METRIC
DOD-P-24562A(SH)
1 November 1982
SUPERSEDING
DOD-P-24562(SH)
28 December 1977
(See 6.6)

MILITARY SPECIFICATION

PROPELLERS, SHIP, CONTROLLABLE PITCH (METRIC)

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers general requirements for marine propellers of the controllable pitch type. Specific requirements will be in accordance with the contract or order. For this specification, a propeller shall be considered as consisting of propeller blades, a hub with an internal activating mechanism for the blades, propulsion shafting, shafting internal components, an oil distribution box or pitch control unit, hydraulic and mechanical systems required for operation of the propeller pitch mechanism, and associated components, tools, and devices.

1.2 Classification. Controllable pitch propellers shall be of the following styles, blade designs, types, and levels, as specified (see 6.2.1):

- Style H - Hydraulic or hydro-mechanical propeller blade actuating mechanism.
- Style M - Mechanical propeller blade actuating mechanism.
- Blade design A - Propeller hydrodynamic blade design provided by the contracting activity (see 3.4.2).
- Blade design B - Propeller hydrodynamic blade design provided by the contractor (see 3.4.3).
- Blade design C - Propeller blade design in accordance with American Bureau of Shipping (ABS) Rules with no ice strengthening requirements (see 3.4.3).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

Blade design D	- Propeller blade design in accordance with ABS Rules, with ice strengthening (see 3.4.3).
Tolerance level 1	- Very high tolerances on hydrodynamic surface measurements (see 3.17.2).
Tolerance level 2	- High tolerances on hydrodynamic surface measurements (see 3.17.3).
Tolerance level 3	- Moderate tolerances on hydrodynamic surface measurements (see 3.17.4).
Tolerance level 4	- Tolerances on hydrodynamic surface measurements to suit the intended service (see 3.17.5).
Type 1	- Hydraulic system main pump, shaft- or gear-driven (see 3.7.4).
Type 2	- Hydraulic system main and standby pumps, electric motor-driven (see 3.7.5).
Type 3	- Hydraulic system main pump, electric motor-driven; standby pump, shaft- or gear-driven (see 3.7.6).
Test level A	- Spin testing of assembled propellers (see 4.4.1, 4.4.2, 4.4.5, 4.5, and 4.6).
Test level B	- Nonrotating testing of assembled propellers (see 4.4.1, 4.4.3, 4.4.5, 4.5, and 4.6).
Test level C	- Testing of assembled propeller following installation in ship (see 4.4.1, 4.4.4, 4.4.5, 4.5, and 4.6).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbook of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL

FF-B-171	- Bearings, Ball, Annular (General Purpose).
FF-B-185	- Bearings, Roller, Cylindrical; and Bearings, Roller, Self-Aligning.
FF-B-187	- Bearing, Roller, Tapered.
FF-S-86	- Screw, Cap, Socket-Head.
FF-S-92	- Screw, Machine: Slotted, Cross-Recessed or Hexagon Head.
FF-S-200	- Setscrews; Hexagon Socket and Spline Socket, Headless.
FF-S-210	- Setscrews: Square Head (Inch) and Slotted Headless (Inch and Metric).
GG-I-492	- Indicator, Sight, Liquid.
QQ-T-390	- Tin Alloy Ingots and Castings and Lead Alloy Ingots and Castings (Antifriction Metal) for Bearing Applications.
TT-S-1732	- Sealing Compound; Pipe Joint and Thread, Lead Free General Purpose.
PPP-B-601	- Boxes, Wood, Cleated-Plywood.
PPP-B-621	- Boxes, Wood, Nailed and Lock-Corner.

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MIL-C-104	- Crates, Wood; Lumber and Plywood Sheathed, Nailed and Bolted.
MIL-S-901	- Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-E-917	- Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-S-1222	- Studs, Bolts, Hex Cap Screws, and Nuts.
MIL-C-2212	- Controllers, Electric Motor A.C. or D.C., and Associated Switching Devices.
MIL-P-2845	- Packaging of Main Propulsion Shafting, Bearings, Boat and Ship Propellers, and Associated Repair Parts.
MIL-C-3774	- Crates, Wood; Open 12,000- and 16,000-Pound Capacity.
MIL-B-3990	- Bearings, Roller, Needle, Airframe, Antifriction, Inch.
MIL-P-5510	- Packing, Preformed, Straight Thread Tube Fitting Boss, Type I Hydraulic (-65° to 160°F).
MIL-C-15730	- Coolers, Fluid, Naval Shipboard: Lubricating Oil, Hydraulic Oil, and Fresh Water.
MIL-B-16392	- Brakes, Magnet, Naval Shipboard.
MIL-T-16420	- Tube, Copper-Nickel Alloy, Seamless and Welded (Copper Alloy Numbers 715 and 706).
MIL-P-16789	- Packaging of Pumps, Including Prime Movers and Associated Repair Parts.
MIL-M-17060	- Motors, 60-Hertz, Alternating Current, Integral-Horsepower, Shipboard Use.
MIL-M-17185	- Mounts, Resilient; General Specifications and Tests for (Shipboard Application).
MIL-I-17244	- Indicators, Temperature, Direct-Reading, Bimetallic, (3 and 5 Inch Dial).
MIL-E-17555	- Electronic and Electrical Equipment, Accessories, and Repair Parts; Packaging and Packing of.
MIL-P-17869	- Pumps and Motors, Power, Oil Hydraulic (Naval Shipboard Use).
MIL-F-18240	- Fastener, Externally Threaded, 250°F Self-Locking Element for.
MIL-I-18997	- Indicator, Pressure, Panel Mounted or Case Supported, General Specification.
MIL-I-20037	- Indicators, Sight, Liquid Level, Direct Reading, Reflex Tubular Gage Glass.
MIL-B-21230	- Bronze, Nickel Aluminum and Manganese-Nickel Aluminum: Castings, Ship Propeller Application.
MIL-T-22085	- Tape, Pressure Sensitive Adhesive, Preservation and Sealing.
MIL-G-23652	- Gasket and Packing Material Petroleum and Phosphate Ester Fluid Resistant.
MIL-E-23765/3	- Electrodes, Welding, Bare, Copper and Copper Alloy.
MIL-L-23886	- Liquid Level Indicating Equipment (Electrical) (Naval Shipboard Use).
MIL-H-24135	- Hose, Reinforced, Water and Oil Resistant, and End Fittings, Reuseable, for Flexible Hose Connections.

MIL-H-24136	- Hose, Synthetic Rubber, Polyester Reinforced, and End Fittings, Reuseable, for Flexible Hose Connections.
MIL-V-24272	- Valve Manifolds, High Pressure Gas Reducing.
MIL-F-24402	- Filters (Hydraulic), Filter Elements (High Efficiency), and Filter Differential Pressure Indicators.
MIL-P-24423	- Propulsion and Auxiliary Control Consoles and Associated Control and Instrumentation Equipment, Naval Shipboard Use, Basic Design Requirements.
MIL-V-24578	- Valves, Globe, Pressure Instrument, Stem Test Connection, Union End.
MIL-V-24586	- Valve, Needle, Size 1/4-Inch for Vent, Drain, and Sampling Service.
MIL-N-25027	- Nut, Self-Locking, 250°F, 450°F, and 800°F, 125 KSI FTU, 60 KSI FTU, and 30 KSI FTU.
MIL-P-25732	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275°F (135°C).
MIL-P-83461	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275°F (135°C).

STANDARDS

FEDERAL

FED-STD-H28	- Screw-Thread Standards for Federal Services.
FED-STD-151	- Metal; Test Methods.
FED-STD-601	- Rubber: Sampling and Testing.

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MIL-STD-22	- Welded Joint Design.
MIL-STD-167-1	- Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-248	- Welding and Brazing Procedure and Performance Qualification.
MIL-STD-278	- Fabrication Welding and Inspection; and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels in Ships of the United States Navy.
MIL-STD-419	- Cleaning and Protecting Piping, Tubing, and Fittings for Hydraulic Power Transmission Equipment.
MIL-STD-740	- Airborne and Structureborne Noise 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-794	- Parts and Equipment, Procedures for Packaging and Packing of.
MIL-STD-798	- Nondestructive Testing, Welding, Quality Control, Material Control and Identification and HI-Shock Test Requirements for Piping System Components for Naval Shipboard Use.
MIL-STD-882	- System Safety Program Requirements.
MIL-STD-1186	- Cushioning, Anchoring, Bracing, Blocking, and Waterproofing; With Appropriate Test Methods.

DOD-STD-1399, Section 300 - Interface Standard for Shipboard Systems, Electric Power, Alternating Current (Metric).
MS17828 - Nut, Self-Locking, Hexagon, Regular-Height, (Non-metallic Insert) 250°F, Nickel-Copper Alloy.
MS17829 - Nut, Self-Locking, Hexagon, Regular Height, 250°F, (Non-metallic Insert) Non-Corrosion-Resistant Steel.
MS17830 - Nut, Self-Locking, Hexagon-Regular Height, 250°F, (Non-metallic Insert) 300 Series Corrosion Resistant Steel.
MS18282 - Relief Valve Operating Characteristics Versus Maximum Operating Pressure for Liquid Service.
MS18283 - Relief Valve Operating Characteristics Versus Maximum Operating Pressure for Steam and Gas Service.
MS33540 - Safety Wiring and Cotter Pinning, General Practices For.

HANDBOOK

MILITARY
MIL-HDBK-227 - Selection and Installation of Regulating and Control Valves for Naval Shipboard Use.

2.1.2 Drawings and publications. The following drawings and publications form a part of this specification to the extent specified herein.

DRAWINGS

NAVSHIPS
S4824-1385509 - Locking Devices - Valves.
810-4435837 - Propeller.

NAVSEA
803-5001025 - Electric Plant Installation, Standard Methods.

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)
0283-LP-228-1000 - Bearing Babbitting Procedures.
0900-LP-000-1000 - Ship Hulls Fabrication Welding and Inspection.
0900-LP-003-8000 - Surface Inspection Acceptance Standards for Metals.
0900-LP-089-5010 - Navy Resilient Mount Handbook.
0987-LP-011-2000 - Manual of Instructions for Design and Application of Propeller Blade Gages.

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN BUREAU OF SHIPPING (ABS)
Rules for Building and Classing Steel Vessels.

(Application for copies should be addressed to the American Bureau of Shipping, 65 Broadway, New York, NY 10006.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
B31.1 - Power Piping.

(Application for copies should be addresed to the American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
B 150 - Aluminum Bronze Rod, Bar, and Shapes. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)
J517 - Hydraulic Hose. (DoD adopted)

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Performance requirements.

3.1.1 Temperature limits. Propeller shall operate in any sea water temperature between minus 2 and 30 degrees Celsius (°C) (28 and 85 degrees Fahrenheit (°F)) and any ambient air temperature between 0 and 50°C (32 and 125°F).

3.1.2 Operating capabilities. Propeller shall operate satisfactorily at the power, revolutions per minute (r/min), ship speed and propeller pitch (see 6.3.3) specified (see 6.2.1) and maintain satisfactory lubrication with no loss of oil under the trim, list, pitch, and roll conditions specified (see 6.2.1) and angle imposed by the propulsion shaft rake.

3.1.3 Electrical systems. Loss of electric power shall not result in the loss of adequate lubrication for the propeller or ability to maintain the propeller pitch. Electrical systems and constraints shall be in accordance with DOD-STD-1399, Section 300.

3.1.4 Noise. Propeller shall meet the structureborne and airborne noise requirements specified (see table II and 6.2.1).

3.1.5 Shock. When shock hardening is required (see 6.2.1), the propeller shall meet the shock requirements in accordance with MIL-S-901, grade A, and the following:

(a) Items in contact with water, except propulsion shafting, shall be tested on a floating shock test platform.
(b) Orifices, flexible hose, standard flanges, simple bolt-on covers or blanks, tanks integral with the ship's structure, and piping system components which comply with MIL-STD-777 and whose sole function is to provide a means for transport of fluid, do not require shock testing.
(c) Shock test criteria for valves shall be in accordance with MIL-STD-798.
(d) Resilient mounts which meet the requirements of MIL-M-17185 may be assumed to meet the shock requirements. Shock test damage to mounts fabricated in accordance with MIL-M-17185 will not vitiate the shock tests.

3.1.6 Bollard pull and towing. Propeller shall develop bollard pull and towing characteristics, when specified (see 6.2.1).

3.1.7 Steady-state operation. Propeller shall be capable of nontransient steadystate operation at any pitch setting from design to full-astern (see 6.3.5 and 6.3.6) at any r/min from zero to 110 percent of rated r/min (see 6.3.2) within the limits of the main engines.

3.1.8 Pitch reversal. Propeller shall have pitch reversal at rated r/min from full-astern pitch to design pitch, and vice versa within the following time limits:

Full-power (see 6.3.1)	Time for pitch reversal
11 megawatts (MW) (15,000 horsepower (hp) and below)	15 seconds
Over 11 MW	30 seconds

For style H propellers, this capability shall be achieved using a single motor-driven hydraulic pump.

3.1.9 Pitch holding. Propeller shall hold any pitch setting from full-astern to full-ahead (see 6.3.4) under all operating conditions within the limits imposed by the main engines.

3.1.10 Reverse rotation. Rotation of the propulsion shaft opposite the normal direction of rotation by the use of a jacking gear, windmilling, or under abnormal circumstances shall not result in damage to the propeller.

3.1.11 Pitch locking device. Means shall be provided to place and lock the propeller blades in the full-ahead pitch position and operate the propeller in the event of loss of pitch control through hydraulic failure.

3.2 Materials and components.

3.2.1 General requirements. Equipment and materials shall conform to the requirements of applicable Government specifications, unless otherwise specified herein.

3.2.2 Noxious fumes. Instruments, equipment, fittings, paint, insulation, adhesives, or other items containing materials or components that would give off noxious fumes at any temperature below 93°C (200°F) shall not be installed or applied. This requirement applies to paint and adhesives after drying or curing is complete.

3.2.3 Brittle material. Brittle material is material showing less than 10 percent elongation for the standard tensile test. Brittle material may be used only for components not subjected to stress and components whose material suitability is proven to the satisfaction of the contracting activity by mechanical shock tests.

3.2.4 Materials. Materials shall be as specified in table I. Materials which have not been specified shall be chosen to minimize galling, fretting, and rapid wear; corrosive effects of sea water; and electrolytic action; and shall have adequate fatigue characteristics. The use of nonmetallic coatings or fillers shall not be considered as providing protection against corrosion or electrolytic attack in a sea water environment.

TABLE I. Materials.

Item	Material	Specification	Remarks
Propeller blades	Ni-Al-Bz	MIL-B-21230, alloy 1	Note 1
Propeller blade attachments	Various		Note 2
Propeller hub components in contact with sea water (except bolts and plugs)	Ni-Al-Bz	MIL-B-21230, alloy 1 or ASTM B 150, alloy C63200	
Hoses (prairie air and oil) in hub and shaft bore	Rubber	MIL-H-24135	Note 3
Flexible connections for water or oil	Rubber	MIL-H-24135 or MIL-H-24136	Note 3
Flexible connections for prairie air in hub, shafting, and oil distribution box	Nylon	SAE J517, 100R7	Note 3

TABLE I. Materials. - Continued

Item	Material	Specification	Remarks
Babbitt	Babbitt	QQ-T-390	
Piping, piping fittings, takedown joints, and flange bolting	Various	MIL-STD-777	Note 4
O-rings (in contact with hydraulic fluids)	Various	MIL-P-5510, MIL-P-25732, MIL-P-83461, or MIL-G-23652, type I	Note 5
Flat gaskets (in contact with hydraulic fluids)	Rubber	MIL-G-23652, type I	Note 5
Nonmetallic gaskets and seals (other than those listed above)	Various	MIL-STD-777	Note 5
Threaded fasteners, other than flange bolting:			
Hexagon head bolts and nuts	Various	MIL-S-1222	Note 6
Socket head cap screws	Various	FF-S-86	Note 6
Machine screws	Various	FF-S-92	Note 6
Set screws	Various	FF-S-200 or FF-S-210	Notes 6 and 7
Studs and stud nuts	Steel	MIL-S-1222	Note 6
Hydraulic fluid			Note 8
Anti-seizing compound		TT-S-1732	
Pressure sensitive tape		MIL-T-22085	

NOTES:

1. Not applicable to blade design A where conformance with ABS Rules for ice strengthening are specified in the contract or order, and not applicable to blade design D.
2. Propeller blade attachments consist of those components which are attached to, and rotate with, the propeller blades and which serve as the means for translating the linear motion of the pitch control mechanism into the rotary motion of the propeller blade. The load-carrying components of the propeller blade attachments shall be formed by processes which minimize the number of inclusions and voids. Components formed of materials with yield strengths in excess of 550 megapascals (MPa) (80,000 pounds per square inch (lb/in^2)) shall have Charpy impact test strengths of not less than 40 joules (30 foot-pounds) at minus 18°C (0°F).

3. Hoses and flexible connections shall have a minimum burst strength of four times their maximum operating pressure. Hoses and flexible connections shall be capable of absorbing the maximum obtainable excursions of the mounted equipment during operation under shock when specified (see 3.1.5, 3.3.9, and 6.2.1), and under the most severe conditions of vibration expected to occur without overstressing the hoses, hose connections, piping, or components to which attached.
4. Prairie air tubing in the shaft bore and hub shall be copper-nickel in accordance with MIL-T-16420, in lieu of the material specified in MIL-STD-777.
5. Dynamic seals shall be recommended by the seal manufacturer for the intended application (see 3.2.14).
6. Other materials may be utilized where necessary for compatibility or resistance to galling.
7. The use of set screws shall be avoided (see 3.3.7).
8. Hydraulic fluid shall be as specified in the contract or order (see 6.2.1).

3.2.4.1 Recovered materials. Unless otherwise specified herein, all equipment, material, and articles incorporated in the products covered by this specification shall be new and shall be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.2.5 Magnesium, cadmium, and zinc coating. Magnesium and its alloys and cadmium shall not be used. Zinc coating shall not be applied to surfaces which are in moving or wearing contact.

3.2.6 Fillers for countersunk holes. The use of epoxy resins, wood, or other non-metallic materials to fill countersunk holes in the propeller blades, hub, shaft flange protector plate, or coupling covers shall be avoided if possible. When used, these fillers shall not be considered as being a barrier to sea water in the selection of compatible materials for bolts, plugs, or other components located in the holes.

3.2.7 Platings and coatings. Platings and coatings less than 1.6 millimeters (mm) (1/16-inch) thick shall not be employed to protect steel parts from sea water.

3.2.8 Welding. Welding and welding inspection shall be in accordance with MIL-STD-278. Welding procedures shall be qualified as specified in MIL-STD-248. Approval of the procedure qualification shall be obtained prior to production application of the welding procedures as specified in MIL-STD-248. The procedures shall include at least the essential elements, as applicable, specified in the table titled "Essential elements of a welding procedure" of MIL-STD-248. Requalification of welding procedures is required when changes to the essential elements are made as specified in MIL-STD-248. Electrodes for welding nickel-aluminum bronze shall be in accordance with MIL-E-23765/3, type MIL-CuNiAl.

3.2.9 Soldering. Soldering of electrical connections shall be in accordance with MIL-E-917.

3.2.10 Painting. Painting shall be in accordance with MIL-E-917. No painting shall be permitted on any surface in contact with hydraulic fluid. Surfaces of propeller blades and propeller hubs exposed to sea water shall not be painted.

3.2.11 Components. Components shall be in accordance with table II.

TABLE II. Components.

Components	Specification	Remarks
Self-locking fasteners	MIL-N-25027, MIL-F-18240, MS17828, MS17829, or MS17830	---
Temperature indicators (local)	MIL-I-17244	See 3.7.17
Pressure indicators (local)	MIL-I-18997	See 3.7.18
Level indicators	MIL-I-20037, type I, class b or MIL-L-23886, type IC/MF/LA/LP	Notes 1 and 2
Sight flow indicators	GG-I-492	See 3.7.19
Hydraulic pumps	MIL-P-17869	---
Hydraulic filter elements	MIL-F-24402	See 3.7.15
Oil coolers	MIL-C-15730, type A class 3	See 3.7.13
Electric motors	MIL-M-17060, service A	Note 3
Controllers	MIL-C-2212	Notes 4 and 5
Electric brakes	MIL-B-16392	Note 5
Bearings, rolling contact	FF-B-171, FF-B-185, FF-B-187, or MIL-B-3990	---
Valves	MIL-STD-777	See 3.2.12 and Note 6

See notes at top of next page

NOTES:

1. When level indicators are provided in accordance with MIL-L-23886, a dipstick type level indicator shall also be provided. Dipstick indicators shall be sealed to prevent the inflow of water under flooded conditions and permit the pneumatic testing specified (see 3.7.8). Dipsticks and level indicators shall be marked with the design operating level and in suitable increments so that the quantity of oil can be determined. Unless otherwise specified (see 6.2.1), level readings shall be gallons.
2. Level indicators shall be located to minimize the effect of list or trim.
3. Motors located in engine rooms, shaft alleys, and compartments subject to flooding shall meet the following requirements:

   (a) Ambient temperature: 50°C.
   (b) Duty: Continuous in air or submerged.
   (c) Enclosure: Submersible 4.6 meters (15 feet) with double face type lubricated pressure compensated seal without element rubbing on shaft.
   (d) R/min: 1800.
   (e) Type: Squirrel cage induction.
   (f) Design: B, with 100 percent locked rotor torque.
   (g) Slip: 1.5 percent maximum at full load and temperature rise.
   (h) Mounting: Foot mounted, horizontal.
   (i) Insulation: Class B or F sealed insulation system.
   (j) Balance: Standard with facilities for fine balance.
   (k) Structureborne noise levels: Not to exceed 5 decibels above the levels shown for type 2 in MIL-STD-740, unless more stringent levels are specified.
   (l) Winding temperature rise: Not to exceed 70°C with minimum 7 hours at full load in 50°C ambient temperature.
   (m) Direction of rotation: Clockwise opposite shaft end.
4. Controllers shall be magnetic, full voltage type and shall be provided with the following features:
   (a) Undervoltage protection or undervoltage release protection (see 6.2.1).
   (b) Overload protection.
5. Insulation, temperature rating, and type of enclosure shall be designed for the environment.
6. Not applicable to valves integral to the hub, propulsion shafting, interior shafting components, and oil distribution box or pitch control unit.

3.2.12 Valves. Directional and volume control, check, pilot, and servo valves shall be designed for minimum resistance to flow when in the open position. Valves may be pilot operated to maintain operating devices such as solenoids, cams, and levers at a minimum size. No valve shall operate improperly because of back pressure or surges. Valve operation shall prevent detrimental surges. Valves shall be permanently marked to indicate proper connection in the system, and directional arrows shall be used where appropriate. The force to operate control valves manually shall not exceed 65 newtons (15 pounds) applied to the rim of the operating wheel or the end of the operating lever.

Valves shall be mounted using cap screws or bolts extending through or into the valve body. Lug mounted valves shall not be used. Bypass or unloading valves shall operate without exceeding 170 kilopascals (kPa) (25 lb/in^2) pressure drop across the valve. Pressure control valves (including relief, unloading, back pressure, and sequence valves) and check valves shall be selected in accordance with MIL-HDBK-227 for guidance and shall be damped to eliminate hydraulic squeal and chatter at all rates of flow. Each control valve shall assume a fail position, using the most likely type of failure, which will best assure personnel safety or, if personnel safety is not involved, will have the least effect on continued operation of the ship. Relief valves shall be adjustable, accurate within 9 percent of setting, and reseat at not less than 90 percent of setting. Relief valves shall be selected and set to meet rated flows and reseat tightly within the accumulation and reseat envelopes specified on MS18282 or MS18283. Relief valves shall be provided where necessary to protect equipment from damage due to excessive pressure during normal or emergency operation, maloperation, or malfunction. The actual relief valve setting required to meet the envelope requirements shall be marked on the valve label plates. When the total back pressure on a relief valve is in excess of 10 percent of the set pressure, a relief valve of balanced design shall be used. Locking devices similar to those specified on Drawing S4824-1385509 shall be provided on adjustable valves to prevent tampering with their settings, and on valves where inadvertent operation during system operation could be hazardous. The use of padlocks is not permitted. If the valve construction does not provide indication of valve position, a position indicator shall be provided. Remotely operated valves shall be provided with position indicators at the operating station.

3.2.12.1 Valves in 1/4-inch vent, drain, sample, and gage lines shall be in accordance with MIL-V-24586 and MIL-V-24578, as appropriate.

3.2.13 Orifices. Orifices for purposes of regulating and not requiring an indicator shall be installed in a flanged joint. They shall have a part protruding beyond the adjacent pipe flanges and insulation, if provided, so that the presence of the orifice is evident. The size of the orifice hole shall be stamped on the protruding part. For prairie air flowmeters, venturis may be substituted for orifices.

3.2.14 Seals. Seals shall be designed for the surface speed, pressure, temperature, and service requirements of the installation. Inboard nonmetallic dynamic seals shall be designed to permit replacement by ship's forces while afloat without the necessity for uncoupling any main propulsion shafting sections. For propellers with a prairie air system, seals which separate air from hydraulic fluid shall permit no leakage of hydraulic fluid into the air or air into the hydraulic fluid. If the prairie air inlet to the propeller is located other than at the forward end of the shafting, the contractor shall utilize dynamic air seal designs for which successful tests or service experience results are available. The tests and service experience shall have been conducted under similar or more severe operating conditions than will be experienced in the propeller.

3.3 General design requirements. The number of propellers per ship and propeller blades per hub, propeller blade tip diameter, propeller blade tip clearance, and direction of rotation of the propeller blades shall be as specified (see 6.2.1). If any of these requirements are not specified, the contractor shall select the number, diameter, or direction to satisfy the performance requirements of the propeller. The propeller shall have feathering (for example, infinite pitch) or attain pitch settings in excess of those required for full-power, ahead and astern operations, when specified (see 6.2.1). A prairie air system shall be provided when specified (see 6.2.1).

3.3.1 Standardization. Propellers for corresponding shafts of ships in the same buy shall be identical. The number of dissimilar parts in opposite rotating propellers for the same ship shall be kept to a minimum.

3.3.2 Strength.

3.3.2.1 For the propeller blades, the maximum (mean plus alternating) stress at full-power, steady ahead, calm sea conditions, except under blade bolt heads or at attachment screw threads, shall not exceed 50 percent of the yield strength of the propeller blade material. The mean stress shall not exceed 35 percent of the yield strength of the propeller blade material. For alloy 1 of MIL-B-21230, these stresses shall be 121 MPa (17,500 lb/in^2) and 86 MPa (12,500 lb/in^2), respectively.

3.3.2.2 For other propeller components (except propulsion shafting), the maximum (mean plus alternating) stresses under any operating condition shall not exceed the applicable fatigue endurance limits as defined in 3.21.4.1.1 and the following:

(a) Bolt shanks, 2/3 of yield stress.
(b) Compressive stress under bolt heads, 90 percent of compressive yield stress of any affected material.
(c) Other propeller components, 50 percent of yield stress.

3.3.2.3 Forces and moments applied on or by the propeller at interfaces between the propeller and other shipboard systems shall be considered in the design of the propeller and shall be taken into account by the designers of the interfacing systems.

3.3.3 Reliability. Reliability requirements shall be as specified (see 6.2.1).

3.3.4 Maintainability. Design shall permit, without drydocking the ship, maintenance and replacement of components located forward of the stern tube shaft seal, except for propulsion shafting sections and components in the shaft bore. Valve installations shall be designed for ease of replacement with a minimum of ship down time. All components shall be designed to permit easy disassembly and reassembly with a minimum number of special tools and to prevent, insofar as practicable, the incorrect reassembly of parts. Additional maintainability requirements shall be as specified (see 6.2.1).

3.3.5 Accessibility. To the greatest extent practicable, pumps, valves, filters, strainers, coolers, and other components shall be located for convenient operation, inspection, and maintenance without interfering with free passage in walking areas or forming an obstruction in working areas. Where remote operation of valves is required, and the type of operating system is not specified, a mechanical operating system shall be installed. Cable-pull or push-pull operating systems are not acceptable. Flexible shafting type valve operators shall not be used where flow regulation or tight closure is required. Pressure, temperature, sight flow, level, and pitch indicators and other monitoring devices shall be arranged to permit ready vision.

3.3.6 Fairness. The outer surfaces of the aftermost fixed ropeguard, the shaft flange protector plate, if provided, and the propeller hub shall form a fair contour. If the ropeguard extends in way of the flange protector plate, the outer surfaces of the ropeguard and the hub shall form a fair contour. At design pitch, no step shall exist between the outer surfaces of the propeller blades and the hub, and the angular discontinuity between these surfaces shall not exceed 30 degrees.

3.3.7 Threaded fasteners. Screw threads 6 inches (nominal diameter) or smaller shall be in accordance with FED-STD-H28. Screw threads larger than 6 inches (nominal diameter) shall be machined to thread gages. Thread fits shall be Unified 2A/2B, except where quick and easy assembly is necessary; where an amount of play is not objectionable, Unified 1A/1B fits may be used. Interference fit threads shall be American National Coarse, class 5. Male threads on threaded fasteners shall extend one to five thread lengths beyond the nut. Washers shall not be used for the sole purpose of lessening thread protrusion. The shear load strength of engaged threads shall exceed tensile load strength of the stud or bolt. Threaded fasteners subject to loosening by vibration, accessible only by disassembly, or not accessible while the propeller shaft is turning, shall be self-locking or shall be provided with cotter pins or safety wires in accordance with MS33540. Lock washers shall not be used. Propeller blade bolts and threaded fasteners installed in locations where the use of self-locking fasteners, cotter pins, or safety wires is impractical shall be torqued or prestressed under controlled conditions to assure the retention of tightness and to minimize the magnitude of cyclic loads transmitted therethrough. Locking devices shall be used for mounting bolts for electrical equipment, except for the fittings specified in NAVSEA 0900-LP-000-1000. Anti-seizing compound shall be used where appropriate to reduce galling. Anti-seizing compound shall not be used in areas in contact with hydraulic fluid except where required. Antiseizing compound shall not be used as an alternative to proper material selection. Plugs in the hub, propeller cap, and areas which are inaccessible while the propulsion system is rotating, shall be staked or peened at assembly to prevent loosening. Set screws shall be utilized only where alternative means are not feasible.

3.3.8 Bolt and pin connections. Bolt and pin connections between the propeller blades and hub, and between the propeller hub and shaft shall be drilled to jigs.

3.3.9 Resilient mounts. When resilient mounts are specified (see 6.2.1) or used, resilient mounts shall be in accordance with MIL-M-17185. Selection and installation of mounts shall be in accordance with NAVSEA 0900-LP-089-5010. Units installed on such mounts shall have sufficient stability to prevent excessive motion under all ship operating conditions, including shock when specified. Sufficient clearances shall be provided to prevent resiliently mounted units from striking structures, adjacent fixed or resiliently mounted units, or other fixed objects under all ship operating conditions, including shock when specified. Piping rigidly attached to a resiliently mounted unit shall be considered as integral with the unit. If in an installation placed on resilient mounts, there is a possibility of misalinement between two or more components connected by shafting, the components shall be mounted on a common subbase with the mounts installed between the subbase and the supporting structure. The subbase shall not result in misalinement of components when the subbase is rigidly supported at three extreme corner points.

3.3.10 Piping and tubing. Piping and tubing shall be designed in accordance with ASME B31.1.

3.3.11 Vents. Tank vents shall be 1-1/2 inches iron pipe size minimum. Tank vents shall be run with the maximum attainable slope and with no pockets to facilitate draining back to the tanks served. Sump tank vents shall terminate in the hub head tank, unless pressurized hub head tanks are provided. Other tank vents shall terminate in return bends, the weather, or ventilated spaces clear of air ports, ventilation intakes, and sources of heat or sparks. Pipe line vents shall be provided at the high points of oil and water lines for bleeding air from lines. Vents on the oil distribution box shall be designed and located to preclude visible oil leakage.

3.3.12 Drains. Drains shall be provided as required for system operation and at low points for complete drainage of the inboard portions of the propeller for maintenance and disassembly. Hydraulic fluid drains shall discharge to the sump tank, except that hydraulic fluid drains used only for maintenance may be arranged to drain into a bucket.

3.3.13 Flexible connections. Piping connections between fixed, shaft mounted, and resiliently mounted equipment shall be through the use of flexible connections.

3.3.14 Shaft bore tubing and hose joints. Joints in tubing and hoses in the shaft bore shall be provided at or immediately adjacent to each shaft section coupling. Joints at any shaft section coupling shall be separable without disturbing the joints at other couplings.

3.3.15 Fluid velocities. Fluid velocities shall not exceed the following:

(a) Air flow through vent piping: 7.6 meters per second (m/s) (25 feet per second (ft/s)) when tanks are being filled at the maximum rate.

(b) Sea water piping: 4.6 m/s (15 ft/s).
(c) Sea water at oil cooler inlet nozzles: 2.3 m/s (7-1/2 ft/s).
(d) Hydraulic fluid (pressurized): 6.1 m/s (20 ft/s).
(e) Hydraulic fluid in pump suction lines and in lines having no positive head: 1.2 m/s (4 ft/s).

3.3.16 Lifting devices. Provision shall be made for eyebolts or other lifting devices for components where mechanical assistance is necessary due to weight or location. No provisions for eyebolts are required for the hub casting. If provision is made for a lifting eyebolt on the propeller hub casting, an eyebolt, designed as specified on Drawing 810-4435837, shall be provided with each hub.

3.3.17 Instrumented trials requirements. If instrumented trials are specified (see 6.2.1), provision shall be made for the installation of test instrumentation as specified in 4.6.6. The equipment used and method of installation shall be in accordance with instrumented trials drawings (see 3.21.1.9).

3.4 Propeller blade and blade attachment design.

3.4.1 Propeller blade attachment. Propeller blades shall be individually attached to the propeller hub. When specified (see 6.2.1), the design of the blade-to-hub attachment shall be such as to permit blades to be changed underwater without loss of oil, without flooding of any space normally filled with hydraulic fluid, and without significant degradation of any propeller parts.

3.4.2 Blade design A. The design of the propeller blades shall suit the hydrodynamic blade design, predicted powering performance, wake data, and unsteady blade forces provided by the contracting activity. Minor modifications in the hydrodynamic blade design are acceptable if the blade palm diameter selected by the contractor differs from the one assumed in the hydrodynamic design, provided that the changes do not degrade the design.

3.4.3 Blade designs B, C, and D. The design of the propeller blades shall be suitable for the intended service. In addition, blade design C shall meet ABS requirements for propellers without ice strengthening, and blade design D shall meet ABS requirements for ice strengthening for the ABS ice class specified (see 6.2.1).

3.4.4 Blade fillet design. The fillet between the hydrodynamic blade surface and the blade palm shall be designed in accordance with Drawing 810-4435837, except that deviations are permissible where hydrodynamic surfaces abut the edge of the blade palm and to improve distribution of forces among propeller blade bolts.

3.4.5 Numerically controlled machining of blades. If numerically controlled machining is specified (see 6.2.1), propeller blades shall be machined using equipment programmed for automatic contouring of hydrodynamic surfaces. Edges and tips may be formed using conventional means.

3.4.6 Prairie air orifices in blades. For propellers with a prairie air system, holes shall be provided in the pressure and suction faces of the blades for passage of air. Holes shall be 1.2 mm (3/64 inch) diameter, drilled normal to the blade surface, and spaced 25 mm (1 inch) apart. Holes shall be located along a locus of points 19 mm (3/4 inch) from the edge of the blade in the developed view. Holes shall extend from the intersection of the blade surface and the fillet, around the leading edge, to a point 125 mm (5 inches) past the blade centerline. The channel for air supply to the holes may be machined in either the pressure or suction face. The channel shall be approximately 25 mm (1 inch) wide. Depth of the channel shall provide sufficient passage for the air to the holes. Minimum depth of the channel shall be 2.4 mm (3/32 inch) at the blade tip. Changes in depth shall be faired smoothly. The channel shall be provided with lands for welding of a cover plate. Minimum dimensions of the cover plate shall be 38 mm (1-1/2 inches) wide by 2.8 mm (7/64 inch) thick after final machining. Joint design shall be in accordance with MIL-STD-22. Joints between prairie air channel cover plates and propeller blade castings shall be of the single "V" or single "U" type with minimum root openings of 4.8 mm (3/16 inch). Butt welds in prairie air channel cover plates shall be such to assure 100 percent penetration without burnthrough. The completed fabrication shall be free of slag, weld chips, and other material which could interfere with air flow.

3.4.7 Blade edge protectors. Following component examination and testing (see 4.4.1), propeller blade edges shall be protected at all times, except during subsequent testing and application of preservation-packaging, by the use of edge protectors. Edge protectors shall be formed and installed as specified in MIL-P-2845.

3.5 Main propulsion shafting. Main propulsion shafting shall meet the requirements as specified (see 6.2.1). The contractor shall ensure that all components of the propeller are compatible with these requirements.

3.6 Bearing design.

3.6.1 General. Babbitt bearings shall be cast in accordance with NAVSEA 0283-LP-228-1000. The babbitting technique used shall be in accordance with one of the destructive tests specified in NAVSEA 0283-LP-228-1000.

3.6.2 Thrust bearings. For shaft-mounted oil distribution boxes, a thrust bearing shall be provided within the oil distribution box to maintain proper longitudinal positioning of the box or unit. For shaft-mounted prairie air inlet housings, a thrust bearing shall be provided within the housing to maintain proper longitudinal positioning of the housing. Thrust bearings shall be provided with replaceable babbitt inserts. Consideration shall be given to the effect of temperature changes on axial clearances.

3.7 Hydraulic system.

3.7.1 Style H propellers. Hydraulic system shall provide the pressure and volume of hydraulic fluid required for power, control, and lubrication of the propeller, and protection against sea water leakage into the hub.

3.7.2 Style M propellers. Hydraulic system shall provide the pressure and volume of hydraulic fluid required for lubrication of the propellers and protection against sea water leakage into the hub.

3.7.3 General requirements. Hydraulic system for each line of shafting shall be complete and independent except for the make-up and purification systems. Hydraulic system exclusive of the hydraulic pumps shall be capable of continuous operation with the presence of solid contaminants able to pass through the filters specified in 3.7.15 without degradation. Hydraulic fluid temperatures shall not exceed 70°C (160°F) in any point in the system, except as described in 3.7.14. The maximum pressure in the system shall not exceed 20.7 MPa (3,000 lb/in^2). Pump inlet pressures shall be within the limits specified by the pump manufacturers for proper service. Mixing of the hydraulic fluid with fluids not conforming to propeller hydraulic fluid requirements in the hydraulic system, purification system, or make-up system shall not occur. Power transmission for shaft-driven and reduction gear-driven pumps shall be by means of gear and pinion or silent chain. Hydraulic pumps (except for the emergency pump described in 3.7.5) shall be of equal capacity and interchangeable. Adequate drains and vents shall be provided to preclude accumulations of air and water in any portion of the system, exclusive of the sump tank and the hub.

3.7.4 Type 1 hydraulic system. The main hydraulic pump shall be driven by the propulsion shaft or reduction gear. An electric motor-driven standby pump shall be provided. Normally, the standby pump shall run only when insufficient pressure and volume of hydraulic fluid is provided by the main hydraulic pump because of low shaft speed or malfunction. For low shaft speed conditions, insufficient pressure and volume of hydraulic fluid shall be considered to exist when the time for pitch reversal is more than twice that specified in 3.1.8. Starting and stopping of the standby pump shall be automatic. Provision for continuous operation of the standby pump shall be provided.

3.7.5 Type 2 hydraulic system. The main hydraulic pump shall be electric motor-driven. An electric motor-driven standby pump shall be provided. An emergency pump driven by the shaft or reduction gear and of sufficient capacity for lubrication and, for style H propellers, maintenance of the pitch setting shall be provided. Under normal operating conditions, the emergency hydraulic pump shall discharge to the sump tank through an unloading valve upstream of the pump discharge filter. The unloading valve shall close automatically upon indication of low hydraulic fluid pressure or flow or electric power failure. Controls shall provide for the utilization of either the main or the standby pump as the main hydraulic pump at the discretion of the ship's crew. The standby pump shall start automatically whenever the pressure or volume of hydraulic fluid is inadequate for proper operation.

3.7.6 Type 3 hydraulic system. The main hydraulic pump shall be electric motor-driven. A shaft or reduction gear-driven standby pump shall be provided. Under normal operating conditions, the standby hydraulic pump shall discharge to the sump tank through an unloading valve upstream of the pump discharge filter. The unloading valve shall close automatically upon indication of low oil pressure or flow or electric power failure.

3.7.7 Make-up system. Means shall be provided for delivering make-up oil to the hydraulic system through the purifier. Where no storage tanks are provided, a flush deck filling connection shall be provided for filling from drums.

3.7.8 Pneumatic test system. Provision shall be made for periodic pneumatic testing by the ship's crew of the sump tank, pump suction piping, and unpressurized drain lines running to the sump tank to assure the absence of air or bilgewater leakage into the hydraulic system.

3.7.9 Propeller hub lubricating system. Propeller hub lubricating system shall provide a positive head on propeller blade seals to prevent ingress of sea water and to lubricate the bearings, linkages, and other devices which permit the blades to change pitch. When the propeller is secured, the hub shall remain pressurized through the hub head tank. Seals shall be protected against over-pressuring or rapid changes in oil pressure.

3.7.10 Propeller hub lubricating system purge system. Provision shall be made for purging the propeller hub lubricating system of sea water and other contaminants from within the ship while waterborne. A positive head shall be maintained on the propeller hub while purging.

3.7.11 Purification system. Provision shall be made for connecting to a purifier to permit continuous removal of particulate contamination and water from the hydraulic system and storage tanks, and for purifying make-up oil to the hydraulic system. For hydraulic system purification, the purifier shall take suction from the sump tank and discharge to the hub head tank. Make-up oil shall enter the hydraulic system through the hub head tank.

3.7.12 Hydraulic piping and valves. Piping shall be in accordance with table I and shall minimize head loss and avoid interference. Installation of piping in bilge areas shall be kept to a minimum. The hydraulic system shall be designed so that a minimum of valve adjustments are required for shut-down or start-up of the propeller. Gate valves shall not be utilized for regulating flow. Check valves shall be installed where reversal of flow would be detrimental to proper functioning of the system. Stop-check valves or combinations of globe or angle valves and check valves shall be installed wherever there is a possibility that reversal of flow could result in loss of hydraulic fluid or the intake of contaminating liquids into the hydraulic system. Pressure control valves shall be provided as necessary, to protect the system or for proper system operation. Inlet piping to relief valves shall be arranged and sized so that the total pressure drop does not exceed 25 percent of the actual blow-down of the relief valves at maximum capacity. The total back pressure on a relief valve shall not exceed 25 percent of the set pressure. Pump suction lines shall be designed so that pump inlet pressures conform with the specified limits of the manufacturer and cavitation in the pumps does not occur under any operating condition, including partial and full clogging of the strainers. Means shall be provided to assure priming of pump suction lines prior to startup.

3.7.13 Hydraulic fluid coolers. Coolers shall be provided to remove excess heat from the hydraulic fluid, if necessary, to achieve the hydraulic fluid temperature requirements (see 3.7.3). Coolers shall be in accordance with table II, shall use sea water at ambient temperatures for the cooling medium, and shall be located so that hydraulic fluid is cooled before it is recirculated. Provision shall be made for automatically impeding the flow of coolant when the hydraulic fluid temperature drops below an adjustable set point. Means shall be provided to prevent excessive pressure drops in the event the cooler becomes clogged. Valves and piping shall permit isolating coolers and bypassing the hydraulic fluid. Easy access for servicing and repair shall be provided. Provision shall be made for periodic hydrostatic testing of the coolant side of the cooler for leaks by the ship's crew. The cooler shall minimize the possibility of oil contamination from a leaking cooler.

3.7.14 Hydraulic fluid heaters. Hydraulic fluid heaters shall be provided to preheat the hydraulic fluid for start-up in cold weather. Heaters shall be sized to heat the volume of hydraulic fluid in the sump tank from 5°C (40°F) to the minimum temperature required for proper operations within 1 hour and shall be self-regulating to prevent overheating. Heaters shall be designed so oil in the immediate vicinity of a heater does not exceed 82°C (180°F). If a fluid is used as the heating medium, provision shall be made for periodic pneumatic or hydrostatic testing of the heating coils for leaks by the ship's crew.

3.7.15 Filters. Duplex oil filters with cutout valves designed to use filter elements in accordance with table II shall be provided at all pump discharges, except on pumps mounted on the propulsion shafting. Filters shall be external to the propulsion shafting. Filters shall be provided with a full-flow bypass designed to open before the filter element is clogged to assure a flow of oil at all times. Indicators shall be provided on filters to show when the filter is bypassing. Filter elements shall be of the noncleanable type.

3.7.16 Strainers. Duplex strainers shall be provided at hydraulic pump inlets. Rating of the strainers shall be in accordance with the recommendations of the pump manufacturer. Strainers shall be provided with a full-flow bypass that will open before the strainer element is clogged, to maintain a flow of oil at all times. Indicators shall be provided on strainers to show when the strainer is bypassing. Strainers shall be external to the propulsion shafting.

3.7.17 Temperature indicators. Temperature indicators in accordance with table II shall be provided at each pump discharge, in the inlet and outlet water and oil connections to the oil coolers, in the sump tank, and elsewhere in the system as required for monitoring operation and troubleshooting. Unless otherwise specified (see 6.2.1), dials shall read in °F.

3.7.18 Pressure indicators. Pressure indicators in accordance with table II shall be provided at each pump discharge, except on pumps mounted on the propulsion shafting, at relief valves external to the propulsion shafting, at oil cooler water and oil inlets and outlets, and elsewhere in the system as required for monitoring operation and troubleshooting. Provision for a pressure indicator shall be provided at each pump suction. Differential pressure indicators shall be provided across strainers and filters. Dials shall be marked to indicate the safe range. Unless otherwise specified (see 6.2.1), pressure indicator dials shall read in units of lb/in^2 (gage pressure) and inches of mercury (vacuum).

3.7.19 Sight flow indicators. Sight flow indicators in accordance with table II shall be provided in those lines where knowledge of the presence or absence of oil flow would substantially assist in troubleshooting or maintaining the system and no other means of determining flow is provided.

3.7.20 Clutches. Shaft and main reduction gear-driven pumps, except for pumps mounted on the propulsion shafting, shall be provided with mechanical clutches between the pump and driving system. The clutches shall be capable of disengaging while the propeller is in service.

3.7.21 Hub head tank. A hub head tank shall be provided and installed on each propeller, located above the ship's water line so as to maintain a minimum static head on the hub of 14 kPa (2 lb/in^2) above sea water pressure when the ship is at full-load displacement. Volume of the hub head tank shall be at least equal to the volume of oil in the hub. The tank shall be provided with a vent, level indicators, access ports for cleaning and maintenance, low level alarm contacts, connections for the oil purifier, and a means for complete drainage to the sump tank. Level indicators shall be marked to indicate the normal operating level.

3.7.22 Pneumatically pressurized hub head tank. When it is not feasible to locate the hub head tank at an elevation as specified in 3.7.21, provision shall be made to pressurize the tank pneumatically to provide a minimum static head of 14 kPa (2 lb/in^2) above sea water pressure on the hub when the ship is at full-load displacement. During operation, air pressure shall be obtained from the ship's air system. When the ship's air system is secured, provision shall be made for the use of compressed air bottles or flasks. The pneumatic supply system shall be in accordance with MIL-V-24272 and shall include a pressure reducing valve, relief valve, air filter, check valve, and stop valve. A stop valve shall be provided in the hub head tank vent. High and low pressure alarm contacts shall be provided.

3.7.23 Sump tank. A sump tank shall be provided for each propeller. The sump tank shall be situated low enough to insure gravity flow from drains under specified or expected conditions of trim and list. The sump tank shall serve as a source for pumps and the purifier and shall receive oil discharged from drains, relief valves, oil coolers, and the overflow from the hub head tank. The minimum usable capacity in the sump tank shall be a minimum of three times the volume of oil in the propeller pitch control and lubricating systems, excepting oil within the propulsion shafting. When filled to the maximum operating level, enough volume shall remain in the tank to permit drainage of all oil from the hub head tank, oil distribution box, and associated piping and fittings. The tank shall be provided with a vent, access ports for cleaning and maintenance, connections for the oil purifier, level indicators, provision for filling, draining, and checking for the presence of water, and high and low level alarm contacts. Level indicators shall be calibrated in gallons and marked to indicate high and low levels. Insofar as possible, sump tank penetrations shall be above the normal operating oil level and maximum bilge water levels.

3.8 Prairie air system requirements.

3.8.1 General requirements. When specific air flow rates or input or discharge pressures are specified (see 6.2.1), the prairie air system shall satisfy the specified requirements. If flow or pressure criteria are not specified, prairie air shall be provided at a rate of 150 cubic centimeters per second (0.32 cubic foot per minute) at standard conditions for each propeller blade prairie air emission hole, at sufficient pressure to overcome pressure drops in the system and sea water pressure. Passage of air between the air injection point and hub shall be by means of supported tubing or hoses. Use of close-fitting shaft bore liners or direct contact between prairie air and shaft bore is not permitted.

3.8.2 Prairie air fittings. A check valve shall be provided in the propeller hub or at the base of each propeller blade to prevent passage of sea water when the prairie air system is not in operation. A manually operated isolation valve shall be located downstream of the air injection point. A second check valve shall be located upsteam of the isolation valve. A bleed valve shall be provided to test for water leakage past the check valves. A regulating valve shall be provided upstream of the air injection point to regulate air flow to the propeller. Means shall be provided for measurement of air flow to the propeller. An automatic cutoff valve shall be provided to prevent air in excess of 65°C (150°F) from entering the shaft. Check valves located within the hub, propulsion shafting, and oil distribution box or pitch control unit shall have replaceable seats.

3.9 Control system.

3.9.1 General requirements. The control system shall permit the propeller to attain the performance requirements specified (see 3.1), protect the propeller from exceeding speed and stress limitations, and provide tuning and adjustment.

3.9.2 Manual pitch controller. A manual pitch controller shall be provided on the oil injection box or pitch control unit which varies the propeller pitch through its complete range for testing or in an emergency. The controller shall be inoperable when pitch control is being exercised through the control system.

3.9.3 Alarms. Alarms shall be provided as necessary to warn the ship's crew of impending trouble. Sensors and associated components shall be in accordance with MIL-P-24423. Provision shall be made for the following alarms:

(a) Low sump tank level.
(b) High sump tank level.
(c) Low pump discharge filter outlet pressure.
(d) High pump discharge pressure.
(e) Low hub head tank level.
(f) Low hub head tank pressure, for pneumatically pressurized hub head tanks only.
(g) High hub head tank pressure, for pneumatically pressurized hub head tanks only.
(h) High oil temperature.
(i) High prairie air temperature, for propellers with prairie air systems only.
(j) Pitch control failure alarm, when a pitch control failure warning system is provided (see 3.9.4).
(k) Loss of electric power.
(l) Standby hydraulic pump in operation.

Provision shall be made for testing the alarms by the ship's crew. Provision for additional alarms shall be provided when specified (see 6.2.1) or when required for safe operation of the propeller.

3.9.4 Pitch control failure warning system. When specified (see 6.2.1), a pitch control failure warning system shall be provided. Pitch control failure warning system shall operate to sound an alarm whenever any of the following conditions occur during operation of the propeller:

(a) Failure of the pitch control system to follow an order to change pitch.
(b) Movement of the pitch control system counter to the direction ordered.
(c) Movement of the pitch control system in either direction when no order to change pitch has been made.

3.9.4.1 The word "order" in 3.9.4 shall mean the movement of the pitch controller on the propulsion control console or operating station while in service. For single lever or combined pitch and power controls, "order" shall mean movement of the controller so as to require a change of pitch. Sensitivity of the pitch control failure warning system shall be adjustable. Provision shall be made for testing the pitch control failure warning system by the ship's crew.

3.10 Pitch indicator. A mechanical pitch indicator shall be provided at the oil injection box or pitch control unit, and provisions shall be made for remote pitch indicators. Indicators shall show the propeller blade pitch with an accuracy of plus or minus 2 percent of design pitch. Accuracy of indication shall be attainable for sea water temperatures of minus 2°C (28°F) to 30°C (85°F), thrust loads of 0 to 100 percent of rated ahead thrust, and with or without prairie air in service. The mechanical pitch indicator shall be calibrated in feet of pitch. If controls or remote pitch indicators are calibrated in other units (such as percent of design pitch), the mechanical pitch indicator shall also be calibrated in these units. The unit or units of measurement shall be clearly marked on the indicator. The mechanical pitch indicator shall minimize parallax.

3.11 Gages.

3.11.1 Propeller blade gages. When required (see 6.2.1), sets of gages for inspection of propeller blades shall be provided for each propeller design. Each set shall consist of cylindrical, edge, tip, and fillet gages and shall be in accordance with NAVSEA 0987-LP-011-2000, except that the fillet gages shall extend 6 mm (1/4 inch) beyond 0.6 radius in lieu of 0.5 radius and the scribe lines thereupon shall be at 0.4 radius in lieu of 0.3 radius. Fillet gages shall be designed for application at design pitch and shall be usable when blades are mounted on the hub. The "hub contour" portion of fillet gages shall terminate at the edge of the blade palm. The opening on edge and tip gages shall be increased over the amount specified in NAVSEA 0987-LP-011-2000, if required, to fit all in-tolerance conditions. As a minimum, cylindrical and edge gages shall be provided for 0.4R, 0.5R, 0.6R, 0.7R, 0.8R, 0.9R, and 0.95R radius lines for both pressure and suction faces of the blades.

3.11.1.1 When the spindle axis is not coincident with the blade center axis, the spindle axis shall be used as the primary reference line for the purposes of defining axial centerline (in NAVSEA 0987-LP-011-2000) and for locating fillet gages. Location of the projection of the blade center axis on blade surfaces shall be engraved on cylindrical gages in addition to the cylinder center element.

3.11.2 Thread gages. When required (see 6.2.1), sets of "go" and "no go" gages for inspection of screw threads larger than 6 inches (nominal diameter) shall be provided for each propeller design. Each set shall consist of male and female thread gages.

3.11.3 Gage usage. Propeller blade gages and thread gages shall be used for final inspection only. If in-process gages are required, separate gages shall be manufactured for this purpose. In-process gages shall remain the property of the contractor.

3.12 Pitch scale. A circular pitch scale for reading blade pitch directly from the propeller hub shall be provided with each hub furnished. The scale shall be read utilizing the lines scribed on the hub and blades specified in 3.19.2(n). Accuracy of the pitch scale shall be plus or minus 1 percent of design pitch.

3.13 Drill jigs. Drill jigs shall be repairable and of sufficient thickness to prevent distortion. When required (see 6.2.1), sets of drill jigs, including all drill jigs necessary for manufacture of the propeller, shall be provided.

3.14 Balancing tools. Balancing tools consist of the items described in 3.14.1 through 3.14.3. When specified (see 6.2.1), sets of balancing tools shall be provided for each propeller design.

3.14.1 Dummy hub. A dummy hub is a tool for the determination of the static balance of a set of propeller blades in accordance with 4.4.1.1. In addition, the dummy hub shall be suitable for use in the inspection of propeller blades. A single dummy hub shall be utilized for both left and right handed propeller blades of the same design, where applicable, unless precluded by the blade attachment configuration.

3.14.2 Hub assembly balancing arbor. A hub assembly balancing arbor is a tool for the determination of the balance of a propeller hub assembly (less blades) when mounted in commercially available dynamic balancing equipment.

3.14.3 Major hub component balancing arbors. Major hub component balancing arbors are tools for the determination of the balance of those hub assembly components listed in 3.18.1 when mounted in commercially available dynamic balancing equipment.

3.15 Patterns. When specified (see 6.2.1), patterns for propeller blades and castings developed for the production of the propeller shall become the property of the contracting activity.

3.16 Special tools. When required (see 6.2.1), the contractor shall provide sets of special tools and fixtures required for handling, assembly, disassembly, testing, and maintenance of the propeller and, if applicable, for changing propeller blades under water. Special tools are defined as those tools not listed in the Federal Supply Catalog (copies of this catalog may be consulted in the offices of the Defense Contract Administration Service Management Area (DCASMA)).

3.17 Dimensional tolerances.

3.17.1 General requirements. Unless otherwise specified herein, tolerances on machined dimensions which are contractual requirements or which are necessary for fit or fairness shall not exceed those listed in table III.

TABLE III. Dimensional tolerances.

Magntiude of dimension	For dimensions in mm	For decimal inch dimensions	For fractional or whole inch dimensions
(mm)	(Plus or minus)	(Plus or minus)	(Plus or minus)
150 or less	0.8		
Over 150	1.2		
Over 600	1.6		
Over 900	2.0		
(Inches)			
6 or less		0.01	1/32
Over 6		0.02	3/64
Over 24		0.03	1/16
Over 36		0.03	5/64

Tolerances are not cumulative. Where two or more tolerances conflict, the closer tolerance shall govern. Where tolerances depend on an assembly of propeller hub and blades, tolerances for the hub and blades shall be chosen so that, without selectivity, any combination of hub and blades shall be within the specified limits. Tolerances on all parts shall be chosen to assure interchangeability, proper fit, and balance and shall take into account the effects of temperature differentials, where applicable.

3.17.2 Tolerance level 1 for propeller blades and the exterior surfaces of propeller hubs.

3.17.2.1 Radius lines. Each radius line specified in 3.19.2 shall be within plus or minus 1/20 percent of the propeller blade diameter or plus or minus 1.2 mm (3/64 inch) of the design location, whichever is larger. Suction and pressure face radius lines shall coincide within 0.8 mm (1/32 inch) at the leading and trailing edges.

3.17.2.2 Blade spindle axis. Surface height distance at each design radius between the blade spindle axis determined from the cylindrical gage applied in accordance with 4.4.1.8(c) and the blade spindle axis selected as specified in 4.4.1.8(b) shall not vary from the "H" dimension of table I of the propeller blade gage application data drawing by more than plus or minus 1.6 mm (1/16 inch). Variation between adjacent design radii shall be not greater than 1.6 mm (1/16 inch).

3.17.2.3 Fore and aft location of blades. Extensions of the blade spindle axes at the propeller hub centerline shall lie between two planes perpendicular to the propeller hub centerline separated by 1/8 percent of the propeller blade diameter or 6.5 mm (1/4 inch), whichever is larger.

3.17.2.4 Radiality of blades. Maximum deviation from the intersection of each blade spindle axis and propeller hub centerline shall not exceed 1/4 percent of the propeller diameter or 15 mm (1/2 inch), whichever is larger.

3.17.2.5 Blade thickness. Tolerance on blade thickness shall be plus zero, minus 1.6 mm (1/16 inch), or 2 percent of the maximum design thickness of each blade section, whichever is greater, when measured as specified in 4.4.1.8(g).

3.17.2.6 Cylindrical gage clearances. Cylindrical gages applied as specified in 4.4.1.8(c) shall fit the propeller blade surfaces with a maximum clearance of 0.8 mm (1/32 inch). The clearance shall not vary at a rate greater than 0.8 mm (1/32 inch) in 150 mm (6 inches). This fit shall be obtained on the pressure face from 5 to 95 percent of the blade section length (2-1/2 to 97-1/2 percent on blade section lengths over 1800 mm (72 inches)) and on the suction face from 10 to 90 percent of blade section length.

3.17.2.7 Edge and tip gage clearances. Leading and trailing edge gages and tip gages applied as specified in 4.4.1.8(d) and 4.4.1.8(f) shall contact the blade edge and pressure or suction face separately with a maximum clearance under the gage of 0.4 mm (1/64 inch). Edges shall not have flat spots unless specifically required by the design.

3.17.2.8 Fillet gage clearances. Clearance under the fillet gages applied as specified in 4.4.1.8(e) shall not exceed 0.8 mm (1/32 inch) between the edge of the blade palm and a point 15 percent of the propeller blade radius outside of the hub. The 0.4 radius fillet gage match mark shall not fall outside the 0.4 radius line on the blades nor more than 3 mm (1/8 inch) inside of 0.4 radius line.

3.17.2.9 Drill rod clearances. Clearance under the drill rod specified in 4.4.1.8(a) when held at any two points, shall not exceed 0.8 mm (1/32 inch) at any location and shall not vary at a rate greater than 0.8 mm (1/32 inch) in 150 mm (6 inches).

3.17.2.10 Blade section half lengths. Blade section half lengths measured in accordance with 4.4.1.8(h) at each design radius shall be within a tolerance of plus zero, minus 1/2 percent of the longest blade section length of the propeller blade. The difference between deviations at two adjacent design radii shall not exceed 1/4 percent of the longest blade section length.

3.17.2.11 Pitch variation on a blade. With the pressure face cylindrical gages applied as specified in 4.4.1.8(c), the heights of gage point "L" relative to the heights of gage points "J" and "K" shall be within plus or minus 0.8 mm (1/32 inch) of the "E" and "F" dimensions, respectively, in table I of the propeller gage application data drawing. Maximum deviation of pitch from design shall not exceed plus or minus 1 percent of design pitch at the radius being measured. Difference between the deviation of pitch from design at adjacent design radii shall not exceed 1/2 percent. Arithmetic average of the deviations of pitch from design at design radii shall not exceed plus or minus 3/4 percent for any blade.

3.17.2.12 Pitch variation on a blade set. When blades are assembled on hubs, variations in pitch among blades at full-ahead, zero, and full-astern pitch settings, as measured with the pitch scale, shall not exceed 25 mm (1 inch) of pitch or 1/2 percent of design pitch, whichever is greater.

3.17.2.13 Track and rake. Blade spindle axes at 0.95 radius shall track within 1/4 percent of the propeller blade diameter or 6.5 mm (1/4 inch), whichever is larger. Maximum deviation of a blade spindle axis from design at 0.95 radius shall be 1/2 percent of the propeller blade diameter or 15 mm (1/2 inch), whichever is larger, measured parallel to the propeller hub axis.

3.17.2.14 Angular blade spacing. Tolerance on the angular spacing of the blade spindle axes shall be plus or minus 15 minutes of arc.

3.17.2.15 Propeller blade radius. Propeller blade radius shall have a tolerance of plus zero, minus 1/4 percent of the propeller blade diameter or 3 mm (1/8 inch), whichever is larger.

3.17.2.16 The blade bolt head seating surfaces on the propeller blades shall be perpendicular to the threaded holes for blade bolt attachment in the propeller hub assembly within 6 minutes of arc.

3.17.3 Tolerance level 2 for propeller blades and the exterior surfaces of propeller hubs.

3.17.3.1 Blade thickness. When measured in accordance with 4.4.1.8(g), the plus tolerance on blade thickness shall be 0.8 mm (1/32 inch). The minus tolerance shall be 2.4 mm (3/32 inch) or 2.5 percent of the maximum design thickness of the blade radius section, whichever is greater.

3.17.3.2 Cylindrical gage clearances. Maximum clearance under the cylindrical gages applied as specified in 4.4.1.8(c) shall not exceed 1.6 mm (1/16 inch), and shall not vary at a rate greater than 1.6 mm (1/16 inch) in 150 mm (6 inches).

3.17.3.3 Edge and tip gage clearances. Leading and trailing edge gages and tip gages shall contact the pressure or suction face separately with a maximum clearance under the gage of 0.8 mm (1/32 inch) when applied in accordance with 4.4.1.8(d) and 4.4.1.8(f).

3.17.3.4 Fillet gage clearances. Clearance under the fillet gages applied in accordance with 4.4.1.8(e) shall not exceed 1.6 mm (1/16 inch).

3.17.3.5 Drill rod clearances. Using the drill rod specified in 4.4.1.8(a), the clearance when held at any two points shall not exceed 1.6 mm (1/16 inch).

3.17.3.6 Blade section half lengths. The half length of each design radius section measured in accordance with 4.4.1.8(h) shall be within a tolerance of plus zero, minus 3/4 percent of the longest section length of the propeller blade. Difference between the deviations at two adjacent design radii shall not exceed 1/4 percent of the longest blade section length.

3.17.3.7 Pitch variation on a blade. Individual pitch at any radius determined as described in 3.17.2.11 shall be plus or minus 1.5 percent of the design pitch at that radius, except that the difference in percentage pitch deviation from design for two adjacent design radii shall not exceed 3/4 percent. Arithmetic average of the percentage deviations shall not exceed plus or minus 1 percent for any blade.

3.17.3.8 Pitch variation on a blade set. When blades are assembled on hubs, variation in pitch among blades at full-ahead, zero, and full-astern pitch, as measured with the pitch scale, shall not exceed 25 mm (1 inch) of pitch or 1/2 percent of design pitch, whichever is greater.

3.17.3.9 Track and rake. Blade spindle axes at 0.95 radius shall track within 6.5 mm (1/4 inch) or 1/4 percent of the propeller design diameter, whichever is greater. Maximum deviation of a blade spindle axis from design at 0.95 radius shall be 15 mm (1/2 inch) or 1/2 percent of the propeller design diameter, whichever is greater, measured parallel to the propeller hub axis.

3.17.3.10 Angular blade spacing. Tolerance on the angular spacing of the blade spindle axes shall be plus or minus 15 minutes of arc.

3.17.3.11 Propeller blade radius. Propeller blade radius shall have a tolerance of plus zero, minus 1 percent of the design radius.

3.17.3.12 The blade bolt head seating surfaces on the propeller blades shall be perpendicular to the threaded holes for blade bolt attachment in the propeller hub assembly within 6 minutes of arc.

3.17.4 Tolerance level 3 for propeller blades and the exterior surfaces of propeller hubs. Tolerances shall be as specified for tolerance level 2 (see 3.17.3), except as specified in 3.17.4.1 through 3.17.4.5.

3.17.4.1 Blade thickness. When measured in accordance with 4.4.1.8(g), the tolerance on blade thickness shall be plus or minus 3 mm (1/8 inch) or plus or minus 3 percent of the maximum design thickness of the blade radius section, whichever is greater.

3.17.4.2 Blade section half lengths. The half length of each design radius section measured in accordance with 4.4.1.8(h) shall be within a tolerance of plus or minus 1 percent of the longest section length of the propeller blade. Difference between the deviations at two adjacent design radii shall not exceed 1/4 percent of the longest blade section length.

3.17.4.3 Pitch. Individual pitch at any radius determined as described in 3.17.2.11 shall be plus or minus 2 percent of the design pitch at that radius, except that the difference in percentage pitch deviation from design for two adjacent design radii shall not exceed 1 percent. Arithmetic average of the percentage deviations shall not exceed plus or minus 1.5 percent for any blade.

3.17.4.4 Track. Blade spindle axes at 0.95 radius shall track within 15 mm (1/2 inch) or 1/2 percent of the propeller design diameter, whichever is greater.

3.17.4.5 Propeller blade radius. Propeller blade radius shall have a tolerance of plus or minus 1 percent of the design radius.

3.17.5 Tolerance level 4 for propeller blades and the exterior surfaces of propeller hubs. Tolerances shall be appropriate for the intended service.

3.18 Balancing and mass tolerances.

3.18.1 Propeller blades and major hub components. Maximum allowable unbalance of the propeller hub casting, propeller blades, dummy hub, and those parts of the hub which are coaxial with the propeller hub centerline, which have a mass more than 1/2 percent of the total mass of the assembled hub and blades, shall not exceed the values determined by the following formulas and 3.18.3:

(a) SI units:

For rated r/min below 125:

$$U = 0.00389W$$

For rated r/min between 125 and 1000:

$$U = 62.3W/R^2$$

For rated r/min in excess of 1000:

$$U = 0.0623W/R$$

Where U = maximum allowable unbalance in newton-meters (N.M)
W = mass of item in kilograms (kg)
R = rated r/min

(b) Non-metric units:

For rated r/min below 125:

$$U = 0.25W$$

For rated r/min between 125 and 1000:

$$U = 4000W/R^2$$

For rated r/min in excess of 1000:

$$U = \frac{4W}{R}$$

Where U = maximum allowable unbalance in ounce-inches
W = mass of item in pounds
R = rated r/min

3.18.2 Propeller blades and major hub components, alternative method. If the propeller blades are formed using numerically controlled machining, maximum allowable unbalance of the items listed in 3.18.1 may be chosen not to exceed the value determined by the following formulas and 3.18.3, in lieu of the formulas in 3.18.1:

(a) SI units:

For rated r/min below 125:

$U = 0.00778W$ (propeller blades and dummy hub only)

$U = \frac{0.00389W(T-2nB)}{T-nB}$ (all components listed in 3.18.1 except propeller blades and dummy hub)

For rated r/min between 125 and 1000:

$U = 124.5W/R^2$ (propeller blades and dummy hub only)

$U = \frac{62.3W(T-2nB)}{R^2(T-nB)}$ (all components listed in 3.18.1 except propeller blades and dummy hub)

For rated r/min in excess of 1000:

$U = 0.125W/R$ (propeller blades and dummy hub only)

$U = \frac{0.0623W(T-2nB)}{R(T-nB)}$ (all components listed in 3.18.1 except propeller blades and dummy hub)

Where U = maximum allowable unbalance in N.M
W = mass of item in kg
T = total dry mass of propeller blades and hub assembly in kg
n = number of propeller blades per hub
B = mass of one propeller blade in kg
R = rated r/min

(b) Non-metric units:

For rated r/min below 125:

$U = 0.5W$ (propeller blades and dummy hub only)

$U = \frac{0.25W(T-2nB)}{T-nB}$ (all components listed in 3.18.1 except propeller blades and dummy hub)

For rated r/min between 125 and 1000:

$U = \frac{8000W}{R^2}$ (propeller blades and dummy hub only)

$U = \frac{4000W(T-2nB)}{R^2(T-nB)}$ (all components listed in 3.18.1 except propeller blades and dummy hub)

For rated r/min in excess of 1000:

$U = \frac{8W}{R}$ (propeller blades and dummy hub only)

$U = \frac{4W(T-2nB)}{R(T-nB)}$ (all components listed in 3.18.1 except propeller blades and dummy hub)

Where U = maximum allowable unbalance in ounce-inches
W = mass of item in pounds
T = total dry mass of propeller blades and hub assembly in pounds
n = number of propeller blades per hub
B = mass of one propeller blade in pounds
R = rated r/min

3.18.3 Propeller blades and major hub component balance adjustments. The maximum allowable unbalances calculated in accordance with 3.18.1 or 3.18.2 shall be adjusted to take into consideration the permissible eccentricity between the propulsion shafting centerline and the propeller hub centerline and, for propeller blades, the permissible variation in the perpendicular distance from the innermost machined surface of a propeller blade to the hub centerline. The resultant adjusted unbalance shall reflect the worst combination of tolerances.

3.18.4 Other rotating parts. For other parts rotating with the hub or propulsion shafting not included under 3.18.1 or 3.18.2, similar components arranged axisymmetrically shall have the same mass within 0.5 percent or 15 grams (0.5 ounce), whichever is greater. Where counter-balancing of dissimilar parts is employed and for items co-axial with the hub or propulsion shafting centerline, tolerances shall be chosen so that the total possible unbalance of each counter-balanced set or co-axial item does not exceed the value obtained by the applicable formula in 3.18.1 or 3.18.2.

3.19 Marking.

3.19.1 General. If no type of marking is specified, marking shall be performed in a manner which is permanent but which will not weaken, deform, or interfere with the function of the item being marked. All items, except the propeller blades, shall be marked with a piece number. Match marking shall be used wherever necessary or as directed by the contracting activity to assure proper assembly of mechanical and electrical components.

3.19.2 Propeller hub and propeller blades. Propeller hub and propeller blades shall be marked using 6 mm (1/4 inch) to 12 mm (1/2 inch) high characters with the following data. Unless otherwise indicated, data shall be stamped:

(a) Serial number (assigned by the contracting activity).
(b) Applicable drawing number.
(c) Ship class.
(d) Design propeller blade diameter (feet and inches).
(e) Name of manufacturer.
(f) Contract number.
(g) Actual weight (pounds) (blades only).
(h) National stock number (assigned by the contracting activity).
(i) Material name and specification.
(j) Propeller blade numbers.
(k) Location of propeller relative to keel ("port" or "starboard").
(l) The following lines shall be very lightly scribed on each propeller blade for locating inspection gages. These lines may be left on the propeller blades.

(1) Axial projection of the blade spindle axis on the pressure face of blades from hub to tip.
(2) Axial projection of each cylindrical design section (radius line) on both the pressure and suction faces of blades.
(3) Location of each fillet gage on both the pressure and suction faces of blades.

(m) Intersection of the axial projection of the blade spindle axis with each radius line on the pressure face shall be center punched. Center punch marks shall be not more than 0.8 mm (1/32 inch) deep or more than 1.6 mm (1/16 inch) in diameter and shall not be removed.
(n) Each blade and hub shall be accurately scribed on the longitudinal centerline aft of each blade center axis to indicate blade position at design pitch. Scribe marks shall be 0.4 mm (1/64 inch) to 0.8 mm (1/32 inch) deep.
(o) For bolted-on propeller blades, a blade bolt identification number shall be stamped on the exterior blade surface adjacent to each blade bolt hole. Numbering shall be sequential, with "1" denoting the blade bolt on the suction face near the trailing edge of the blade, and the highest number denoting the blade bolt on the pressure face near the trailing edge of the blade.

3.19.2.1 Location of markings. Propeller hubs shall be marked on the outer diameter adjacent to the aft end of the hub casting in the space identified by the lifting eyebolt, if provided. Propeller blades shall be marked on the blade palm, clear of the fillets. Stamping shall be visible when the propeller is fully assembled. The propeller blade number on the hub shall be stamped adjacent to the aft end and in line with each propeller centerline. Blades shall be numbered consecutively counter to the direction of rotation with the number one blade immediately following the stamped data on the hub.

3.19.3 Special tools and devices. Special tools and devices shall be marked with the ship class, applicable drawing number, and National stock number (assigned by the contracting activity).

3.19.4 Propeller hub casting eyebolts. Propeller hub casting eyebolts shall be marked in accordance with Drawing 810-4435837.

3.19.5 Gages. Each gage shall have the following data engraved or etched:

(a) Markings required by NAVSEA 0987-LP-011-2000 (propeller blade gages only).
(b) Identification of the offset stations and points "J", "K", "L", and "M" (propeller blade gages only).
(c) Ship class.
(d) Applicable component drawing number.
(e) Serial number (assigned by the contracting activity).
(f) Location and application of the gage.
(g) National stock number (assigned by the contracting activity).

3.19.6 Patterns. Patterns shall be marked to indicate the manufacturer, contract number, ship class, and applicable drawing number.

3.19.7 Drill jigs. Drill jigs shall be stamped on their peripheries to indicate ship class, applicable drawing numbers, use, and direction of application. For drill jigs specified to become the property of the contracting activity, serial numbers and National stock numbers, assigned by the contracting activity, shall also be stamped.

3.20 Assembly and installation.

3.20.1 General requirements. Preparation for assembly and assembly of the propeller for testing and shipboard installation of components shall be as specified in 3.20.2 through 3.20.5 and the installation instructions (see 3.21.6). Components shall be cleaned and flushed. Protective coatings shall be removed from surfaces which may be in contact with the hydraulic fluid, including the interior surfaces of storage tanks.

3.20.2 Protection and handling. Openings into the hydraulic and, where provided, prairie air systems shall be sealed at all times in accordance with MIL-STD-419. Prairie air holes in propeller blades, when provided, shall be sealed with pressure sensitive tape. Edge protectors shall not be removed from propeller blades, except where necessary for examination and testing of the propeller blades, until the blades have been installed. Edge protectors removed for examination or testing shall be replaced when examination or testing is complete. In handling the propeller components, lifting devices shall be used where provided. Where no lifting devices have been provided and mechanical assistance is required, handling shall be performed as specified in the test agenda (see 3.21.5) and the installation instructions (see 3.21.6). Slings and cables shall not be permitted to rub or score the propeller hub and blades and propulsion shafting sections.

3.20.3 O-rings, gaskets, and seals. New O-rings, gaskets, and seals shall be used; however, the components as received for assembly or installation shall not be disassembled for the sole purpose of replacing an O-ring, gasket, or seal.

3.20.4 Mounting of hydraulic system components. Except for components contained in or supported by the propulsion shafting or hub, components shall utilize bulkheads or other permanent ship structures for support. Supports on structures designed for deflection under shock shall not be located where deflection could disable the system. Supports shall permit concurrent movement of piping caused by thermal motion and external forces, including shock.

3.20.5 Electrical equipment. Installation of electrical equipment shall be in accordance with Drawing S6202-73980. Motors shall be positioned on the bedplate or foundation by dowel pins or fitted motor mounting bolts to facilitate realinement. Motors shall be installed as high above the bilges as practicable.

3.21 Technical data. The contractor shall prepare technical data in accordance with the data ordering documents included in the contract or order (see 6.2.2) and as specified in 3.21.1 through 3.21.9.

3.21.1 Drawings. In addition to the drawing content required by the data ordering document (see 6.2.2), the features specified in 3.21.1.1 through 3.21.1.10 shall be included.

3.21.1.1 General requirements. Assembly and detail drawings shall be prepared for components of the propeller. For commercially acquired components such as valves, pumps, filters, and motors, outline and installation drawings will suffice. Drawings shall include test requirements, mass, marking instructions, tolerances, information on resilient mountings (where utilized), and procedures for torquing and prestressing bolts. Where applicable, requirements for balancing and procedures for achieving acceptable balance limits shall be included. Estimated mass and tolerances shall be shown until component inspection for the initial propeller has been completed for the pieces involved. At that time, the drawings shall be revised to show actual mass and tolerances. Estimated mass shall be clearly identified as estimated. The propeller blade drawing shall include tables of offsets, blade section, and adequate manufacturing and inspection notes so that reference to other drawings or instructions for the manufacture of the propeller is unnecessary. Assembly drawings shall include the location of the center-of-gravity at design ahead pitch. In addition, the hub assembly drawing shall contain the following information:

(a) Total mass of components, dry (including propeller blades).
(b) Volume and mass of oil or other fluids in the hub.
(c) Total mass of components (including propeller blades) and oil less the buoyancy effect of immersion in sea water.
(d) Centers-of-gravity at design, full-ahead, and full-astern pitch settings.

3.21.1.2 Hydraulic system drawings. Hydraulic system drawings shall be prepared including schematic drawings. Piping and fittings shall be sized and estimated flow rates shall be given for the various operating conditions. Performance curves for pumps shall be prepared. The hydraulic system drawing shall include a tabulation of oil volume in each portion of the system, including piping and tanks.

3.21.1.3 Electrical system drawings. Electrical system drawings shall be prepared including schematic drawings. The electrical system schematic drawing shall include a tabulation of power requirements under operating conditions. The electrical drawings shall include the following data:

(a) Motors:
  (1) Number required.
  (2) Rating: watts (W) or hp, voltage, and phases.
  (3) Full-load or synchronous r/min.
  (4) Starting torque as percent of full-load torque.
  (5) Load data: full-load amperes and power factor, starting current across-the-line, starting current at reduced voltage, and starting power factor.
  (6) Duty.
  (7) Type of winding.
(b) Controllers:
  (1) Rating: W or hp, voltage, and phases.
  (2) Operation (magnetic).
  (3) Type.
  (4) Duty.
  (5) Protective features.
  (6) Number required.

(c) Electric brakes:
  (1) Operation.
  (2) Type.
(d) All of (a), (b) and (c):
  (1) Manufacturer.
  (2) Service.
  (3) Ambient temperature in °C.
  (4) Enclosure.
  (5) Drawing number.
  (6) Function in the system.

3.21.1.4 Prairie air system drawings. For propellers with a prairie air system, drawings, including a schematic drawing, shall be prepared.

3.21.1.5 Drawings for special tools and fixtures. Drawings for special tools and fixtures shall be prepared which shall include application drawings or descriptions.

3.21.1.6 Balancing tool drawings. Balancing tool drawings shall be prepared.

3.21.1.7 Gage drawings. Propeller gage data and application data drawings shall be prepared in accordance with NAVSEA 0987-LP-011-2000.

3.21.1.8 Noise and vibration test arrangement drawings. Detailed drawings of the noise and vibration test arrangements shall be prepared.

3.21.1.9 Instrumented trials drawings. If instrumented trials are specified (see 6.2.1), drawings shall be prepared showing the type and location of all instrumentation to be provided and the means of securing the devices to the propeller components.

3.21.1.10 Drawing lists and schedules. Drawing lists and schedules shall be prepared.

3.21.2 Technical manuals. A single technical manual shall be prepared for the propeller. In addition to the requirements specified for technical manuals (see 6.2.1 and 6.2.2), the following features shall be included:

(a) Cleaning, purging, purifying, flushing, and hydraulic fluid sampling instructions.
(b) Instructions for returning the propeller to service following flooding of the compartments housing the propeller components.
(c) Operating instructions for modes of normal and emergency operation of the propeller, including the following:
  (1) Maintaining the level in the hub head tank during periods of shutdown.
  (2) Operating the hydraulic fluid make-up system.
  (3) Operating the pitch locking device.
(d) Operation of the pneumatic test system (see 3.7.8).
(e) Procedures for hydrostatic testing of the hydraulic fluid heaters, if applicable (see 3.7.14), and coolers.
(f) Testing of the pitch control failure warning system, if provided.

(g) Instructions and criteria for adjusting control and relief valves.
(h) Instructions for the replacement of seals, gaskets, and parts subject to wear.
(i) Instructions for the installation of the propeller blade edge protectors.
(j) Handling instructions for the propeller blades, hubs, propulsion shafting, and components provided with lifting eyebolts or other lifting devices.
(k) Instructions for changing propeller blades underwater, if applicable.
(l) Unpacking and repacking. Instructions shall be included for items falling in the categories listed below. The instructions shall be sufficiently detailed to prevent handling damage to the equipment or injury to personnel. Illustrations shall be provided to clarify procedures and materials and may conform to the data required by 5.1.1.

(1) Depreservation required prior to use or installation.
(2) Represervation-packaging required prior to repacking for shipment or storage.
(3) Intricate mountings, blocking, or bracing.
(4) Special cushion inserts.
(5) Repairable items (rotating pool type).
(6) Sensitive or fragile components.
(7) Items held in special cradles.
(8) Items furnished in reusable containers.
(9) Special environmental conditions required for storage.

3.21.3 Technical repair standards. Technical repair standards shall be prepared in accordance with the data ordering documents included in the contract or order (see 6.2.2), for propeller blades, propeller hubs, oil distribution boxes or pitch control units, and all other subassemblies and components for which overhauling is contemplated. Existing technical repair standards may be utilized to fulfill this requirement, if applicable. A list of proposed technical repair standards shall be prepared.

3.21.4 Calculations. The contractor shall prepare calculations in accordance with the data ordering document included in the contract or order (see 6.2.2), and as specified in 3.21.4.1 through 3.21.4.7.

3.21.4.1 Stress calculations. Calculations shall be prepared on all parts subject to stress, including the propeller blade attachments, to demonstrate that permanent deformation or failure cannot occur under any operating condition and that stress levels are within specified limitations. It shall be assumed that, for steady ahead operation in calm seas, the alternating forces on propeller blades, as the blades revolve through the wake field, are a minimum of plus or minus 50 percent of the mean forces less the centrifugal force component. For bolted-on propeller blades, it shall be assumed that 90 percent of the forces on the blade are transmitted through any bolt in tension, unless the distribution of forces among propeller blade bolts can be definitively shown to be otherwise. Calculations shall include fatigue studies of all components subject to alternating forces. The effects of underwater blade changing, if applicable, shall be addressed. Following the post-installation tests (see 4.6) the calculations shall be revised if actual forces or stresses differ from those used in the calculations by more than 10 percent.

3.21.4.1.1 Fatigue studies shall be prepared as follows: The cyclic stress amplitude shall be calculated for each component. An equivalent cyclic stress amplitude shall be established from each calculated cyclic stress amplitude and mean stress acting simultaneousl, on the component. The equivalent cyclic stress amplitude shall be utilized in conjunction with design fatigue curves to estimate the fatigue life of the component. The design fatigue curves shall be derived from failure fatigue curves for the applicable material. The failure fatigue curves shall have been conducted at zero mean stress. To establish the design fatigue curve, a safety factor of 2 on cyclic stress or 20 on cycles, whichever is more conservative at each point, shall be applied to the failure fatigue curve. For components for which actual fatigue data is available, that is, where fatigue tests have been run using the actual components, as opposed to models or specimens, safety factors of 1.5 on cyclic stress and 5.7 on cycles may be substituted for the above. The equivalent cyclic stress amplitude shall be calculated as follows:

(a) For bolts formed of high strength material:

$$S_{eq} = \frac{7S_{alt}}{8 - \left(1 + \frac{S_m}{S_u}\right)^3}$$

Where S_{eq} = equivalent cyclic stress amplitude
S_{alt} = calculated cyclic stress amplitude
S_u = ultimate strength of material
S_m = adjusted mean stress, which shall be determined as follows:

If $S_{alt} + S_{mean} \leq S_y$, then $S_m = S_{mean}$

If $S_{alt} + S_{mean} > S_y$ and $S_{alt} < S_y$, then $S_m = S_y - S_{alt}$

If $S_{alt} \geq S_y$, then $S_m = 0$

Where S_{mean} = calculated mean stress

S_y = cyclic yield strength of material

(b) For all other components:

$$S_{eq} = \frac{S_{alt}}{1 - \frac{S_m}{S_u}}$$

3.21.4.1.2 For blade design A, the contractor shall demonstrate, either by numerical analysis or experiment, that the modifications to hydrodynamic design caused by fillets, blade palm diameter, bolt or thread attachment, and hub configuration do not adversely affect blade design to the extent that performance characteristics or strength requirements are not met. Numerical analysis shall be performed as specified in 3.21.4.1.3.

3.21.4.1.3 For blade design B, the contractor shall prepare predictions of the time-average and unsteady loadings on the propeller blades at full-power ahead and the maximum time-average and unsteady stress. Strength integrity of propeller blades and blade attachments shall be determined by numerical analysis or experiments. If numerical analysis is used, the technique shall be acceptable to the contracting activity. The analysis shall include the loadings due to centrifugal forces, radial load distribution on the blades, and unsteady forces. Although the strength integrity will generally be based on the full-power ahead conditions, the contractor shall make stress analyses, including consideration of the transient loads and periodic loads due to the blades rotating through the wake field, for crash back, crash ahead, and full power full rudder turn maneuvers for assurance that maximum stresses in the blade attachment under any operating condition shall not exceed the limits stated in 3.3.2.2. Calculations shall be prepared for at least two maneuvering conditions which comprise the most critical loads expected.

3.21.4.1.4 For blade designs C and D, propeller blade calculations shall be prepared to show compliance with ABS Rules.

3.21.4.1.5 Calculations are not required for commercially acquired components, such as pumps, provided that they are operated within the limitations recommended by the manufacturer.

3.21.4.2 Blade seal calculations. The maximum pressure on blade seals before blowout or failure and actual seal pressure under all operating conditions shall be calculated.

3.21.4.3 Vibration calculations. Calculations shall be prepared to demonstrate that excessive vibration of the piping and rods in the shaft bore due to critical speeds in the operating range of the propulsion system is not present.

3.21.4.4 Tolerance calculations. Calculations shall be prepared to demonstrate that dimensional tolerances which depend on an assembly of hub and blades are within the specified limits. In addition, calculations shall be prepared to establish the maximum allowable unbalance of propeller blades and major hub components (see 6.2.2).

3.21.4.5 Heat calculations. Sizing of hydraulic fluid coolers and heaters and acceptability of fluid temperatures throughout the hydraulic system shall be verified by calculations. Maximum heat gain in watts or British thermal units per hour in each compartment containing a portion of the propeller shall be determined. Hydraulic fluid temperatures in each portion of the hydraulic system shall be determined. For propellers with a prairie air system, calculations shall be prepared with and without prairie air in service. Following post-installation testing, calculations shall be revised if warranted by the data obtained.

3.21.4.6 Piping calculations. Piping calculations shall be prepared to demonstrate the adequacy of the valves, flow rates in each section of piping, hydraulic pump suction pressure, wall thicknesses of pipes and tubes, and strength and amount of flexibility of hoses. For relief valves, calculations shall identify the normal and maximum pressures of the system being relieved; maximum relief flow required to protect against overpressure, size, length (developed and equivalent); associated pressure drop of inlet and outlet relief valve piping; and size, operating characteristics, flow capacity, and manufacturer of the relief valve.

3.21.4.7 Gear calculations. Calculations shall be prepared to demonstrate the adequacy of gears utilized in the propeller. Where packaged reduction gears are utilized, the gear manufacturer's certification that the reduction gear unit is satisfactory for use in the application will be acceptable in lieu of the calculations.

3.21.5 Test agenda. The contractor shall prepare test agenda in accordance with the data ordering document included in the contract or order (see 6.2.2). The following features shall be included:

(a) Component, assembly, and load test agenda. For component, assembly, and load testing, an agenda shall be prepared which shall include lists and descriptions of tools, fixtures, instrumentation, and other ancillary items necessary for the conduct of the tests, assembly and handling instructions, cleaning procedures, test procedures, drawings, data sheets, and acceptance criteria.

(b) Installation and post-installation test agenda. Agenda shall be prepared for installation and post-installation testing. Agenda shall include lists of special tools, devices, and instrumentation necessary for the conduct of the tests, instructions for installation, and use of the test equipment, necessary drawings, test procedures, data sheets, and acceptance criteria.

3.21.6 Installation instructions. The contractor shall prepare installation instructions in accordance with the data ordering document included in the contract or order (see 6.2.2). Instructions shall include lists and descriptions of special tools, devices, and instrumentation necessary for the installation and testing during installation, handling and test procedures, cleaning procedures, applicable drawings, data sheets, and acceptance criteria. The program for cleanliness shall be in accordance with MIL-STD-419 and shall extend from manufacturing through final shipboard installation and filling.

3.21.7 The contractor shall prepare requests for assignment of serial numbers, as applicable in accordance with the data ordering document included in the contract or order (see 3.19.2, 3.19.3, 3.19.5, 3.19.7, and 6.2.2).

3.21.8 Deviations and waivers. Requests for deviations and waivers shall be in accordance with the data ordering document included in the contract or order (see 6.2.2).

3.21.9 Safety program. The contractor shall prepare, implement, and maintain a system safety program in accordance with the requirements as specified (see 6.2.1). As a minimum, the program shall include a subsystem hazard analysis and an operating hazard analysis as defined in MIL-STD-882 and in accordance with the data ordering documents included in the contract or order (see 6.2.2).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Inspection system program. The contractor shall provide and maintain an inspection system program in accordance with the data ordering document included in the contract or order (see 6.2.2).

4.2 Acceptance criteria.

4.2.1 General requirements. Performance requirements, dimensions, mass, physical and chemical material characteristics, system cleanliness, flows, temperatures, and accuracy of indications of components and the assembled propeller shall comply with the specified tolerances and limits. Mechanical properties shall be verified in accordance with the requirements of the applicable material specification or FED-STD-151 (for metals) and FED-STD-601 (for rubber).

4.2.2 Blade seals. Ratio of the maximum permissible pressure on blade seals to the maximum actual pressure under any operating conditions shall be at least 5.

4.2.3 Liquid penetrant inspection. The result of the liquid penetrant inspection shall not exceed the limits established in NAVSEA 0900-LP-003-8000, except for the following:

(a) Defects in the external surface of the hub shall not have any dimension greater than 6.5 mm (1/4 inch), shall not be closer together than 25 mm (1 inch), and shall not cause leakage into or from the propeller.
(b) Defects on propeller blades within 25 mm (1 inch) of the leading edge and within 25 mm (1 inch) of the break of the knuckle, if provided, on the trailing edge shall not exceed 0.25 mm (0.010) inch maximum dimension.

4.2.4 Radiographic inspection. Radiographic inspection shall be in accordance with MIL-STD-278, except that portions of the hub specified to be radiographically inspected shall meet the criteria set forth for nickel-aluminum-bronze in table titled "RT acceptance criteria for nonferrous castings", level 1 of MIL-STD-278.

4.2.5 Navy certification. For propellers acquired by or for the Navy propeller blade gages, propeller blades, and propulsion shafting shall be certified prior to acceptance. Certification consists of a document prepared by the Navy attesting that the applicable item conforms with requirements of the applicable manufacturing drawing, including, but not limited to, material, surface finish, balance, mass and dimensional tolerances, and nondestructive test results. The Navy shall be given the opportunity to witness and participate in testing and examinations, to repeat such testing and examinations, and to conduct such additional testing and examinations as the Navy may deem necessary.

4.2.6 Noise certification. Certification of noise levels, when specified (see 6.2.1), shall be prepared. Propeller components shall be tested under operating conditions which simulate shipboard installation in accordance with a noise test arrangement drawing.

4.3 Reports. The contractor shall prepare reports in accordance with the data ordering documents included in the contract or order (see 6.2.2) and as specified in 4.3.1 through 4.3.7.

4.3.1 Propeller blade inspection reports. Each propeller blade inspection report shall include the following:

(a) Propeller blade identification data.
(b) Clearances under cylindrical gages applied in accordance with 4.4.1.8(c):
  (1) Pressure and suction face cylindrical gage clearances at each 10 percent offset station at each design cylindrical section.
  (2) At locations other than the 10 percent offset stations, the location and magnitude of pressure and suction face cylindrical gage clearances which exceed the specified tolerance shall be recorded for all design cylindrical sections.
(c) Blade section half lengths (see 4.4.1.8(h)):
  (1) Blade section half length deviations at each design cylindrical section.
  (2) Difference in blade section half length deviations between adjacent cylindrical sections.
(d) Pitch (see 4.4.1.8(i)):
  (1) Height of points "J" and "K" on each pressure and suction face cylindrical gage.
  (2) Calculation of percent pitch deviation at each design cylindrical section for pressure face only.
  (3) Calculation of percent pitch deviation between adjacent cylindrical sections for pressure face only.
  (4) Calculation of average pitch deviation of each blade for pressure face only.
(e) Rake (see 4.4.1.8(i)):
  (1) Height of point "L" or "M" on each cylindrical gage. For pressure face cylindrical gages which do not have a point "L", the height of the pressure face center offset station or the height of the axial projection of the blade center line at the pressure face shall be recorded.
  (2) Calculation of actual rake for each blade using pressure face measurements.
  (3) Calculation of actual rake deviation from design rake.
(f) Calculation of track for each set of blades from actual rake of blades in the set (see 4.4.1.8(i)).
(g) Actual radius of each cylindrical section (see 4.4.1.8(j)).
(h) Blade thickness and deviations from design at each 10 percent offset station at each design cylindrical section (see 4.4.1.8(g)).

(i) Location and magnitude of leading and trailing edge gage clearances at each design cylindrical section on pressure and suction faces (see 4.4.1.8(d)).
(j) Location and magnitude of tip gage clearances on pressure and suction faces (see 4.4.1.8(f)).
(k) Fillet gages (see 4.4.1.8(e)).
    (1) Fillet gage clearances at 0.6 radius, 0.55 radius, 0.5 radius, 0.45 radius, 0.4 radius, tangent point of the hub and fillet, end of the hub gage and three locations equally spaced between 0.4 radius and tangent point.
    (2) At locations other than those specified in 4.3.1(k)(1), the locations and magnitudes of fillet gage clearances which exceed the specified tolerance shall be recorded.
    (3) Radial displacement of 0.4 radius reference line on the fillet gage from the 0.4 radius.
    (4) Axial location of the hub gage and its axial displacement from the design position.
(l) Radius of each propeller blade and deviation from design (see 4.4.1.8(j)).
(m) Locations and magnitudes of drill rod clearances which exceed the specified tolerance on blade and fillet surfaces and along blade edges (see 4.4.1.8(a)).
(n) Angle between palm and spindle axis (see 4.4.1.8(b)).
(o) Deviations from design of all other dimensions shown on the propeller blade drawing (see 4.4.1.8(m)).
(p) Balance (see 4.4.1.1):
    (1) Identification of and relative position of the blades constituting the set.
    (2) Magnitude and location of residual static unbalance for each set of blades.
    (3) Location of zero degree reference position.
    (4) Specified unbalance tolerance.
    (5) Direction of angular rotation during test.
(q) Results of the liquid penetrant inspection (see 4.4.1.5).
(r) Visual inspection results for each blade (see 4.4.1.5).
(s) Location of areas which have been welded, excluding mandatory welds (for example, prairie air channel cover plate welds).
(t) Material inspection data required by material specifications (see 4.4.1.4).
(u) Thread gage clearances exceeding tolerance limits (see 4.4.1.8(l)).

4.3.2 Hub inspection reports. Each hub inspection report shall include the following:

(a) Hub identification data.
(b) Material inspection data required by material specifications (see 4.4.1.4).
(c) Results of visual, liquid penetrant, and magnetic particle inspections (see 4.4.1.5).
(d) Results of radiographic inspection. The report shall include the photographic plates (see 4.4.1.5).

(e) The track and the deviations in rake, angular blade spacing, fore and aft location of blades, radiality, and propeller radii from design due to deviation of the hub-to-blade securing devices from true (see 4.4.1.8(k)).
(f) List and description of all out of tolerance dimensions (see 4.4.1.8(m)).
(g) Report of balancing, including the amount of unbalance and the plane of largest unbalance for the assembled hub (without blades). The report shall include the location of the zero degree reference portion and the direction of angular rotation (see 4.4.1.1.)
(h) Thread gage clearances exceeding tolerance limits (see 4.4.1.8(l)).

4.3.3 Propeller blade gage inspection reports. Each propeller blade gage inspection report shall include the following (see 4.4.1.7).

(a) Propeller blade gage set identification data.
(b) Cylindrical gages:
    (1) Deviation from design of all offsets and scribe lines.
    (2) Deviation from design of dimensions A, B, and C or D. (See NAVSEA 0987-LP-011-2000).
(c) Edge gages:
    (1) Deviation from design of all offsets and scribe lines.
    (2) Deviation from design of leading edge radius and leading edge fairing radius for leading edge gages only.
    (3) Deviation from design of trailing edge radius, trailing edge fairing radius, knuckle angle for trailing edge gages only.
    (4) Deviation from design of tip radius, tip fairing radius, knuckle angle for tip gage only.
(d) Fillet gage components:
    (1) Deviation from design of all offsets, scribe lines and radii for fillet and hub gages.
    (2) Angle of gage bracket and deviation from design.

4.3.4 Assembly test reports. Assembly test reports shall include the following (see 4.4.2, 4.4.3, and 4.4.4):

(a) All data recorded during testing.
(b) Comments, calculations, sketches, and photographs as necessary for interpretation of the data or test method.

4.3.5 Component laboratory test reports. Laboratory test reports shall be prepared for each component for which material testing is required herein.

4.3.6 Noise test reports. When noise level requirements are specified, noise test reports shall be prepared.

4.3.7 Shock test reports. When shock hardening is required by the contract or order (see 6.2.1), shock qualification data, shock test extension action requests (if applicable), and shock test reports shall be prepared.

4.4 Pre-installation examinations and tests.

4.4.1 Component examination and tests (test levels A, B, and C).

4.4.1.1 Balancing. Balancing shall be performed in accordance with MIL-STD-167-1. Equipment used for balancing shall be sensitive enough to detect 10 percent of the maximum allowable unbalance of any component. The dummy hub shall be dynamically balanced prior to use. Components for which balancing tolerances are specified in 3.18 shall be dynamically balanced before assembly. Balancing of propeller blades shall be accomplished by mounting the blades at design pitch on a dummy hub and determining the single-plane unbalance while the dummy hub is rotating.

4.4.1.2 Determining mass. Actual mass of components shall be determined.

4.4.1.3 Hydrostatic tests. Castings, forgings (except propulsion shafting sections), extruded metal, and hoses which contain fluids or form a fluid barrier shall be hydrostatically tested after final machining at 150 percent of their maximum operating pressures for 30 minutes without a pressure drop. Components which form the water-oil barrier in the hub, including the hub casting, shall be tested at 150 percent of the maximum hub pressure.

4.4.1.4 Physical and chemical tests. In addition to the mandatory physical and chemical tests required by the material and component specifications, tests shall be performed to verify any other material properties (for example, hardness, radiographic integrity) which are necessary in order for a component to perform its function. For the load-carrying components of the propeller blade attachments, these shall include Charpy impact tests, cold-bending tests, magnetic particle (or liquid penetrant) test, macroetch tests (for steel forgings only), and ultrasonic tests. Charpy impact specimens may be taken from material provided for this purpose when made from the same heat, formed by the same type of process, and heat treated (if applicable) with the components whose properties are to be demonstrated.

4.4.1.5 Nondestructive tests. Castings shall be inspected in accordance with MIL-STD-278, except that liquid penetrant inspections shall be performed on finished surfaces only and radiographic inspections shall be performed only on the minimum hub sections between propeller blade openings. Propeller blades shall be inspected in accordance with MIL-STD-278 table titled, "Non-pressure containing castings in machinery or pressure vessels". Repair and fabrication welds shall be inspected in accordance with the requirements specified in MIL-STD-278.

4.4.1.6 Prairie air system tests. Air pressure drop at the specified flow rate through each propeller blade shall be measured. When the inlet air pressure to the prairie air system is specified, tests shall verify that the inlet air pressure, less the back pressure due to the depth of the propeller blade in the water at full-draft, less the estimated air pressure drop in the prairie air system between the air inlet and blade is equal to or greater than the measured air pressure drop through the blade. Each propeller blade prairie air channel shall also be pressurized with water in a horizontal position with pressure face up and with suction face up. Height of the discharge from the holes shall form a faired curve with no evidence of irregularity due to blockage of the holes or air passages.

4.4.1.7 Gage and dummy hub examination. Propeller blade gages and thread gages shall be dimensionally examined to verify their accuracy within the tolerances specified in NAVSEA 0987-LP-011-2000 and gage manufacturing drawings. The dummy hub shall be balanced and dimensionally examined. Following use, the gages and dummy hub shall be re-examined. Defects shall be repaired by the contractor. Gages and the dummy hub shall be examined following any repair or suspected damage.

4.4.1.8 Propeller blade and hub measurements. Following balancing of the propeller blades and hub and certification of one set of propeller blade gages and thread gages, propeller blades and external surfaces of the propeller hub shall be examined to verify fairness, contours, and dimensional accuracy. Propeller blade and hub measurements shall be taken in accordance with NAVSEA 0987-LP-011-2000 and the following:

(a) Fairness of blade and hub exterior surfaces and blade outline shall be examined with a 3 mm (1/8-inch) diameter straight carbon steel drill rod of a length of 400 mm (16 inches) or 30 percent of the propeller radius, whichever is smaller. This test shall only be utilized on those areas whose curvature is such that the drill rod can be applied without exceeding its elastic limit.

(b) Projection of the blade spindle axis on the pressure face of each blade at each design radius shall be measured and corrected by dimension "H" from table I of the propeller blade gage data drawing to determine axial location of the blade spindle axis of each blade. The average of the heights of the individual blade spindle axes shall become the propeller blade spindle axis from which the position of the "hub contour" portion of each suction face and pressure face fillet gage shall be determined.

(c) Cylindrical section gages are to be applied in a truly cylindrical position. Cylindrical elements of the gages shall be parallel to the propeller hub axis within a tolerance of 8 parts in 1000. Positioning of the gages shall be checked with levels at the "J", "K", and "L" or "M" locations (see NAVSEA 0987-LP-011-2000) and also midway between these points for blade widths greater than 1000 mm (40 inches). Pressure face cylindrical gages shall be positioned on blades with the cylindrical center element alined with the local axial projection of the blade spindle axis. Suction face cylindrical gages shall be alined with the position of the end lines of the pressure face cylindrical gages. Cylindrical gages shall be alined with the axial projection of design sections (radius lines) so that the lines are covered by the gages. Clearances shall be measured at each 10 percent offset station on each gage.

(d) Leading and trailing edge gages are to be applied flat (not rolled on a chord that touches the cylindrical section (radius lines) at the blade edge and open end of the gage. Edge gages shall be applied parallel to the propeller hub axis and used as a contour gage for each side of the blade separately. To insure proper contour of the leading edge, clearance under the leading edge gages shall be measured around the leading edge to a point on the opposite face 5/8 percent of the blade section length (3 mm (1/8 inch) minimum, 6.5 mm (1/4 inch) maximum) from the leading edge. Maximum clearance under the suction and pressure face sides of each edge gage shall be measured.

(e) The position of the blade portion of pressure face fillet gages shall be transferred from cylindrical gages to blades when pressure face cylindrical gages are alined with the axial projection of the blade center axis. The position of the blade portion of suction face fillet gages shall be transferred from suction face cylindrical gages to blades when suction face cylindrical gages are alined with end lines of pressure face cylindrical gages. The "hub contour" portion of fillet gages shall be perpendicular to the spindle axis. The blade portion shall be alined with marks transferred from cylindrical gages. Clearances at ten equally spaced locations along each fillet gage and the location of the scribe line on each gage relative to 0.4 radius line shall be measured.

(f) The tip gage shall be flat (not rolled) and held normal to the design pitch helix at the tip and as a chord along the propeller blade centerline (mid-length of sections). The gage shall be used as a contour gage for each side of the blades separately. Maximum clearance on each side of the gage shall be measured.

(g) Thickness measurements shall be taken with calipers on each design radius at each 10 percent station. Stations shall be determined from the cylindrical gages positioned as specified in 4.4.1.8(c).

(h) Blade section half lengths shall be measured with pressure face cylindrical gages positioned as specified in 4.4.1.8(c).

(i) Pitch, rake, and track of blades shall be determined with pressure face cylindrical gages positioned as specified in 4.4.1.8(c) by measuring the heights parallel to the propeller axis of points "J", "K", and "L" (see NAVSEA 0987-LP-011-2000). For these measurements, the blade shall be mounted in the dummy hub or a suitable inspection fixture with the propeller centerline vertical and blade set to design pitch. Values shall be corrected to eliminate the effect of variances in the dummy hub or inspection fixture from true.

(j) For blades, values of cylindrical blade section radii, propeller tip radius, and blade bolt head perpendicularity shall be determined and corrected to eliminate the effect of variances in the dummy hub or inspection fixture from true.

(k) For hubs, values of track, rake, angular blade spacing, fore and aft location of blades, radiality, propeller radii, and blade bolt thread perpendicularity shall be determined assuming perfect blades.

(l) Thread gage clearances, if applicable, shall be measured.

(m) Dimensions shown on propeller blade and hub assembly and detail drawings shall be measured.

4.4.1.9 Inspection of propeller blades produced by numerically controlled machining. When more than two hub sets of blades are being acquired, the examination specified in 4.4.1.8 shall be made on the first blade and, thereafter, every fifth blade of each type. At the discretion of the contracting activity, another blade may be chosen in lieu of the fifth blade. The remaining blades shall be inspected as follows:

(a) Nondestructive tests as specified in 4.4.1.5.
(b) Dimensions shown on the propeller blade drawing in the hub attachment area.
(c) Thread gage clearances, if applicable.

4.4.1.10 Calibration of indicating and regulating devices. Calibration and accuracy of gages, temperature indicators, and indicating and regulating devices shall be verified. A tag or sticker shall be placed on each device attesting to the calibration and stating the date of calibration. Test equipment used for calibration shall be acceptable to the contracting activity.

4.4.1.11 Electrical components. Electrical components shall be subjected to an examination to ascertain that no piece of equipment or its insulation has been cut, bruised, or otherwise damaged as a result of handling or storage; that no parts have been bent, broken, or lost; and that the equipment has not been damaged by weather, dirt, moisture, oil, or other deleterious substances.

4.4.1.12 Fastener torque tests. Tests shall be conducted to determine the proper method for obtaining proper torque or pre-stress on propeller blade bolts and other preloaded fasteners which are load-carrying components of the propeller blade attachments (see table I, note 2). Fasteners of the final design instrumented with strain gages shall be utilized for the tests.

4.4.2 Assembly tests (test level A).

4.4.2.1 General requirements. Following completion of component examination and tests, the propeller shall be cleaned, assembled, flushed, and spin tested in air to achieve or demonstrate the following:

(a) Proper fit of the parts and joint integrity.
(b) Adjustments and modifications necessitated by the tests.
(c) Accuracy of pitch indication under varying combinations of shaft speed, pitch, and oil temperature.
(d) Capability to change pitch in the specified time.
(e) Capability of the propeller to respond to the control system.
(f) Proper functioning of the alarms provided.
(g) Proper functioning of the prairie air system, when provided, and determination of the total air pressure drop at design air flow.
(h) No visible oil leakage from any part of the system.
(i) When instrumented sea trials are specified (see 6.2.1), the adequacy and accuracy of the test instrumentation.

4.4.2.2 Assembly tests for prototype propeller. For the first propeller, the contractor shall completely assemble the propeller blades and hub, oil distribution box or pitch control unit, hydraulic system, and the prairie air system. Complete assembly of the propulsion shafting is not required, but the test assembly shall be of sufficient length to demonstrate the suitability of shafting internal component joints, guides, supports, and other design features. Hoses and nonstandard piping may be used in nonrotating portions of the hydraulic and prairie air systems provided that specified flow rates and pressure drops are not exceeded. Assembly of the control system shall demonstrate remote pitch control and response of the pitch control system to remote combined pitch and speed control, including the accuracy of the remote pitch indication.

Indicating and recording instrumentation shall be provided to prove that parts of the system, including alarms, interlocks, and functional characteristics operate satisfactorily. Indicating and recording devices used in the assembly testing shall have been calibrated within six months of the assembly testing. Devices which have not been calibrated within six months shall be recalibrated as specified in 4.4.1.10 before commencement of assembly testing. The hub mechanism and oil distribution box or pitch control unit shall be instrumented for a direct readout of blade pitch, hydraulic pressures, and other data required to permit evaluation of the propeller design. Pressure and pitch measurements in the hub shall be made through the use of transducers. If hub-instrumented trials are specified in the contract or order, the system specified in 3.3.17 shall be used during assembly testing. Nonrotating testing of pitch controls, limits, accuracy of indicators, and prairie air flow shall be performed. The hydrostatic integrity of the joints shall be verified at 150 percent of their maximum operating pressure for 30 minutes without a pressure drop. Joints in the propeller hub shall be verified at 150 percent of the maximum hub pressure. Hydrostatic testing may be performed before completion of the assembly. The contractor shall verify by analysis of oil samples that all portions of the hydraulic system are within established standards of cleanliness. Following the satisfactory completion of nonrotating testing, the system shall be spin tested without interruption for 100 hours. During this test, the system shall be operated at a series of speed increments up to and including 110 percent of design r/min. At each speed increment, complete pitch reversals from full-ahead to full-astern and back to full-ahead of at least 15 per hour at design rate of pitch change shall be accomplished for 50 percent of the time. Ten percent of the time at each speed increment shall be at design ahead pitch. The prairie air system, if provided, shall be operated for at least 5 percent of the time. Oil samples shall be taken from the hydraulic system at representative locations every 24 hours and analyzed to verify the maintenance of oil cleanliness standards. At the conclusion of the test, the nonrotating tests described above shall be repeated as necessary to demonstrate repeatability and absence of degradation. Following the test, up to 200 hours of additional spin testing may be performed at the option of and under a schedule prepared by the contracting activity. The contracting activity will have one week after the conclusion of the initial test to exercise the option.

4.4.2.3 Assembly tests for follow-on propellers. For subsequent propellers, a similar test will be performed except that the initial rotation test shall be conducted for a continuous period of 24 hours, with an additional period of 24 hours at the option of the contracting activity. The contracting activity will have three working days following completion of the initial test, to exercise its option and provide a schedule for the additional test period. If hub-instrumented trials are specified in the contract or order, the instrumentation shall be utilized during the test. Oil samples shall be taken from the hydraulic system at representative locations at the conclusion of each test and analyzed to verify the maintenance of oil cleanliness standards.

4.4.2.4 Disassembly examination. Following assembly testing, the prototype propeller shall be disassembled and all parts shall be examined for wear, leakage, binding, and material failure. Disassembly examination is not required for follow-on propellers unless abnormal conditions were observed during assembly testing.

4.4.3 Assembly tests (test level B).

4.4.3.1 General requirements. Following completion of component examination and tests, each propeller shall be cl aned, assembled, flushed, and tested in air to achieve or demonstrate the following:

(a) Proper fit of parts and joint integrity.
(b) Adjustments and modifications necessitated by the tests.
(c) Proper functioning of the prairie air system and determination of the total air pressure drop at design air flow.
(d) No visible oil leakage from any part of the system.

The contractor shall completely assemble the propeller blades and hub, oil distribution box or pitch control unit, and the prairie air system. Complete assembly of the propulsion shafting is not required, but the test assembly shall be a sufficient length to demonstrate the suitability of shafting internal component joints, guides, supports, and other design features. Assembly of hydraulic and control systems shall be sufficient to demonstrate pitch changing ability. Hoses and nonstandard piping may be used provided that specified flow rates and pressure drops are not exceeded. Nonrotating tests of limits, accuracy of the mechanical indicator, prairie air flow and hydrostatic integrity of joints shall be performed.

4.4.3.2 Disassembly examination. Following assembly testing, the prototype propeller shall be disassembled and all parts shall be examined for wear, leakage, binding, and material failure. Disassembly examination is not required for follow-on propellers unless abnormal conditions were observed during assembly testing.

4.4.4 Assembly tests (test level C). The ability of the controllable pitch propeller to achieve performance requirements specified shall be demonstrated as specified in 4.5 and 4.6.

4.4.5 Load test (test levels A, B, and C). When specified (see 6.2.1), the first propeller shall be load tested in accordance with an agenda (see 3.21.5). As a minimum, highly stressed components of the propeller hub shall be instrumented with strain gages or other devices and one blade shall be loaded to simulate hydrodynamic and centrifugal forces during operating conditions.

4.5 Tests during shipboard installation (test levels A, B, and C).

4.5.1 General requirements. Deficiencies shall be promptly reported to the contracting activity. Testing shall be conducted in accordance with an agenda (see 3.21.5).

4.5.2 Hydraulic system cleanliness. During and following installation, the hydraulic system shall be cleaned and flushed to remove dirt, slag, rust, metallic particles, water, preservatives, and other contaminants. Cleanliness shall be verified by analyses of oil samples taken from the hydraulic system in accordance with MIL-STD-419.

4.5.3 Hydrostatic integrity. Hydrostatic integrity of joints shall be verified at 150 percent of their maximum operating pressure for 30 minutes without a pressure drop or visible oil leakage. Joints in the propeller hub shall be verified at 150 percent of the maximum hub pressure. Hydrostatic testing may be performed before completion of the assembly. If tested joints are broken, they shall be retested upon reassembly.

4.5.4 Electrical checks. Adequacy of the electrical and control systems shall be verified by wire to wire continuity checks with a low-voltage test instrument or apparatus. The operation or warning and indicating lamps shall be verified. Insulation resistance tests shall be conducted on motors.

4.6 Post-installation tests (test levels A, B, and C).

4.6.1 General requirements. Post-installation tests shall be performed in accordance with an agenda (see 3.21.5) to demonstrate proper operation and verify the requirements of the specification. Additional indicating and recording instrumentation shall be provided as required for these tests. Indicating and recording devices shall be calibrated within 6 months of the testing. Devices which have not been calibrated within 6 months shall be recalibrated in accordance with 4.4.1.10 before commencement of testing. Deficiencies shall be reported immediately to the contracting activity.

4.6.2 Hydraulic system cleanliness. Oil samples shall be taken from representative locations in the hydraulic system following each day of testing and analyzed for water and particulate contamination in accordance with MIL-STD-419. Sources of any water in the sample shall be determined and corrective action taken, if necessary.

4.6.3 Maintainability. The contractor shall demonstrate the performance of maintenance tasks specified as being within the capability of the ship's crew. The demonstration shall validate the adequacy of the maintenance procedures and accessibility of the equipment.

4.6.4 Dockside tests. Prior to getting underway, the propeller shall be activated and blades cycled to demonstrate pitch controls, functional characteristics, limits, alarms, interlocks, accuracy of indicators, prairie air flow (if applicable), hub lubricating system purge system (when provided), and joint integrity.

4.6.5 Sea trials. During sea trials, the propeller shall be operated to demonstrate the following:

(a) Joint integrity.
(b) Accuracy of pitch indication under different operating conditions and varied oil temperature.
(c) Proper functioning of the prairie air system, when provided.
(d) Proper functioning of the mechanical pitch locking device, when provided.
(e) Proper functioning of the hub lubricating system purge system.
(f) Operation of hydraulic and pneumatic regulating and relief valves, interlocks, and alarms.
(g) Verification of calculated propeller blade turning effort and heat calculations.
(h) Validation of operating instructions.

(i) Interrelationship between propeller blade pitch, power load, shaft r/min, ship speed, and, where required, propeller noise, throughout the range of each variable.
(j) Pitch change rate (see 3.1.8).

4.6.6 Instrumented sea trials. Where instrumented sea trials have been specified (see 6.2.1), the contractor shall provide and install test instrumentation such as strain gages and transducers in the hub, oil distribution box or pitch control unit, and elsewhere in the propeller as specified or required to provide direct readouts of blade pitch, hydraulic pressures, stresses and other data specified or required for in-service evaluation of the propeller. The contractor shall prepare, in addition to the provisions of 4.6.5, recordings of the interrelationship between measured stresses, propeller blade pitch, servo valve pressure (for style H propellers), and shaft speed during steady-state, maneuvering, crash back, and crash ahead conditions. The time, chart scales, location of instrumentation devices, and other parameters necessary to interpret the data shall be included. Upon completion of instrumented sea trials, the test instrumentation shall be removed.

4.7 Inspection of packaging. Sample packages and packs and the inspection of the preservation-packaging, packing, and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The preparation for delivery requirements specified herein apply only for direct Government acquistions. For the extent of applicability of the preparation for delivery requirements of referenced documents listed in section 2, see 6.5.)

5.1 General requirements.

5.1.1 Technical data. Descriptive details of (a) the packaging, packing, and marking concept and (b) the packaging, packing, and transportation support data shall be prepared in accordance with the data ordering documents included in the contract or order (see 6.2.2).

5.2 Preservation-packaging, packing, and marking. Preservation-packaging shall be level A or C, packing level A, B, or C as specified (see 6.2.1), and marking shall be in accordance with MIL-P-2845, except as modified in 5.2.1 through 5.2.10.

5.2.1 Preservatives used shall provide the required protection and shall be easily removable upon reassembly and installation of the equipment. For internal surfaces of mechanical components, the normal operating hydraulic fluid shall be used as the preservative.

5.2.2 For systems, assemblies, and components acquired for incorporation into a ship or assembly prior to delivery to the Government, the requirements of 5.2.3 through 5.2.7 do not apply. In lieu thereof, preservation-packaging, packing, and marking of these systems, assemblies, or components shall be sufficient to provide protection from damage and deterioration until incorporation.

5.2.3 Hubs.

5.2.3.1 Packaging. Each hub shall be filled with the system's normal operating hydraulic fluid. An expansion tank shall be provided to protect the hub against temperature changes and to insure that the fluid completely fills the hub at all times. All hub openings shall be sealed to prevent leakage during handling, shipment, and storage. Moving parts shall be secured or cushioned in a manner to prevent damage during handling, shipment, and storage. External preserved surfaces and areas shall be protected with a greaseproof barrier. Each hub shall be tagged stating that the hub is filled with the normal operating lubricant, its identification (for example, specification, type), including precautionary information necessary for hub handling, shipment, and storage.

5.2.3.2 Packing. Each hub over 90 kg (200 pounds) in mass shall be cradled and secured to a skid type base. For other hub boxes conforming to PPP-B-601 (overseas type) or PPP-B-621, class 2 shall be used. The skid type base shall be of a design and construction format similar to the skid bases depicted in MIL-C-104. Anchoring of the hub shall be in accordance with MIL-STD-1186 or the appendix to MIL-C-104. A neutral barrier material shall be applied to all wood surfaces that come in direct contact with the hub. For hubs mounted on skid type bases, further protection shall be provided by an open-type, bolted, wood constructed cover (sides, ends, and top) similar to MIL-C-3774, type II, except that MIL-C-104 shall be used for guidance for selection of sizes of members and hardware for the cover assembly and fastening to the skid type base. To facilitate crate handling, the special markings as specified in MIL-P-2845 for multiple trip containers, center of balance, sling points, and structural characteristics shall be applied. The markings in MIL-P-2845 regarding container damage shall also be applied.

5.2.3.3 Hub attachment bolts and other attached components of hub assemblies shall be packed with the hub. When multiple containers are required for a hub assembly, each container shall be marked with serial numbers to ensure that the complete hub assembly is furnished or issued as required.

5.2.4 Propeller blades. References to eye bolts and propeller diameters in MIL-P-2845 shall be disregarded. Propeller blades incorporating a prairie air system shall have the prairie air holes protected with pressure sensitive tape in accordance with table I prior to application of strippable compound. Acrylic or transparent protective coatings or coverings shall not be applied. The propeller blade serial number shall be stencilled on the top (white) coating on the pressure face and the suction face of each blade. Propeller blades shall be packed in hub sets. When multiple containers are required for a single hub set, the exterior of each container shall be marked with the propeller blade serial numbers to ensure that the complete set is furnished or issued when required.

5.2.4.1 Blade bolts and other detached components of propeller blades shall be packed with the appropriate blade.

5.2.5 Electrical and electronic equipment. Preservation-packaging, packing, and marking shall be in accordance with MIL-E-17555.

5.2.6 Pumps and associated parts. Preservation-packaging, packing, and marking shall be in accordance with MIL-P-16789.

5.2.7 Accessories and detached parts. Consolidation of accessories and detached parts in common shipping containers shall be applied where feasible.

5.2.8 Other deliverable ancillary items. Special tools, gages, pitch scales, drill jigs, dummy hubs, and patterns shall be prepared for delivery for the level specified as follows:

	Level	
Type	Preservation-packaging	Packing
On board	A	C
Shore-based	A	B

5.2.8.1 Special tools and gages shall be prepared for shipment in accordance with MIL-STD-794. Special tools shall be packaged one per unit pack except that all parts constituting a single tool shall be packaged together. When a unit package consists of more than one part, each part shall be wrapped or cushioned to prevent direct surface contact with the surface of adjacent parts. Propeller blade gages and thread gages shall be unpreserved and each set shall be packed vertically in a lamellated container.

5.2.9 All level B containers shall be reusable. Rough handling tests are not required.

5.2.10 Data. Data shall be prepared for delivery in such a manner as to ensure the required information is protected against deterioration, physical damage, or loss during shipment from the contractor to the receiving activity. Packages or shipping containers as a minimum shall conform to level C of MIL-P-2845. Technical manuals and propeller certification forms shall be prepared for delivery as specified in MIL-P-2845.

6. NOTES

6.1 Intended use. This specification is intended to be applicable to any controllable pitch propeller for shipboard use.

6.2 Ordering data.

6.2.1 Acquisiton requirements. Acquisition documents should specify the following:

(a) Title, number and date of this specification.
(b) Style, blade design, tolerance level, hydraulic type (for style H only), and test level required (see 1.2).
(c) Full-power per propeller ahead and astern requirements (see 3.1.2).
(d) Rated r/min, maximum astern r/min, and propeller pitch (see 3.1.2).
(e) Trim, list, pitch, and roll requirements (see 3.1.2).
(f) Noise, shock, and vibration requirements (see 3.1.4, 3.1.5, table I, note 3, and 4.2.6).
(g) Bollard pull and towing requirements (see 3.1.6).
(h) Type of hydraulic fluid (see table I, note 8).

(i) When SI units are to be utilized on level indicators, temperature indicators, and pressure indicators (see table II, note 1, 3.7.17, and 3.7.18).
(j) Type of undervoltage protection for controllers (see table II, note 4).
(k) General design requirements (see 3.3):

    (1) Number of propellers per ship.
    (2) Number of propeller blades per hub and propeller blade tip diameter.
    (3) Direction of propeller rotation.
    (4) Minimum clearance between propeller blade tips and hull.
    (5) When a pitch range in excess of that required for normal operation is required.
    (6) When a prairie air system is required.
    (7) When capability of feathering is required.

(l) Reliability and maintainability requirements (see 3.3.3 and 3.3.4).
(m) When resilient mounts are required (see 3.3.9).
(n) When instrumented trials are required (see 3.3.17, 3.21.1.9, and 4.4.2.1 and 4.6.6).
(o) When changing propeller blades underwater is required (see 3.4.1).
(p) For blade design D only, ABS ice class (see 3.4.3).
(q) When numerically controlled machining of propeller blades is required (see 3.4.5).
(r) Main propulsion shafting requirements (see 3.5).
(s) Prairie air flow rates, input or discharge pressures required (see 3.8.1).
(t) When additional alarms are required (see 3.9.3).
(u) When a pitch control failure warning system is required (see 3.9.4).
(v) Provision and quantities of propeller blade gages, thread gages, drill jigs, balancing tools, and special tools (see 3.11.1, 3.11.2, 3.13, 3.14, and 3.16).
(w) When patterns are to belong to contracting activity (see 3.15).
(x) Requirements for technical manuals (see 3.21.2).
(y) System safety program requirements (see 3.21.9).
(z) Where shock hardening is required (see 4.3.7).
(aa) When a load test is required (see 4.4.5).
(bb) Preservation-packaging and packing requirements (see 5.2).

6.2.2 Data requirements. When this specification is used in an acquisition which incorporates a DD Form 1423, Contract Data Requirements List (CDRL), the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved CDRL incorporated into the contract. When the provisions of DAR 7-104.9 (n) (2) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification is cited in the following paragraphs.

Paragraph no.	Data requirement title	Applicable DID no.	Option
3.21.1, 5.1.1	Drawings, engineering and associated lists	DI-E-7031	Level 3 Design activity designation-contractor Drawing No.-contractor
3.21.2	Technical manual manuscript copy	DI-M-2042	Type I of MIL-M-15071
	Manual, technical, preliminary	DI-M-2043	---
	Manaul, technical, standard	DI-M-2044	---
3.21.3	List, engineering document requirements (EDRL)	DI-L-2100	---
	Technical repair standard outline	UDI-M-22403	---
	Technical repair standard	UDI-M-22404	---
3.21.4	C.P. propeller calculations	UDI-E-23134	---
3.21.4.4	Tolerance analysis report	DI-E-5251	---
3.21.5	Report, format of test	UDI-T-23739	
3.21.6	Plan, installation and integration	UDI-E-20463	
3.21.7	Request Government nomenclature, name plate approval, serial number	UDI-P-22502	---
3.21.8	Engineering change proposals (ECP's) and requests for deviations and waivers (long form)	DI-E-2037	---
3.21.9	System safety hazard analysis report	DI-H-7048	---
4.1.1	Inspection system program plan	DI-R-4803	---
4.3.1, 4.3.2, 4.3.3	Controllable pitch propeller inspection reports	UDI-T-23735	---
4.3.4	Report, format of test	UDI-T-23739	---
4.3.5	Manufacturer's test reports	UDI-T-23797	---
4.3.6	Component shop noise tests report	UDI-T-23764	---
4.3.7	Equipment shock test reports	UDI-T-23753	---
	Shock qualification data sheet	UDI-T-23761	---
	Shock test extension action request	UDI-T-23763	---
5.1.1	Packaging and transportation support data	UDI-P-23508	---

(Data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DoD 5000.19L., Vol. II, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.2.1 The data requirements of 6.2.2 and any task in section 3, 4, or 5 of the specification required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for an identical item acquired to this specification. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

6.3 Definitions.

6.3.1 Full-power. Full-power is the maximum power output of the main propulsion engines as given in the contract or order for each propeller.

6.3.2 Rated r/min. Rated r/min is the shaft speed at design pitch corresponding to full-power in ahead operation of the ship.

6.3.3 Pitch. Pitch is the theoretical advance of the propeller hub in one revolution with no slip. The pitch of a propeller blade is considered to be the pitch at the 0.7 radius propeller blade section. Pitch is always denominated in linear units.

6.3.4 Full-ahead pitch. Full-ahead pitch is the maximum ahead propeller pitch setting attainable with the control system.

6.3.5 Design pitch. Design pitch is the ahead propeller pitch setting which, under full-power conditions, will result in ship operation at rated r/min.

6.3.6 Full-astern pitch. Full-astern pitch is the maximum astern propeller pitch setting attainable with the control system.

6.4 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified in the contract.

6.4.1 When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

6.5 Sub-contracted material and parts. The preparation for delivery requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.6 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 2010-N017)

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION *(Mark one)*

☐ VENDOR

☐ USER

☐ MANUFACTURER

☐ OTHER *(Specify)*: ______

b. ADDRESS *(Street, City, State, ZIP Code)*

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional

b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional

c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional

8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 1426, 82 MAR

PREVIOUS EDITION IS OBSOLETE.