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An American National Standard

Standard Specification for Centrifugal Pump, Shipboard Use[1]

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 (ε) 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 standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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]

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 Steel, Alloy Steel, and Stainless 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, Socket Head Cap Screws, and Studs for General Use

F1511 Specification for Mechanical Seals for Shipboard Pump Applications

2.2 *ANSI Standards:*[3]

ANSI B1 ISO Metric Screw Threads (ANSI-B1 Report)

ANSI B1.1 Unified Screw Threads

ANSI B16.1 Cast Iron Pipe Flanges and Flange Fittings

ANSI B16.5 Steel Pipe Flanges, Flanged Valves and Fittings, 150, 300, 400, 600, 900, 1500, and 2500 lb

ANSI B16.11 Forged Steel Fittings, Socket Welding and Threaded

ANSI B16.24 Bronze Flanges and Flanged Fittings, 150, 300 lb

2.3 *Hydraulic Institute Standards:*[3]

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

ANSI/HI 1.6 American National Standard for Centrifugal Pump Tests

[1] 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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[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.

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

2.4 *ABMA Standards:*[4]

ANSI/ABMA 9 Load Ratings and Fatigue Life for Ball Bearings

ANSI/ABMA 11 Load Ratings and Fatigue Life for Roller Bearings

2.5 *ISO Standards:*[3]

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

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.

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

[4] Available from American Bearing Manufacturers Association (ABMA), 330 N. Wabash Ave., Ste. 2000, Chicago, IL 60611, https://www.americanbearings.org.

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: ____________

☐ TEST REPORTS REQUIRED

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 ____ ______

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: ______

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:

ADDED REQUIREMENTS

COMMENTS (OEM & PURCHASER DEFINED)

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)

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 (PURCHAUSER-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: ____________

____

____

____

☐ TEST REPORTS REQUIRED

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	______	______

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:

ADDED REQUIREMENTS

COMMENTS (OEM & PURCHASER DEFINED)

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)

FIG. 2 Centrifugal Pump Ordering Data (Metric)

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

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 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 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.

30 hp, 115 % of pump brake-horsepower at rated design condition for motors rated between 30 hp 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.

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 gauge, 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 ANSI/ABMA 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 9.1–9.6).

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,
10.2.4 ASTM F998 Class ____, and
10.2.5 Design parameters (expressed in English or SI units):
10.2.5.1 Capacity (rated) (GPM or m^3/h),
10.2.5.2 Suction requirements (ft or m),
10.2.5.3 Total developed head (rated) (ft or m),
10.2.5.4 Rated speed (RPM),
10.2.5.5 BHP, and
10.2.5.6 Hydrostatic test pressure (psi or bar).

10.3 Attached accessory units such as the driver, controller, and gearbox shall have an identification plate.

10.4 The manufacturer shall provide necessary safety information in the form of information plates.

11. Testing Requirements

11.1 Testing shall be in accordance with Fig. 1 and Fig. 2.

11.2 Hydrostatic tests shall be performed at a pressure of 1.5 times of design working pressure (or 50 psig minimum) for a minimum of 30 min. The pump shall exhibit no leakage through the pressure boundary material or joints during the hydro test. Mechanical seal leakage criteria shall be in accordance with Specification F1511.

11.3 The mechanical run test shall consist of a short operation of the pump to ensure there is no abnormal noise, vibration, or excessive mechanical seal leakage from the pump before shipment.

11.4 Performance tests shall be conducted in accordance with the Hydraulic Institute centrifugal pump tests standards (ANSI/HI). The performance tolerance acceptance levels shall be as specified by ANSI/HI.

11.5 Net positive suction head (NPSH) tests, when specified, shall be conducted in accordance with the Hydraulic Institute centrifugal pump tests standards (ANSI/HI). The acceptance level shall be in accordance with ANSI/HI.

11.6 Vibration tests, when specified, shall be conducted in accordance with the Hydraulic Institute centrifugal pump tests standards (ANSI/HI). The acceptance level shall be in accordance with ANSI/HI.

11.7 Acoustic tests, when specified, shall be conducted in accordance with the Hydraulic Institute centrifugal pump tests standards (ANSI/HI). The acceptance level shall be in accordance with ANSI/HI.

11.8 If a test report is required or if tests must be witnessed, the purchaser shall specify the requirements in Fig. 1 and Fig. 2.

12. Technical Documentation

12.1 Unless otherwise specified, each pump shall include an instruction book that shall be composed of the following:
12.1.1 Unit description;
12.1.2 Installation instructions;
12.1.3 Operating instructions;
12.1.4 Maintenance procedures (including complete pump disassembly and assembly);
12.1.5 Outline dimension drawing, including weight;
12.1.6 Typical cross-sectional assembly drawing and list of materials;
12.1.7 Performance curve that plots total head, efficiency, NPSH, (if required), and brake horsepower as a function of capacity; and
12.1.8 List of fluids with material safety data sheets (MSDS).

12.2 *Submittal Documents*—Proposal documents shall consist of the following:
12.2.1 Outline dimension drawing with weight and center of gravity;
12.2.2 Typical cross-sectional drawing and list of materials;
12.2.3 Performance curve which plots total head, efficiency, water NPSH, and brake horsepower as a function of capacity; and
12.2.4 List of recommended spare parts.

13. Packaging and Preservation

13.1 All openings shall be sealed with covers. Small piping (1 in. or less) may be sealed with tape. Cover design shall preclude the makeup of connecting piping with covers in place.