INCH-POUND

MIL-DTL-32408
07 February 2012

DETAIL SPECIFICATION

INTEGRAL MOTOR PUMP (IMP)

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers vertical or horizontal centrifugal Integral Motor Pumps (IMP) (see 6.1) for shipboard applications on U.S. Navy ships and submarines. Pumps are to be sealless and configured for either end suction where impeller is overhung with all bearings on one side of the impeller, or in an inline configuration with the impeller positioned between two sets of bearings. The motor is an axial-field integral permanent magnet machine controlled by a variable speed drive (VSD). These characteristics are intended to result in a pump design that has no routine maintenance requirements and weight and dimensions that are significantly smaller than the equivalent close coupled, end suction, induction motor driven centrifugal pump.

1.2 Classification. Integral motor pumps are classified using the following ratings:

1.2.1 Pump suction and discharge flange sizes. Pump suction and discharge flange sizes are specified as follows:

Pump flange size	Code	Pump flange size	Code
0.75" NPS	0.75	3.5" NPS	3.5
1.0" NPS	1	4.0" NPS	4
1.25" NPS	1.25	5.0" NPS	5
1.5" NPS	1.5	6.0" NPS	6
2.0" NPS	2	8.0" NPS	8
2.5" NPS	2.5	10.0" NPS	10
3.0" NPS	3	12.0" NPS	12

1.2.2 Nominal impeller diameter. Pump nominal impeller diameter in inches is rounded to the nearest whole number.

1.2.3 Maximum operating speed. Pump maximum operating speed in rpm is rounded to the nearest hundred.

1.2.4 Power rating. Motor power rating in horsepower is rounded to the nearest whole number.

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard, DC 20376-5160 or emailed to CommandStandards@navy mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.daps.dla mil.

1.2.5 Pump class. Pump application class is specified as follows:

Pump class	Code
Freshwater	C1
Saltwater/freshwater	C2
Saltwater duplex	C3
Saltwater	C4
Hydrocarbon (less than 1500 SSU)	C5

1.3 Part or identifying number (PIN). PINs to be used for IMPs acquired to this specification are created as follows: (see 1.2.1 through 1.2.5)

M Prefix	Specification number	Hyphen	Discharge flange size	X	Suction flange size	Hyphen	Impeller diameter	Hyphen	Operating speed	Hyphen	Power rating	Pump class
M	32408	-	1	X	1.5	-	4	-	5600	-	5	C2

The example above (M32408-1X1.5-4-5600-5C2) is for a 1-inch NPS discharge by 1.5-inch NPS suction, 4-inch diameter, 5600 RPM, 5 horsepower (hp), seawater service IMP.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

QQ-N-286 - Nickel-Copper-Aluminum Alloy, Wrought (UNS N05500)

FEDERAL STANDARDS

FED-STD-H28 - Screw-Thread Standards for Federal Services

FED-STD-H28/2 - Screw-Thread Standards for Federal Services Section 2 Unified Inch Screw Threads - UN and UNR Thread Forms

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-S-901 - Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for

MIL-E-917 - Electric Power Equipment Basic Requirements

MIL-DTL-1222 - Studs, Bolts, Screws and Nuts for Applications Where a High Degree of Reliability is Required, General Specification for

MIL-DTL-15024 - Plates, Tags, and Bands for Identification of Equipment, General Specification for

MIL-DTL-15090	-	Enamel, Equipment, Light Gray, (Navy Formula No.111)
MIL-DTL-17060	-	Motors, Alternating Current, Integral-Horsepower, Shipboard Use
MIL-PRF-20042	-	Flanges, Pipe, Bronze (Silver Brazing)
MIL-PRF-32168	-	Variable Speed Drive System for Induction and Synchronous Machines

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-167-1	-	Test Method Standard for Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)
MIL-STD-461	-	Interface Standard for Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-740-1	-	Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-777	-	Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships
MIL-STD-882	-	Standard Practice for System Safety
DOD-STD-1399-301	-	Interface Standard for Shipboard Systems, Section 301A, Ship Motion and Attitude (Metric)
MIL-STD-1474	-	Design Criteria Standard for Noise Limits
MIL-STD-1687	-	Thermal Spray Processes for Naval Ship Machinery Application

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-454	-	General Guidelines for Electronic Equipment

(Copies of these documents are available online at https://assist.daps.dla.mil/quicksearch/ or https://assist.daps.dla.mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SEA SYSTEMS COMMAND (NAVSEA) DRAWINGS

803-7226047	-	Qualification Requirements for Composite Material Components as Alternate Candidates for Centrifugal Pump Parts
810-1385850	-	Piping, Installation, Pressure for all Services

(Copies of these documents are available from the applicable repositories listed in NAVSEA S0005-AE-PRO-010/EDM. Copies of NAVSEA S0005-AE-PRO-010/EDM are available from the Naval Logistics Library, 5450 Carlisle Pike, Mechanicsburg, PA 17055 or online at https://nll1.ahf.nmci navy mil.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA) TECHNICAL MANUALS

S9074-AR-GIB-010/278	-	Requirements for Fabrication and Inspection, and Casting Inspection and repair for Machinery, Piping and Pressure Vessels
T9074-AS-GIB-010/271	-	Requirements for Nondestructive Testing Methods

(Copies of these documents are available from the Naval Logistics Library, 5450 Carlisle Pike, Mechanicsburg, PA 17055 or online at https://nll1.ahf nmci.navy.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S2.19	-	Mechanical Vibration - Balance Quality Requirements of Rigid Motors - Part 1: Determination of Possible Unbalance, Including Marine Applications

(Copies of this document are available from the American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036 or online at http://webstore.ansi.org/.)

ASME INTERNATIONAL

ASME B16.5	-	Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24

(Copies of this document are available from ASME International, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 or online at www.asme.org.)

ASTM INTERNATIONAL

ASTM A36/A36M	-	Standard Specification for Carbon Structural Steel
ASTM A193/A193M	-	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194/A194M	-	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A582/A582M	-	Specification for Free-Machining Stainless Steel Bars
ASTM A743/A743M	-	Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
ASTM A747/A747M	-	Specification for Steel Castings, Stainless, Precipitation Hardening
ASTM A890/A890M	-	Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
ASTM B61	-	Standard Specification for Steam or Valve Bronze Castings
ASTM B148	-	Standard Specification for Aluminum-Bronze Sand Castings
ASTM B164	-	Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B271	-	Standard Specification for Copper-Base Alloy Centrifugal Castings
ASTM B367	-	Standard Specification for Titanium and Titanium Alloy Castings
ASTM B369	-	Standard Specification for Copper-Nickel Alloy Castings

ASTM B446	-	Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650)* Rod and Bar
ASTM B473	-	Standard Specification for UNS N08020, UNS N08024, and UNS N08026 Nickel Alloy Bar and Wire
ASTM B505/B505M	-	Standard Specification for Copper-Base Alloy Continuous Castings
ASTM B584	-	Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM D5363	-	Standard Specification for Anaerobic Single-Component Adhesives (AN)
ASTM F468	-	Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use

(Copies of these documents are available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or online at www.astm.org.)

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	-	Centrifugal Pumps for Nomenclature and Definitions
HI 1.6	-	Centrifugal Pump Tests
HI 9.1-9.5	-	Pumps-General Guidelines for Types, Applications, Definitions, Sound Measurement, and Documentation

(Copies of these documents are available from the Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ 07054 or online at www.pumps.org.)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 115	-	Test Procedures for Synchronous Machines

(Copies of this document are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 or online at www.ieee.org.)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60034-18-41	-	Qualification and Type Tests for Type 1 Electrical Insulation Systems Used in Rotating Electrical Machines Fed from Voltage Converters
IEC 61934	-	Electrical Measurements of Partial Discharge During Short Risetime Repetitive Voltage Impulses

(Copies of these documents are available from the IEC Central Office, 3 rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland or online at www.iec.ch.)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MW1000	-	Magnet Wire

(Copies of this document are available from the National Electrical Manufacturers Association, 1300 N 17th Street, Suite 1847 Rosslyn, VA 22209 or online at www.nema.org.)

NSF INTERNATIONAL

NSF 61 - Drinking Water Systems Components - Health Effects

(Copies of this document are available from NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48113-0140 or online at www.nsf.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 Materials. The materials of the pump shall conform to the materials specified in table I for the class of service specified (see 6.2).

TABLE I. Material specifications.

	Class 1 Freshwater	**Class 2 Saltwater/ Freshwater**	**Class 3 Saltwater Duplex**	**Class 4 Saltwater**	**Class 5 Hydrocarbon**
Casing and pressure boundary parts	Bronze (ASTM B584, Alloy C90500, C92200, or C87500) Stainless steel (ASTM A743/ A743M, CF8M)	70-30 Cu-Ni (ASTM B369 (C96400)) Ni-Al bronze (ASTM B148, Alloy C95500, or C95800)	Corrosion-resistant duplex alloy (ASTM A890/ A890M, Grade CD4MCu)	Titanium (ASTM B367)	Bronze (ASTM B584, Alloy C90500, C92200, or C87500) Stainless steel (ASTM A743/ A743M, CF8M, J92900)
Shaft and rotor parts	Stainless steel (ASTM A582/ A582M, Cond alloy S41600) Nickel-copper alloy (ASTM B164, UNS N04400, or N04405)	Nickel-copper alloy (Monel) (ASTM B164, UNS N04400)	Alloy 20 ASTM A743/A743M (CN-7M) ASTM B473	Inconel 625 ASTM B446	Stainless steel (ASTM A582/ A582M, Alloy S41600)

TABLE I. Material specifications – Continued.

	Class 1 Freshwater	**Class 2 Saltwater/ Freshwater**	**Class 3 Saltwater Duplex**	**Class 4 Saltwater**	**Class 5 Hydrocarbon**
Impellers	Bronze (ASTM B584, Alloy C90500, C92200, or C87500)	Nickel-copper alloy (Monel) (ASTM B164, UNS N04400) 70-30 Cu-Ni (ASTM B369 (C96400)) Ni-Al bronze (ASTM B148, UNS C95500, or C95800) Composites 803-7226047	Corrosion-resistant duplex alloy (ASTM A890/ A890M, Grade CD4Mcu) Composites 803-7226047	Titanium (ASTM B367)	Bronze (ASTM B584, Alloy C90500, C92200, or C87500)
Wear rings	Bronze (ASTM B271, ASTM B505/ B505M, or ASTM B584)	Nickel-copper alloy (Monel) (ASTM F468, Alloy 400) Bronze (ASTM B271, ASTM B505/ B505M, or ASTM B584) Composites 803-7226047	Stainless steel (ASTM A747/ A747M, CB7Cu-1, Cond H1150, J92180) Alloy 20 ASTM A743/A743M (CN-7M) ASTM B473 Composites 803-7226047	Titanium (ASTM B367)	Bronze (ASTM B271, ASTM B505/ B505M, or ASTM B584)
Casing bolts, studs, nuts	Corrosion-resisting steel (ASTM A193/ A193M, Grade B8M and ASTM A194/A194M, Grade 8M)	Nickel-copper alloy (Monel) (ASTM F468, Alloy 400)	Alloy 20 ASTM A743/A743M (CN-7M) ASTM B473	Nickel-copper-AL alloy (K-Monel) (QQ-N-286)	Corrosion-resisting steel (ASTM A193/ A193M, Grade B8M and ASTM A194/A194M, Grade 8M)
Base	Structural steel (ASTM A36/ A36M)	Structural steel (ASTM A36/ A36M)	Structural steel (ASTM A36/ A36M)	Structural steel (ASTM A36/ A36M)	Structural steel (ASTM A36/ A36M)

3.2.1 Alternate materials. Alternate materials may be substituted for the material specified in table I provided the alternate material provides equal or better service for the specified application. Alternate materials shall be approved by NAVSEA prior to use. Components of the IMP for which the specific materials are not specified shall be materials best suited for the intended service. Materials, which can be sensitized and are subjected to heat treatment in the sensitization range during fabrication shall pass the intergranular corrosion tests of the base material specifications. Particular attention should be given to avoiding sensitization of materials during hard facing, stress relieving, or repair welding. Use of cadmium-plated parts and fasteners, including washers, is prohibited. Galvanic compatibility between dissimilar metals when used in saltwater applications must be considered.

3.2.2 Excluded materials. The following materials shall be prohibited: magnesium and its alloys, cadmium plating, asbestos, and any radioactive materials. Lead and its compounds shall not be used where they can come in contact with seawater feed, permeate, or freshwater. The lead content in bronze alloys shall not exceed levels allowed by ASTM B61.

3.2.3 Mercury contamination. The IMP and its appurtenances and controls shall be free of mercury contamination and free of functional mercury as specified (see 6.2). The product offered shall not come in direct contact with mercury, any of its compounds, nor with any mercury-containing device, such as gauges and thermometers. The manufacturer shall certify that the IMP and its appurtenances and controls, when shipped, are free from mercury contamination.

3.2.4 Non-metallic materials. Composite material shall be in accordance with 803-7226047. All stand-alone non-metallic materials that may come in contact with potable freshwater shall be NSF 61 approved for drinking water contact. Material certification requirements shall be specified in the pump material list and on the IMP general arrangement drawing. IMPs not intended for potable water due to use of non-certified material shall so state on its general arrangement drawings.

3.2.5 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.3 Design.

3.3.1 Dimensions. The space and weight requirements of the IMP shall be as specified (see 6.2).

3.3.2 Component alignment. To ensure component alignment, separate pressure boundary parts such as casing halves, suction heads, and end covers shall be attached to the IMP casing using rabbit fits, dowel pins, or fitted bolts.

3.3.3 Provision for handling. Eyebolts, lugs, holes, and other means shall be provided to permit attachment of lifting gear for lifting the assembled IMP, driver, and attached accessories as a complete unit. Means shall be provided for the handling of parts and components weighing 150 pounds (verify weight) and over which cannot be handled manually during unit overhauls and preventive maintenance inspections.

3.3.4 Threaded parts. Internal threaded fasteners and threaded machine elements shall be secured by locking devices where continuous operation under the condition of shock, vibration, and temperature, specified herein, depend on maintaining tight connections of parts. All setscrews internal to the pressure boundary of the IMP and all setscrews on internal rotating portions of the IMP shall be secured by locking devices.

3.3.4.1 Fasteners. Threaded parts, such as bolts, studs, and nuts, shall conform to FED-STD-H28, FED-STD-H28/2, or MIL-DTL-1222 as specified (see 6.2). The use of tap-bolts or cap screws is prohibited unless approved in cases where the use of through bolts or studs is impractical. For temperatures under 250 °F (121 °C), the setting end of studs shall be a Class 2 fit or preferably a Class 3 fit, both with locking resin in accordance with ASTM D5363, Type I, Grade K. The nut end shall be a Class 3 fit or as specified (see 6.2).

3.3.4.2 Length. The length of minimum stud engagement shall be computed as specified in FED-STD-H28. Unless otherwise specified (see 6.2), threaded fasteners of normally stocked lengths shall be used. Male threads on threaded fasteners, after being installed and tightened, shall protrude at least one thread beyond the top of the nut or plastic locking element. Excessive protrusion shall be avoided, particularly where necessary clearances, accessibility, and safety are important. Where practicable, the number of threads protruding shall not exceed five; however, in no case shall thread protrusion exceed 10 threads. Washers shall not be used for the sole purpose of lessening thread protrusion.

3.3.5 Terminal boxes and terminal box covers. Terminal boxes and covers shall be provided and securely bolted, welded, or cast to the pump casing. Terminal boxes shall be provided with conduit openings as specified (see table II). For motors rated over 320 amps, the conduit openings shall be sized to suit the number and diameter of ship cables specified (see 6.2).

TABLE II. National pipe thread (NPT) assignments for motor terminal boxes – nylon tubes. 1/

Maximum full-load amps	NPT	Tube size
18	0.75	2
25	1	3
110	1.5	5
185	2	6
250	2.5	7
320	3	8
400	3.5	9

NOTE:
1/ NPT sizes are based on the maximum expected three-conductor cable size. If cable size permits, the hole size may be reduced to the next lower size by use of a reducing bushing which will be inserted by the installing activity. If steel tubes are used, the installing activity shall provide the proper size reducing bushing to fit.

3.3.6 Rotor temperature. The permanent magnet material in the rotor shall not reach a temperature that demagnetizes the magnet or causes a loss of power.

3.3.7 Insulation class. Insulation class shall be F, H, or N in accordance with MIL-E-917 (see 6.2).

3.3.7.1 Class H and N. Class H and N insulation shall be used where temperature of fluid to be pumped exceeds 311 °F (155 °C).

3.3.7.2 Class F. Class F insulation systems shall be used where temperature of the fluid to be pumped is less than 311 °F (155 °C).

3.3.8 Inverter duty systems. When specified (see 6.2), inverter duty insulation systems on stator windings shall use partial discharge resistant magnet wire that has characteristics defined by NEMA MW1000.

3.3.9 Terminal box insulation. The terminal box of motors that use inverter duty insulation systems shall use electromagnetic interference (EMI)/environmental gasketing for sealing purposes (see 3.7.3).

3.3.10 Casings. Casings shall permit the examination and replacement of wearing parts. Suction covers shall be removable to permit removal of the impeller or casing wearing rings (if required) without removing the rotating assembly. Forcing bolts shall be provided for breaking joints.

3.3.10.1 Casings thickness. Casing thickness shall include an allowance for corrosion, erosion, and the possibility of a core shift. The minimum casing thickness shall be 0.5 inch excluding IMPs with a rated total head of 115 feet or less.

3.3.10.2 Casing vents and drains. Casings shall be provided with bosses and vent and drain connections in the proper locations to vent all air pockets from the pump casing and completely drain the pump. Vent and drain connections shall be provided with plugs.

3.3.10.3 Casings bosses. Casings shall be provided with the necessary bosses and connections for suction and discharge pressure gauge connections. Pressure gauge connections shall be provided with plugs.

3.3.10.4 Nozzle loading. Casings shall be sufficiently rugged to withstand, without fracture or appreciable distortion, the strains to which they may be subjected. Under the combined effect of nozzle loads and design pressure (see 6.2), no parts of the casing or other IMP parts shall exceed yield strength and no rotating clearances shall make contact.

3.3.10.5 Wearing rings. Casings shall be fitted with removable wearing rings. The casing wearing rings shall be located and shaped in such a manner that leakage through wearing ring clearance shall not be allowed to impinge directly on the casing. Casing wearing rings shall be secured from rotating by setscrews mounted in the joint between the casing and the ring.

3.3.10.5.1 Replacement wear ring. Spare casing wearing rings, if required, shall be machined undersize by at least 0.05 inch on the diameter.

3.3.11 Impeller. Impellers shall be of the closed type. Impellers may be single suction or double suction type. Outside surfaces of the impeller shall be smooth finished.

3.3.11.1 Impeller wear ring. Impellers shall not be furnished with wearing rings. The impeller wearing surfaces shall have enough material thickness to permit reducing the diameter of the impeller wearing surface by as much as 0.050 inch to accommodate undersize casing wearing rings to restore design running clearance.

3.3.11.2 Impeller balance. The complete impeller rotating assembly shall be dynamically balanced in accordance with ANSI S2.19, Grade G6.3.

3.3.12 Welding. Welding and welding repair shall be in accordance with S9074-AR-GIB-010/278. Brazed joints shall not be used.

3.3.13 Suction and discharge connections. Suction and discharge connections shall be flanged for mating with flanges in accordance with MIL-PRF-20042 or ASME B16.5 and MIL-STD-777 as specified (see 6.2). All IMP flanges shall have a face circular lay finish as detailed in the applicable general note of MIL-STD-777.

3.3.14 Pressure gauges. Pressure gauges, when provided with the pump units (see 6.2), shall be mounted in accordance with 810-1385850. Gauges shall be positioned for accessibility of reading and maintenance. Gauges shall be secured on the parent equipment in such a manner as to prevent vibration, breakage, and disconnection.

3.3.15 Safety. Hazards to equipment and personnel shall be minimized by the application of system safety principles in the design of the equipment in accordance with the guidelines of MIL-STD-882. In addition, the safety guidelines for electrical/electronic components of MIL-HDBK-454 shall apply. The unit shall be designed so as to be free of personnel hazards. All safety features shall be such that their functions cannot be inadvertently degraded or negated during operation, storage, shipping, handling, or maintenance. All parts, components, and assemblies shall be free from sharp edges, burrs, protruding surfaces, and other harmful extraneous material. Means shall be provided to ensure against damage to wires and cables from contact with rough or irregular surfaces and sharp edges.

3.4 Painting. Painting shall be in accordance with MIL-DTL-15090. External unmachined surfaces of ungalvanized ferrous metal parts shall be thoroughly cleaned and coated with one coat of pretreatment and one coat of zinc chromate primer followed by a finish coat of light gray equipment enamel. Painting of surfaces of nonferrous IMPs shall not be required.

3.5 Identification plates. Nameplates shall be furnished for each IMP and shall be in accordance with MIL-DTL-15024. The IMP identification plate shall contain the following information:

a. Manufacturer's name
b. Manufacturer's model or type and size
c. Service application
d. Manufacturer's serial number
e. Salient design characteristics:
    (1) Capacity in gallons per minute (gal/min)
    (2) Total head in lb/in^2
    (3) Operating speed of shaft in r/min
    (4) Brake horsepower
    (5) Test pressure
    (6) Motor rated voltage
    (7) Motor rated current
    (8) Special data vital to the unit:
        (a) Suction pressure
        (b) Submergence
        (c) Impeller diameter
        (d) Total head
        (e) Contract number (and item number for multiple unit orders)
        (f) National stock number
        (g) Section for Defense Contract Administration Service Management Area (DCASMA) stamp.
        (h) Navy standard pump number
        (i) Component identification number (CID) consisting of nine digits that will be supplied to the successful bidder. No materials shall be shipped until the CID is included on the identification plate.

3.6 Performance characteristics.

3.6.1 Pump performance. The performance characteristics of the IMP shall be as specified (see 6.2). IMP performance characteristics including the net positive suction head required (NPSHR) shall be developed in accordance with HI 1.1-1.2.

3.6.2 Operation. IMPs shall operate satisfactorily at any condition of operation from shutoff capacity to wide-open while pumping the specified fluid.

3.6.2.1 Continuous operation. Pumps shall operate continuously at any point over the entire flow range and the design conditions as specified (see 6.2).

3.6.2.2 Motor overload. The IMP motor and VSD controller shall not be overloaded during any condition of operation from shutoff capacity to wide-open while pumping the specified fluid at design speed.

3.6.2.3 Maximum operational speed. The IMP's maximum operational speed shall not exceed its rated speed.

3.6.3 Controller. The IMP shall be powered by a variable speed drive in accordance with MIL-PRF-32168.

3.6.4 Suction condition. IMP suction conditions shall be as specified (see 6.2). Flooded suction IMPs shall be capable of satisfactory operation at a dynamic suction lift of 25 feet of water at 95 °F (35 °C).

3.6.5 Head-capacity curve. IMPs for all services shall have constantly rising head-capacity curves from maximum or wide-open capacity to zero or shutoff capacity at all IMP speeds.

3.6.6 Rated capacity. IMP rated capacity at the rated dynamic head shall be as specified (see 6.2). The IMP shall be designed to operate near the best efficiency point at this rated capacity and dynamic head.

3.6.7 Liquid to be pumped. Liquid to be pumped, liquid specific gravity, and normal liquid temperature shall be as specified (see 6.2).

3.6.8 Motor cooling. IMPs shall utilize the pumped fluid for motor cooling. Maximum fluid operating temperature shall be equal to the design operating temperature (see 3.6.11).

3.6.9 Current rating. Motor current rating shall match the VSD rating.

3.6.10 Nominal VSD controller input voltage. Pump nominal controller voltage is 3-phase, 60-hertz, 450-volt AC. Non-standard voltages, if needed, shall be as specified (see 6.2).

3.6.11 Design pressure and temperature. IMP fluid design pressure and temperature shall be as specified (see 6.2).

3.6.12 Rotation. IMP normal rotation shall be specified by the manufacturer. The IMP motor lead identification shall ensure the correct rotation is obtained.

3.6.13 Reverse rotation. IMPs shall withstand reverse rotation due to reverse flow through the pump without damage.

3.6.14 Casings. The casing or suction cover shall exhibit no leakage through the pressure boundary material or joints when subjected to a hydrostatic test in accordance with 4.5.1.11.

3.6.15 Bearings. Pumped fluid lubricated hydrodynamic radial bearings shall be designed to operate under full-fluid film lubrication under all operating conditions except startup and shutdown. Boundary lubrication will be permitted during IMP start up and shutdown. Bearing material coatings applied to metal parts shall be applied in accordance with MIL-STD-1687.

3.6.16 Motor requirements.

3.6.16.1 Motor type. The motor shall be an inverter duty axial gap permanent magnet type.

3.6.16.2 Resistance. Average terminal-to-terminal winding resistance, corrected to 77 °F (25 °C), shall not differ from the value measured during first article testing by more than the percentage specified in table III. The resistance balance shall be as follows:

TABLE III. Tolerance for no-load input and stator resistance.

Horsepower	No-load input		Stator resistance at 77 °F (25 °C) (percent)
	Amps (percent)	Watts (percent)	
All	±10	+15	±5

3.6.16.3 Dielectric strength. IMP stator windings shall withstand dielectric test voltages of 1000 plus twice the rated voltage or 1200 plus 2.4 times rated voltage for at least one minute (see 4.5.10).

3.6.16.4 Electrical balance. With balanced voltage applied, amperes in any phase at rated load shall not differ from the arithmetic average of the maximum and minimum phase amperes by more than 10 percent for motors rated 1.5 hp and under; by more than 7.5 percent for motors rated 2 and 3 hp; and by more than 5 percent for motors over 3 hp.

3.6.16.5 Terminal box. The terminal box shall be watertight.

3.6.16.6 Insulation resistance. Insulation resistance to ground and partial discharge inception voltage shall be in accordance with MIL-DTL-17060 (see 4.5.1).

3.6.16.7 Power consumption. Unit power consumption at rated conditions shall not exceed that specified (see 6.2).

3.7 Environmental conditions.

3.7.1 Ambient temperature. The IMP shall continuously operate at its full load amperage at an ambient temperature of +122 °F (+50 °C) and with its cooling medium at the maximum design temperature (see 3.6.8 and 3.6.11).

3.7.2 Relative humidity. The IMP shall operate satisfactorily during and subsequent to exposure to relative humidity ranging up to 95 percent for both continuous and intermittent periods, including conditions where condensation occurs on equipment.

3.7.3 Electromagnetic interference. The motor shall meet the radiated electromagnetic interference (EMI) requirements for inverter duty motors of MIL-DTL-17060.

3.7.4 Shock. Unless otherwise specified (see 6.2), the IMP and its appurtenances and controls shall meet the Grade A shock requirements of MIL-S-901 and the acceptance criteria specified in 4.5.3 when tested as specified in 4.5.3.

3.7.4.1 Shock mounts. Unless otherwise specified (see 6.2), shock mounts (resilient mounts for shock attenuation) shall not be used. All IMPs shall pass the specified shock test solidly mounted whether or not noise attenuation mounts are specified.

3.7.4.2 Fastener shock loading. Bolts designed to be stressed in shear shall be installed in holes with a minimum of clearance. Hole diameters shall not be more than $\frac{1}{32}$ inch larger than the bolts for sizes up to and including 0.75 inch, and no more than $\frac{1}{16}$ inch larger than bolts of greater than 0.75-inch size.

3.7.4.3 Shock extension. Equipment exactly duplicating that previously shock tested and accepted need not be retested except when evidence of low shock resistance develops in installed pump units. NAVSEA will initiate action with the manufacturer for correction of deficiencies and reserves the right to require additional shock tests.

3.7.5 Vibration. The IMP and its appurtenances and controls shall meet the Type I and Type II vibration requirements of MIL-STD-167-1 when tested as specified in 4.5.4. In addition, the IMP shall not be damaged, malfunction, or exceed the limits specified in HI 1.6 when tested at the rated and intermediate speeds following the tests.

3.7.6 Noise. The IMP and its appurtenances and controls shall pass the airborne noise test in accordance with MIL-STD-1474 or HI 9.1-9.5 and the structureborne noise test in accordance with MIL-STD-740-2. The design, construction, and workmanship of the equipment shall be such that operation under design conditions shall meet the airborne noise and structure borne vibration noise requirement as specified (see 6.2).

3.7.7 Operating conditions. The IMP shall be fully operational without damage, maintain lubrication, and avoid loss of fluid when subjected to the most unfavorable combination of design limits for ship motion specified for surface ships and submarines in DOD-STD-1399-301.

3.8 Maintainability.

3.8.1 Maintenance time. The time required to perform pump maintenance action requiring part removal shall not exceed 2 hours for end suction pumps and 5 hours for inline pumps.

3.8.2 Tools. Special tools not available in the Federal Supply Catalog required for maintenance and repair of the IMP and its appurtenances and controls shall be furnished. The number of sets of special tools shall be as specified (see 6.2).

3.9 Service life. Each IMP shall have a service life of 30 years, of which 40 percent shall be actual operation. There shall be no limit on the number of starts during the life of the pump. It shall be assumed that during the life of the pump, parts subject to unavoidable wear and deterioration (such as impeller running fits and the bearings), shall have a minimum operational life of 18,000 actual operating hours and shall be identified on the drawings and manuals. The parts subject to wear, deterioration, and normally requiring replacement at 5-year intervals during the service life of the pump shall have a life of 18,000 actual operating hours, and they shall be identified in appropriate drawings and manuals.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 First article inspection. First article inspection shall be performed on the IMP and its appurtenances and controls when a first article sample is required (see 6.2). This inspection shall include the examination of 4.4 and the tests specified in table IV. The first article tests on one IMP design may be conducted concurrently if practicable.

4.3 Conformance inspection. Conformance inspection shall include the examination of 4.4 and the tests specified in table IV.

TABLE IV. Inspection requirements.

Attribute	Requirement paragraph	Verification paragraph	First article inspection	Conformance inspection
Materials	3.2	4.4	X	X
Alternate materials	3.2.1	4.4	X	X
Excluded materials	3.2.2	4.4	X	X
Mercury	3.2.3	4.4	X	X
Non-metallic materials	3.2.4	4.4	X	X
Recycled, recovered, or environmentally preferable materials	3.2.5	4.4	X	X
Design	3.3	4.4	X	X
Dimensions	3.3.1	4.4	X	X
Component alignment	3.3.2	4.4	X	
Provision for handling	3.3.3	4.4	X	
Threaded parts	3.3.4	4.4	X	
Terminal boxes and terminal box covers	3.3.5	4.4	X	
Rotor temperature	3.3.6	4.4	X	
Insulation class	3.3.7	4.4	X	
Inverter duty systems	3.3.8	4.4	X	
Terminal box insulation	3.3.9	4.4	X	
Casings	3.3.10	4.4	X	

TABLE IV. Inspection requirements – Continued.

Attribute	Requirement paragraph	Verification paragraph	First article inspection	Conformance inspection
Impeller	3.3.11	4.4	X	
Welding	3.3.12	4.4	X	
Suction and discharge connections	3.3.13	4.4	X	
Pressure gauges	3.3.14	4.4	X	
Safety	3.3.15	4.4	X	X
Painting	3.4	4.4	X	X
Identification plates	3.5	4.4	X	X
Pump performance	3.6.1	4.5.1.1 - 4.5.1.6	X	X
Operation	3.6.2	4.5.1.2	X	X
Continuous operation	3.6.2.1	4.5.1.2	X	X
Motor overload	3.6.2.2	4.5.1.4	X	X
Maximum operational speed	3.6.2.3	4.5.1.7	X	X
Controller	3.6.3	4.4	X	X
Suction condition	3.6.4	4.5.1.3	X	X
Head-capacity curve	3.6.5	4.5.1.1 - 4.5.1.6	X	X
Rated capacity	3.6.6	4.5.1.1 - 4.5.1.6	X	X
Liquid to be pumped	3.6.7	4.5.1.1 - 4.5.1.6	X	X
Motor cooling	3.6.8	4.5.1.1 - 4.5.1.6	X	X
Current rating	3.6.9	4.4	X	X
Nominal VSD controller input voltage	3.6.10	4.4	X	X
Design pressure and temperature	3.6.11	4.5.1.1 - 4.5.1.6	X	X
Rotation	3.6.12	4.5.1.1 - 4.5.1.6	X	X
Reverse rotation	3.6.13	4.5.1.10	X	X
Casings	3.6.14	4.5.1.11	X	X
Bearings	3.6.15	4.5.1.1 - 4.5.1.6	X	X
Motor	3.6.16	4.5.1.12 and 4.5.10	X	X
Ambient temperature	3.7.1	4.4		
Relative humidity	3.7.2	4.4		
Electromagnetic interference	3.7.3	4.5.2	X	
Shock	3.7.4	4.5.3	X	
Vibration	3.7.5	4.5.4	X	X
Airborne noise	3.7.6	4.5.5 and 4.5.5.1	X	X
Structureborne noise	3.7.6	4.5.5 and 4.5.5.2	X	X
Operating conditions	3.7.7	4.5.6	X	
Maintainability	3.8	4.5.7	X	

TABLE IV. Inspection requirements – Continued.

Attribute	Requirement paragraph	Verification paragraph	First article inspection	Conformance inspection
Service life	3.9	4.5.1.9	X	
Power consumption	3.6.16.7	4.5.8	X	

4.4 Examination. Each IMP assembly shall be examined for compliance with the requirements specified in 3.2 through 3.5. Any redesign or modification of the contractor's standard product to comply with specified requirements, or any necessary redesign or modification following failure to meet the specified requirements shall receive particular attention for adequacy and suitability. This element of inspection shall encompass all visual examinations and dimensional measurements. Welding and castings shall be inspected in accordance with S9074-AR-GIB-010/278. Noncompliance with any specified requirements or presence of one or more defects shall constitute cause for rejection.

4.5 Methods of inspection.

4.5.1 Performance tests.

4.5.1.1 Performance curves. Performance tests shall be conducted in accordance with the requirements of 4.5.1.8. In addition, a full-performance map for the rated impeller shall be established. The full-performance map shall be developed by measuring and establishing curves for total head versus capacity, electrical horsepower input to VSD controller versus pump capacity, and net positive suction head required versus capacity. For each of those curves, measurements shall be taken at shutoff, rated condition, as close to free delivery as practicable, and at five other capacities approximately evenly spread between these test points. Test data shall be converted to the specified operating conditions for plotting of all performance curves. The performance curves shall be determined at maximum and minimum operating speed for multispeed pumps. A full net positive suction head (NPSH) curve is required on the lead production unit, and, on subsequent units, the NPSH shall be determined at design rated capacity only.

4.5.1.2 Operational test. Each IMP shall be tested at its rated operating speed and at one point of rating by a continuous nonstop run of at least 8 hours to check operation and smoothness of running.

4.5.1.3 Suction performance. Performance tests shall demonstrate the ability of the IMP to handle its rated capacity of specified liquid at the maximum temperature and minimum suction head, or maximum suction lift or vacuum, as applicable.

4.5.1.4 Test curves. Head-capacity and electrical horsepower curves shall demonstrate that the IMP is not over-loaded at any point from shutoff to wide open. The following test curves shall be supplied for the rated speed conditions and varying speed conditions of the IMP:

a. Total head vs. capacity

b. Electrical horsepower input to VSD controller vs. pump capacity

c. Net positive suction head vs. capacity

4.5.1.5 NPSH test. Net positive suction head tests shall be conducted in accordance with the HI 1.6. The acceptance level shall be in accordance with this specification.

4.5.1.6 Performance test acceptance criteria. The acceptance criteria shall be as specified in 4.5.1.8.1.1 and 4.5.1.8.2.1. The performance map shall be used to verify the specified IMP performance characteristics. The net positive suction head required shall not exceed the minimum suction head available as specified by the contract or order (see 6.2). Controls and safety devices shall function reliably as intended throughout the full operating ranges of capacity and speed.

4.5.1.7 Overspeed test. Each IMP shall be operated continuously for 30 minutes at a speed of 25 percent above maximum design operating speed. The IMP need not be under load except as necessary to prevent damage or injury. The dynamic balance shall be checked using a vibration instrument capable of measuring vibration amplitude of 0.001 (in peak to peak). The IMP shall not exhibit abnormal noises or roughness of operation. Vibration shall not exceed the Type II vibration limits of MIL-STD-167-1 during the test.

4.5.1.8 Mechanical soundness and capacity test. This test shall be conducted, recorded, and reported in accordance with HI 1.6 to the extent that these standards are applicable and are not in conflict with the contract or order requirements. The test record for each pump unit shall include the following as a minimum:

a. Certification of the major IMP components by the manufacturer's drawing number and serial number that was tested.

b. Identification of the diameter of the impellers tested in the IMP.

c. A dimensional sketch of the test loop showing location of the IMP, location of all instruments, distance (vertical along the pipe axis) from the suction and discharge gauge taps to the IMP suction and discharge flanges, vertical distance from the gauge(s) to the elevation datum to which they are calibrated, azimuthal location of the gauge taps on the pipe circumference, and location and orientation of any elbows in the IMP suction piping.

d. The test loop water temperature during the test.

e. A list of the test instruments including date of last calibration, advertised accuracy, size (for example, 0.25 lb/in^2) of the smallest graduation on the readout scale, range of the readout scale (for example, from 0 to 100 lb/in^2), and the IMP (for example, lb/in^2) of measurement including the water temperature the gauges are calibrated for if a gauge is calibrated in feet of water rather than in lb/in^2.

f. The data sheets of all recorded data, with the IMP of measurement identified for all data.

g. A sample calculation of each type of calculation converting the raw data into specified conditions and showing the conversion in sufficient detail to permit an independent reviewer to verify the calculations, including the temperature and density corrections.

h. A copy of the specific table of water properties used in the calculations and a reference to the source of that table.

i. A plot of the measured head-capacity curve, corrected to the specified operation, following the method described in the sample calculations.

4.5.1.8.1 Mechanical soundness test. The IMP shall operate continuously at the rated speed and capacity with the pumped fluid at ambient temperature for 8 hours. The IMP operation shall be monitored for proper functioning of safety devices and for smooth running.

4.5.1.8.1.1 Acceptance criteria for mechanical soundness test. The IMP shall be free of abnormal vibrations and noises. Controls and attached instruments shall function as specified and shall be in calibration. There shall be no leakage of water.

4.5.1.8.2 Capacity test. The IMP shall operate at the maximum rated speed with the pumped fluid at normal temperature from recirculation flow to 130 percent of rated capacity specified or a flow that does not overload the VSD controller and with the minimum suction pressure. The unit shall be operated at shutoff rated condition, 130 percent of rated capacity, and at five other capacities approximately evenly spaced between these points. The IMP shall be operated at each test point until the test values being measured stabilize.

4.5.1.8.2.1 Acceptance criteria for capacity test. The IMP shall deliver the rated capacity, head and efficiency. The head-capacity characteristic curve at maximum rated speed shall satisfy the specified requirements. The total head at all capacities from 0 to 120 percent of rated capacity on the curve shall not deviate by more than +5 percent or -5 percent of rated head at the corresponding capacity on the head-capacity characteristic curve at maximum rated speed established during initial design testing of the IMP. If more than one performance test has been performed for a given IMP design for use in a given ship class, then the average of all performance head-capacity characteristic curves established is the one to which the preceding sentence refers. In no case shall the IMP deliver less than the rated head at rated flow. The required net positive suction head shall not exceed the minimum net positive suction head available as specified (see 6.2).

4.5.1.9 Endurance test.

4.5.1.9.1 Duration. The IMP and its appurtenances and controls shall be operated for a period of not less than 1000 hours of actual running time with a minimum of 100 starts and 3 idle periods lasting at least 8 hours to ascertain reliability of performance and operation. For pumps designed for seawater service, the test fluid shall be natural seawater. The start/stop cycle requires that the IMP be at rest for a 5-minute minimum before restarting.

4.5.1.9.2 Internal inspection. Prior to the commencement of the endurance test and immediately after completion of the endurance test, the IMP shall be disassembled to the extent necessary and the critical dimensions and running clearance of parts subject to wear, erosion, and derangement shall be measured, calculated, and recorded. Components such as impellers, pinions, bearings, and casings subject to erosion, cavitation, and wear, the effects of which are not subject to routine measurement, shall be listed in the inspection record and after completion of the test, the condition of each component determined and recorded.

4.5.1.9.3 Performance test. During the initial and final hours of the endurance test, noise and the performance tests shall be performed to determine the changes in the IMP's performance characteristics and noise signature. Vibration measurements shall be taken at the housing of the IMP at the same speeds during the initial and final capacity test to determine the changes in mechanical operation.

4.5.1.9.4 Operational requirements. The endurance test shall not be continuous, but shall be interrupted by at least 3 rest periods of a minimum of 8 hours each. The number of starts specified in 4.5.1.9.1 at full line voltage shall be performed during the course of the test. During an early part of the endurance test, the IMP shall be operated continuously for 24 hours at a capacity as near free delivery as possible at maximum rated speed and normal specified temperature, submergence, and suction conditions. During the latter part of the endurance test, the IMP shall be operated as near shutoff as possible for 12 hours continuously. The remainder of the endurance test shall be run at minimum rated speed and within +20 °F, -0 °F of minimum specified liquid temperature. The IMP shall be operated at one-third, two-thirds, and rated capacity in approximately equal time intervals. Operations shall be at minimum specified net positive suction head available, or minimum specified suction lift or vacuum, as applicable.

4.5.1.9.5 Data collection. Data shall be collected as specified (6.2 and 6.4).

4.5.1.9.6 Endurance test acceptance criteria.

4.5.1.9.6.1 Performance test. The head-capacity curve at maximum rated speed after 1000 hours of IMP operation shall conform to the specification requirements and shall show no abnormal deviations from the curve before the 1000-hour test.

4.5.1.9.6.2 Vibration. The IMP operation at the end of the endurance test shall be smooth and shall exhibit noise and vibration levels that are normal and in conformance with the specification.

4.5.1.9.6.3 Internal clearances. Running clearances shall meet original design requirements.

4.5.1.9.6.4 Internal wear. Components subject to attack from corrosion, erosion, and cavitation shall be in a condition commensurate with 1000 hours of service. Wear rates for wearing parts critical for proper operation shall show a rate of wear for the test period that shall be consistent with the specified design life requirements.

4.5.1.9.6.5 Failures. No relevant failures shall have occurred throughout the 1000-hour test.

4.5.1.9.7 Post endurance test restoration. The IMP and its appurtenances and controls subjected to the 1000-hour endurance test shall be restored to the as-new condition by replacement of all parts worn beyond the as-new design tolerances. Test documentation shall indicate that the unit was subjected to the endurance test and subsequently restored and successfully passed 4.5.1.11, 4.5.1.8, and 4.5.5 tests and that it is certified as fully conforming to the specification for unrestricted service.

4.5.1.10 Reverse rotation. Operate the IMP for a minimum of 1 minute in reverse rotation at the maximum speed possible. The IMP shall not be damaged by reverse rotation.

4.5.1.11 Hydrostatic test. Each IMP shall be subjected to a hydrostatic test pressure equal to 150 percent of the IMP design working pressure. The test shall be conducted with water at ambient temperature. The test pressure shall be held for 30 minutes before the casing is inspected for leakage and the test pressure maintained until the inspection is complete.

4.5.1.11.1 Hydrostatic test acceptance criteria. The casing or suction cover shall exhibit no leakage through the pressure boundary material or joints.

4.5.1.12 Motor test. The motor shall be tested in accordance with IEEE 115.

4.5.2 Electromagnetic interference (EMI). Unless otherwise specified (see 6.2), the IMP and its appurtenances and controls shall be tested in as a complete unit in accordance with the RE102 test procedure specified in MIL-STD-461.

4.5.3 Shock test.

4.5.3.1 Test unit. One IMP of each size and its appurtenances and controls shall be subjected to a Grade A, Class I, Type A shock test in accordance with MIL-S-901. The IMP shall be qualified with the mounting location, mounting plane, and orientation consistent with that specified in 4.5.3.4. The IMP and its appurtenances and controls shall meet the acceptance criteria specified in 3.7.4 after the test.

4.5.3.2 Internal inspection. Before and after the shock test, the IMP and its appurtenances and controls susceptible to internal distortion shall be disassembled and the dimensions and running clearances measured, calculated, and recorded. During this disassembly, the components and assemblies subject to shock damage and distortion shall be identified and listed in the inspection record after completion of the test. The condition of each component and assembly shall be determined and recorded. Pinions, impellers, and motor rotors shall be inspected by one of the applicable nondestructive test procedures, other than radiography, specified in T9074-AS-GIB-010/271.

4.5.3.3 Performance test. Before and after the shock test, tests in accordance with 4.5.1.8 and 4.5.4 shall be performed. Vibration measurements shall be taken at the housing at the same speeds during initial and final capacity tests to determine the changes in mechanical operation.

4.5.3.4 Mounting and operation. The IMP and its appurtenances and controls shall be mounted on the shock machine or barge essentially identical to the actual shipboard installation. The purchasing activity will furnish the contractor a drawing of shipboard mounting arrangement and foundations stiffness. Horizontal IMPs, when tested in the inclined position on the medium weight shock machine, shall be orientated so that the direction of shock is perpendicular to the axis of the IMP orientation. The IMP shall be operated at highest speed. The IMP shall be operated at as close to the rated condition as possible within the capability of the test facility.

4.5.3.5 Test inspection. The IMP shall be carefully observed during each shock blow and thoroughly visually examined after each blow. After each blow, the unit shall be operated as close to maximum rated speed as possible and checked for abnormal noises and vibration and proper functioning of controls. Tightening of bolts, except for IMP hold-down bolts, during shock tests will not be permitted.

4.5.3.6 Test failure. The IMP and its appurtenances and controls shall fail the shock test in the event of any of the following:

a. Breakage of parts, including mounting bolts.

b. Appreciable distortion or dislocation of a part, such as a pinion, mounting feet, and bearings.

c. The amplitude of vibration after test at maximum rated speed exceeds twice the amplitude measured at the same speed before the test.

d. Distortion or derangement of any part, which would render the unit incapable of performing as specified.

e. Adequate lubrication to all bearings is not maintained.

f. Critical dimensions and running clearances are not maintained.

g. A significant change in the head-capacity curve.

h. Inability to control IMP speed.

4.5.3.7 Post shock test procedure. After shock testing, tests shall be performed verifying performance characteristics, IMP capacity, and integrity.

4.5.3.7.1 Unit restoration. Pump units which have passed the shock test shall be considered acceptable for such service as NAVSEA may authorize. The equipment shall be restored by the manufacturer to an as-new condition by replacement of all parts damaged or distorted beyond the as-new tolerances. The as-new conditions are as follows:

a. Minor deformations of mounting flanges shall be corrected.

b. Bearings shall be replaced regardless of condition.

c. Each part shall be carefully examined by the manufacturer and any substandard part shall be replaced.

d. The restored unit shall successfully pass the 4.5.1.11, 4.5.1.8, and 4.5.5 tests.

4.5.3.7.2 Deformations. Minor deformations shall be defined as those which do not cause rejection of the design under shock test, but which are in excess of the design dimensional tolerances specified on the applicable IMP drawing.

4.5.3.7.3 Pump conformance. The pump unit that was subjected to the shock test shall be restored, tested, and inspected in accordance with contract requirements (see 6.2).

4.5.4 Vibration test. The IMP and its appurtenances and controls shall be subjected to a Type I and Type II vibration test in accordance with MIL-STD-167-1. The IMP shall meet the requirements of 3.7.5 after the test.

4.5.4.1 Mounting. The IMP and its appurtenances and controls shall be mounted on typical shipboard foundations during the vibration test. The shipboard mounting arrangement shall be simulated in spring mass characteristics except where this mounting arrangement causes the largest test capacity to be exceeded.

4.5.5 Noise test. Airborne and structureborne noise tests, when specified (see 6.2), shall be conducted in accordance with MIL-STD-740-1, MIL-STD-1474, and MIL-STD-740-2, respectively. Noise tests shall be performed as a pump unit and tests shall be conducted on all pump units.

4.5.5.1 Airborne noise test. The IMP and its appurtenances and controls shall undergo an airborne noise test conducted in accordance with MIL-STD-1474 and MIL-STD-740-1 and as specified (see 6.2).

4.5.5.2 Structureborne noise. The IMP and its appurtenances and controls shall meet the structureborne noise level limits as specified (see 6.2). If specific structureborne noise levels are not specified in the contract or order, then Type II of MIL-STD-740-2 shall apply.

4.5.6 Inclined operation. Operation in the inclined position shall be as close to rated speed and capacity as practicable. The performance point shall be indicated in the test report. The following tests shall be performed:

a. Horizontal IMPs:

(1) Shaft inclined 45 degrees for one hour, front end low.

(2) Shaft inclined 45 degrees for one hour, rear end low.

(3) Shaft horizontal, IMP base tilted 45 degrees to the right, for one hour.

(4) Shaft horizontal, IMP base tilted 45 degrees to the left, for one hour.

b. Vertical IMPs:

(1) Incline 45 degrees from normal position, in the direction that imposes the most severe condition, for one hour.

4.5.7 Maintainability analysis. The technical manual furnished as part of the contract shall be analyzed for proper service procedures (see 6.2 and 6.5).

4.5.8 Power consumption. One IMP of each size on the contract or order shall be given a test to determine the overall power consumption of the unit under the specified conditions (see 3.6.16.7).

4.5.9 Heat-run test. The heat-run test for motors shall utilize embedded thermocouples in accordance with the following and Methods 1 and 2 of MIL-E-917 for the first article test. Periodic tests may be in accordance with Method 2 of MIL-E-917. The heat-run test for continuous duty motors shall be in accordance with the following:

a. Rated motor load – 100 percent

b. Voltage – rated

c. Time – until motor temperatures are constant

d. Rated speed

Motor load may be obtained by maintaining the current or watt input corresponding to rated motor horsepower output.

4.5.9.1 Details of temperature tests. Normal load heat-runs on continuous duty motors shall be continued until constant temperatures have been attained in all parts of the motor. For motors having several continuous ratings, the heat-run shall be conducted using the rating giving the highest temperature rises. In cases where the highest temperature rises cannot be determined prior to the test, the motor shall be tested separately for each rating. Temperature measurements by thermocouple shall be used during the progress of the heat-run to determine when the constant operating temperature has been reached. It shall be considered that constant temperatures have been reached when at least three consecutive readings taken at 15-minute intervals show no increase in the temperature in any part of the motor, when adjusted for changes in ambient temperature. The winding temperature rise shall then be determined in accordance with the procedures for Method 2 of MIL-E-917. The bearings' temperature rise shall be determined in accordance with the procedures of Methods 1 or 3.

4.5.9.2 Duration of temperature test. The duration of the temperature test of a motor with a short-time or overload requirement shall be the time specified for that rating. Intermittent and varying duty motors shall be tested at the specified duty cycle. In lieu thereof, the motors may be tested as short-time duty motors of sufficient rating to meet the actual load requirements.

4.5.9.3 Heat-run measurements. The following measurements shall be made for each heat-run test:

a. Motor input voltage and current, watts and revolutions per minute.

b. Motor output power (may be calculated using current, torque, or watt inputs).

c. Temperatures measured concurrently as follows:

(1) Motor parts as required in the stress factor limits and rating factors table of MIL-E-917

(2) Room ambient

4.5.9.4 Measurement of temperature rise. The temperature rise of each motor component part shall be determined immediately at the conclusion of the heat-run. Temperature rise (see the stress factor limits and rating factors table) shall be determined in accordance with the Thermometer Method, Resistance Method, and Embedded Detector Method of MIL-E-917. In determining temperature rise, no correction shall be made for barometric pressure, humidity, or for any differences in heat transfer characteristics between the test ambient temperature and the maximum design ambient temperature.

4.5.10 Dielectric tests. The dielectric test shall be conducted after all other tests have been completed. The frequency of the testing voltage shall be not less than 60 hertz and shall approximate a sine wave. If the insulation resistance of the windings is known to be lower than specified, due to dirt or moisture or damage to windings, this shall be remedied before the application of the dielectric test voltage. The dielectric test shall be conducted on the completely assembled machine and not upon individual parts. An exception is made in case of repair parts which require dielectric test; for example, repair coils and repair rotating elements with insulated windings. In the case of motors using capacitors, the dielectric test on the motor may be conducted with the capacitor disconnected. The capacitor shall be given a separate dielectric test according to the rating of the capacitor used.

4.5.10.1 Measurement of test voltage. The measurement of the voltage used in dielectric tests shall be made by the voltmeter method whereby the instrument derives its voltage from the high-volt circuit either directly or by means of a voltmeter coil placed in the testing transformer, or through an auxiliary ratio transformer. In any case, if the capacitance of the machine to be tested is such as to cause wave distortion, the testing voltage shall be checked by a crest-voltage meter. If the crest-voltage meter is calibrated in crest volts, its reading shall be reduced to the corresponding rms sinusoidal value by multiplying by 0.707.

4.5.10.2 Points of application. Test voltage shall be successively applied between each electric circuit and all other electric circuits and metal parts grounded. Test voltage shall be applied in such a manner as to preclude the possibility of pitting the bearings in case of insulation failure. Voltage need not be applied between stationary and rotating windings.

4.5.11 Partial discharge inception voltage (for inverter duty insulation systems). Partial discharge inception voltage shall be measured in accordance with IEC 61934 and IEC 60034-18-41. The environment the motor insulation shall withstand is classified as Type 1, Stress Category D as defined in IEC 60034-18-41. Guidance on the test procedure is provided in IEC 61934. The waveform for the test must have a 100 nanosecond rise time. The equipment used to measure the inception voltage must have a bandwidth between 50 KHz and 20 MHz.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. IMPs covered by this specification are intended for seawater, brine, distilled water, fresh water, potable water, chilled water, fuel oil, lube oil, and condensate services on board naval ships.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. The specific issue of individual documents referenced (see 2.2.1 and 2.3).
c. When a first article is required (see 3.1, 4.2, and 6.3).
d. Class of service specified (see 3.2).
e. Mercury exclusion required (see 3.2.3).
f. Pump orientation, maximum dimensions, and weight requirements (see 3.3.1).
g. If threaded fasteners are other than specified (see 3.3.4.1 and 3.3.4.2).
h. Terminal box cable penetration size and number (see 3.3.5).
i. Motor insulation class (see 3.3.7).
j. Inverter duty requirements (see 3.3.8).
k. Pipe nozzle loading (see 3.3.10.4).
l. Piping and flanged connections requirements (see 3.3.13).
m. Gauge connections requirements (see 3.3.14).
n. Performance characteristics.
    (1) Rated capacity - gal/min (see 3.6.6)
    (2) Rated dynamic head - lb/in^2 or feet (see 3.6.6)

(3) Liquid to be pumped (see 3.6.7)

(4) Specific gravity of liquid to be pumped (see 3.6.7)

(5) Temperature of liquid to be pumped (see 3.6.7)

(6) Suction head (see 3.6.4)

(7) Voltage (see 3.6.10)

(8) Power consumption (see 3.6.16.7)

o. Design pressure and temperature (see 3.6.11).

p. Special EMI test requirements (see 4.5.2).

q. Mounting of unit (see 3.7.4.1).

r. Shock test requirements (see 3.7.4.1 and 4.5.3).

s. Noise level limits and whether noise is required (see 3.7.6).

t. Number of sets of special tools required (see 3.8.2).

u. Requirement for data collection (see 4.5.1.9.5 and 6.4).

v. Shock test documentation (see 4.5.3.7.3).

w. Packaging requirements (see 5.1).

x. Requirements for technical manuals and technical repair standards (TRSs) (see 6.5).

y. When test reports and test data are required (see 6.6).

z. Requirements for provisioning (see 6.9).

6.3 First article. Consideration is to be made to accept the results of previous first article testing from vendors who have supplied this product under an earlier contract.

6.4 Data collection. The pump unit should be monitored during the endurance test to accurately record the conditions of operation, speed at which operated, and the general performance observed. Data should be collected and the pump unit examined at least twice per day during operation. For each periodic examination, in addition to all measured data, the record should indicate the following:

a. The smoothness of operation (normal-abnormal)

b. Other abnormal findings

c. Adjustments made

d. Changes made in the conditions or method of operation

6.5 Technical manuals. When specified (see 6.2), a technical manual and/or technical repair standard (TRS) will be provided in accordance with technical manual contract requirements (TMCRs).

6.6 Test reports. Test reports for the performance evaluation tests (see 4.5.1.1) should be compiled into a single document as specified (see 6.2). The document should identify the IMP by manufacturer's serial numbers of the IMP, the contract or order number under which the tests were performed, the ship or class of ships for which the IMP is intended, if known, and the letter and date of the test procedure acceptance.. Sufficient data should be taken during the tests to prepare IMP characteristic curves as specified in 4.5.1.4. Test data should be corrected to the specified operating conditions as to voltage, frequency, temperatures, specific gravity, suction head or lift, and vacuum, as specified (see 6.2). Such conditions should clearly be shown on the data sheets. The data sheets should state the actual finished diameter of the IMP impellers installed on test. Test data and curves should be complete over the entire range of capacities from shutoff to as near free delivery as possible.

6.7 Test procedures. The contractor will prepare test procedures in accordance with the data ordering documents included in the contract or order (see 6.2).

6.8 Test performance. The contracting activity and Government representatives have the right to examine the facilities at the contractor's plants and at the contractor's subcontractor's plants, and to witness all tests specified herein.

6.9 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified (see 6.2).

6.10 Subject term (key word) listing.

Centrifugal

Permanent magnet motor

Sealless

Custodians:
Army – AT
Navy – SH
Air Force – 99

Review Activities:
Army – AV, MI
Navy – AS
Air Force – 03, 84
DLA – CC

Civil Agency:
GSA - FAS

Preparing Activity:
Navy – SH
(Project 4320-2012-004)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.daps.dla mil.