate pump and driver, combined pump and driver (close coupled), coupling, and coupling guard, and may include a gear box and base plate.

3.1.26 *rated point*, *n*—applies to the capacity, head, net positive suction head, and speed of the pump as specified by the order.

3.1.27 *specific gravity (Sp. Gr.)*, *n*—the ratio of the density of the liquid to the density of water at 64°F (17.8°C).

3.1.28 *vapor pressure*, *n*—the pressure exerted when a liquid is in equilibrium with its own vapor. The vapor pressure is a function of the substance and of the temperature.

3.1.29 *viscosity*, *n*—the resistance of a fluid to shear motion, its internal friction.

#### 4. Ordering Information

4.1 **Fig. 1** and **Fig. 2** are provided for use by the procuring activity and the OEM. The sections of **Fig. 1** and **Fig. 2** marked “User Defined,” must be completed by the procuring activity and submitted with the request for bid. This will ensure that the potential bidder provides a pump unit that meets all performance, operational, and reliability requirements of the purchaser. The OEM will fill out all sections of **Fig. 1** and **Fig. 2** marked “OEM Defined,” and return the data sheet to the purchaser upon delivery of the pump.

4.2 For the convenience of the procuring activity, **Fig. 1** and **Fig. 2** are provided in both U.S. customary and SI versions.

#### 5. Material

5.1 The materials cited in **Table 1** are provided as a guide. Other materials may be substituted as approved by the purchasing activity and as specified in **Fig. 1** and **Fig. 2**.

5.2 When selecting material combinations, the pump supplier shall take into consideration the conditions under which the various materials interact with each other. Material hardness shall be such that any rubbing, sliding, or tight clearance parts shall be selected so that no binding or galling occurs. Special care shall be taken with Class 2 pump materials that interact with each other in a seawater environment.

5.3 Consideration shall be given to the use of nonmetallic (composite) pump components where the use of that material

## CENTRIFUGAL PUMP ORDERING DATA (ENGLISH)

USER/CUSTOMER \_\_\_\_\_ OEM/BIDDER \_\_\_\_\_ DATE \_\_\_\_\_

CLASS(1 THRU 6) \_\_\_\_\_ NO. OF PUMPS \_\_\_\_\_ NO. OF DRIVERS (MOTORS/TURBINE) \_\_\_\_\_ ITEM NO. \_\_\_\_\_

### OPERATING CONDITIONS (PURCHASER-DEFINED)

FLUID \_\_\_\_\_

°F RATED \_\_\_\_\_ °F MAX. \_\_\_\_\_ (GPM) RATED \_\_\_\_\_

SP. GR. AT RATED PT. \_\_\_\_\_ TOTAL HEAD, (FT) RATED \_\_\_\_\_

VAP. PRESS. AT RATED PT. \_\_\_\_\_ SUCT. PRESS. (PSIG) MAX. \_\_\_\_\_, RATED. \_\_\_\_\_

VISCOSITY AT RATED, SSU \_\_\_\_\_ NPSHA, (PSIG) \_\_\_\_\_

AMBIENT CONDITIONS \_\_\_\_\_

PITCH \_\_\_\_\_ ROLL \_\_\_\_\_ LIST \_\_\_\_\_ TRIM \_\_\_\_\_

### PERFORMANCE (OEM-DEFINED)

PERFORMANCE CURVE NO. \_\_\_\_\_

RPM \_\_\_\_\_ NPSH (WATER) \_\_\_\_\_

EFF. \_\_\_\_\_ % BHP RATED \_\_\_\_\_

MAX. BHP RATED IMPELLER \_\_\_\_\_

MAX. HEAD RATED \_\_\_\_\_

MAX DISCH. PRESS. (PSIG) \_\_\_\_\_

MIN CONTINUOUS (GPM) \_\_\_\_\_

### TESTING (PURCHASER-DEFINED)

HYDRO TEST     WITNESS     NON-WITNESS

MECH TEST     WITNESS     NON-WITNESS

PERF TEST     WITNESS     NON-WITNESS

NPSH     WITNESS     NON-WITNESS

VIBRATION     WITNESS     NON-WITNESS

ACOUSTIC     WITNESS     NON-WITNESS

DISMANTLE/INSPECT AFTER TEST

OTHER : \_\_\_\_\_

### CONSTRUCTION (PURCHASER REQUIREMENTS)

PUMP TYPE:  HORIZ  VERT  CLOSE COUPLED  OEM OPTION (CHECK ONLY IF OEM CAN SPECIFY ALTERNATE)

SPLIT:  RADIAL  AXIAL

PAINTING/COATINGS SPECIFICATION: \_\_\_\_\_

ACOUSTICS SPECIFICATION: \_\_\_\_\_, OR

dBA \_\_\_\_\_, CENTERBAND VALUES \_\_\_\_\_

CONNECTIONS: \_\_\_\_\_ SIZE \_\_\_\_\_ TYPE (O-RING, ETC...)

DRAIN/VENT \_\_\_\_\_

INLET GAGE \_\_\_\_\_

DISCHARGE GAGE \_\_\_\_\_

TEST REPORTS REQUIRED

### PUMP DETAILS (OEM-DEFINED)

PRESS:  MAX. ALLOW. \_\_\_\_\_ PSIG \_\_\_\_\_ °F \_\_\_\_\_ HYDRO TEST \_\_\_\_\_ PSIG

IMPELLER DIA. RATED \_\_\_\_\_ MAX. \_\_\_\_\_ IMPELLER TYPE \_\_\_\_\_

BEARING TYPES: RADIAL \_\_\_\_\_ THRUST \_\_\_\_\_

LUBE:  OIL  GREASE  PERM. GREASE

COUPLING: MFR. \_\_\_\_\_ MODEL \_\_\_\_\_

DRIVER HALF MTD. BY:  PUMP MFR.  DRIVER MFR.  PURCHASER

MECH. SEAL:  MFR. & MODEL \_\_\_\_\_ MATERIAL CODE \_\_\_\_\_

EXT. SEAL FLUSH COOLING WATER: GPM \_\_\_\_\_, PSIG \_\_\_\_\_, °F \_\_\_\_\_

IN ACCORDANCE WITH ASTM F1511

### MATERIALS (PURCHASER DEFINED)

CASING \_\_\_\_\_

IMPELLER \_\_\_\_\_

WEAR RINGS \_\_\_\_\_

SHAFT/SLEEVE \_\_\_\_\_

GLAND \_\_\_\_\_

BASEPLATE \_\_\_\_\_

OTHER: \_\_\_\_\_

### INSPECTIONS (PURCHASER-DEFINED)

IN-PROCESS REQUIRED

FINAL

\_\_\_\_\_ DAYS NOTIF. REQ'D

### DRIVER (PURCHASER-DEFINED)

MOTOR  TURBINE  OTHER SUPPLIED BY \_\_\_\_\_

BHP \_\_\_\_\_ RPM \_\_\_\_\_ FRAME \_\_\_\_\_ VOLTS/PHASE/HERTZ \_\_\_\_\_

MFR. \_\_\_\_\_ BEARINGS \_\_\_\_\_ SERVICE FACTOR \_\_\_\_\_

TYPE \_\_\_\_\_ INSULATION \_\_\_\_\_ AMPS: FL \_\_\_\_\_ LR \_\_\_\_\_

LUBE \_\_\_\_\_ TEMP. RISE °F \_\_\_\_\_ ENCL. \_\_\_\_\_

ORIENTATION (REL. TO PUMP INLET) \_\_\_\_\_

FOR STEAM TURBINE DRIVER:

INLET PRESS. \_\_\_\_\_ EXH. PRESS. \_\_\_\_\_ STEAM TEMP. \_\_\_\_\_ WATER RATE \_\_\_\_\_

OTHER:

### PUMP DATA (AFTER PRODUCTION BY OEM)

CUSTOMER/USER \_\_\_\_\_

LOCATION \_\_\_\_\_ CUSTOMER P.O. NO. \_\_\_\_\_

ITEM NO (S) \_\_\_\_\_ EQUIP. NO (S) \_\_\_\_\_

FACTORY ORDER NO (S) \_\_\_\_\_ PUMP SERIAL NO (S) \_\_\_\_\_

ISSUED BY \_\_\_\_\_ DATE \_\_\_\_\_

REVISION \_\_\_\_\_ DATE \_\_\_\_\_

(WORD 6.0, DOCS/FCE/001)

### ADDED REQUIREMENTS

### COMMENTS (OEM & PURCHASER DEFINED)

**FIG. 1 Centrifugal Pump Ordering Data (English)**

## CENTRIFUGAL PUMP ORDERING DATA (METRIC)

USER/CUSTOMER \_\_\_\_\_ OEM/BIDDER \_\_\_\_\_ DATE \_\_\_\_\_

CLASS(1 THRU 6) \_\_\_\_\_ NO. OF PUMPS \_\_\_\_\_ NO. OF DRIVERS (MOTORS/TURBINE) \_\_\_\_\_ ITEM NO. \_\_\_\_\_

### OPERATING CONDITIONS (PURCHASER-DEFINED)

FLUID \_\_\_\_\_  
 °C RATED \_\_\_\_\_ °C MAX. \_\_\_\_\_ (Lpm) RATED \_\_\_\_\_  
 SP. GR. AT RATED PT. \_\_\_\_\_ TOTAL HEAD, (bar) RATED \_\_\_\_\_  
 VAP. PRESS. AT RATED PT. \_\_\_\_\_ SUCT. PRESS. (bar) MAX. \_\_\_\_\_, RATED. \_\_\_\_\_  
 VISCOSITY AT RATED, Centistokes \_\_\_\_\_ NPSHA, (bar) \_\_\_\_\_  
 AMBIENT CONDITIONS \_\_\_\_\_  
 PITCH \_\_\_\_\_ ROLL \_\_\_\_\_ LIST \_\_\_\_\_ TRIM \_\_\_\_\_

### PERFORMANCE (OEM-DEFINED)

PERFORMANCE CURVE NO. \_\_\_\_\_  
 RPM \_\_\_\_\_ NPSH (WATER) \_\_\_\_\_  
 EFF. \_\_\_\_\_ % BHP RATED \_\_\_\_\_  
 MAX. Kw RATED IMPELLER \_\_\_\_\_  
 MAX. HEAD RATED \_\_\_\_\_  
 MAX DISCH. PRESS. (bar) \_\_\_\_\_  
 MIN CONTINUOUS (Lpm) \_\_\_\_\_

### TESTING (PURCHASER-DEFINED)

HYDRO TEST     WITNESS     NON-WITNESS  
 MECH TEST     WITNESS     NON-WITNESS  
 PERF TEST     WITNESS     NON-WITNESS  
 NPSH     WITNESS     NON-WITNESS  
 VIBRATION     WITNESS     NON-WITNESS  
 ACOUSTIC     WITNESS     NON-WITNESS  
 DISMANTLE/INSPECT AFTER TEST  
 OTHER : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

### CONSTRUCTION (PURCHASER REQUIREMENTS)

PUMP TYPE:  HORIZ  VERT  CLOSE COUPLED  OEM OPTION (CHECK ONLY  
 IF OEM CAN SPECIFY ALTERNATE)

SPLIT:  RADIAL  AXIAL

PAINTING/COATINGS SPECIFICATION: \_\_\_\_\_

ACOUSTICS SPECIFICATION: \_\_\_\_\_, OR

dBA \_\_\_\_\_, CENTERBAND VALUES \_\_\_\_\_

CONNECTIONS: \_\_\_\_\_ SIZE \_\_\_\_\_ TYPE (O-RING, ETC...)

- DRAIN/VENT \_\_\_\_\_
- INLET GAGE \_\_\_\_\_
- DISCHARGE GAGE \_\_\_\_\_

TEST REPORTS REQUIRED

### PUMP DETAILS (OEM-DEFINED)

PRESS:  MAX. ALLOW. \_\_\_\_\_ bar \_\_\_\_\_ °C \_\_\_\_\_ HYDRO TEST \_\_\_\_\_ bar

IMPELLER DIA. RATED \_\_\_\_\_ MAX. \_\_\_\_\_ IMPELLER TYPE \_\_\_\_\_

BEARING TYPES: RADIAL \_\_\_\_\_ THRUST \_\_\_\_\_

LUBE:  OIL  GREASE  PERM. GREASE \_\_\_\_\_

COUPLING: MFR. \_\_\_\_\_ MODEL \_\_\_\_\_

DRIVER HALF MTD. BY:  PUMP MRF.  DRIVER MFR.  PURCHASER

MECH. SEAL:  MFR. & MODEL \_\_\_\_\_ MATERIAL CODE \_\_\_\_\_

EXT. SEAL FLUSH COOLING WATER: Lpm \_\_\_\_\_, bar \_\_\_\_\_, °C \_\_\_\_\_

IN ACCORDANCE WITH ASTM F1511

### MATERIALS (PURCHASER DEFINED)

CASING \_\_\_\_\_

IMPELLER \_\_\_\_\_

WEAR RINGS \_\_\_\_\_

SHAFT/SLEEVE \_\_\_\_\_

GLAND \_\_\_\_\_

BASEPLATE \_\_\_\_\_

OTHER: \_\_\_\_\_

### INSPECTIONS (PURCHASER-DEFINED)

- IN-PROCESS REQUIRED
- FINAL
- \_\_\_\_\_ DAYS NOTIF. REQ'D

### DRIVER (PURCHASER-DEFINED)

MOTOR  TURBINE  OTHER SUPPLIED BY \_\_\_\_\_

BHP \_\_\_\_\_ RPM \_\_\_\_\_ FRAME \_\_\_\_\_ VOLTS/PHASE/HERTZ \_\_\_\_\_

MFR. \_\_\_\_\_ BEARINGS \_\_\_\_\_ SERVICE FACTOR \_\_\_\_\_

TYPE \_\_\_\_\_ INSULATION \_\_\_\_\_ AMPS: FL \_\_\_\_\_ LR \_\_\_\_\_

LUBE \_\_\_\_\_ TEMP. RISE °C \_\_\_\_\_ ENCL. \_\_\_\_\_

ORIENTATION (REL. TO PUMP INLET) \_\_\_\_\_

FOR STEAM TURBINE DRIVER:

INLET PRESS. \_\_\_\_\_ EXH. PRESS. \_\_\_\_\_ STEAM TEMP. \_\_\_\_\_ WATER RATE \_\_\_\_\_

OTHER:

### PUMP DATA (AFTER PRODUCTION BY OEM)

CUSTOMER/USER \_\_\_\_\_

LOCATION \_\_\_\_\_ CUSTOMER P.O. NO. \_\_\_\_\_

ITEM NO (S). \_\_\_\_\_ EQUIP. NO (S) \_\_\_\_\_

FACTORY ORDER NO (S). \_\_\_\_\_ PUMP SERIAL NO (S) \_\_\_\_\_

ISSUED BY \_\_\_\_\_ DATE \_\_\_\_\_

REVISION \_\_\_\_\_ DATE \_\_\_\_\_

(WORD 6.0, DOCS/FCE/002)

### ADDED REQUIREMENTS

### COMMENTS (OEM & PURCHASER DEFINED)

FIG. 2 Centrifugal Pump Ordering Data (Metric)

**TABLE 1 Material Specifications**

	Class 1: Freshwater	Class 2: Seawater <sup>A</sup>	Class 3: Hydrocarbon
Casing and Pressure Boundary Parts	Bronze (Specification <b>B584</b> , Alloy C90500, C92200, or C87500)	Corrosion-resistant Duplex Alloy (Specification <b>A890/A890M</b> , Grade CD4MCu)	Bronze (Specification <b>B584</b> , Alloy C90500, C92200, or C87500)
	Stainless Steel (Specification <b>A743/A743M</b> , CF8M)	Ni-Al Bronze (Specification <b>B148</b> , Alloy C95500 or C95800)	Stainless Steel (Specification <b>A743/A743M</b> , CF8M, J92900)
Shaft and Rotor Parts	Stainless Steel (Specification <b>A582/A582M</b> , Cond, Alloy S41600)	Stainless Steel (Specification A276, S31600)	Stainless Steel (Specification <b>A582/A582M A</b> , Alloy S41600)
	Nickel-copper alloy (Specification <b>B164</b> , UNS N04400 or N04405)	Nickel-copper Alloy (Monel) (Specification <b>B164</b> , UNS N04400)	
	Composite <sup>B</sup> (shaft sleeves only)	Composite <sup>B</sup> (shaft sleeves only)	
Impellers	Bronze (Specification <b>B584</b> , Alloy C90500, C92200, or C87500)	Corrosion-resistant Duplex Alloy (Specification <b>A890/A890M</b> , Grade CD4MCu)	Bronze (Specification <b>B584</b> , Alloy C90500, C92200, or C87500)
	Stainless Steel (Specification <b>A743/A743M</b> , Grade CF8M or CF8)	Ni-Al Bronze (Specification <b>B148</b> , UNS C95500 or C95800)	Stainless Steel (Specification <b>A743/A743M</b> , Grade CF8M or CF8)
	Composite <sup>B</sup>	Composite <sup>B</sup>	
Wear Rings	Bronze (Specification <b>B271</b> , <b>B505/B505M</b> or <b>B584</b> )	Stainless Steel (Specification <b>A747/A747M</b> , CB7Cu-1, Cond H1150, J92180)	Bronze (Specification <b>B271</b> , <b>B505/B505M</b> , or <b>B584</b> )
	Composite <sup>B</sup>	Bronze (Specification <b>B271</b> , <b>B505/B505M</b> or <b>B584</b> )	
		Composite <sup>B</sup>	
Casting Fasteners	Corrosion-resisting steel (Specification <b>A193/A193M</b> , Grade B8M and <b>A194/A194M</b> , Grade 8M)	Monel (Specification <b>F468</b> , Alloy 400)	Corrosion-resisting steel (Specification <b>A193/A193M</b> , Grade B8M and <b>A194/A194M</b> , Grade 8M)
		Corrosion-resisting steel (Specification <b>A193/A193M</b> , Grade B8M and <b>A194/A194M</b> , Grade 8M)	
Base	Structural Steel (Specification <b>A36/A36M</b> )	Structural Steel (Specification <b>A36/A36M</b> )	Structural Steel (Specification <b>A36/A36M</b> )

<sup>A</sup> Materials used for seawater services may also be used for Class 1 and 3 service pumps. Galvanic compatibility must be taken into consideration when choosing allowable materials.

<sup>B</sup> Material property of composites must be suitable for pump service life and intended service.

can benefit the operation and maintenance of the pump. Purchaser approval must be obtained for the use of nonmetallic materials.

## 6. General Requirements

6.1 Pumps shall be designed to meet all operational requirements of the intended service and be constructed in such a manner as to allow for reliable operation and maintenance.

6.2 Pumps shall be selected to operate at or near the best efficiency point (BEP) on the head-capacity curve.

6.3 Motors shall have power ratings, including a service factor, if any, at least equal to 125 % of pump brake-horsepower at rated design condition for motors less than 30 hp, 115 % of pump brake-horsepower at rated design condition for motors rated between 30 and 75 hp and 110 % of pump brake-horsepower at pump-rated design condition for motors greater than 75 hp. The power required at pump-rated conditions shall not exceed the motor nameplate horsepower rating.

6.4 Pumps shall be designed for a shipboard environment including both pitch and roll conditions specified by the

purchaser in **Fig. 1** and **Fig. 2**. Pumps shall also be capable of sustained operation at the maximum angles of list and trim specified in **Fig. 1** and **Fig. 2**.

6.5 For horizontal pumps, the pump and driver shall be mounted on a common base of sufficient strength and stiffness to allow for proper alignment and operation. Where necessary to maintain proper alignment, dowels or fitted bolts shall be provided.

6.6 All vertical pumps shall be entirely supported by a horizontal foundation or a vertical ship structure, but not both. Where necessary, the upper portion of the pump unit may be bolted to a frame erected on the horizontal foundation.

6.7 Bedplates for Class 3 pumps shall be equipped with driprims and drain connections.

6.8 Horizontal pumps of the coupled type shall be driven through a flexible coupling. Coupled vertical pumps may be connected to their drivers by a flexible or rigid coupling. Couplings between the pump and driver shall be keyed to both shafts.

6.9 All pump units shall incorporate guards over the couplings, belts, and other external rotating parts. The guards shall prevent personnel contact with the rotating elements. Guards shall be rigid enough to support a 200-lb (88-kg) person.

6.10 Pump and driver seating surfaces of mounting bed-plates, bracket mounting plates, or other mounting arrangements shall be machined.

6.11 Sufficient means shall be provided for attaching conventional lifting gear for the installation, removal, and maintenance of both the pump and driver.

6.12 Pumps with face-mounted motors shall be arranged such that there are four possible orientations of the motor to pump.

6.13 Shaft alignment between the pump and driver will be specified by the OEM to allow the pump unit to operate within the vibration limits set in Section 8 over the expected service life of the pump.

6.14 Direction of rotation shall be indicated on the pump by either an arrow cast into the pump casing or by a direction arrow plate permanently attached to the pump.

6.15 The driver type and requirements shall be specified in Fig. 1 and Fig. 2.

## 7. Pump Design

7.1 Pump inlet and outlet connections shall be flanged in accordance with ANSI B16.1, B16.5, B16.11, or B16.24.

7.2 Pump casings, except for close-coupled pumps, shall be arranged so that the rotating components can be removed without disturbing the driver or the suction and discharge connections.

7.3 The pump casings shall be provided with bosses drilled and tapped or socket welded and flanged for suction, discharge pressure gage, and vent and drain connections if specified in Fig. 1 and Fig. 2 (refer to Fig. 1 and Fig. 2 for type and size). All connections shall be plugged or blank flanged using material suitable for design conditions.

7.4 Coupled pumps shall be equipped with radial and thrust bearings to support the rotor and counteract any unbalanced forces in the pump and ensure that the pump will operate satisfactorily over the pump's entire design range.

7.5 Close coupled pumps and rigidly coupled vertical pumps shall have radial and thrust bearings located in the driver that are capable of supporting the rotating assembly and counteracting any unbalanced forces in the pump unit.

7.6 Bearings shall be securely fitted by snap rings, shoulders, or other means to prevent axial movement within the bearing housing. Bearing housings shall be integral or bolted to the pump case to maintain internal alignment of components and external alignment between the pump and driver. Bolted connections require fitted bolts, dowels, or rabbet fit to ensure alignment of the bearing housing to the casing.

7.7 Journal and thrust bearings may be of the fluid film or rolling element (antifriction) type. The bearings may be sealed and self or externally lubricated or may be lubricated by the process fluid.

7.8 Rolling element bearings shall be selected in accordance with AFBMA Standards 9 or 11, or both, and shall have a calculated minimum L10 life of 15 000 h.

7.9 Unless otherwise specified in Fig. 1 and Fig. 2, all pumps shall be equipped with mechanical seals in accordance with Specification F1511. The installation shall ensure that adequate circulation of liquid at the seal faces occurs to minimize deposits of foreign matter and to provide adequate lubrication of the seal faces.

7.10 Material selection shall be in accordance with Section 5.

7.11 Separate pressure boundary parts such as casing halves, suction heads, and end covers shall be attached to the pump casing using rabbet fits, dowel pins, or fitted bolts to ensure component alignment.

7.12 Screw threads shall conform to ANSI B1.1. Metric screw threads shall conform to ISO Metric Screw Threads (ANSI B1 Report.)

## 8. Performance Requirements

8.1 The operating conditions of the pump shall be as specified in Fig. 1 and Fig. 2.

8.2 The NPSHR of the pump as determined by the Hydraulic Institute Standards (ANSI/HI 1.1-1.5) shall not exceed the NPSHA that is specified at the rated condition.

8.3 Pumps that handle liquids more viscous than water shall have their water performance corrected in accordance with the Hydraulic Institute Standard (ANSI/HI 1.1-1.5).

8.4 The internally excited vibration levels of the pump unit shall not exceed the requirements of the centrifugal pump test standards of the Hydraulic Institute (ANSI/HI 1.1-1.5).

8.5 The acoustic levels of the pump shall not exceed those specified in Fig. 1 or Fig. 2 when measured in accordance with the centrifugal pump test standards of the Hydraulic Institute (ANSI/HI 9.1-9.5).

8.6 Pressure containing parts shall be capable of withstanding a pressure of at least 1.5 times the maximum allowable design pressure.

## 9. Painting and Coatings

9.1 *Painting*—External unmachined and nonmating machined surfaces (except for stainless steel) shall be thoroughly cleaned and painted with a hydrocarbon-resistant, anticorrosive (lead and chromate free) primer and topcoat. Heat-resistant paint requirements, if any, will be specified in Fig. 1 and Fig. 2.

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

## 10. Equipment Identification Plates

10.1 Identification plates shall be made of a corrosion-resistant material that will last throughout the service life of the pump. The identification plate must be securely attached to each pump.

10.2 The pump identification plate shall contain, at a minimum, the following information:

- 10.2.1 Manufacturer's name,
- 10.2.2 Manufacturer's model number and size,
- 10.2.3 Manufacturer's serial number,