



Standard Specification for Centrifugal Pump, Shipboard Use¹

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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:²

- A36/A36M [Specification for Carbon Structural Steel](#)
- 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 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](#)
- A995/A995M [Specification for Castings, Austenitic-Ferritic \(Duplex\) Stainless Steel, for Pressure-Containing Parts](#)
- 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)³
- B1.1 Unified Screw Threads³
- B16.1 Cast Iron Pipe Flanges and Flange Fittings³
- B16.5 Steel Pipe Flanges, Flanged Valves and Fittings, 150, 300, 400, 600, 900, 1500 and 2500 lb.³
- B16.11 Forged Steel Fittings, Socket Welding and Threaded³
- B16.24 Bronze Flanges and Flanged Fittings, 150, 300lb³

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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 Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

2.3 Hydraulic Institute Standards:

ANSI/HI 1.1-1.5 American National Standard for Centrifugal Pumps for Nomenclature, Definitions, Applications and Operation³

ANSI/HI 1.6 American National Standard for Centrifugal Pump Tests³

ANSI/HI 9.1-9.6 American National Standard for Pumps—General Guidelines for Types, Definitions, Applications and Sound Measurements³

2.4 AFBMA Standards:

9 Load Ratings and Fatigue Life for Ball Bearings⁴

11 Load Ratings and Fatigue Life for Roller Bearings⁴

2.5 ISO Standards:

ISO 9001 Quality Systems and Quality Assurance—Design/Development, Production, Installation and Service³

3. Terminology

3.1 Definitions:

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.

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

- 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 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 bedplates, 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.

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 (PURCHASUER-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) _____

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 (0-RING, ETC...) _____
 DRAIN/VENT _____
 INLET GAGE _____
 DISCHARGE GAGE _____

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 : _____

 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 MRF. 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: _____

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: _____

INSPECTIONS (PURCHASER-DEFINED)

IN-PROCESS REQUIRED
 FINAL
 _____ DAYS NOTIF. REQ'D

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 _____

ADDED REQUIREMENTS

COMMENTS (OEM & PURCHASER DEFINED)

(WORD 6.0, DOCS/FCE/001)

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 ^A	Class 3: Hydrocarbon
Casing and Pressure Boundary Parts	Bronze (Specification B584, Alloy C90500, C92200, or C87500)	Corrosion-resistant Duplex Alloy (Specification A890/A890M, Grade CD4MCu)	Bronze (Specification B584, Alloy C90500, C92200, or C87500)
Casing and Pressure Boundary Parts	Bronze (Specification B584, Alloy C90500, C92200, or C87500)	Corrosion-resistant Duplex Alloy (Specification A890/A890M or A995/A995M, Grade CD4MCuN)	Bronze (Specification B584, Alloy C90500, C92200, or C87500)
	Stainless Steel (Specification A743/A743M, CF8M)	Ni-Al Bronze (Specification B148, Alloy C95500 or C95800)	Stainless Steel (Specification A743/A743M, CF8M, J92900)
Shaft and Rotor Parts	Stainless Steel (Specification A582/A582M, Cond, Alloy S41600)	Stainless Steel (Specification A276, S31600)	Stainless Steel (Specification A582/A582M A, Alloy S41600)
	Nickel-copper alloy (Specification B164, UNS N04400 or N04405)	Nickel-copper Alloy (Monel) (Specification B164, UNS N04400)	
	Composite ^B (shaft sleeves only)	Composite ^B (shaft sleeves only)	
Impellers	Bronze (Specification B584, Alloy C90500, C92200, or C87500)	Corrosion-resistant Duplex Alloy (Specification A890/A890M, Grade CD4MCu)	Bronze (Specification B584, Alloy C90500, C92200, or C87500)
Impellers	Bronze (Specification B584, Alloy C90500, C92200, or C87500)	Corrosion-resistant Duplex Alloy (Specification A890/A890M or A995/A995M, Grade CD4MCuN)	Bronze (Specification B584, Alloy C90500, C92200, or C87500)
	Stainless Steel (Specification A743/A743M, Grade CF8M or CF8)	Ni-Al Bronze (Specification B148, UNS C95500 or C95800)	Stainless Steel (Specification A743/A743M, Grade CF8M or CF8)
	Composite ^B	Composite ^B	
Wear Rings	Bronze (Specification B271, B505/B505M or B584)	Stainless Steel (Specification A747/A747M, CB7Cu-1, Cond H1150, J92180)	Bronze (Specification B271, B505/B505M, or B584)
	Composite ^B	Bronze (Specification B271, B505/B505M or B584)	
		Composite ^B	
Casting Fasteners	Corrosion-resisting steel (Specification A193/A193M, Grade B8M and A194/A194M, Grade 8M)	Monel (Specification F468, Alloy 400)	Corrosion-resisting steel (Specification A193/A193M, Grade B8M and A194/A194M, Grade 8M)
		Corrosion-resisting steel (Specification A193/A193M, Grade B8M and A194/A194M, Grade 8M)	
Base	Structural Steel (Specification A36/A36M)	Structural Steel (Specification A36/A36M)	Structural Steel (Specification A36/A36M)

^A 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.

^B Material property of composites must be suitable for pump service life and intended service.

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.