MIL-T-17523D(SH)
7 June 1976
SUPERSEDING
MIL-T-17523C(SHIPS)
15 April 1966
(See 6.6 and 6.8)

MILITARY SPECIFICATION

TURBINE, STEAM, AUXILIARY (AND REDUCTION GEAR) MECHANICAL DRIVE

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

1. SCOPE

1.1 Scope. This specification covers auxiliary mechanical drive non-condensing steam turbines and associated reduction gears (where used) for pumps and forced draft fans (blowers) for Naval ships and includes additional equipment, fittings and accessories (see 3.3.2). Propulsion turbines and gears and generator turbines and gears are not included.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, 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.
- QQ-C-390 - Copper Alloy Castings (Including Cast Bar).
- QQ-S-624 - Steel Bar, Alloy, Hot Rolled and Cold Finished (General Purpose).
- QQ-S-630 - Steel, Bar, Carbon, Hot Rolled (Merchant Quality).
- QQ-S-631 - Steel, Bar, Carbon, Hot Rolled (Special Quality).
- QQ-S-634 - Steel, Bar, Carbon, Cold Finished (Standard Quality).
- QQ-S-635 - Steel Plate, Carbon.
- QQ-S-691 - Steel Plate, Carbon-Silicon, Carbon Molybdenum and Manganese-Molybdenum Alloys Hot Rolled, (Marine Boiler Quality).
- QQ-S-699 - Steel Sheets, Carbon, Hot-Rolled, Heavy Gage Structural Quality.
- QQ-S-763 - Steel Bars, Wire, Shapes and Forgings, Corrosion-Resisting.
- QQ-S-764 - Steel Bar, Corrosion Resisting, Free Machining.
- QQ-S-766 - Steel Plates, Sheets, and Strip--Corrosion Resisting.
- QQ-T-390 - Tin Alloy Ingots and Castings and Lead Alloy Ingots and Castings (Antifriction Metal) For Bearing Application.
- TT-L-201 - Linseed Oil, Heat Polymerized.
- TT-P-38 - Paint, Aluminum, Ready Mixed.

MILITARY

- JAN-W-562 - Wire, Nickel-Alloy, Spring (Heat-Resistant and Age-Hardenable).
- MIL-S-860 - Steel Forgings for Steam Turbine Rotors.
- MIL-S-861 - Steel Bars, Corrosion Resisting, Naval Steam Turbine Parts Use.
- MIL-S-866 - Steel: Bars and Billets (For Carburizing).
- MIL-S-869 - Steel Bars, Billets and Forgings-Alloy Nitriding Application.
- MIL-S-870 - Steel Alloy, Molybdenum Castings.
- MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Ship Engineering Center, Center Building, SEC 6124, Prince Georges Center, Hyattsville, Maryland 20782 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

MILITARY (continued)

MIL-P-1144 - Pipe, Corrosion-Resistant Stainless Steel, Seamless or Welded.
MIL-S-1222 - Studs, Bolts, Hex/Cap Screws, and Nuts.
MIL-C-2212 - Controllers, Electric Motor, AC or DC and Associated Switching Devices, Naval Shipboard.
MIL-G-2860 - Glasses, Sight, Flat, Clear, Borosilicate.
MIL-F-3541 - Fittings, Lubrication.
MIL-N-7786 - Nickel-Chromium Alloy, Sheet and Strip, Age Hardenable Annealed.
MIL-T-9047 - Titanium and Titanium Alloy Bars, Forgings and Forging Stock.
MIL-M-15071 - Manuals, Technical Equipment and Systems, Content Requirements for.
MIL-S-15083 - Steel Castings.
MIL-P-15137 - Provisioning Technical Documentation for Repair Parts For Electrical and Mechanical Equipment (Naval Shipboard Use).
MIL-C-15345 - Castings, Nonferrous, Centrifugal.
MIL-S-15464 - Steel, Alloy, Chromium-Molybdenum; Castings.
MIL-L-15719 - Lubricating Grease (High-Temperature, Electric Motor, Ball and Roller Bearings).
MIL-C-15730 - Coolers, Fluid, Industrial, Naval Shipboard: Lubricating Oil, Hydraulic Oil, and Fresh Water.
MIL-T-16049 - Tachometers. Electric; Self-Generating; Mechanical, Fixed Mounting and Hand Held; and Vibrating Reed.
MIL-S-16113 - Steel Plate, High Tensile (HT) Hull and Structural.
MIL-S-16216 - Steel Plate, Alloy, Structural, High Yield Strength (HY-80 and HY-100).
MIL-G-16265 - Gaskets, Metallic-Asbestos, Spiral Wound (for Navy Flanged Joints in Piping Systems).
MIL-E-16298 - Electric Machines Having Rotating Parts and Associated Repair Parts. Packaging of.
MIL-P-16789 - Packaging of Pumps, Including Prime Movers and Associated Repair Parts.
MIL-S-16974 - Steel Bars, Billets, Blooms and Slabs; Carbon and Alloy (For Reforging or Other Operations Before Heat Treatment).
MIL-S-16993 - Steel Castings (12-Percent Chromium).
MIL-M-17060 - Motors, 60 Hertz, Alternating Current, Integral Horsepower (Shipboard Use)
MIL-R-17131 - Rods, and Powders Welding, Surfacing.
MIL-I-17244 - Indicators, Temperature, Direct-Reading, Bimetallic (3 and 5 Inch Dial).
MIL-P-17286 - Propulsion and Auxiliary Steam Turbines and Gears (Including Repair Parts, Tools, Accessories and Instruments); Packaging of.
MIL-L-17331 - Lubricating Oil, Steam Turbine (Noncorrosive).
MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Repair Parts; Packaging and Packing of.
MIL-L-17672 - Lubricating Oil, Hydraulic and Light Turbine, Noncorrosive.
MIL-S-17849 - Strainers, Sediment, Pipeline, Duplex (With and Without Magnet).
MIL-G-17859 - Gear Assembly, Propulsion (Naval Shipboard Use).
MIL-B-17931 - Bearings, Ball, Annular, For Quiet Operation.
MIL-S-18410 - Steel Bars, Billets and Forgings-Chromium-Molybdenum Alloy.
MIL-P-18493 - Packing, Preformed Carbon: and Carbon Stock, Packing.
MIL-F-18602 - Fans, Vaneaxial, Forced Draft, Steam Turbine Driven.
MIL-F-18866 - Fittings, Hydraulic Tube, Flared, 37 Degree and Flareless; Steel.
MIL-I-18997 - Indicator, Pressure, Panel Mounted or Case Supported, General Specification.
MIL-P-19131 - Pumps, Rotary, Power Driven, Miscellaneous.
MIL-S-19434 - Steel Gear and Pinion Forgings, Carbon and Alloy, Heat Treated, Naval Shipboard Propulsion Unit and Auxiliary Turbine.
MIL-T-19646 - Thermometers, Remote Reading, Self-Indicating Dial, Gas Actuated.
MIL-T-20157 - Tube and Pipe, Carbon Steel, Seamless.
MIL-S-20166 - Steel Structural Shapes, Weldable Medium Carbon and High Tensile, Hull and Structural.
MIL-G-21032 - Gaskets, Metallic Asbestos, Spiral Wound.
MIL-S-21427 - Strainer, Assemblies, Main Steam, High Pressure (Sizes 4 Inches and Above).
MIL-S-22698 - Steel Plate, Carbon, Structural, For Ships.
MIL-S-23284 - Steel Forgings, Carbon and Alloy, For Shafts, Sleeves, Couplings, and Stocks (Rudders and Diving Planes).
MIL-S-24093 - Steel Forgings, Carbon and Alloy Heat Treated.
MIL-S-24113 - Steel Plates, Carbon Manganese-Heat Treated by Normalizing Or Quenching and Tempering.

MILITARY (continued)

MIL-I-24137 - Iron Castings, Nodular Graphitic (Ductile Iron) and Nodular Graphitic (Corrosion Resisting, Austenitic, Low Magnetic Permeability) (For Shipboard Application).
MIL-L-24467 - Lubricating Oil, Steam Turbine, Vapor-Space Inhibited.
MIL-N-25027 - Nuts, Self Locking, 250°F, 450°F and 800°F, 125 KSI FTU, 60 KSI FTU and 30 KSI FTU.
MIL-I-45208 - Inspection System Requirements.

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-271 - Nondestructive Testing Requirements for Metals.
MIL-S 78 - Fabrication Welding and Inspection; and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels in Ships of the United States Navy.
MIL-STD-438 - Schedule of Piping, Valves, Fittings and Associated Pipings Components for Submarine Services.
MIL-STD-777 - Schedule of Piping, Valves, Fittings and Associated Piping Components for Surface Ships.
MS15003 - Fittings, Lubrication (Hydraulic) Surface Check, 1/8 Pipe Threads, Steel, Type III.
MS21208 - Insert, Screw Thread, Coarse and Fine, Free Running, Helical Coil, CRES.

DRAWINGS

MILITARY

810-1385850 - Piping, Gage, For All Service.
5000-S4824-1385797 - Valves, Steel Flanged, Globe, Combined Exhaust and Relief, 50 PSI Maximum at 775°F.
5000-S4824-1385798 - Valves, Steel Flanged, Angle, Combined Exhaust and Relief, 50 PSI Maximum at 775°F.

PUBLICATIONS

MILITARY

NAVSHIPS 0283-228-1000 - Bearing Babbitting Procedures.
NAVSEA 0900-LP-001-7000 - Fabrication and Inspection of Brazed Piping Systems.
NAVSEA 0900-LP-003-8000 - Metal Surfaces, Inspection Standards for Metals.
NAVSEA 0900-LP-003-9000 - Radiographic Standards for Production and Repair of Welds.
NAVSHIPS 0919-000-9010 - Procedure for Electrodeposition of Chromium on Steel Shafting.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring 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. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A434 - Quenches and Tempered Alloy Steel Bars, Hot-Rolled or Cold-Finished.
E186 - Reference Radiographs for Heavy-Walled (2 to 4-1/2 Inches) Steel Castings.
E208 - Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels.
E280 - Reference Radiographs for Heavy-Walled (4-1/2 to 12 Inches) Steel Castings.

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
PTC-6 - Power Test Code for Steam Turbines.

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

AMERICAN WELDING SOCIETY (AWS)
A2.2 - Nondestructive Testing Symbols.

(Application for copies should be addressed to the American Welding Society, 345 East 47th Street, New York, N.Y. 10017.)

NATIONAL BUREAU OF STANDARDS
Handbook H28 - Screw Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.)

AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)
B16.11 - Forged Steel Fittings, Socket-Welding and Threaded.
Y32.3 - Welding Symbols.

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.)

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)
000 - Standards and Technical Publications Index.
390 - Gear Classification Manual.

(Application for copies should be addressed to the American Gear Manufacturers Association, 1330 Massachusetts Avenue, N.W., Washington, D.C. 20005.)

UNITED STATES POSTAL SERVICE
Postal Regulations

(Application for copies should be addressed to the United States Postal Service, 475 L'Enfant Plaza West, S.W. Washington, D.C. 20260.)

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

3. REQUIREMENTS

3.1 Definitions. Unless otherwise specified hereinafter, terms and expressions shall be interpreted in accordance with the definitions contained in the following.

(a) Webster's New International Unabridged Dictionary.
(b) Mechanical Engineers' Handbook by Lionel S. Marks.

3.1.1 Rated speed. Rated speed is the speed required to drive the pump or fan at its rated speed. Rated speed applies to the identification plate design value of speed for rated power output.

3.1.2 Rated power. Rated power of a turbine shall be the hp required to drive the connected auxiliary (plus gear, if installed) when delivering its maximum output. All turbines shall deliver their rated power under the specified steam and exhaust conditions at the speed of the driven auxiliary corresponding to its maximum output.

3.1.3 Gear nomenclature. Nomenclature for gearing shall be in accordance with the publications listed in AGMA 000.

3.1.4 Main pinion, gear or shaft (element). A main pinion, main gear, or main shaft is a respective element which exists in the assembly for the purpose of transmitting or transferring torque from an input to the output flange or fitting which drives the pump or fan.

3.1.5 Accessory drive (train). An accessory drive train is any power transmission path driving an attached accessory such as a lubricating oil pump, governor, tachometer, and so forth.

3.2 Materials. Specified materials are listed in table I, except that the special material requirements (see 3.2.7) apply where turbines operate on saturated steam. Manufacturer's List of Preferred Materials (see 3.2.8.1.1), then shall replace table I and 3.2.7 and is not subject to revision under each contract to reflect later issues of Government specifications unless specified (see 6.2.2(b)). Materials listed in table I shall be used for the parts indicated, unless the manufacturer has previously prepared a LIST OF PREFERRED MATERIALS (see 3.2.8.1.1) and has received prior approval to use the material listed thereon. Materials for other parts shall be at the manufacturer's option, however, corrosion-resistant materials shall be used for internal turbine applications of shims, lugs, keys and other removable parts exposed to the steam atmosphere. Nozzle block bolting which is countersunk and shielded is not included.

TABLE I. Materials.

Part A - Materials of principal parts.					
Part or service		Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(a) Antifriction metal		QQ-T-390, grade 2 or 3	Babbit (tin base)	280°F hot-spot metal temperature	See note 1 and 3.4.35
(b) Bearing ball		FF-B-171	Steel	See note 2	See 3.4.35
		MIL-B-17931	Steel	See note 2	See 3.4.35
(c) Bearing pedestals and caps		QQ-S-691, all classes	Carbon steel and alloy boiler plate	---	See note 3
		MIL-S-15083, grade B, CW or 70-36	Carbon steel (casting)	---	See note 3
		MIL-S-22698	Carbon steel plate	---	See note 3
		MIL-S-24113	Carbon manganese steel plate	---	---
(d) Bearings, roller	(1) Radial and locating thrust	FF-B-185	Steel	See note 2 200	See 3.4.35
	(2) Combined radial and thrust	FF-B-187	Steel	See note 2 200	See 3.4.35

TABLE I. Materials. - Continued

Part A - Materials of principal parts.						
Part or service		Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(e) Bearings, thrust	(1) Shoes	QQ-S-631 or QQ-S-634, QQ-S-630	C1015-C1025 carbon steel (bar)	---	See note 4 and 3.4.35
		QQ-S-635, (SAE 1020)	Carbon steel (plate)	---	---
		QQ-S-691, class A, B or C	Carbon steel (boiler plate)	---	See note 4 and 3.4.35
		MIL-S-24093, type V, class H	Carbon steel (forging)	---	See note 4 and 3.4.35
		MIL-S-15083, grade B or CW	Carbon steel (casting)	---	See 3.4.35
	(2) Leveling plates	QQ-S-635, (SAE 1020)	Carbon steel (plate)	---	See 3.4.35
		QQ-S-624	Alloy steel (bar)	---	See note 4 and 3.4.35
		QQ-S-630	Carbon steel bar	---	See note 4 and 3.4.35
		MIL-S-24093, type I, II or III, class C, D or E	Alloy steel forging	---	Magnetic particle inspection required See note 4 and 3.4.35
	(3) Collar	MIL-S-24093, class A, types I and II	Alloy steel (forging)	---	Heat treat to 350 ± 50 BHN See note 4 and 3.4.35
		QQ-S-624	Alloy steel (bar)	---	Heat treat to 350 ± 50 BHN See note 4 and 3.4.35
(f) Bedplates		QQ-S-691, class A, B or C	Carbon steel (boiler plate)	---	---
		MIL-S-15083, grade B	Carbon steel (castings)	---	See note 3
		MIL-S-20166	Medium carbon and high tensile steel (structural shapes)	---	
		MIL-S-22698	Carbon steel (plate, structural)	---	---
		MIL-S-24113	Carbon-manganese steel (plate)	---	

TABLE I. Materials. - Continued

Part A - Materials of principal parts.					
Part or service		Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(g) Blades, blade holders for stationary blades (intermediate segments), a locking pieces		MIL-S-861, class 403 or 410 condition HT (machined) (forged or rolled)	12 Cr corrosion-resisting steel (bar and forging)	900	---
		MIL-S-861, class 422, condition HT (machined, forged or rolled)	12 CR corrosion-resisting steel (bar and forging)	1000	---
		MIL-T-9047, comp. 7 GAL-4V ELI	Titanium and titanium alloys (bars, forgings and forging stock) 6AL, 4V	---	---
(h) Fasteners for casing steam joints, valve chest covers, hold down bolts, nozzle blocks and other highly stressed (> 2/3 yield) structural applications	(1) Bolts-studs	MIL-S-1222, type IV, grade B7	Cr-Mo alloy steel	775	Magnetic particle test is not required Continuous threads not required Also see 3.4.25
		MIL-S-1222, type IV, grade B16	Cr-Mo V alloy steel	1000	
		MIL-S-861, class 422, condition HT	Corrosion-resistant steel	1000	
	(2) Cap screws	MIL-S-1222, type I, grade B7	Cr-Mo alloy steel	775	
		MIL-S-1222, type I, grade B16	Cr-Mo V alloy steel	1000	
		MIL-S-861, class 422, condition HT	Corrosion-resistant steel	1000	
	(3) Nuts	MIL-S-1222, type II, grade 2H, type II, grade 4	Carbon and alloy steel	---	

TABLE I. Materials. - Continued

Part A - Materials of principal parts.				
Part or service	Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(i) Casing (housing, covers) (reduction gear)	MIL-S-24093, all classes	Carbon steel (forgings)	---	See note 3
	MIL-S-16113	Steel plate	---	See note 3
	MIL-S-15083, grade B, CW or 70-36	Carbon steel castings	---	See note 3
	QQ-S-691, class A, B or C	Carbon steel (boiler plate)	---	See note 3
	QQ-S-635, SAE 1020	Carbon steel (plate)	---	See note 3
	MIL-S-20166	Carbon steel (shapes)	---	See note 3
	MIL-S-22698, type I, class A, B or C	Carbon steel (plate)	---	See note 3
	QQ-S-699, class 3	Carbon steel (sheets)	---	See note 3
(j) Casings and steam chests (turbine) (includes gland housings and packing ring holders)	QQ-S-691, class A, B or C	Carbon steel (boiler plate)	800	See 3.2.7(c) and 3.4.40
	MIL-S-15083, grade B or CW	Carbon steel (casting)	775	
	MIL-S-22698	Carbon steel plate structural	750	
	MIL-S-24113	Carbon-manganese (plate)	750	
	MIL-S-870	Carbon-Mo alloy (steel (casting))	850	
	QQ-S-691, class D	Carbon-Mo alloy steel (plate)	875	
	MIL-S-15464, class 1	1-1/4 Cr-1/2 Mo alloy steel (casting)	950	
	MIL-S-15464, class 3	1-1/4 Cr-1/2 MoV alloy steel (casting)	1050	
	MIL-S-15464, class 2	2-1/4 Cr-1 Mo alloy steel (casting)	1050	
	MIL-S-16993, class 2	12 Cr alloy steel (casting)	1050	
	QQ-S-766, class 410	12 Cr alloy steel (plate)	900	
	MIL-S-16993, class 1	12 Cr alloy steel (casting)	1200	

TABLE I. Materials. - Continued

Part A - Materials of principal parts.				
Part or service	Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(k) Glasses, oil sight flow indicator	MIL-G-2860	Borosilicate glass	400	50 lb/in^2 max.
(l) Nozzle blocks (excluding partitions)	QQ-S-631, condition A	Carbon steel (bar) (0.35 max. carbon)	750	See 3 2.7(c) and 3.4.38
	MIL-S-15083, class B or CW	Carbon steel (casting)	775	
	QQ-S-691, classes A, B, C	Carbon steel (boiler plate)	800	
	QQ-S-691, classes D and E	Carbon-moly and manganese-moly	875	
	MIL-S-870	Carbon - 1/2 Mo alloy steel (casting)	850	
	MIL-S-15464, class 1	1-1/4 Cr - 1/2 Mo alloy steel (casting)	950	
	QQ-S-763, class 405 or 410	12 Cr corrosion-resisting steel (bars and forging)	950	
	MIL-S-16993, class 2	12 Cr alloy steel (casting)	1050	
	MIL-S-18410, class a	1-1/4 Cr-1/2 Mo alloy steel (bar, billet, forging)	1050	---
	MIL-S-18410, class b	2-1/4 Cr-1 MO alloy steel (bar, billet, forging)	1050	
	MIL-S-15464, class 2	2-1/4 Cr-1 Mo alloy steel (casting)	1050	
	MIL-S-16993, class 1	12 Cr alloy steel (casting)	1200	

TABLE I. Materials. - Continued

Part A - Materials of principal parts.				
Part or service	Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(m) Nozzle block partitions	QQ-S-763, class 403 or 410, condition T or class 405	12 Cr corrosion-resisting steel (bar and forging)	950	---
	QQ-S-766, class 410	12 Cr corrosion-resisting steel (plate, sheet and strip)	900	
	MIL-S-861, class 403 or 410, condition HT, or class 405	12 Cr corrosion-resisting steel (bar and forging)	950	
	MIL-S-861, class 422, condition HT	12 Cr corrosion-resisting steel (bar and forging)	1000	
	QQ-S-763, class 403 or 410	12 Cr corrosion-resisting steel (bar and forging)	950	Reamed nozzle blocks
	QQ-S-764, class 416	12 Cr corrosion-resisting steel (bar)	950	
(n) Packing, carbon (gland)	MIL-P-18493, class 2	Preformed carbon packing and carbon packing stock	750	---
(o) Packing, labyrinth (gland) and stationary seal strips	QQ-S-763, class 410, (maximum hardness 200 BHN) condition A	12 Cr corrosion-resisting steel (bar and forging)	Use only for 850-950	Seal strips only, see note 1
	QQ-S-764, class 416 (maximum hardness 200 BHN), condition A	12 Cr corrosion-resisting steel (bar)	Use only for 850-950	Seal strips only, see note 1
	MIL-C-15345, alloy no. 7	Leaded-nickel-brass, 6 Pb, 13 Ni-65 Cu (casting)	850	Sand castings are permitted, See note 1
	MIL-I-24137, class C	22 percent Ni ductile iron	1000	Centrifugally cast only, See note 1
	QQ-C-390, alloy numbers D5, E1, E3, E5, E6, E7 and E8	Copper alloy, (castings)	550	See note 1

TABLE I. Materials. - Continued

Part A - Materials of principal parts.				
Part or service	Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(p) Packing springs (flat and coil)	ASTM A434 Ni-Cr-Fe alloy	0.08 carbon (max.) 1.00-1.05 Mo 1.00-2.00 Mn 1.75-2.25 Ti 0.40-1.00 Silicon 0.10-0.5 Vanadium 0.030 (max.) Sulfur 0.35 (max.) Al 0.040 (max.) P 0.001-0.01 Boron 13.5-16.0 Cr 24.0-27.0 Ni balance iron	1000	See 3.2.4
	JAN-W-562, class 1 or 2	74 Ni-15 Cr-7 Fe, 1 Cb (wire)	1050	
	MIL-N-7786	74 Ni-15 Cr-7 Fe, 1 Cb alloy (sheet and strip)	1050	
(q) Pins (for notch block and locking blades)	MIL-S-1222, type I, symbol B16	Cr-Mo-V alloy steel (bar)	1000	---
(r) Reversing chambers and re-entry nozzles	QQ-S-763, class 410	12 Cr corrosion-resisting steel (bars and forgings)	950	---
	MIL-S-861, class 403 condition HT	12 Cr corrosion-resisting steel (bar and forgings)	950	
	MIL-S-16993, class 2	12 Cr alloy steel (casting)	1050	
	MIL-S-16993, class 1	12 Cr alloy steel (casting)	1200	
(s) Rotating elements, reduction gear, main (helical gears)				
(1) Pinion	MIL-S-19434, classes 2 through 6	Alloy steel (forgings)	---	With or without nitriding
	MIL-S-866, classes 4615 and 8615	Steel bars and billets (for carburizing)	---	Carburized only
	MIL-S-16974 classes 4140 4340	Alloy steel bars, billets, blooms and slabs	---	With or without nitriding
	QQ-S-624, classes 4140 and 4340	Alloy steel bars	---	---

TABLE I. Materials. - Continued

Part A - Materials of principal parts.

Part or service	Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(s) Rotating elements, reduction gear, main (helical gears) (continued)				
(2) Gear				
a. Solid forging (including shaft)	MIL-S-19434, classes 2 through 5	Alloy steel (forgings)	---	With or without nitriding
	MIL-S-866, classes 4615 and 8615	Steel bars and billets for carburizing	---	Carburized only
b. Ring (or rim)	MIL-S-19434, classes 2 through 5	Alloy steel (forgings)	---	With or without nitriding
c. Hub	MIL-S-24093	Carbon and alloy steel (forgings)	---	For welded construction
	MIL-S-23284	Carbon and alloy steel (forgings)		
	MIL-S-15083, grade B	Steel castings		
	QQ-S-691, classes A and B	Carbon steel (boiler plate)		
d. Webs (side plates)	QQ-S-691, classes A and B	Carbon steel (boiler plate)	---	For welded construction
	MIL-S-22698, type I, classes A, B, and C	Carbon steel (plate)		
e. Tubes (stiffeners, web plates)	QQ-S-691, classes A and B	Carbon steel (boiler plate)	---	For welded construction
	MIL-S-22698, type I, classes A, B and C	Carbon Steel (plate)		
	MIL-T-20157	Tube and pipe, carbon steel		
(3) Shaft	MIL-S-24093	Carbon and alloy steel (forgings)	---	---
	MIL-S-23284	Carbon and alloy steel (forgings)	---	---

TABLE I. Materials. - Continued

Part A - Materials of principal parts.				
Part or service	Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(t) Rotating elements, reduction gear, main (worm and spiral bevel gears (also for accessory drive°				
(1) Worm for worm gear drives	MIL-S-19434, classes 2 through 6	Carbon and alloy steel (forgings)	---	See 3.4.46 Shall be nitrided
	MIL-S-866, classes 4615 and 8615	Steel bars and billets (for carburizing)	---	Carburized only
	MIL-S-16974, classes 4140 and 4340	Alloy steel bars, billets, blooms and slabs	---	Shall be nitrided
	QQ-S-624, classes 4140 and 4340	Alloy steel bars	---	Shall be nitrided
(2) Gear, driven for worm gear drives	MIL-C-15345, alloy number 15 or 16	Bronze	---	---
(3) Pinion and gear, spiral bevel	MIL-S-866, classes 4615 and 8615	Steel bars and billets (for carburizing)	---	Carburized only
(u) Rotors, wheels and shafts (turbine)	MIL-S-860, grade A	Carbon steel	650	See notes 5 and 6 also see 3.2.7(a) and (b), and 3.4.41
	MIL-S-860, grade B	Ni-Mo-V steel (forgings)	750	
	MIL-S-860, grade C, D or E	Ni-Cr-Mo-V alloy steel (forging)	750	
	MIL-S-860, grade G	12 chrome forgings	750	
	MIL-S-860, grade F	Cr-Mo-V-alloy steel (forging)	1050	
(v) Shrouding for blading	MIL-S-861, class 403, condition HT	12 Cr corrosion-resisting steel (strip and bar)	900	180 degree bend test required
	MIL-S-861, class 410, condition AN or HT	12 Cr corrosion-resisting steel (strip and bar)	900	
	MIL-S-861, class 422, condition HT	12 Cr corrosion-resisting steel (strip and bar)	1000	
	Commercial	Titanium and titanium alloys (bars, forgings and forging stock) 6 AL, 4V	---	---

TABLE I. Materials. - Continued

Part A - Materials of principal parts.					
Part or service		Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
(w) Sumps, lube oil		QQ-S-763, classes 304L and 316L	Corrosion-resisting steel, bars, wire, shapes and forgings	---	See 3.4.48.8
		QQ-S-766, classes 304L and 316L	Corrosion-resisting plates, sheets, strips		
(x) Supports, flexible (for casing)		QQ-S-691, all classes	Carbon steel and alloy grades	To suit service	See note 3
		MIL-S-24113	Carbon manganese-steel plate	To suit service	See note 3
		MIL-S-16216	HY-80	To suit service	---
(y) Valves control	(1) Disc (pop-pets and seats)	MIL-S-18410, class a	1-1/4 Cr-1/2 Mo (bar and forging)	1050	See 3.4.50.2.7.2
		QQ-S-763, class 405 or 410, condition A or T	12 Cr corrosion-resisting steel (bar and forging)	950	
		MIL-S-861, class 422, condition HT	12 Cr corrosion-resisting steel (bar and forging)	1000	
		MIL-S-18410, class b	2-1/4 Cr-1 Mo (bar and forging)	1050	
	(2) Lift rods and valve stems (and sleeve valves where used)	QQ-S-763, class 410 with or without nitriding, condition T	12 Cr corrosion-resisting steel (bar and forging)	950	See 3.4.50.2.7.4
		QQ-S-764, class 416, with or without nitriding condition T	12 Cr corrosion-resisting steel (bar)	950	
		MIL-S-861, class 422, condition HT	12 Cr corrosion-resisting steel (bar and forging)	1000	
		MIL-S-869, class A or B	Alloy steel for nitriding	950 and 850 respectively	VDPH 800 (minimum)

TABLE I. Materials. - Continued

Part or service		Applicable documents	Material and properties	Temperature limit (°F) (maximum) (see 3.2.2)	Remarks
Part A - Materials of principal parts.					
(y) Valve control (continued)	(3) Bushings and guides	QQ-B-691, class B	Carbon steel (plate)	800	See 3.4.50.12.7.4
		MIL-S-18410, class a	1-1/4 CR-1/2 Mo (forging)	1050	
		MIL-S-861, class 410, condition AN	12 Cr corrosion-resisting steel (strip and bar)	950	
		MIL-S-869, class A or B	Alloy steel for nitriding	950 and 850 respectively	VDPH 800 (minimum)
		QQ-S-763, class 440A, 440B or 440C with or without nitriding	16-18 Cr corrosion-resisting steel (bar and forging)	1000	---
	(4) Seating surface	MIL-R-17131, type MIL-RCoCr-A	Rod, welding	1050	See 3.4.50.2.7.3
Part B - Piping					
(z) Piping, (main steam)		MIL-STD-438	As required by referenced standard	As applicable	Submarines
		MIL-STD-777	As required by referenced standard	As applicable	Surface ships
(aa) Piping (lube oil and control oil)		MIL-STD-438 MIL-STD-777	As required by MIL-STD-438, except piping shall be in accordance with MIL-P-1144 seamless composition 304 or 316	---	---
Part C - Oils and greases					
(bb) Oil	(1) Lubricating	MIL-L-17331, Navy symbol 2190-TEP	Mineral oil	---	
(cc) Grease, lubricating		MIL-L-15719	---	300	---

NOTES to table I, parts A, B and C:

1. Fracture and other physical tests are waived; a visual examination is substituted.
2. General purpose use bearings are limited to applications of 200°F; applications above 200°F shall utilize bearings heat-stabilized for expected temperature. Selection of ball and roller bearings shall be based upon the optimum combination of allowable speed, load and life as determined by the bearing manufacturer.
3. Nil-ductility transition temperature (NDTT) tests are required only for carbon steels, with less than 1 percent (nominal) of any one alloy, that are used for structural members. NDTT shall not exceed plus 10°F as determined by the method described in ASTM E208. This requirement does not apply to plate thickness less than 5/8 inch or greater than 4 inches.

4. The 180 degree cold bend test is waived.
5 Heat indication tests and longitudinal test specimens are not required for carbon steel (grade A) single pressure stage turbine rotors or wheels.
6 Grade A is to be used only for turbine rotors or wheels for turbines that meet both of the following conditions:

(a) Steam inlet temperature does not exceed 650°F under normal operating conditions.
(b) Turbines are used on non-combatant ships.

3.2 1 Associated equipment specifications Documents governing selection of material for associated equipment shall be as follows:

	Equipment or accessory	Applicable document
(a)	Controllers (for oil pump motor)	MIL-C-2212
(b)	Coolers (for lubricating oil)	MIL-C-15730
(c)	Fittings, lubrication	MIL-F-3541
(d)	Gages, pressure (for oil or steam)	MIL-I-18997
(e)	Indicators, pressure (see gages)	
(f)	Indicators, temperature (see thermometers)	
(g)	Motors (for oil pumps)	MIL-M-17060
(h)	Pumps, rotary (for motor driven oil pump)	MIL-P-19131
(i)	Strainers (for oil system)	MIL-S-17849
(j)	Strainers (for main steam)	MIL-S-21427
(k)	Tachometers	MIL-T-16049
(l)	Thermometers (indicators)	MIL-I-17244 MIL-T-19646
(m)	Valves, combined exhaust and relief (shipbuilder furnished)	5000-S4824-1385797 or 5000-S4824-1385798

3 2 2 Maximum temperatures Table I specifies maximum temperature limits for materials required in major parts of turbines and gears. Average temperature to which these parts are subjected over any extended operating period shall not exceed the specified limit. Maximum temperature to which parts are subjected shall not exceed the temperature limit by more than 15°F, except for short swings. "Short swings" are temperature swings during abnormal or unusual operating conditions, during which the temperature shall not exceed

(a) Design temperature plus 25°F for more than 5 percent of the total operating life
(b) Design temperature plus 50°F for swings of 15 minutes duration or less, aggregating not more than 1 percent of the total operating life.

3 2.3 Chemical composition. Chemical composition of the materials shown in table I, may be changed to permit use at higher temperatures In such cases, complete examination and testing shall be performed in accordance with the basic specification. Prior approval shall be obtained as required for substitute materials (see 3.2.8).

3.2.4 Packing springs. Packing springs, in accordance with table I, shall be drawn without the use of metallic lubricant.

3 2.5 Stress criteria and allowable stresses.

3.2.5.1 Stress criteria. Maximum allowable stresses for the specified operating conditions shall be based on whichever of the following is limiting. Centrifugal stresses shall be based on the rated speed.

(a) Yield strength (at maximum temperature with offset of applicable material specification).
(b) Stress rupture (minimum of 40,000 hours)
(c) Creep (0.1 percent) for life specified (see 3.4.4) where temperature exceeds 800°F. (Creep is not applicable to specified factors of safety.)

3.2 5.2 Blading. Centrifugal stress (centrifugal load divided by full cross-section area) in the most highly-stressed row shall not exceed stress levels corresponding to a minimum factor of safety of two, except that a factor of safety of 1.5 is allowed for shrouding Vibratory stress data (see table X) shall be submitted to NAVSEC. The manufacturer's acceptance criteria shall also be submitted. Data shall be prepared as specified in 3.2.5.2.1 and 3.2.5.2.2.

3.2.5.2.1 Data reported. The blade design data report shall include the following for each stage:

(a) Centrifugal stress at 130 percent design r/min for blades and wheel.
(b) Steam bending stress at design r/min.
(c) Number of nozzles or stationary blades.
(d) Number of rotating blades per stage and per group.
(e) Maximum blade vibratory stress and location (tenon, vane, and so forth) for axial, tangential, and torsional in and out of phase modes of vibration.
(f) Frequencies in hertz and corresponding shaft r/min at which maximum vibratory stresses occur.
(g) Maximum blade combined stress and frequency at which maximum occurs.
(h) Manufacturer's acceptance criteria for centrifugal, steam bending, vibratory, and combined stresses.

3.2.5.2.2 Special operations. Data shall include any special limitations on shaft r/min for special operations such as locked shaft for multi-shaft ships or singled-up operations on single shaft ships.

3.2.5.3 Bolting. Turbine casing and steam chest bolting shall be designed to provide leak-tight joints for an initial period (following casing assembly) of at least 20,000 hours and, after retightening, for an additional period of 20,000 to 30,000 hours before again retightening based on relaxation strength of the material at maximum temperature involved.

3.2.5.4 Turbine rotors or wheels. Design primary stresses shall not exceed stress levels corresponding to the following minimum factors of safety:

(a) Centrifugal - 2.0
(b) Average tangential - 2.5
(c) Torsional - 5.0

3.2.6 Cast iron. Except as noted below, the use of cast iron parts is not permitted. Nodular iron, gray iron and close-grain semi-steel are, for the purposes of this specification considered to be cast iron. Nodular (ductile) iron conforming to MIL-I-24137, class A, is permitted for governor housings, governor servo housings, valve operator housings, lube oil pump casings, and other parts not listed in table I, providing nodular iron is not specifically prohibited in the specifications listed in section 2 herein and all items using nodular iron meet all of the other specification requirements, including shock (see 3.4.9).

3.2.7 Special material requirements. Special material requirements for turbines operating on saturated steam are as follows.

(a) Solid rotors, where wheel and shaft are forged integral, shall be made of a 12 percent chrome steel alloy material, grade G of MIL-S-860. Rotor journals or surfaces in way of bearings or babbitted sealing surfaces shall be chrome plated, or surface covered by a process previously approved by NAVSEC. The quality assurance procedures of MIL-S-860 will apply.
(b) Where the shaft and wheel are fabricated separately and assembled, the wheel shall be made of a 12 percent chrome steel alloy material, grade G of MIL-S-860, and the shaft of a material as shown in table I, part A.
(c) Turbine casings including exhaust end casings, steam chest covers, packing boxes, and packing ring holders (inner housing) shall be 12 percent chrome alloy steel in accordance with the material requirements of MIL-S-16993 or QQ-S-766.
(d) Nozzle plates or blocks shall be fabricated of 12 percent chrome alloy steel using material and welding procedure previously approved by NAVSEC.
(e) Internal parts of turbine such as diaphragm support lugs, gland and interstage packing anti-rotation pins, crush pins, internal moisture collectors, drain orifices, steam windage shields, valve lift beam, lift rods and all threaded fasteners subject to direct impingement of steam shall be corrosion-resisting steel of MIL-S-861. In addition, all threaded fasteners of the same size in the above applications on each turbine shall be of the same material.
(f) All external drain piping and manifolds from turbine (interstage, gland, and so forth) shall be fabricated of corrosion/erosion resistant material.
(g) Valve seat expansion lips or rings used for absorbing expansion between seat and body shall be constructed of nickel-chromium-iron alloy (73-15-7 nominal).

3.2.8 Substitute materials. The use of materials (either additional Government specifications or company materials in lieu of specified Government specifications) differing from those specified in table I will be permitted when all of the following conditions are met:

(a) The use of other materials represents no cost increase to the Navy
(b) Minimum factors of safety can be met with material in accordance with the applicable Government specification.
(c) List of preferred materials has been approved prior to the contract. (The date of the NAVSEC approval letter must be within 2 years of the contract date.)

3.2.8.1 Substitute material lists. The manufacturer shall prepare a technical report containing a "List of (company name) Preferred Materials for Mechanical Drive Steam Turbines and Gears" in accordance with the data ordering documents included in the contract or order (see 6.2.3) except the unique requirements of this paragraph and 3.2.8.1.1 shall apply. Once the list is approved, it shall be reviewed at least every 2 years for currency wih the referenced Government specifications. The revised list and related comparison sheets shall be submitted to NAVSEC for review. Changes to the manufacturer's materials require approval when they occur if revisions involve physicals, chemistry, processing or relaxation of quality control Revisions to the List of Preferred Materials are not retro-active unless mutually agreed upon. As a backup to the List of Preferred Materials, material comparison sheets (see 3.2 8.1.2) shall be submitted in order to evaluate the acceptability of the proposed substitute material. Where it is not obvious, the forwarding letter shall indicate the reasons for departures from the quality control requirements of the applicable Government specification. Approval of a comparison sheet constitutes approval to substitute that material only for the applications shown on the List of Preferred Materials.

3.2 8 1.1 List of preferred material. The List of Preferred Material shall be a drawing similar in format to the following

Part or service	Government specification	Company spec.	ASTM spec	Temperature limit	Remarks	NAVSEC approval letter
(List in same order as table I)			(If applicable)	(Shall not exceed limit of table I)		(Serial number and date)

Only the Government specifications which are used or substituted for by the company need be shown. Material comparison sheet or index number shall be shown in the remarks or separate column unless material identification number is identical. If the company specification is identical in every respect to the Government specification, such may be noted in remarks column and comparison sheets are not required.

3.2.8.1.2 Material comparison sheets. The manufacturer shall prepare Material Comparison sheets (i.e. technical report) in accordance with the data ordering document included in the contract or order (see 6.2.3) for each substitute material which is different from the applicable Government specification except that the following unique requirements shall apply. The manufacturer shall document on a separate sheet of paper a complete comparison in any of the following areas where any difference exists between the substitute material and the specified material:

(a) Chemical composition.
(b) Mechanical or physical properties.

Only significant differences between the substitute material and the specified material require documentation for the following areas, however, all instances where a requirement of the specified materials is not reflected in the substitute specification shall be included:

(c) Processing (heat treatment, and so forth).
(d) Examination, tests and quality control provisions.

If the substitute material is identical in all respects with the specified material in any of the above areas, a statement shall be made to that effect in lieu of a comparison, the statement "equal or better" is not acceptable. Each of the above documentations shall constitute one or more sheets in a multi-sheet drawing, properly indexed and titled. The issue of the Government specification for which comparison is being made shall be shown. If there is no applicable Government specification, the comparison sheet shall provide a comparison with an ASTM specification if applicable; if not, submit information covering only the company material. Each sheet shall be dated when issued and when revised. When a comparison sheet has been approved, it shall be resubmitted for information with NAVSEC approval letter noted thereon.

3.2.8.2 Non-specified materials. Materials for parts not specified in table I shall be as selected by the manufacturer.

3.3 Equipment required.

3.3.1 Turbines and gears. Turbines and gears shall be furnished in the quantity, in accordance with the requirements herein and as specified (see 6.2.2(c)).

3.3.1.1 Turb operating steam conditions.

3.3.1.1.1 Normal conditions. Normal (rated) steam inlet pressure and temperature (or percent moisture for class A and B turbines), at the trip throttle valve or trip valve inlet and normal (rated) exhaust pressure shall be as specified (see 6.2.2(d)).

3.3.1.1.2 Maximum and minimum conditions. Maximum and minimum steam inlet pressure and temperature (or percent moisture), at the trip throttle valve or trip valve inlet and maximum and minimum exhaust pressure shall be as specified (see 6.2.2(e)). (Also see 3.4.2 and 3.4.5.)

3.3.2 Additional equipment, fittings and accessories. Additional equipment, fittings and accessories shall be furnished with the turbines and gears as necessary to meet the requirements herein. The items to be furnished shall include, but not be limited, to those listed in table II, unless otherwise specified (see 6.2.2(f)).

TABLE II. Additional equipment, fittings and accessories.

Item	Turbine and gear
Y = Turbine manufacturer is required to furnish. N = Turbine manufacturer is not required to furnish (N items will be shipbuilder furnished unless otherwise specified.)	
Back pressure trip system (see 3.4.27.1)	Y (submarines)
Bedplates (see 3.4.17 and applicable pump or fan specification)	Y
Control systems (see 3.4.50) including:	
Trip throttle valve or trip valve as applicable	Y
Speed-limiting governing system, including:	Y
Speed governor (mechanical/hydraulic)	Y
Speed adjustment	Y
Speed control mechanisms	Y
Valve operator	Y
Nozzle control valves	Y
Emergency control system, including:	Y
Overspeed and manual trip system	Y
Orifices	Y
Couplings (see applicable pump of fan specification)	Y
Drawings and microfilm (see 3.7 and 3.8)	Y
Gage piping (see 3.4.29.3) and connections	Y
Gears, reduction (where used) (see 3.4.43 through 3.4.46)	Y
Identification plates (see 3.4.31)	Y
Instruments and special fittings (see 3.4.33 and 3.4.34), including:	
Gages, pressure, steam inlet and exhaust	Y
Gages, pressure, oil	Y
Gageboards	Y
Thermometers (indicators)	Y
Speed indicators	Y
Rotor position indicators	Y
Grease fittings	Y
Clips or fittings for holding insulation and lagging	Y

TABLE II. Additional equipment, fittings and accessories. - Continued

Item	Turbine and gear
Y = Turbine manufacturer is required to furnish. N = Turbine manufacturer is not required to furnish (N items will be shipbuilder furnished unless otherwise specified.)	
Lubricating oil systems (see 3.4.48), including:	
Sumps	Y
Attached oil pumps	Y
Motor driven oil pumps with controller (for main feed pump turbines of 501 hp and larger)	Y
Hand oil pumps (for main feed pumps only)	Y
Strainers (for main feed pumps only)	Y
Centrifugal jet reaction oil filters (for main feed pump turbines of 501 hp and larger)	Y
Filters	Y
Coolers	Y
Relief valves	Y
Check valves	Y
Cooler by-pass valves	Y
Gages	Y
Alarm switches (only for main feed pump turbines 501 hp and larger)	Y
Sight flow fittings	Y
Thermometers	Y
Orifices	Y
Repair parts and tools (see 3.5 and 3.6)	Y
Steam strainers (see 3.4.28)	Y
Technical data books (see 3.10) (only for group 1 turbines and gears 501 hp and above)	Y
Technical manuals (see 3.9)	Y
Turning devices, manual (see 3.4.32.1)	Y
Turning devices, power operated (for turbines of 2000 hp and more)	Y
Turning devices, power operated (for turbines under 2000 hp)	N
Valves, combined exhaust and relief (see 3.4.27.2)	N

3.4 Design concepts and basic criteria.

3.4.1 Reliability. All parts, except those parts classified as onboard repair parts, shall be designed such that they shall not be replaced or repaired during the specified life except for damage incurred due to external causes unrelated to design. Planned maintenance actions to be performed will be in accordance with table III with replacement or renewal of parts as found necessary. NAVSEC shall be notified if the proposed design requires planned maintenance actions different from table III. Turbine and gear casings will normally not be lifted for routine examination of internal parts unless there are indications of damage or deterioration of performance.

TABLE III. Planned maintenance actions.

Action	Frequency
Examine for steam and oil leaks Examine for loose items Check for unusual noise Check for unusual vibration Check pressure drop across strainers and filters. If excessive, clean or replace cartridge as applicable.	Once a watch

TABLE III. Planned maintenance actions. - Continued

Action	Frequency
Sample and examine lube oil Lubricate governor linkages Operate by steam, if available, or turn idle unit by hand	Weekly
Test speed-limiting governor, and test over-speed trips by overspeeding	Monthly
Clean lube oil sump Clean lube oil filters and strainers Replace lube oil Lubricate flexible couplings Sound and set up foundation bolts Measure thrust clearance Check lube oil low pressure alarm	Quarterly
Examine high speed flexible coupling Examine pir[illegible] and gears	Semi-annually
Determine be[illegible]ing clearances Examine and clean steam strainer Remove and test combined exhaust and relief valve	Annually
Examine all journal and thrust bearings Examine turbine and gear exterior Check gland packing for wear	At each regular overhaul

3.4.2 Standardization. Interchangeability of components and parts with units previously furnished is desired with particular reference to repair parts. The manufacturer shall notify NAVSEC when design changes are made which result in non-interchangeability with repair parts previously furnished. In addition, turbines and gears for pumps on non-nuclear surface ships shall be designed to operate over a definite range of horsepowers and speeds, as applicable (see table IV). To meet any requirements within the range, it shall be necessary to change only a few parts such as nozzle blocks and steam inlet valves, and this change shall be capable of accomplishment without any alteration to other parts of the turbine.

3.4.3 Accessibility. Design shall, within space limitations, provide the maximum accessibility to turbine and gear parts which require routine examination, maintenance and repairs. It is intended that design provide for minimum effort required to accomplish planned maintenance actions and to effect repairs.

TABLE IV. Standardized turbines and gears (for non-nuclear surface ships - turbines only).

Type 1/	Hp range	Speed range (pump speed) (r/min)	Inlet: Gage pressure up to lb/in^2	Inlet: Temperature up to (°F)	Inlet: Pipe size (Inches)	Exhaust: Gage pressure up to lb/in^2	Exhaust: Pipe size (Inches)	Rotation
Vertical application								
AGV	5-30	1000-2000	615	700	1	20	2-1/2	2/
BGV	35-150	1000-2000	615	700	1-1/2	20	3	
CGV	151-350	650-1500	615	700	2	20	6	
DGV	151-350	650-1500	615	850	2	20	6	
ADV	5-60	1000-2000	615	700	1-1/2	20	3	
CDV	151-350	1000-2000	615	700	2	20	6	
Horizontal application								
CGH	250-500	1000-2000	615	700	3	20	8	
ADH	35-150	3000-4000	615	700	1-1/2	20	3	
BDH	101-350	1000-2000	615	700	2	20	6	
CDH	151-500	5000-7500	615	700	2	20	6	
DDH	151-500	8000-10000	615	700	2	20	6	
JDH	501-1000	6000-8000	1200	1035	2-1/2	20	8	

1/ First letter: Designation of hp and speed ranges.
Second letter: G-Geared; D-Direct connected.
Third letter: V-Vertical, H-Horizontal.

2/ Rotation. Turbines and gears of the same type, service and rating procured under the same contract or order shall have the same rotation.

3.4.4 Life. Turbines and gears shall operate satisfactorily over an operating life of 100,000 hours at varying loads and speeds.

3.4.5 Hp rating. Hp rating of the turbines and gears shall be as required by the pump or fan specification. Turbines and gears shall also be capable of meeting the emergency requirements of 3.4.5.1

3.4.5.1 Emergency power. Turbines identified in table IV shall be capable of delivering rated power at the corresponding speed of the driven auxiliary, with satisfactory operation in all respects, including governing, under the following emergency conditions:

- (a) Steam pressure 10 percent greater than normal, other conditions as specified.
- (b) Steam pressure 20 percent less than normal, other conditions normal. This does not apply to forced draft fan (blower) turbines, unless specifically required (see 6.2.2(e)).
- (c) Exhaust gage pressure 25 lb/in^2, other conditions normal.

3.4.5.2 Hand-controlled nozzle valves. Auxiliary turbines shall be designed to deliver rated output of the driven at normal operating speed and under normal (non-emergency) specified steam and exhaust conditions without the use of hand-controlled nozzle valves. One hand-controlled nozzle valve shall be furnished for meeting the emergency low steam pressure requirement of 3.4.5.1(b) or high back pressure requirement of 3.4.5.1(c).

3.4.5.3 Multi-valves. Multi-valve governing (or nozzle control) valves, which are automatically controlled or under control of a single hand wheel are acceptable

3.4.6 Weight and space When specific weight and space limitations exist, they shall be specified (see 6.2.2(g)), if not specified, weight and space shall be kept to a minimum consistent with other requirements herein.

3.4.7 Extraction, induction and reheat No provision shall be made for extraction, induction or reheat.

3.4 8 Exceptions to specifications Where the manufacturer believes that he can supply turbines and gears of acceptable quality by proposing a substitution for any given design requirement in this specification, he may do so, providing all of the following are satisfied

- (a) Substitution does not compromise reliability or other criteria herein.
- (b) Substitution does not increase the contract cost or result in the subsequent higher cost of maintaining the equipment in service after acceptance by the Government
- (c) Substitution represents sound engineering approach to the original specification requirements based upon any of the following:
  - (1) Previous experience in service (Naval or comparable service).
  - (2) Test results acceptable to NAVSEC.

Request(s) for substitution may also be submitted after award of contract and are encouraged where either design improvements or cost reductions are involved.

3.4.9 Shock resistance. Mechanical drive auxiliary steam turbines and gears with associated accessories (see 3.3.2), that are mounted on the same bedplate, base or other support, shall withstand HI (high-impact) shock regardless of ship motion (see 3.4.12), load or speed up to and including rated load and speed. Turbines, gears and accessories shall comply with the requirements of MIL-S-901 for grade A, hull mounted, class I equipment. Turbines, gears and accessories shall be shock tested, assembled with the driven equipment, in accordance with the requirements of the specification for the driven equipment.

3.4.10 Vibration. Turbines and gears shall meet the vibration limits specified in 3.4.10.1 and 3.4.10.2.

3.4.10.1 Environmental vibration. Turbines and gears shall be designed to withstand, without malfunction, environmental vibration (type I of MIL-STD-167-1) applied at the turbine and gear mounting feet or base.

3.4 10 2 Internally excited vibration. Turbines and gears shall be designed to meet the vibration limits of 3.4.24 and the requirements of the specification for the driven pump or fan.

3.4.11 Steam economy. Steam economy is a basic design criteria. Guaranteed rates and method of evaluation shall be as specified (see 6.2.2(h)). Turbines for pumps and fans shall be designed for maximum economy, under the specified steam and exhaust conditions, at rated power of the driven auxiliary. Steam consumption determinations shall include all losses through the trip throttle valves, or trip valves, if used, steam strainers and governor valves, as well as through the turbine proper.

3.4.12 Trim, list, roll and pitch. Turbines and gears shall operate satisfactorily when the ship is in other than a normal condition, as shown in table V (trim and list or roll and pitch can occur simultaneously).

TABLE V. Trim, list, roll and pitch.

Condition	Surface ships
	Degrees
Permanent trim (down, bow or stern)	5
Permanent list (port or starboard)	15
Roll (port or starboard from normal) 1/	45
Pitch (up or down from normal) 1/	10

1/ Pitch and roll time cycle, if required shall be as specified (see 6.2.2(i)).

3.4.13 Basic design.

3.4.13.1 Turbines. Mechanical drive auxiliary steam turbines shall be in accordance with 3.4 13.1.1 through 3.4.13.1.5.

3.4.13.1.1 Pressure stages. Turbines shall have only one pressure stage.

3.4.13.1.2 Velocity stages. Turbines shall have not more than 2 velocity stages.

3.4.13.1.3 Steam flow. Steam flow shall be any one or any combination of the following:

(a) Axial flow
(b) Radial flow
(c) Helical (or tangential) flow
(d) Axial or radial re-entry flow

3.4.13.1.4 Non-condensing. Turbines shall be non-condensing.

3.4.13.1.5 Overhung wheels. Designs incorporating overhung turbine wheels will be given consideration provided bearing areas, size and rigidity of shafts and balance of wheels are satisfactory to NAVSEC (see 3.4.35.2.4).

3.4.13.2 Reduction gears. Reduction gears associated with mechanical drive auxiliary steam turbines shall be in accordance with 3.4.43 through 3.4.46.

3.4.14 Use of mercury. Turbines and gears and associated equipment for nuclear ships shall not contain mercury in any form and devices employing mercury shall not be used in the manufacture and testing, where the possibility of contamination of the equipment by mercury exists.

3.4.15 Fire hazard. Designs shall be such as to minimize the possibility of fire hazard. The following are areas to be carefully considered:

(a) Oil leaks onto lagging or hot surfaces.
(b) Lube oil gage and piping failures under shock or vibration resulting in spraying oil onto hot surfaces.
(c) Location of lubricating oil strainers to be as remote as possible from surfaces normally at high temperature.

3.4.16 Arrangement. Turbines and gears shall be designed to operate satisfactorily, when installed onboard ship, in either the fore and aft or athwartship orientation of the turbine, gear, pump and fan shafts. Horizontal pumps will normally be mounted fore and aft. Horizontal fans will be mounted either fore and aft or athwartships as ship arrangement dictates

3.4.16.1 Rotation and gear offset. Turbines and gears furnished under the same contract or order shall have the same rotation and the same gear offset.

3.4.17 Mounting and bracing. Turbines, gears and associated accessories shall be supported on the same bedplate, base or ring (center of gravity mount) as the driven pump or fan, in accordance with the requirements of the specification for the driven equipment. In addition, the requirements of 3.4.17 1 through 3.4.17.3 shall apply.

3.4.17.1 Materials. Materials of all mounts shall be in accordance with table I.

3.4 17 2 Mounting. Mounting shall be rigid to permit handling, shipment, and installation onboard ship, without unduly disturbing alinement (see 3.4.18). During installation the shipyard will check alinement and correct as necessary.

3.4.17.2.1 Bearing and seating surfaces. Bearing and seating surfaces of mounts (bedplates, bases, and so forth) shall be finish machined.

3.4.17.2.2 Doweling. Each component part of an assembled machine supported directly by the bedplate or supports shall be doweled thereto to facilitate reassembly and maintenance of alinement. Dowels shall be unequally spaced or of different sizes, to avoid improper reassembly.

3.4 17.3 Bracing. Turbines and gears shall not be braced, restrained or otherwise restricted, except by bolts, keys or dowels, securing them to their bedplates or supports.

3.4 18 Alinement. Design shall be such that alinement will not be disturbed or undue stresses set up in any part by normal vibration or contraction and expansion of turbine, gear and piping attached thereto in service. Dowels, keys, rabbets or other positive locating means shall be used as necessary to assure that alinement will be maintained despite slight loosening of hold-down bolts under shock load conditions. Outline drawing shall show the limits of forces and moments that may be imposed by shipbuilder's piping.

3 4 19 Expansion and flexibility Turbines shall include those supports which are necessary to permit free longitudinal and radial casing expansion to allow for rated power temperature.

3 4 20 Bolts The responsibility for drilling flanges and providing bolting shall be as indicated hereinafter. Whoever provides bolting is responsible for liaison with all others concerned to determine thickness of mating parts (and gaskets if used).

3.4.20 1 Bolts for securing to external systems. Bolts for securing external system connections shall be furnished and installed by the shipbuilder Holes for these bolts shall be drilled by the turbine manufacturer, except that holes for fitted bolts will be finish-reamed by shipbuilder at installation. A 1/16 inch stock allowance on the bolt hole diameter shall be made by the manufacturer for reaming by the shipbuilder.

3.4.21 Lifting. Means shall be provided for lifting all items weighing 35 pounds or more. (Also see 3.4.35.2.5.7, 3.4.40.10 and 3.4.40.11.)

3.4.22 Marking of parts Use of low stress die stamps for marking on low stressed surfaces is permitted, however, depth of penetration shall not exceed 0.020 inch except for radiographic location markings on castings which may be 1/32 inch in accordance with MIL-STD-271.

3.4.23 Clearance requirements. Design clearances shall be provided to prevent rubbing between stationary and moving parts during all specified operating conditions except that minor contact of labyrinth type packing rings with rotor and minor rubs of oil deflectors, bands and spill strips are acceptable. Carbon type packing rubbing the shaft is acceptable (see 3.4.23.1.2).

3.4.23.1 Packing (gland) clearances. Gland packing clearances shall be in accordance with 3.4.23.1.1 or 3.4.23.1.2.

3.4.23.1.1 Packing (labyrinth type) clearances. Radial clearances between labyrinth packing rings and shaft shall (at installation) be not less than either 0.005 inch (tolerance included) or the clearance corresponding to 80 percent of "normal clearance" (clearance expected to exist after preliminary acceptance trails) whichever is larger.

3.4.23 1.2 Packing (carbon type) clearances. Carbon packing, where permitted (see 3.4.42.3 2), may have either shaft or butt clearance. Type and amount of clearance is the manufacturer's option.

3.4.23.2 Rotor clearance measurement and adjustment. Provision shall be made to measure and adjust the axial position of each rotor; however, such adjustment shall not be possible when rotor is rotating.

3.4.24 Mechanical vibration and balancing.

3.4.24.1 Allowable vibration. Unless special structureborne noise levels are specified (see 6.2.2(k)), the maximum allowable levels of forced vibration shall be as shown on figure 1.

3.4.24.2 Shop balance. Turbine rotors shall be dynamically balanced to meet the vibration limits of 3.4.24.1 with all rotating parts installed. Balancing shall be conducted at the maximum safe operating speed of the balancing machine or rated speed of the turbine whichever occurs first. Final shop balance shall be accomplished by the removal of metal from the rim of the turbine wheels. Rotor drawings shall clearly indicate the locations and the amounts of metal that may be safely removed for the shop balance. For requirements for balancing gear rotating elements see 3.4.45.15.

3.4.24.3 Special balance. When contract requires special efforts to obtain noise reduction, maximum efforts shall be made in the production phase to minimize the amount of corrections required during either spin testing or load balancing.

3.4.24.4 In-field balance. When contract requires special efforts to obtain noise reduction (see 6.2.2(j)), provision shall be made for in-field balancing each turbine rotor without lifting the casing in accordance with 3.4.24.4.1 through 3.4.24.4.4.

3.4.24.4.1 Correction planes. A minimum of two correction planes shall be provided for each turbine rotor. Use of weights in in-field balance planes is to be limited, during factory balance, to 15 percent of the total correction available in each plane.

3.4.24.4.2 Access to correction planes. Access to correction planes shall be through either existing inspection openings, outer removable gland covers, bearing caps, coupling guards or special flanged access holes. Minimum effort to install weights is desired.

3.4.24.4.3 Balance weights. Balance weights shall be either threaded weights for tapped holed or weights secured in dovetail grooves. Provision shall be made to mechanically lock in the weights.

3.4.24.4.4 Phase angle measurement. Provision shall be made for taking phase angle measurements during balancing. Special parts for so doing are not required to be furnished. Shafts shall be marked for use of a stroboscope, photocell or magnetic pick-up. The technical manual shall indicate where the shaft is marked.

3.4.25 Threaded fasteners. Threaded fasteners shall conform to the applicable documents listed in table I for the applications indicated and as specified in 3.4.25.1 through 3.4.25.1.4. The various types of screw threaded fasteners shall conform to ANSI standards. Threaded fasteners for all steam joints shall be installed using an anti-seize compound which is compatible with the base materials involved. In addition, all threaded fasteners of the same size internal to each turbine shall be of the same material.

3.4.25.1 Screw threads.

3.4.25.1.1 Unified thread series. Screw threads shall be of the unified thread series in accordance with Handbook H28.

3.4.25.1.2 Coarse versus fine thread series. Coarse thread series shall be used unless the component design indicates a necessity for the use of the fine thread series.

3.4.25.1.3 Eight-thread series. For fasteners 1-inch diameter and larger, the eight-thread series shall be used wherever practicable.

3.4.25.1.4 Preferred thread-series. In the selection of special threads, preference shall be given to the use of the 20, 28, 36, 44 and 56 thread series.

3.4.25.2 Class of fit.

3.4.25.2.1 Class 2A-2B. Class 2A-2B fit shall be used for the major portion of interchangeable screw thread fasteners.

3.4.25.2.2 Class 3A-3B. Class 3A-3B fit shall be limited to applications where the necessity for accuracy of lead and angle of thread can be justified.

3.4.25.2.3 Class 5. Class 5 interference fits shall not be used.

3.4.25.3 General rules for applications.

3.4.25.3.1 Regular versus heavy series. Where necessary for purpose of bearing loads, pressure tight flanges and other special applications, heavy series shall be used for 1 inch size and larger.

3.4.25.3.2 Thread engagement. Thread engagement for studs and cap screws shall be not less than the nominal diameter. Threads of nuts shall be fully engaged. The maximum protrusion of the fastener from the face of the nut shall not exceed approximately 1/2 of the full nominal thickness of the nut for sizes up to 1-1/2 inch diameter or 1/2 of the nut thickness for larger sizes.

3.4.25.3.3 Tapped holes. Tapped holes for stud-bolts and cap screws shall be bottom tapped if the thickness of the remaining material is equal to or less than major diameter of the thread and in such instances they shall have full threads for the specified depth.

3.4.25.3.4 Fitted (body-bound) fasteners. Bolts stressed in shear shall be fitted. Holes for body-bound fasteners shall be reamed with coupled parts in position, to dimensions that will assure a tight fit. Tolerances in table VI shall be used for body-bound bolts.

3.4.25.3.5 Locking devices. Nuts on moving parts, internal parts directly exposed to blade path, control mechanisms, and support structures shall be securely locked. Self-locking nuts conforming to MIL-N-25027 may be used. Locking wire shall not be used for securing nuts. Self-locking threaded fasteners shall not have been threaded on to an engaging part more than 5 times.

TABLE VI. Tolerances for body-bound fasteners.

Nominal bolt size	Tolerances in inches		
	Maximum clearance-body of bolt and hole	Diameter of hole	Body of bolt
Inches	Plus	Plus	Minus
1/4 to 3/8, incl.	0.0015	0.0009	0.0006
7/16 to 11/16	.0017	.0010	.0007
3/4 to 1-1/8	.0020	.0012	.0008
1-1/4 to 1-7/8	.0026	.0016	.0010
2 to 3	.0030	.0018	.0012
3-1/4 to 4-3/4	.0036	.0022	.0014
5 to 7, incl.	.0041	.0025	.0016

3.4.25.3.6 Internal bolting. Use of internal bolts and studs in way of steam path shall be avoided to the maximum extent practicable without unduly complicating the design. Where internal bolting must be removed to lift casing, a warning plate so stating shall be permanently attached to the casing and shall protrude beyond lagging.

3.4.25.3.7 Acceptable types of fasteners. Threaded fasteners shall be through bolts or through studs (two-nut type). Where impracticable to comply with the foregoing, bottoming studs (one-nut type) or tap bolts may be used; however, tap bolts shall not be used for the following.

(a) Steam chest cover.
(b) Horizontal joints.

Bottoming studs shall be either class 2A or 3A fit. Details of bottoming studs shall be submitted to NAVSEC for information. Class 5 interference fits shall not be used. Studs which cannot enter the casing if they come loose may be treated with "Loctite" or equal for temperatures below 300°F.

3.4.25.3.8 Bolt heating. Highly stressed studs 2 inches in diameter and larger in non-gasketed steam joints (such as casing joints and steam chest cover-joint) shall be drilled to permit the use of bolt heaters to obtain required stud extension without undue slugging and overtorquing. The corresponding cover nuts shall also be drilled to permit the use of extensiometers to determine stud extension.

3.4.25.3.9 Bolt heaters. Electrical bolt heaters and extensiometers shall be furnished for submarine machinery. Cable assembly shall be grounded. For surface ships, gas heaters may be used in lieu of electric heaters Bolt heaters shall be designed with thermal capacity (based upon 15 minutes heating time per bolt) to produce required bolt extensions.

3.4.25.3.10 Stud removal. An internal socket-head machined in end of stud or square end (or hex end) shall be provided to facilitate removal of one-nut studs 1 inch in diameter or larger where used in non-gasketed steam joints. At the manufacturer's option, stud removers (collet-type) may be furnished in lieu of the internal socket-head recess or external wrenching flats on end of one-nut studs.

3.4.25.4 Torque. For critical applications such as steam joints and support structures, the threaded fasteners shall be tightened to specified tension by either elongation measurement or measuring flats. The turbine manufacturer shall establish these requirements and shall control adherence thereto during manufacture.

3.4.25.5 Pins and dowels. Tapered pins and dowels shall be secured from backing out by staking or other locking devices, welding is permitted where the dowel or pin becomes a permanent part of the removable piece. Dowels and pins shall be provided with means of removal such as tapped holes, external wrenching or pulling heads, or shouldered shanks.

3.4.26 Welding and allied processes. Welding and allied processes shall be in accordance with MIL-STD-278. Spray metallizing shall not be acceptable. Chrome plating on shafting shall be in accordance with NAVSHIPS 0919-000-9010.

3.4.27 Protection from high back pressure. Turbine exhaust casing shall be protected from overpressurization in accordance with 3.4.27.1 and 3.4.27.2.

3.4.27.1 Combined exhaust and relief valve. A combined exhaust and relief valve, similar to those shown on Drawings 5000-S4824-1385797 and 5000-S4824-1385798, will be supplied by the shipbuilder for all turbines. The valve will be sized so that the main valve will limit the pressure inside the turbine casing to the hydrostatic test pressure of the casing with the steam inlet fully opened and the valve hand wheel in the relief position.

3.4.28 Steam strainers. A steam strainer shall be provided upstream of the turbine governing, trip or trip throttle valve. Strainer (all pipe sizes) shall be in accordance with MIL-S-21427 and shall be readily accessible for replacement, examination, and cleaning, and arranged so that all steam to the turbine shall pass through it. Wye type strainers are preferred, but other types will be permitted where space is limited. Strainers shall have only one inlet and one outlet connection. Inlet connection shall be flanged. The outlet connection shall be either flanged or welded to the governing, trip or trip throttle valve inlet connection. Strainers shall be composition A, B or C in accordance with MIL-S-21427 as required for the design steam conditions. Design shall be such that all steam will enter the inside of the strainer basket, so that any foreign material intercepted by the strainer may be withdrawn with the basket. Flanges shall be in accordance with 3.4.29. Blow-down connections are required. A steam strainer need not be supplied at the turbine inlet when a pump pressure regulating device, incorporating a steam strainer in accordance with the foregoing is supplied external to the turbine.

3.4.28.1 Steam strainer gaskets. Gaskets for steam strainer flanges shall be in accordance with MIL-G-21032 or MIL-G-16265, as applicable.

3.4.29 Piping, valves and associated equipment.

3.4.29.1 General requirements. Main steam inlet flange on the governing, trip or trip throttle valve and the main steam piping, if any, upstream of the valve, furnished with the turbines shall be in accordance with MIL-STD-777 (surface ships) or MIL-STD-438 (submarines) as applicable. Spiral wound gaskets may be of the inner and outer ring type. Piping for lube oil and control oil systems and oil gages shall be stainless steel in accordance with MIL-P-1144, type I, seamless, composition 304 or 316. Other piping furnished with the turbines and gears shall be to ASTM standards with allowable stresses, flange rating and geometry as outlined in the applicable ANSI standards. Piping shall be seamless except where such is not commercially available for large sizes. Gaskets to commercial standards are acceptable except that joint design shall be such that replacement with gaskets to Government specifications can be made. Tapered pipe threads are not permitted.

3.4.29 2 Connections to shipbuilders' systems.

3 4.29.2.1 Allowable reactions. Steam and oil connections at turbine or gear shall be such that unacceptable strains are not imposed on equipment by shipbuilder's piping. Data on allowable force and moment reactions which turbine can safely withstand shall be forwarded to the shipbuilder and shall be shown on the outline drawing (see 3.7.4.1).

3.4.29.2 2 Flanged connections. Steam piping connections to which shipbuilder connects shall be flanged and shall terminate at a point outside of turbine lagging line. All oil piping connections to which shipbuilder connects shall have male-female flanges conforming to ANSI standards. Mating flange, of a material comparable to the turbine or gear flange, shall be furnished with the turbine or gear. Bolting and gaskets will be shipbuilder furnished.

3.4.29.3 Gage piping and gage connections. Piping and connections for all gages shall be in accordance with Drawing 810-1385850, MIL-F-18866 and the following:

(a) Pressure gage connections shall be in accordance with the standard seat requirements of MIL-F-18866.
(b) Only 1/4 inch outside diameter (od) tube size shall be used.
(c) The pressure rating of fittings will be upgraded for 1/4 inch od tube size and below from 3000 to 6000 lb/in working pressure with a minimum test pressure of 10,000 lb/in.
(d) On gage testers where the connections are 1/4 inch NPT, an adapter shall be furnished with a 1/4 inch NPT connection on one end and a swivel type connection (similar to the swivel 90 degree elbow end, shown in MIL-F-18866) on the other end.
(e) Gages shall have connections externally threaded for fittings
(f) Pressure gages shall not be stem mounted

3 4 29 3 1 Root valve. A root valve of light weight construction, shall be installed between each gage and the piping system or component to which the gage is attached

3 4.29 4 Other component piping and connections. Other component piping and connections may be welded, if take-down joint is not required for maintenance and overhaul. Where take-down joint is required, it shall be flanged using male-female flanges or it shall have straight threads with O-rings in accordance with the requirements of MIL-F-18866 The wall thickness of tubing used shall be not less than 0.065 inch in sizes above 1/2 inch Where flanges are used in oil piping, male-female flanges conforming to ANSI standards shall be used. Tapered pipe threads are not permitted. Steel socket welding fittings in accordance with ANSI B16.11, schedule 40, are suitable for 50 lb/in self-contained lube oil systems. Face-feed silver-braze fittings in sizes 1/2 inch and above are not permitted for any components furnished. Only preinserted ring fittings shall be used in sizes 1/2 inch and above. Face-feed fittings may be used in sizes below 1/2 inch. Brazing shall be accomplished in accordance with NAVSEA 0900-LP-001-7000. Mechanical bite-type fittings shall not be used.

3.4.30 Pipe plugs and petcocks.

3.4.30.1 Pipe plugs. Use of tapered pipe plugs shall be limited to only essential applications due to their susceptibility to coming adrift under shock. Where use is unavoidable, they shall be secured by tack or seal welding.

3.4.30.2 Petcocks. Petcocks shall not be used on turbines, gears or any associated accessories, such as lube oil strainers or filters due to their susceptibility to opening when subjected to shock or vibration or to being otherwise opened accidentally.

3.4.31 Identification plates. Metallic identification plates shall be attached to each turbine and gear. Plate shall be made of corrosion-resisting steel, nickel-copper-alloy or brass. The markings on these plates shall be stamped, etched, engraved or cast in such a manner as to produce permanent and durable markings. Etchings, engravings or stampings shall be not less than 0.003 inches deep. The characters on cast plates shall be raised to at least 0.03 inches. Etched, engraved or stamped markings shall be filled with black enamel or lacquer. The plate shall include the information shown on figures 2 and 3 for turbines and gears respectively.

3.4.32 Turning device (jacking gear). A turning device shall be furnished in accordance with 3.4.32.1, to prevent bowing of rotors when turbine is being secured or is at standby.

3.4.32.1 Manual turning device. Turbines and gears, shall have provision for turning rotor, by hand, using either a ratchet turning tool, a bronze headed bar to fit between coupling bolts or a bar to fit in special drilled holes in the shaft. Turbines 150 hp and below, where space limitations must be considered, strap wrenches will be satisfactory.

3.4.32.2 Power-operated turning devices. Turbines of 2000 hp or more shall be equipped with a power-operated turning device. A three-way valve or an interlock shall be furnished and installed such that the trip throttle valve cannot be opened when the turning gear is engaged and so the turning gear cannot be engaged unless the trip throttle valve is closed. Design shall be such that damage to the device or a personnel hazard will not result from momentary engagement of the device with the turbine rotor rotating or by driving the turbine rotor with steam while switching from one mode of operation to the other.

3.4.33 Instruments and special fittings (also see 3.4.28, 3.4.34 and 3.4.48).

3.4.33.1 Gage (indicators). All required pressure gages (indicators) shall be furnished as required by table II, and shall be in accordance with MIL-I-18997.

3.4.33.2 Gage locations. Provision shall be made for pressure taps and piping leading to gages from the following locations:

(a) Pressure gage - on the steam chest, ring or bowl downstream of the control valves.
(b) Pressure or compound gage - on exhaust casing.
(c) Pressure gages as required by 3.4.48.19 for the lubricating oil system.

3.4.33.3 Gage size. Pressure gages shall be 4-1/2 inches in diameter.

3.4.33.4 Gageboard. The turbine manufacturer is not required to furnish a gageboard for the gages required by 3.4.33.2(a) and (b). A gageboard with gages will be shipbuilder furnished. All other gages (see 3.4.48.19) shall be furnished by the turbine and gear manufacturer and mounted on individual or common gageboards or brackets, as desired. These gageboards or brackets shall be attached to the bedplate and shall also support the piping to the gages to prevent relative movement between the gage and piping due to shock or vibration. Gages shall not be stem mounted.

3.4.33.5 Gage connections. The connections on the pressure gages shall be in accordance with the figure shown in MIL-F-18866 for standard seat. The hardness and the finish of the connections shall be in accordance with the requirements for hardness and finish specified in MIL-F-18866. Only the 1/4 inch o.d. tube size shall be used.

3.4.33.6 Thermometers. All required thermometers shall be furnished by the turbine and gear manufacturer.

3.4.33.7 Thermometer locations. Thermometers shall be furnished at the oil cooler, oil and water inlet and outlet (four required) and in each journal and thrust bearing drain line. Thermometers shall be located so that they are accessible and readable after installation onboard ship. Thermometers may be combined with sight flow fittings.

3.4.33.8 Thermometer range. Thermometers shall have a range of 30°F to 240°F.

3.4.33.9 Thermometers. Thermometers shall be in accordance with MIL-I-17244 or MIL-T-19646.

3.4.33.10 Speed-indicators (tachometers). Speed-indicators shall be furnished as follows:

(a) For forced draft fans (blowers). Speed-indicators for forced draft fans (blowers) shall be furnished in accordance with the requirements of MIL-F-18602.
(b) For 501 hp and above turbines for pumps. Permanently installed speed-indicators shall be provided on all 501 hp and above turbines for pumps, so located that they may be readily observed; in case it is impracticable to mount these indicators on the turbines, mounting on the driven pump will be permitted. The speed-indicator shall conform to type IC/EFC or IC/EFD of MIL-T-16049. A 4 to 4-1/2 inch diameter indicating instrument shall also be furnished. The speed range shall be from 0 speed to 25 percent above rated speed. System inaccuracy shall not exceed 1-1/4 percent in the speed range of 5 percent below to 20 percent above rated speed. At all other speeds the system inaccuracy shall not exceed 5 percent.

3.4.33.11 Hand tachometers. Hand (portable) tachometers are not required, but provisions shall be made on the main shafts of all classes and groups of pump turbines for the use of tachometers for setting over-speed trips and speed-limiting governors. Provisions are required for use of two independent hand tachometers as follows:

(a) In the end of the main shaft for use of a portable rubber tipped tachometer.
(b) By a mark on an exposed area of the main shaft for use of a non-contact, portable self-contained tachometer conforming to MIL-T-16049, type IC/PEC.

3.4.33.12 Rotor position indicator. Indicators shall be provided for determination of rotor axial position while the turbine is at rest. They shall also be capable of determining total rotor movement (float) forward and aft with thrust shoes removed.

3.4.33.13 Grease fittings. Grease fittings conforming to type III of MIL-F-3541 shall be provided where grease lubrication is required.

3.4.34 Thermal insulation and lagging. Shipbuilder will be responsible for furnishing and installing thermal insulation and lagging. Turbine manufacturer shall advise the lead (design) shipyard of maximum casing temperatures. The lead shipyard will inform the turbine manufacturer of the requirements for attachments on casing. Such attachments shall be furnished by the turbine manufacturer and shall not involve welding after final heat treatment of the casings, except for carbon steel casings or where the manufacturer elects to weld large nickel-chromium-iron (73-15-7 nominal) "buttons" on alloy casings before heat treatment. The wires or hooks can then be welded on the "buttons" at any convenient time. Turbine manufacturer shall also advise the lead shipyard of any areas of insulation that should be shielded to prevent oil soaking with consequent risk of fire. Type, size and location of attachment devices shall be such as to permit removal of insulation covering examination openings and flanged joints. For permanent insulation, high temperature insulating cement may be used in lieu of hooks.

3.4.35 Bearings, radial (journal) and axial (thrust).

3.4.35.1 Bearings for forced draft fan turbines. Bearings for forced draft fan (blower) turbines shall be in accordance with the requirements of MIL-F-18602.

3.4.35.2 Bearings for pump turbines and gears.

3.4.35.2.1 Bearings for main shafts (see 3.1.4). Bearings for pump turbine and gear main shafts shall be in accordance with 3.4.35.2.2 through 3.4.35.2.10.

3.4.35.2.2 Materials. Materials for all bearing parts shall be in accordance with table I.

3.4.35.2.3 Type and number of bearings. The following applies to all bearings on a common shaft or on two rigidly connected shafts:

(a) Radial bearings shall be either all sliding contact type or, where allowed (see 3.4.35.2.6) all rolling contact type; dissimilar types will not be permitted.
(b) If practicable, all radial bearings shall be interchangeable.
(c) There shall be not more than three sliding contact radial bearings.
(d) Where rolling contact bearings are allowed (see 3.4.35.2.6 and 3.4.35.2.8), not more than one radial and one angular type or two radial and one axial type are permitted; the axial bearing shall be mounted to take no radial load.
(e) Where rolling contact axial (thrust) bearings are allowed (see 3.4.35.2.8), they may be used with sliding contact radial bearings, provided the rolling contact thrust bearings are mounted so that they take no radial load.

3.4.35.2.4 Overhung turbine and gear rotors. Overhung turbine rotors (or wheels) and pinion and gear rotors are acceptable on turbines and gears of 500 hp and below for either horizontal or vertical pumps, provided the bearing areas and shaft diameters are adequate and the manufacturer can furnish evidence of satisfactory performance of identical or similar turbines and gears in similar service. NAVSEC will consider new designs for turbines and gears of 500 hp and below, if the manufacturer can furnish sufficient justification for substituting the new design (see 3.4.13.15).

3.4.35.2.5 Radial bearings for turbines and gears, 501 hp and above. Radial bearings for pump turbine and gear main rotating elements, for 501 hp and above, shall be either plain cylindrical, elliptical, multi-lobed, tilting shoe (or pad) or pivoted shoe (or pad) type in accordance with 3.4.35.2.5.1 through 3.4.35.2.5.12.6 and shall be split along the axis. Precision insert type bearings are acceptable. Axial, spiral or circumferential grooving is permitted.

3.4.35.2.5.1 Loading. Bearing load based on projected area shall be not greater than 250 lb/in under steady load or 500 lb/in under sudden load changes. Projected area is defined as the product of the nominal diameter and length of the journal bearing.

3.4.35.2.5.2 Wear pattern. Load shall be distributed so as to produce an essentially rectangular wear pattern extending throughout the length of the bearing. Scraping following initial operation to obtain uniform patterns is permissible but shall not increase the original diametral clearance by more than 15 percent of the nominal clearance for the turbine bearings and 0.002 inch deviation for pinion and gear bearings. All contact shall be only in the middle 120 degrees of arc in the lower half of turbine bearings or in the loaded half of pinion and gear bearings.

3.4.35.2.5.3 Clearance. Nominal design diametral clearance shall be not less than 1.5 mils per inch of nal diameter for turbine and pinion bearings or not less than 1 mil per inch of journa. diameter for gear bearings.

3.4.35.2.5.4 Interchangeability. Maximum interchangeability (consistent with design requirements) is required among bearings.

3.4.35.2.5.4.1 Doweling. Doweling shall be provided when necessary to prevent inadvertent assembly of a bearing in a location of position for which it was not inteded. Where thin wall construction of bearing halves will not permit the use of dowels, other means will be considered.

3.4.35.2.5.5 Shell stiffness. Bearing shells shall be stiff to prevent warping in service.

3.4.35.2.5.6 Rolling out bearing. It shall be possible to remove each lower-half bearing without removing the rotor.

3.4.35.2.5.7 Lifting and handling bearings. Provision shall be made for removal, lifting and handling of bearings as follows:

(a) Cap. Each bearing cap shall either have integral lifting lugs or be tapped for lifting eyes which shall be so located as to prevent cocking when lifting the cap.
(b) Bearing shells. Each upper half-shell weighing more than 35 pounds shall be tapped for one or more lifting-eyes. In addition, regardless of weight, each lower half-shell shall be provided means for removal, when rolling out around journal.

3.4.35.2.5.8 Reboring directions. Each rebabbittable spherically-seated bearing and each sleeve bearing which is not bored concentric with the outer surface of the shell shall be provided with a concentric reference shoulder at each end for reboring. Unless otherwise marked on the bearing, the outside diameter (od) of the shell will be used as the reference shoulder for boring.

3.4.35.2.5.9 Support. Each bearing shall be supported by and contained in a housing consisting of a bearing pedestal and cover (also see 3.4.40.8). Journal and thrust bearings shall be contained in a common housing. Bearings may be mounted in a fixed position or mounted to provide for self alignment by using a spherical seat or flexible supports. Spherical seats may be either loose or tight according to manufacturer's standard practice. If a loose spherical seat is employed, adequacy of design with respect to fretting damage and tolerance to dirt shall be established.

3.4.35.2.5.10 Bearing surfaces.

3.4.35.2.5.10.1 Babbitt lining. Friction or rubbing surfaces shall be lined with anti-friction metal in accordance with table I. Babbitt thickness shall be not more than 3/16 inch.

3.4.35.2.5.10.2 Babbitting procedures. Procedure for babbitting bearings shall be in accordance with NAVSHIPS 0283-228-1000 except that bond tests are not required.

3.4.35.2.5.10.3 Surface finish. Babbitt surfaces shall be finished to 32 rhr or less prior to scraping or initial operation.

3.4.35.2.5.10.4 Edge relief and chamfer. Babbitt shall be relieved along the joint at bore to prevent babbitt carryover and scoring of journals.

3.4.35.2.5.10.5 End flow control. End leakage of oil from multi-lobe fixed-pad, tilting pad and pivoted-pad bearings shall be controlled by a circumferential dam or seal strip at each end of bearing. Circumferential drain groove(s) shall be provided at one or both ends of other type bearings, with drain areas equal to or greater than end leakage areas.

3.4.35.2.5.11 Rotor radial position setting. Where adjustable seating shims or pads are used for fixed-position mounting of bearings, means for determining the radial position of the rotor shall be provided.

3.4.35.2.5.12 Crown thickness measurement. Provision shall be made for measuring wear by the crown thickness method, as specified in 3.4.35.2.5.12.1 through 3.4.35.2.5.12.6.

3.4.35.2.5.12.1 Scribe lines on cylindrically-bored sleeve bearing. At each end of the bearing, the unloaded half shall have a radial scribe line at the vertical center line, and the loaded half shall have, at each end, three radial scribe lines (the central scribe at the vertical center, and one on each side at an angle approximately 45 degrees). Both ends of bearing shall have an o.d. machined to provide a reference surface for the micrometer.

3.4.35.2.5.12.2 Scribe lines on multi-lobed bearing types. A radial line shall be scribed on each end of the bearing shell at the geometric center of each bearing surface arc whose center is displaced from the bearing center.

3.4.35.2.5.12.3 Scribe lines on fixed-pad bearings. A radial line shall be scribed on each end of the bearing shell at the geometric center of the concentric arc of each pad.

3.4.35.2.5.12.4 Scribe lines on tilting or pivoted-pad (or shoe) bearings. A radial line shall be scribed on each end of each tilting or pivoted-pad or shoe in line with the fulcrum or pivot point on the back of the pad or shoe.

3.4.35.2.5.12.5 Point of measurement. Crown thickness of each sleeve type bearing shell and each pivoted shoe at the scribe points shall be measured from the end of the shell or shoe during assembly at a distance established by the manufacturer and shown in the manual and on applicable drawings.

3.4.35.2.5.12.6 Marking of constants. Crown thickness constants shall be stamped adjacent to scribed lines at both ends of bearing. For spare bearings, constants shall be stamped at time of installation.

3.4.35.2.6 Radial bearings for turbines and gears 500 hp and below. Radial bearings, for main shafts of turbines and gears of 500 hp and below may be of either the sliding contact or rolling contact type.

3.4.35.2.6.1 Sliding contact bearings. Where sliding contact bearings are used, they shall be in accordance with 3.4.35.2.5 through 3.4.35.2.5.12.6.

3.4.35.2.6.2 Rolling contact bearings. Where rolling contact bearings are used, they shall be in accordance with FF-B-171, FF-B-185 or FF-B-187, except where quiet operation is required (see 3.4.35.2.11). Bearings shall be selected to result in a minimum L-10 life of 10,000 hours. Rolling contact bearings on turbine and gear main shafts shall be oil lubricated.

3.4.35.2.6.2.1 Pulling tools. Where special pulling tools are required, they shall be furnished (see table VIII).

3.4.35.2.7 Axial (thrust) bearings for turbines and high speed pinions 501 hp and above. Axial bearings for pump turbine and high speed pinion main shafts, for 501 hp and above, shall be of the tilting or pivoted shoe (pad) segmental thrust type in accordance with 3.4.35.2.7.1 through 3.4.35.2.7.9.

3.4.35.2.7.1 Tilting or pivoted shoe (pad) segmental thrust bearings. Tilting or pivoted shoe (pad) segmental thrust bearings shall be of the automatic load equalizing type designed to take thrust in both directions. Preferably, thrust shoes shall not be attached to, or derive support from, the journal bearing. Sliding contact between leveling plates and base ring is prohibited.

3.4.35.2.7.2 Load. Thrust bearing shall be capable of absorbing any thrust loads which may be developed during specified operation. In addition, the thrust bearing shall be sized to include ample capacity for absorbing loads corresponding to 25 percent (minimum) of the tangential driving force in the flexible coupling connecting turbines and pumps or gears. Unit design loading, including the coupling force above, but excluding transients shall not exceed 500 lb/in under normal steady state condition. The 500 lb/in loading shall be based upon net pad area of the bearing with no area subtracted for chamfers and radii on the edges of the shoes.

3.4.35.2.7.3 Housing. Thrust bearing housing shall be integral with the journal bearing pedestal. Housing shall be rigid to maintain axial clearances in turbine under load. A 1/8 to 3/16 inch permanently-open drain shall be provided from the lowest practicable part of the thrust cavity to ensure drainage at shutdown.

3.4.35.2.7.4 Shims. Liners or shims shall be fitted to permit adjustment of thrust clearance and of ax clearances within turbine. Stacking of shims is not permitted.

3.4.35.2.7.5 Collar. A removable thrust collar keyed to shaft shall be provided, with a sliding fit (0.002 ± 0.001 inch loose) on the rotor, with a nut to secure the collar against the rotor shoulder. Room shall be incorporated in the design to permit slugging tight the securing nut, which shall have a right-hand thread, regardless of direction of rotor rotation. A positive means of locking thrust nut shall be provided; the use of a radial set screw is not acceptable. A thrust collar integral with a removable stub shaft is acceptable. Consideration will be given to a thrust collar made as an integral part of the turbine shaft in arrangements where a collar with a sliding fit cannot be tolerated, such as an arrangement whereby the thrust collar serves a double function of a thrust collar and coupling flange for transmitting power or where a tight, non-readily removable fit is considered necessary to maintain thrust surface squareness. With an integral thrust collar the thrust bearing must be of the pivoted shoe type having a rating of at least 50 percent greater than the application requirements, and the thrust surface on the thrust collar must have a stock allowance of at least 1/4 inch on the thrust surface for reconditioning purposes. The rotor configuration having an integral thrust collar must be so designed that a replacement of the integral collar with a keyed, shrunk-on and axially locked thrust collar will be possible.

3.4 35.2.7.6 Shoes. Thrust shoes (or pads) shall be lined with anti-friction metal in accordance with table I. Dovetail grooves in shoes to anchor the babbitt are permitted but are not required. Each thrust shoe shall pivot about a line or point contact. Each thrust shoe shall be interchangeable with all other thrust shoes on both sides of the thrust collar. Shoes shall be designed so that they cannot be inadvertently installed in a location or orientation for which they were not intended.

3 4.35.2.7.7 Contact areas and bearing surfaces. Friction and contact surfaces shall be smoothly and accurately finished. Surface finish and Brinell hardness requirements shall be as follows:

- (a) Collar (or runner) - 32 rhr or better (300 Brinell minimum).
- (b) Leveling plate (or link) contact areas - 32 rhr or better on surfaces in contact with shoes or base ring, 63 rhr or better on wing surfaces.
- (c) Buttons - 32 rhr or better (500 Brinell minimum).
- (d) Base ring contact areas (or hardened inserts, where used) 63 rhr or better.
- (e) Shoe babbitted surface - 32 rhr or better.

3.4.35.2.7.8 Wear measurement. The detail drawing of the shoe shall indicate by note the place (thickness between button or other indicated surfaces on back of shoe and babbitted face of shoe) and design value of such a measurement, so that a micrometer check can be made to determine when to rebabbitt shoe. Drilling of holes through the body of a shoe for driving out buttons is not permitted in rebabbitting. The button shall be removed from the rear of the shoe by minor machining operations at the rear only.

3.4.35.2 7.9 Clearance. Design clearance shall be at the manufacturer's option; however, allowable increase in clearance shall be at least 50 percent of the maximum initial clearance.

3.4.35.2.8 Axial (thrust) bearings for turbines and high speed pinions 500 hp and below. Axial bearings for pump turbine and high speed pinion main shafts, for 500 hp and below shall be of the following types:

- (a) Tilting or pivoted shoe (pad) segmental type in accordance with 3.4.35.2.7.1 through 3.4.35.2.7.9.
- (b) Tapered land in accordance with 3.4.35.2.8.1.

(c) Flat face (or land) in accordance with 3.4.35.2.8.1.
(d) Combined radial and axial rolling contact (angular) in accordance with 3.4 35.2.8.2.
(e) Axial rolling contact in accordance with 3.4.35.2.8.2.

3.4.35.2.8.1 Tapered land and flat face thrust bearings. Tapered land and flat face thrust bearings shall be in accordance with 3.4.35.2.7.2 through 3.4.35.2.7.5, 3.4.35.2.7.7(a), 3.4.35.2.7.7(e), 3.4.35.2.7.8, 3.4.35.2 7.9 and the following.

(a) The thrust shoes, pads or plates shall be lined with anti-friction metal in accordance with table I.
(b) Dovetail grooves, to anchor the babbitt, are permitted, but are not required.

3.4.35.2.8.2 Rolling contact axial and angular (thrust) bearings. Where rolling contact bearings are used, they shall be in accordance with 3.4.35.2.6.2.

3.4.35.2.9 Axial (thrust) bearings for low speed gear shafts. Axial bearings for low speed gear shafts may be any of the following:

(a) Tilting or pivoted shoe (pad) segmental type in accordance with 3.4.35.3.7.1 through 3.4.35.3.7.9.
(b) Tapered land type in accordance with 3.4.35.2.8.1.
(c) Flat face type in accordance with 3.4.35.2.8.1.
(d) Combined radial and axial rolling contact (angular) in accordance with 3.4.35.2.6.2.
(e) Axial rolling contact in accordance with 3.4.35.2.6.2.

3.4.35.2 10 Bearings for accessory drive shafts (see 3.1.5). Elements of accessory drives may be supported by sliding surface bearings or rolling contact bearings or combination thereof provided that flexibility is incorporated in each design using both types of bearings in a line of shafting Materials shall be in accordance with table I.

3 4 35.2.11 Noise tested bearings. Noise tested bearings in accordance with MIL-B-17931 shall be used on all turbines and gears and where required to meet specified noise levels (see 6.2.2(j)).

3.4.35.3 Special bearing tools.

3.4.35.3.1 Bearing yokes and jack bolts. Lifting gear set shall include yokes, jack bolts, and other special items necessary for removing the weight of rotors from, lower-half bearings to permit removal of same from one generator set.

3.4.35.3.2 Rotor jack. A special device shall be furnished to provide for jacking rotor forward and aft to measure thrust clearance.

3.4.35.4 Oil deflectors. Aluminum or bronze oil deflectors shall be provided to prevent leakage of oil from bearing housing.

3.4.35.5 Steam shields. A steam shield shall be provided to prevent gland steam from entering bearings.

3.4.36 Couplings. Couplings shall be in accordance with the requirements of the specification for the driven equipment. Couplings shall be capable of ready disassembly, without moving turbine, gear or driven equipment, in order to test the speed-limiting governor and the overspeed trips. Coupling halves when uncoupled, shall be such as to allow operating the turbine and gear up to the overspeed trip setting speed without endangering personnel or equipment.

3.4.37 Turbine blading and seal strips.

3.4.37.1 Materials. Blades, locking pieces and pins shall be of material specified in table I.

3.4.37.2 Production method. Blades shall be machined (milled, cut, or broached) from bar or forged stock.

3.4.37.3 Solid blades. Vane shall be solid and shall be produced with blade base from same piece of blade stock; welding of vane to base is not permitted.

3.4.37.4 Edge radii. Blades shall have vane edge radii equal to or greater than the minimum values shown on figure 4.

3.4.37.5 Surface finish. Blading shall be free from imperfections. Steam flow from surfaces of blading and root or dovetail load carrying surfaces shall be finished to 63 rhr or better.

3.4.37.6 Stellite erosion shields. Where the combination of moisture and tip speeds are such that erosion of blades may be a problem, blade inlet convex side shall be hard-faced with stellite brazed with a nickel rich silver-brazing alloy. Decision as to whether or not stellite shields are required will be based on previous operating experience under similar conditions for tip speeds in excess of 800 feet per second (f/s) and moisture content of 10 percent or greater. Alternate means of erosion protection will be considered.

3.4.37.7 Contour of contact root surfaces. Bucket dovetail surface which contacts wheel outside diameter shall be cut to the same or slightly larger radius than the wheel; bucket dovetail hook load surfaces shall be cut to the same or slightly smaller radius as the corresponding wheel dovetail surfaces.

3.4.37.8 Blade tenon. Shrouding shall be attached to blades by riveted (peened) tenons; welding is prohibited. Hot peening is acceptable; however, temperature shall be controlled by positive means such as a surface pyrometer or tempil sticks.

3.4.37.8.1 Fillets. Sharp corners between tenon and tip of blade and between vane and blade base shall be avoided by filleting.

3.4.37.8.2 Tenon shape. Tenons shall be of round cross section unless other shapes are required due to either geometry or strength reasons.

3.4.37.8.3 Tenon head. Riveted tenon shall form a head on outer surface of shroud. Where holding power of tenon provides the required safety factors, the head and any excess shroud thickness may be machined off to provide flush tenon heads. Tenon shall be peened or riveted to the extent that the chamfer in the shroud band hole is filled.

3.4.37.9 Shrouding.

3.4.37.9.1 Materials for shrouding. Shrouding shall be of the materials specified in table I.

3.4.37.9.2 Number of blades per shroud strip. Number of blades per shroud strip shall be as recommended by the turbine manufacturer and shall be indicated on the applicable drawings.

3.4.37.9.3 Notch block gap. The shroud strip segment may span the gap where a notch block is used (and the blade omitted). Where quietness of operation is a requirement, (see 6.2.2(k)) every effort shall be made to close the gap with a closing blade which can be shrouded.

3.4.37.9.4 Drilling or punching of shroud. Shroud tenon holes may be drilled, milled or punched. When shrouds are milled or punched, each set of blades for stock shall include the necessary milling template or punches. Drilled or milled shrouding requires no annealing. Punched shrouds with thickness of 3/16 inch and larger shall be stress relief annealed after punching. Tenon holes shall have a chamfer or radius on both sides of the shroud and shall be located directly from the bladed wheel, or from templates made or set therefrom; spare shroud bands shall be furnished without tenon holes. A note on detail drawings shall indicate that the method of making holes in the shroud is an acceptable method, known not to cause cracks. Method of installation, showing or stating number of holes in each strip, shall also be shown. If a choice of milling or punching shrouding for replacement blading exists, the drawing note shall so state.

3.4.37.9.5 Contact area with vane tip. Shrouding shall, at installation, have maximum bearing practicable against the end of blade vane. Limits in gap clearance shall be as specified in 4.5.2.2.

3.4.37.9.6 End gap between adjacent shroud strips. Shroud strips shall have enc clearance to ensure that, under maximum operating speed and temperature, they do not expand so as to touch each other and impose stress on blade tenons.

3.4.37.9.7 Bevel on sealing edge. Shroud strips of more than 1/16 inch thickness used to seal axially, shall be beveled along the sealing edge to approximately 1/32 inch edge thickness.

3.4.37 9.8 Slanted shrouding. The installation of shrouding at an angle is permitted up to 15 degrees maximum angle with rotor axis.

3.4.37.9.9 Channel shrouding. Channel shrouding is permitted only in conjunction with segmental blading.

3 4.37.10 Blade root fastenings in rotor. Rotor blade root fastenings may be either radial-entry or axial-entry. Blade attachment to rotor shall be by mechanical means and shall use either "T" of "Fir Tree" shaped roots, except that pin type blade roots are acceptable for turbines 500 hp and below. The entering edge of blade roots shall have a 0.010 inch minimum chamfer.

3.4 37.10 1 Axial entry blades. For axial entry blades, nonhardened steel pins (of size and shape to permit shearing when driving individual blades out of grooves) shall be provided to secure blades against axial movement in operation. Blades shall obtain necessary blade fit in blade grooves by filing metal ridge on bottom of blade root or by other means. Where pitch of blades is controlled, blades may be installed with clearance in the root; however, maximum movement as measured at the blade tenon shall not exceed 0.020 inch per inch of overall blade height for double tang roots and 0.010 inch per inch of overall blade height for triple tang roots.

3.4.37.10 2 Radial entry blades. Radial entry blades shall be installed with a machined fit as specified by pertinent dovetail drawing Required fit may be obtained by either filing or trimming a metal ridge on the blade or by use of calking strips Calking strips shall be rectangular or half-round pieces equal in length to the approximate thickness of the blade root Locking pins for the notch block or closing blade shall be of the material specified in table I The use of shims for circumferential fitting of blades is not permitted

3.4 37 10.3 Pin type blade roots Blades with pin type roots shall be installed with a machined fit as specified on the blade or wheel detail drawings. A template, or other means, shall be used to assure that blades are installed at the correct angle, when assembling blades on the wheel. Provision shall be made to prevent blades rotating out of position when in service. Pin roots may be riveted against the wheel.

3 4.37.11 Stationary blading Stationary blades may be installed individually or as groups of blades Intermediate segments and separate blade rings shall be secured to the casing by either mechanical means, or calked in to a dovetail groove of the casing Materials used shall be as required by table I.

3.4.37.12 Seal strips. Axial and radial seal strips may be used. If used, they shall be firmly secured and shall be replaceable. Materials for seal strips shall be in accordance with table I.

3.4.38 Nozzle blocks, plates or jets.

3.4.38.1 Materials. Materials for nozzle blocks, plates or jets, partitions and bolts shall be in accordance with table I and 3.2.7.

3.4.38.2 Steam flow surfaces. Steam flow passages shall have a surface finish of 63 rhr or better in direction of steam flow except for approach to throat section which may be 125 rhr maximum.

3.4.38.3 Construction. Nozzle blocks, plates or jets shall be either fabricated, cast, or reamed construction.

3.4.38.4 Nozzle block, plate or jet details.

3.4.38.4.1 Securing block in casing. Nozzle blocks, plates or jets shall be removable from casing When bolts are used for this purpose, the bolt heads shall be recessed below the surface of the surrounding metal and shall be secured by either peening in at least 3 places, or by suitable shielding. Shielding or retaining segments shall be made of the same material as the nozzle block and shall be retained either by welding center of the segment to the nozzle block or by peening segment grooves at outer ends of segments. Tack welding is not permitted. Where more than one segment is used they shall be installed with gaps between segments. Each gap shall be greater than the maximum thermal growth the segments can experience, but less than the diameter of a nozzle block bolt head. Calking strips and spacers used to retain nozzle blocks in casing grooves shall be secured to prevent their falling out or rotating in the groove.

3.4.38.4.2 Nozzle bridges. Adjacent arcs or groups of nozzles shall be bridged to minimize leakage.

3.4 38.4.3 Nozzle spacing. Nozzles shall be spaced to avoid resonance with blade passing frequency.

3 4.38.5 Partitions. Partitions shall be rolled, cast or machined. Trailing edges of partition vanes shall conform to radii shown on figure 4. The following additonal requirement applies to cast partitions:

Precision-cast 13-chrome partitions may be used, provided each casting includes a partition integral with a thick band or ring segment at each end, such segments, when welded together are to form heavy inner and outer bands or rings.

3.4.39 Reversing chambers and re-entry nozzles. Reversing chambers and re-entry nozzles shall be readily replaceable. Materials shall be in accordance with table I. Partitions shall be polished to remove all tool marks. Surface finish shall be 63 rhr or better. The edges of the partitions shall be in accordance with figure 4 and shall be free of any nicks or cracks. Fillets shall have a minimum radius of 1/8 inch.

3.4.40 Turbine casings and steam chests.

3.4.40.1 Materials. Casings, including gland housings and packing ring holders, and steam chests, shall be of materials specified in table I and 3.2.7, except that, where carbon packing is used, (see 3.4.42.3.2) gland housings shall be of corrosion-resisting steel.

3.4.40.2 Construction. Casings and steam chests may be cast, fabricated or combinations thereof. Steam chests and casings shall be sufficiently rugged to withstand without fracture or appreciable distortion, the strains to which they may be subjected. Steam chests shall be suitably stayed and stiffened and unless integral with the casings, shall be secured thereto by through bolting. Casings and steam chests shall be steam tight ie no steam leaks. This requirement also applies to all joints such as the turbine casing, vertical and horizontal joints, the steam chest and cover joints and the gland housing joints.

3.4.40.2.1 Blade throw-out protection. Each casing shall be designed to contain blades which may be thrown from any row of the turbine at any speed up to 110 percent of rated speed.

3.4.40.3 Allowable steam velocity. Design of all turbines and their connections shall be such that with full load and normal steam conditions the inlet steam velocity will not exceed 9,000 feet per minute (ft/min). Steam passages shall be smooth and free from burrs or other obstructions likely to cause eddies. The exhaust velocity shall not exceed 15,000 ft/min when operating at rated speed and with rated steam inlet and exhaust conditions.

3.4.40.4 Casing joints. Turbine casings for horizontal pumps and blowers shall be divided at the horizontal centerline. Turbine casings for vertical pumps and blowers shall be divided into at least two parts. These divisions shall be such as to allow easy access to the interior of the turbine and to permit ready removal of wheels (or rotors) and nozzles.

3.4.40.4.1 Access for wrenching. Clearance shall be provided around bolt heads and nuts to permit use of standard tools; however where joint integrity would be compromised, the use of special tools (to be furnished with the turbine) to accommodate closer bolt spacing is acceptable.

3.4.40.4.2 Joint surface. Flange faces shall be finished to parallel surfaces with a surface finish of 63 rhr or better. The sealing surface of each flange shall be a plane with no discontinuities or steps along the flange except at junction of other major joints.

3.4.40.4.3 Flange chamfer. Joint surfaces in way of flange bolts or studs shall be chamfered or counterbored.

3.4.40.4.4 Making-up joint high pressure, high temperature. Joints shall be made-up metal-to-metal at room temperature; however, flange faces may be coated with either a thin coating of bodied linseed oil, or other commercially available sealing compounds. Procedure and compounds to be used shall be submitted to NAVSEC for information. Joints subjected to only exhaust pressure and less than 500°F may be made up using a suitable joint compound or a sheet asbestos gasket, providing there is no mechanical necessity, such as supporting bearing shells, for a metal-to-metal joint. However, where gaskets are used, casings shall be rigid to maintain alinement and prevent distortion under any normal operating condition.

3.4.40.4 5 Pumping grooves Flange pumping grooves shall not be provided.

3.4.40.4 6 Steam chest joint. The joint between steam chest cover and chest shall be metal-to-metal and shall be made-up in the same manner as the casing horizontal joint. As an alternate, the joint between the steam chest and steam chest cover may be made up using a spiral wound gasket providing

(a) Required gasket is round or other regular readily available shape. (No odd or irregular shapes will be permitted.)
(b) Joint is provided with dowels and stops to assure proper alinement.

3.4.40.5 Steam inlet connection. Steam inlet pipe shall be attached to the side or end of the steam chest and not interfere with removal of steam chest cover. The location of the connection shall be as specified (see 6.2.2(l)).

3 4.40.6 Test connection. Special test connections may be provided at manufacturer's option, however, such connections shall be closed by threaded plugs (taper or straight thread) or by blank flanges. Plugs, if used, shall be seal welded.

3.4.40 7 Exhaust connections. Exhaust connections shall be circular. Horizontal forced draft fan (blower) turbines and type JDH pump turbines shall have a double exhaust, one on either side of the turbine. A cover with bolts, nuts and gaskets shall be furnished for blanking the side not used Other horizontal turbines exceeding 150 hp shall be provided with direct downward or side outlet exhaust connections in the lower halves of the casing. The exhaust connection for horizontal turbines 150 hp and below and for all vertical turbines shall be arranged so that the connection need not be broken for routine shipboard maintenance or when turbine rotor or wheel requires replacement.

3.4.40.7 1 Responsibility for bolting Bolting and gasket (if required) will be furnished by shipbuilder except that cap screws or one-nut studs shall be furnished with the component tapped for same

3 4 40.8 Bearing housings If the bearing housings are separate from casing, a centering shoulder, spigot, radial keys or radial dowels shall be provided at the joint between housing and casing. Space shall be provided between bearing and glands to prevent leakage oil from entering the glands and gland steam blow from entering the bearings Drain pockets and cavities between bearing and gland shall be avoided, so as to reduce the possibility of contamination of oil and condensate systems due to flooding of an improperly-drained pocket. When the use of a pocket is unavoidable, the cavity shall be as deep as possible with maximum volume and shall be drained by a 1-inch diameter (minimum) drain (or equivalent area with minimum dimension not less than 1/2 inch), such drains shall not be plugged, or otherwise restricted and outline drawing shall so indicate. If necessary, a pipe shall be attached to the drain hole to lead the drainage around any lagging or hot surfaces (see 3.4 15(a)).

3 4.40.9 Access openings. Access openings shall be provided at both ends of all turbines (where special noise levels are specified to permit in-place balancing of rotors without lifting the casings or performing other major time consuming operations (see 6.2.2(j)).

3.4.40.10 Casing lifting.

3.4.40 10.1 Jacking bolts. Flange jacking bolts shall be provided as necessary to permit readily breaking joints.

3.4.40.10.2 Stud removal. Design shall be such that dismantling or assembly does not require the removal of studs.

3.4.40.11 Lifting gear. Lifting and handling gear (including flange jacking bolts) necessary for lifting the turbine and gear upper-half casings, rotors and gear rotating elements of one turbine and gear constitutes one set. Lifting shall be possible when the ship has a list and trim of 5 degrees.

3.4.40.11.1 Materials for lifting and handling gear. Lifting and handling gear shall be of steel except that aluminum may be used for casing supports and rotor guides.

3.4.40.11.2 Lifting and supporting upper-half casing. Lifting gear set shall include at least 3 corner guide pins or posts, dowelled casing supports, special eye-bolts, and such other items as are necessary to lift and support the upper-half casing. Casing supports shall be 36 inches in height or of a height to clear the turbine and gear rotors, whichever is less.

3.4.40 11.3 Lifting and supporting rotor. Lifting gear set shall include rotor guides and saddle support assemblies, special eye-bolts, and any other special equipment necessary for lifting and supporting turbine rotors and gear rotating elements.

3.4.40.11.4 Shipbuilder-furnished lifting gear. Traveler bars and trolleys, pulleys, deck-beam clamps, turnbuckles, shackles, hooks, chains, hoists, wire slings with thimbles, and spreader beams (for rotors) will be shipbuilder-furnished.

3.4.40.12 Moisture separation and drainage.

3.4.40.12.1 Internal moisture separation. Provision shall be made for the damage of all parts of turbine casings and steam chests. Ample drain pockets shall be provided.

(a) Casing drains. Casing drainage shall be collected internally and the turbine manufacturer shall provide a drain connection at the low point of the [illegible]ine casing. Turbine and gear assembly drawing shall show the dra[illegible] Outline and arrangement drawing shall also show the drain connection and indicate whether it is a continuous drain or is to be open only when the turbine is secured and during start-up. If the drain is open continuously the drawing shall indicate if an orifice is used or if a trap is required (traps are not desired because of their high maintenance). Orifices, if required, shall be furnished by the turbine manufacturer. Traps, if required, will be shipbuilder furnished.
(b) Steam chest drains. Blanked-off flanges shall be provided to permit drainage of steam chest.

3.4.40.13 Steam shields. Steam (or windage) shields are not required.

3.4.40.14 Non-destructive testing requirements. Casing and steam chest castings and weldments shall be tested in accordance with the requirements of 4.4.

3.4.41 Turbine rotors (or wheels and shafts).

3.4.41.1 Materials. Rotors, wheels and shafts shall be of materials specified in table I and 3.2.7.

3.4.41.2 Construction. Rotors, or wheels and shafts may be either of the following:

(a) Wheel and shaft machined from a single forging.
(b) Wheel shrunk or pressed on shaft, their positions being positively fixed by a shoulder on one side and lock nuts or shrink rings on the other.

3.4.41.3 Stresses. Stresses shall be in accordance with 3.2.5.4.

3.4.41.4 Balancing. Balancing and vibration limits shall be as required by 3.4.24.

3.4.41.5 Coupling flange. Coupling flange on the drive end of each rotor shall be shrunk on or shall be integral either with the rotor or with a stub shaft bolted to the rotor. The turbine manufacturer shall collaborate with the manufacturer of the driven component to obtain mutually acceptable coupling design and loads (see the specification for the driven equipment).

3.4.41.6 Provision for hand tachometers. (See 3.4.33.11.)

3.4.41.7 Surface finish. Surface finish of the overall rotor shall be 125 rhr maximum except as follows (maximum rhr values):

(a) Bearing journals - 32 (axial and circumferential direction)
(b) Radii of equalizing or steam or mechanical balancing holes - Polished to 63 (see note)
(c) Fillets and radii - 63
(d) Axial blade grooves - 63
(e) Circumferential blade grooves - 63
(f) Load carrying surfaces of blade dovetail - 63

Note: Tapped holes for balance weights are excluded.

3.4.41.8 Bearing journals. Special attention shall be paid to roundness and concentricity of journals. Deviation from true roundness shall not exceed 0.000050 inch for turbines (submarines) and other turbines where quiet operation is specified, (see 6.2.2(j) and (k) and 0.0003 inch for all other applications. Deviation in true roundness is defined as the difference in radii of two concentric coplanar circles which just contain the measured profile of the journal surface.

3 4.41.9 Packing journals. Packing journals shall be smooth or stepped as necessary to match packing teeth The use of packing sleeves shrunk on or keyed to rotor is prohibited. Lands shall be rugged to withstand contact both radially and axially with the fins of the packing rings. Shafts shall be suitably protected against corrosion by chrome plating in way of carbon packing.

3.4.41.10 Limiting reduction of journal diameter. Drawings and technical manuals shall show the limits below which bearing and packing journals should not be reduced when making repairs and using special bearings or packing. Where reducing diameters is unsafe or impracticable, the drawings and technical manuals shall so state (see 3.7.4.4.2 and table XI, category I, item 5).

3.4.41.11 Rotor bores. Rotors may be solid or bored, if bored, the bore shall be chemically cleaned, purged with an inert gas and sealed with air tight plugs.

3.4.41.12 Match marks. At installation of the rotor, axial and circumferential position of the rotor relative to the casing shall be marked for future reference when reinstalling rotor after repair or overhaul. These marks shall be accessible without lifting the casing but removal of bearing caps is acceptable and shall be in tenths of a mil.

3.4.41.13 Helical flow turbine wheels (or rotors) Partitions of helical flow turbine wheels shall be polished smooth and free of machine tool marks or other imperfections The leading edge of the partition shall be rounded to a minimum of 1/16 inch radius. Bucket partition thickness shall be 0.140 inch minimum and shall have a root fillet radius of 1/8 inch minimum

3 4 41.14 Steam balance holes The number and location of steam balance holes shall be such that they will not be coincident with nodal diameters

3.4.41 15 Critical speeds. Design of rotors shall be such that either the calculated or actual running first critical speed is at least 25 percent above the maximum operating speed.

3.4.42 Turbine shaft gland housings and gland packing. Gland housings and gland packing shall be fitted around all turbine shafts to prevent leakage of steam and water from, or ingress of air, oil or oil vapor into the turbines under all conditions of operation.

3.4.42.1 Materials. Materials used in shaft gland housings shall be as required for casings (see 3.4.40). Materials for gland packing assemblies shall be in accordance with table I and 3.2 7. (Also see 3.2 4 for additional requirements for springs.)

3.4.42.2 Design. One-half of each gland housing (the upper half for horizontal turbines) shall be bolted to the "upper" half turbine casing, so that the housings can be removed for examination, removal and repair of all gland packing rings, on both ends of the turbine, without lifting the turbine casing. The design shall also be such that the "upper" half gland housing can remain attached to the "upper" half turbine casing when the turbine casing is lifted. The "upper" half packing rings shall be secured so that they do not fall out when the housing is lifted. The design shall permit rolling out of "upper" half packing rings after housings are lifted and shall also permit rolling out of the "lower" half packing rings without lifting the turbine rotor. The "lower" half gland housing may be either integral with or bolted to the "lower" half turbine casing. If bolted, the "lower" gland housing shall have a rabbet for accurate positioning.

3.4.42.3 Type of gland packing. Type of gland packing shall be as required by 3.4 42 3 1 and 3.4.42.3.2.

3.4.42.3.1 Gland packing (metallic labyrinth). Metallic labyrinth packing shall be used for all shaft gland packing on all turbines 501 hp or above and on turbines less than 501 hp where any one of the following exists:

(a) Exhaust gage pressure exceeds 350 lb/in^2.
(b) Exhaust temperature exceeds 750°F.
(c) Shaft surface speed exceeds 600 feet/second (ft/s).

3.4.42.3.2 Gland packing (carbon). Carbon packing may be used for shaft glands, on turbines less than 501 hp where operating conditions do not exceed any of the limits given in 3.4.42.3.1.

3.4.42.4 Gland exhaust connection. Provision shall be made for collecting any possible leakage through the packings. Where labyrinth packing is used, the turbine gland exhaust connections shall be sized to pass the steam and air discharged when the gland seals are worn to twice the design clearance, or at the manufacturer's recommended maximum service clearance, whichever is largest.

3.4.42.5 Flexibility. Each ring shall be spring backed to control radial movement. Springs for labyrinth packing may be either flat or coil type. Springs for carbon packing shall be coil (garter) type and shall also hold the ring tight against the sealing surface.

3.4.42.6 Stops. A stop shall be provided for each packing ring to prevent the ring from turning with the shaft. The stops shall be located at the joint between the two halves of the gland housing and shall engage a recess in the outer circumference of each packing ring. The recess r the ring shall be at the end of one segment of the ring.

3.4.42.7 Surface finish. Steam seal surfaces shall have a surface finish of 63 rhr or better.

3.4.42.8 Marking of rings. To ensure correct installation, each seal ring shall be marked as follows:

(a) The mating surfaces of adjacent segments shall be match marked.
(b) Each ring with "T" shaped retaining shoulders and which can be improperly installed shall be stamped either with an arrow pointing aft or other marking to clearly indicate proper installation.

3.4.42.9 Labyrinth packing (metallic). Labyrinth packing rings shall be machined from cast cylinders. Each ring shall be divided into at least 4 segments, each segment spring backed to allow the segment to move radially in case of contact with shaft. Rings shall be machined with integral fins, thinned on the inner diameter to an axial dimension of 0.010 ± 0.005 inch. Calked-in fins are not acceptable.

3.4.42.10 Carbon packing. Where carbon packing rings are used, there shall be at least 4 rings fitted in each gland housing. Each ring shall be divided into 3 segments and backed by a garter type spring. The segments may be butt-fitted, with shaft clearance or may have butt clearance (shaft fitted). Each ring shall be in a separate compartment, the sides of the rings and the walls of the compartment forming a sealing surface to minimize leakage around the rings. The ring and spring design shall be such that the spring will hold the ring against the sealing surface. For turbines 150 hp and above the rings shall be approximately 1/2 inch square in cross-section. Deep recesses or slots, which may weaken the segments or render them unduly fragile are not acceptable.

3.4.43 Reduction gears. Reduction gears for mechanical drive auxiliary steam turbines shall be in accordance with 3.4.43.1 through 3.4.46.

3.4.43.1 Number of reductions. Reduction gears shall be in either single or double reduction.

3.4.43.2 Gears 151 hp and above. Reduction gears for turbines 151 hp and above shall be either:

(a) Single helical.
(b) Double helical.

3.4.43.3 Gears 150 hp and below. Reduction gears for turbines 150 hp and below shall be one of the following:

(a) Single helical.
(b) Double helical.
(c) Spiral bevel.
(d) Combination of (a) and (c) or (b) and (c).
(e) Worm and worm wheel.

3.4.44 Reduction gear casings.

3.4.44.1 Materials. Casings shall be of material specified in table I.

3.4.44.2 Construction. Casings may be cast, fabricated or combinations thereof.

3.4.44.3 Bearing housings. Thrust and journal bearings shall be directly mounted on or within the gear casing.

3.4.44.4 Bearing bores. Bearing bores shall be properly machined and scraped, as necessary, to ensure correct alinement.

3.4.44.5 Casing splits. Casings shall be divided as necessary to provide accessibility to pinions, gears, bearings and other parts which will require routine maintenance.

3.4.44.6 Access openings. Access openings shall be provided to permit examination of the interior of the casing. The openings shall provide for examination of the entire tooth length of each element and observation of the oil spray pattern. Each access opening shall have a raised lip and shall be provided with a closure secured by a hinge pin on one end and a clevis on the other. Bolts, pins and nuts shall be riveted on such that parts cannot fall into the gear case during examination. Each closure shall be designed so that foreign material cannot enter the access opening and oil cannot leak from the opening when the closure is secured.

3.4.45 Gear rotors.

3.4.45.1 Materials. Materials of gear main rotating elements shall be in accordance with table I.

3.4.45.1.1 Through hardened gears. Where through hardened gears are required (see 3.4.45.3), the pinions and gears shall be in accordance with MIL-S-19434 and the pinion shall be at least one class higher than the gear.

3.4.45.1.2 Case hardened gears. Where case hardened gears are required, (see 3.4.45.2 through 3.4.45.5), the pinions and gears shall be either nitrided or carburized unless otherwise specified (see 6.2.2(m)). Where gear elements are to be nitrided, they shall be in accordance with classes 2 through 4 of MIL-S-19434 or AISI class 4140 or 4340 steels. Where gear elements are to be carburized, they shall be either class 4615 or 8615 in accordance with MIL-S-866.

3.4.45.1.3 Nitrided gear properties. Gears and pinions, case haidened by nitriding, shall have properties as follows:

(a) Case hardness shall be 50 Rockwell C minimum.
(b) Case thickness shall be 0.015 inch minimum.
(c) Core hardness shall be 27 Rockwell C minimum and 33 Rockwell C maximum.

3.4.45.1.4 Carburized gear properties. Gears and pinions, case hardened by carburizing shall have properties as follows:

(a) Case hardness shall be 58 Rockwell C minimum.
(b) Case thickness shall be a minimum of 1/16 of the tooth thickness at the pitch circle.
(c) Core hardness shall be 30 Rockwell C minimum and 44 Rockwell C maximum.

3.4.45.2 Single helical gears. Single helical gears shall be case hardened by nitriding or carburizing, unless otherwise specified (see 6.2.2(n)).

3.4.45.3 Double helical gears. Double helical gears shall be either case hardened or through hardened, unless otherwise specified (see 6.2.2(n)).

3.4.45.4 Spiral bevel gears. Spiral bevel gears shall be in accordance with the Gleason practice. Spiral bevel gears (pinions and gears) shall be case hardened by carburizing, unless otherwise specified (see 6.2.2(n)).

3.4.45.5 Worms and worm wheels. Worms and worm wheels shall be in accordance with the latest applicable AGMA publication. Worms shall be case hardened by nitriding or carburizing, unless otherwise specified (see 6.2.2(n)).

3.4.45.6 Shot-peening. Shot-peening of main pinion and gear teeth root fillets is required, if the tooth beam stress (Sk), as determined by the method of MIL-G-17859, exceeds 15 percent of the tensile strength of the material used in fabricating the elements. Shot-peening shall be done prior to finishing teeth by shaving, lapping, grinding or honing.

3.4.45.7 Chordal thickness. Drawings of pinions and gears shall indicate, by note, the minimum acceptable chordal thickness after rehobbing.

3.4.45.8 Matched sets. Pinions and gears (or worms and worm wheels) shall be furnished in matched sets. Elements shall be serialized. Part numbers, housing center distance and actual backlash shall be etched on elements.

3.4.45.9 "K" factor. For through hardened gears the "K" factor for main rotating elements shall not exceed 175 where:

$$K = \frac{Wt}{Fe.d}\left(\frac{1 + 1}{Mg}\right)$$

Wt = tangential tooth load in pounds.

Fe = effective tooth face width.

d = pinion pitch diameter.

Mg = reduction ratio ($\geqq$ 1).

3.4.45.10 Helix angle. Single helical gears shall have a maximum helical angle of 25 degrees. Double helical gears shall have a minimum helical angle of 25 degrees. Modified involute profiles, helix angle modifications, and crowned teeth or combinations, thereof may be incorporated to compensate for distortions under load.

3.4.45.11 Lead (worm). Lead of worms shall be in accordance with the requirements of the latest applicable AGMA publication.

3.4.45.12 Contact pattern. Each set of meshing elements shall exhibit the design contact pattern or relationship when meshed together on true centers and when assembled in the gear case. The contact pattern when assembled in the gear case shall be obtained with each bearing supporting each pinion and each bearing supporting each gear having equal wall thickness (in each pair) at the load line within $\frac{0.0015 + 0.001LS}{F}$ inch, where LS is the span of midpoints of supporting bearings in inches and F is the face width in inches.

3.4.45.12.1 Contact pattern area. Mating teeth of gears shall have a contact pattern at the rated load condition of at least 75 percent of the working depth (excepting areas of tip relief) distributed across at least 85 percent of the active face width (excepting areas of end relief) as shown by a wear pattern on a marking compound. A band of at least 5 teeth to represent each mating pair shall be provided to demonstrate this pattern.

3.4.45.13 Tooth finish. Meshing surfaces and root areas of teeth shall blend to form smooth surfaces free of sharp edges. Rounded tooth fillets shall be used. Tooth profile surface finish (all directions) shall be 32 microinches rhr or better.

3.4.45.14 Gear accuracy. Unless otherwise specified (see 6.2.2(o)), pinion and gear accuracies shall be as follows:

(a) Accumulated tooth spacing error shall be in accordance with figure 5.
(b) Adjacent tooth spacing (pitch) error shall be in accordance with quality 13 of AGMA 390.
(c) Runout shall be in accordance with quality 14 of AGMA 390.
(d) Profile shall be in accordance with quality 14 of AGMA 390.

3.4.45.15 Gear balancing. Pinions, gears and shafts shall be balanced dynamically. Preliminary balance can be performed after finish machining, before teeth are cut. All balancing shall be by removal of material. Addition of weights will not be permitted due to possibility of weights coming adrift and dropping into the gear mesh. Drawing shall state permissible amount of residual unbalance in inch - ounces. For additional requirements see 3.4 24.

3.4.46 Accessory drive gears. Gear elements and other parts for accessory drives shall be designed and rated in accordance with the applicable AGMA publications listed in the latest AGMA publication index except that materials shall be in accordance with table I. Items (t)(1) and (t)(3) of table I shall have case and core hardness and case thickness as required by 3 4.45.1.3 or 3.4.45.1.4 as applicable.

3.4.47 Lubrication. Turbines and gears shall be designed for pressure lubrication from the lubricating oil system, except that external parts may use individual grease fittings. Passages, fittings and sprays shall be provided for lubrication and cooling of all parts under all specified operating conditions. Take-down components shall be used to the maximum extent practicable to facilitate cleaning.

3.4.48 Lubricating and control oil systems. Lubricating and control oil systems for forced draft fan (blower) turbines shall be in accordance with the requirements of MIL-F-18602. Lubricating and control oil systems for turbine driven pump turbines and gears shall be in accordance with 3.4.48.1 through 3.4.48.27.

3.4.48.1 Lubricating oil system (pump, turbines, and gears). A complete self-contained, forced-feed, lubricating oil system shall be provided, by the turbine or gear manufacturer, to supply all oil required by the following:

(a) Turbine and gear bearings.
(b) Pump bearings, if forced-feed oil lubrication is required by the design or by the applicable pump specification.
(c) Gear oil sprays.
(d) Flexible couplings, if forced-feed oil lubrication is required by the design or by the applicable pump specification.
(e) Control system, if required by the design, the applicable pump specification or this specification (see 3.4.50).

Ring or disc lubrication is not acceptable.

3.4 48.2 Control system oil. Lubricating oil system may be used to supply high pressure oil to the control system (see 3.4 50) provided that a regulating or relief valve, designed so that it cannot be closed positively, is furnished to reduce oil pressure for lubrication.

3.4.48.3 Type of lubricating oil. Oil systems shall be designed for use with Military symbol 2190 TEP lubricating oil conforming to MIL-L-17331 or vapor space inhibited lubricating oil conforming to MIL-L-24467.

3.4.48.4 Lubricating oil pressure. Lubricating oil pressure shall be not less than 10 lb/in at any bearing, gear spray nozzle or, if oil is required, at the flexible coupling.

3.4.48.5 Oil inlet temperature. Turbines, gears and all accessories including the governing systems, shall be designed for and be capable of satisfactory operation with 2190 TEP oil with the following oil inlet temperatures:

(a) Start-up. Turbines, gears and accessories shall be capable of being started and operated at low speed and low load with oil inlet temperature of 60°F.
(b) Warm-up. Warm-up shall be at low speed and low load until the oil inlet temperature reaches 90°F.
(c) Full load. Turbines, gears and accessories shall be capable of satisfactory operation, including governing, at any speed and any load up to and including full speed and full load with oil inlet temperature of 90°F. (Normally oil inlet temperatures shall be in the range of 120°F to 130°F.)
(d) Exception. Where the governor proper has a separate lube oil sump and an integral oil system, (a), (b) and (c) shall apply, except that a lighter oil conforming to Military symbol 2075T-M, 2110T-H or 2135T-H of MIL-L-17672 may be used in lieu of 2190 TEP. The rest of the governing system, such as valve operators, and so forth, which are operated by the turbine oil shall comply fully with (a), (b) and (c).

3.4.48.6 Oil discharge temperature. Maximum temperature rise of the oil discharged from any bearing under any specified operating condition shall not exceed 55°F nor shall the temperature exceed 185°F when measured by thermometers.

3.4.48.7 Bearing oil supply and return. Each turbine and gear journal bearing and thrust bearing shall have separate oil connections and separate oil discharge connections; however, inlet and discharge for thrust bearing may be manifolded with those of adjacent journal bearing to permit a single oil supply connection and a single oil discharge connection to serve both bearings.

3.4.48.8 Oil sumps. Oil sumps shall be provided with all pump turbines and gears. Oil sump shall be oil tight (zero leakage).

3.4.48.8.1 Materials. Oil sump materials shall be corrosion-resisting in accordance with table I.

3.4.48.8.2 Oil sump capacity. Oil sumps for turbines and gears shall have a capacity, in gallons, equal to twice the flow in gallons per minute (gal/min) of oil required by the control and lubricating oil systems, including requirements for transients, when operating at rated high speed. [illegible] sump capacity shall include twice the capacity required by the centrifugal lube oil [illegible]lter, where used (see 3.4.48.13).

3.4.48.8.3 Oil level indicators. Oil level indicators having low, normal and high levels clearly indicated shall be furnished. Bayonet type oil gages shall be secured against coming adrift under shock by a quick disconnect means other than a threaded connection.

3.4.48.8.4 Heating and cooling coils. Internal heating or cooling coils are not permitted.

3.4.48.8.5 Paint. Paint shall not be used on surfaces in contact with oil.

3.4.48.8.6 Access holes. Access holes shall be provided as necessary to permit manual cleaning. All areas or pockets in the sump shall be accessible for cleaning.

3.4.48.8.7 Oil sampling valve. A valve shall be furnished to permit taking of oil samples from bottom of sump.

3.4.48.8.8 Drainage. Connections shall be provided for complete drainage of the sumps. Connections shall be in accordance with 3.4.29.4.

3.4.48.8.9 Vents. Gear cases and oil sumps shall be vented to atmosphere. The total venting area shall be not less than the following:

Tank capacity (gallons)	Venting area (square inches)	Nominal ips vent which provides required area
		Inches
1 to 20	0.53	3/4
21 to 50	.86	1
51 to 100	1.50	1-1/4
101 to 200	2.04	1-1/2

Where oil sump is separate from gear case, vents are required for both gear case and oil sump. Gear case vents shall be in the top of the gear case cover and shall be 3/4 inch iron pipe size (ips) minimum.

3.4.48.8.10 Location. Oil sumps shall be located so that oil drains by gravity from the bearing under all operating conditions, including trim, list, roll and pitch (see 3.4.12).

3.4.48.9 Attached oil pumps. One self-priming attached oil pump shall be provided with each turbine and gear to provide forced feed lubricating and control oil.

3.4.48.9.1 Pump drive. The pump drive shall be driven either directly or by gearing from the turbine or gear shaft.

3.4.48.9.2 Lubrication while shutting down. Design and size of attached pumps shall be such that lubrication is provided when pumps are being shut-down without supplying oil by any other means.

3.4.48.9.3 Pump location. Pumps shall be self-priming under all operating conditions, including trim, list, roll and pitch (see 3.4.12).

3.4.48.9.4 Lubrication while idling. Design and size of attached pumps shall be such that lubrication is provided when idling. Idling speed for pumps is no greater than 1/3 of rated speed. Idling speed for fans is given in the applicable fan (blower) specification.

3.4.48.10 Motor driven oil pump. One positive displacement, rotary type, motor driven oil pump, in accordance with MIL-P-19131, shall be furnished with each main feed pump turbine of 501 hp and above. The oil pump flanges shall be in accordance with 3.4.29. The oil pump shall have a capacity large enough to enable starting the turbine driven main feed pump and to supply oil to the main feed pump bearings during coast-down, in the event of failure of the attached oil pump.

3.4.48.10.1 Motor. Motor shall be in accordance with MIL-M-17060 ("V-" frame) and shall have the following characteristics:

Service	A
Ambient temperature	50°C
Enclosure	Totally enclosed
Insulation	Class B
Number of phases	3
Frequency	60 hertz per second (Hz/s)
Voltage	440 alternating current (ac)
Duty	Continuous

3.4.48.10.2 Controller. A controller shall be furnished for each motor driven lube-oil pump and shall be in accordance with MIL-C-2212. Controller shall be of the magnetic type with low voltage release (LVR) and thermal overload protection and a selector switch with three positions, "off", "manual", and "automatic". Controller shall function automatically to start the pump in the event of low oil pressure, but shall require manual operation to stop the motor driven oil pump. Type of enclosure shall be dripproof. This controller shall not be used for any other function.

3.4.48.11 Hand oil pumps. For all main feed pumps, a positive displacement, rotary type hand pump shall be provided for starting the turbines. Hand pump shall develop the required pressure to open the nozzle control valves and the throttle valve for starting, in the event the motor driven pump is inoperable. It shall also develop the required oil flow at lower pressure for the required lubrication during start-up. The hand oil pump shall be capable of supplying the required capacity without imposing unreasonable physical demands on the operator. To reduce the cranking effort required, the pump may be a duplex type, that is two pump elements on one crank (one element to supply oil to the governing system and the other to the bearings through the strainer and cooler). The hand oil pump shall be located so that it is accessible to the man at the throttle.

3.4.48.12 Oil strainers for main feed pump turbines. The total lubricating oil flow, excluding control oil, for all main feed pump turbines shall pass through an external duplex basket type, magnetic, oil strainer in accordance with type I, class 4 of MIL-S-17849, modified as specified in 3.4.48.12 1 through 3.4.48.12.4, prior to supplying the bearings.

3.4.48.12.1 Strainer baskets. Strainer baskets (elements) shall conform to the following:

(a) Rated flow - As required by system design (full flow).
(b) Rated inlet pressure - As required by system design.
(c) Normal operating pressure - As required by system design.
(d) Preferred basket material - Corrosion-resisting steel wire mesh, pleated.
(e) Particle removal - 25 micrometers absolute.
(f) Oil temperature range - 90°F to 160°F.
(g) Pressure drop, clean (max.) - 8 lb/in at 90°F.
(h) Pressure drop, dirty (max.) - 12 lb/in at 90°F.
(i) Collapse differential pressure - 75 lb/in.
(j) Dirt holding capacity (min.) with maximum pressure drop of 12 lb/in[1/] - 150 grams per 100 gal/min of rated flow.
(k) Type - Cleanable.
(l) Cleaning method - Strainers shall be cleanable by facilities available on the ship for which intended.
(m) Basket condition after cleaning - Original clean basket pressure drop.
(n) Elapsed time for cleaning (maximum) - 45 minutes.

[1/] Based upon a contaminant of ac fine test dust or equal.

3.4.48.12.2 Strainer basket covers. Covers shall have an integral lip or deflector to direct oil away from the operator, and hot surfaces, in case of a flange leak. In addition, covers shall be fitted with a 1/8 inch ips vent valve and copper tube to permit the operator to direct the vented air and oil to a safe location.

3.4.48.12.2.1 Basket cover joints. Basket cover joint design shall be based on the use of carbon steel bolting or joint sealing materials shall be a type which seals with pressure. The use of materials that require a definite compression and yielding for joint tightness is not acceptable, since these materials rapidly lose their effectiveness.

3.4.48.12.2.2 Gasket surface. Gasket surface, or O-ring groove, shall be recessed into the body flange so that the cover will make-up metal-to-metal with the body, where O-rings are used, and metal-to-metal with the gasket retainer where other types of gaskets are used.

3.4.48.12.3 Body drains. Each strainer body shall be fitted with a drain valve and a drain line, not exceeding 1/4 inch in diameter, for draining oil from the body back to the lubricating oil sump prior to removing the basket for cleaning.

3.4.48.12.4 Strainer drip pans. Drip pans shall be provided under lubricating oil strainers to catch any oil that might drip or be spilled inadvertently when cleaning baskets. Drip pans shall be fastened securely to prevent their being dislodged due to shock.

3.4.48.12.5 Strainer location. To reduce fire hazards, every effort shall be made to locate oil strainers at an area of the pump that is most remote from high temperature surfaces but shall be accessible for cleaning.

3.4.48.13 Centrifugal jet reaction oil filter (for main feed pump turbines of 150 hp and above. A centrifugal jet reaction oil filter shall be installed, in a by-pass arrangement, on each main feed pump turbine of 150 hp and above. The filter shall be on or near the oil sump and shall be as follows:

Motive force - Oil pressure directly from the attached oil pump discharge line, upstream of any relief or regulating valve.
Inlet oil pressure - Attached oil pump discharge gage pressure (approximately 50 to 100 lb/in^2.
Discharge - Unobstructed drain directly to the oil sump above the oil level (about atmospheric pressure).
Oil flow capacity - 2 gal/min (minimum) at 60 lb/in^2 oil inlet gage pressure.
Dirt and water capacity - 50 cubic inches (approximately 2-1/2 pounds).
Water removal - The filter shall have a valve for periodic water removal, without securing the unit.
Inlet shut-off - A valve shall be installed in the oil supply line so that the filter can be isolated for cleaning without securing the turbine.
Low pressure cutout valve - A valve, built into the filter, shall automatically shut-off the oil supply if the inlet oil gage pressure drops to 20 lb/in^2 or below and shall re-open automatically when 20 lb/in^2 or greater oil inlet gage pressure is restored.
Housing - Shall be steel.
Drip pans - Drip pans shall be installed and shall be in accordance with 3.4.48.12.4.

3.4.48.14 Oil strainers or filters for all turbine driven pumps, except main feed pumps. The lubricating oil system for turbine driven pumps, except main feed pumps shall be furnished with full flow strainers or filters. The total lubricating oil flow, excluding control oil, required by the pump, the turbine and the gear, if used, shall pass through a filter or strainer of one of the following types:

(a) An external, duplex, basket-type, magnetic oil strainer in accordance with 3.4.48.12 through 3.4.48.12.5.
(b) A cleanable, metal-edge type oil strainer, capable of 40 micrometers particle removal, with internal by-pass (Cuno or equivalent).
(c) Two parallel single-element or one duplex element automotive, replaceable cartridge type filter, with collapse differential pressure of 75 lb/in minimum.

3.4.48.14.1 Filter switching valve. Where two single-element filters are used (see 3.4.48.14(c)), a four-way valve shall be installed for switching from one element to the other. The valve shall be sized to allow full flow to either element. The valve shall shut off all flow to the element not in use when full flow is passing through the other element.

3.4.48.14.2 Drip pans. Drip pans, in accordance with 3.4.48.12.4, shall be installed under all full flow filters and strainers.

3.4.48.14.3 Oil filter and strainer location. Oil filters and strainers shall be located so that they are readily accessible for switching and cleaning. Wherever practicable, filters and strainers shall be located remotely from high temperature surfaces.

3.4.48.15 Coolers. Lubricating oil coolers shall be installed in the lubricating oil system of all turbine driven pumps. Coolers for turbines shall be in accordance with type A, class 2 of MIL-C-15730. The coolers shall have a minimum capacity equal to the total lubricating oil flow requirements. Cooler size shall be based upon inlet sea water temperature of 95°F and an oil outlet temperature of 130°F.

3.4.48.16 Oil regulating or relief valves. Oil regulating or relief valves shall be furnished as required by the system design, to limit control oil and lubricating oil pressures. The valves shall be located in the discharge from each attached or motor driven oil pump and shall be arranged to relieve excess oil back to the oil sump.

3.4.48.17 Check valves. Check valves shall be provided in the discharge line from each positive displacement pump (ahead of system regulating or relief valve) and other locations as required by the system design.

3.4.48.18 Cooler by-pass valve. A four-way cross cock shall be installed in the oil line ahead of the cooler and designed so that the cooler can be by-passed without interruption of the oil flow. The valve shall be designed so that in no position can the oil to the bearings be completely cut-off.

3.4.48.19 Gages and differential pressure indicators. Pressure gages shall be furnished to meet system requirements, and shall include gages to indicate control oil pressure, oil filter and oil strainer pressure drops and pressure at the bearing with the lowest oil pressure Oil gages shall be in accordance with the requirements of 3.4.33. In lieu of gages to indicate pressure drop across oil filters and strainers, differential pressure indicators may be used provided they meet the shock requirements herein. Gages shall be located near the item being checked.

3.4.48.20 Alarm switches for pump turbines of 501 hp and above. Alarm switches shall be installed on all pump turbines of 501 hp and above as follows.

(a) Low oil pressure alarm switch in the piping at the point of lowest oil pressure. The switch shall be single pole, double throw (SPDT). Low oil pressure alarm switch shall also cause the motor driven oil pump to start when low bearing oil pressure occurs.
(b) Low oil level alarm switch installed such that the alarm will sound in the event of low lube oil level in the oil sump.

3.4.48.21 Sight flows. Sight flow fittings shall be furnished and installed in accordance with 3.4.48.21.1. The fittings shall have male-female flanges or shall have straight threads with O-rings (see 3.4.29.4). The fittings shall be of bronze or brass and the windows shall be of 1/4 inch minimum thickness, thermally tempered borosilicate (pyrex), shock resistant glass in accordance with MIL-G-2860.

3.4.48.21.1 Location of sight flows. Sight flow fittings shall be located in accordance with the following:

(a) Turbines and gears 501 hp and above. Sight flows for turbines and gears 501 hp and above shall be installed on each journal bearing cap and each thrust bearing cover or housing to provide visual indication of oil discharge from bearing pressure pad or loaded area of the bearing during operation.
(b) Turbines and gears 151 hp to 500 hp. Sight flows for turbines and gears 151 to 500 hp, with sliding contact bearings, shall be located as in (a). Sight flows for turbines and gears, with rolling contact bearings, may be located in the bearing oil supply line.
(c) Turbines and gears 150 hp and below. Sight flows for turbines and gears 150 hp and below may be located in the bearing oil supply line.

3 4.48.22 Thermometers. Thermometers shall be in accordance with the requirements specified in 3.4.33.6 to 3.4.33.9.

3.4.48.23 Flow-limiting orifices. Orifices shall be provided in the oil supply to each journal bearing and in the inlet to or discharge from each thrust bearing. Orifices may be of a design which permits removal but they shall be installed in such a manner as to prevent external adjustment of oil flow.

3.4.48.24 Test connections. Test connections (for use of a pressure gage) are not required before each bearing. If such connections are provided for use during shop tests, they shall be plugged and seal welded prior to shipment.

3.4.48.25 Cleaning of systems. All parts of the lubricating oil system shall be thoroughly cleaned prior to conducting the operating tests.

3.4.48.26 Oil p rg. Lubricating oil and control oil piping shall be in accordance with the requirements of 3.4.29. All oil piping shall be supported in a manner to prevent damage from vibration or shock, with special consideration being given to bracing the piping at gage take-off connections. Wherever practicable, oil piping shall be routed such that operators or watch standers will not step or stand on the piping. If such routing is not practicable, a guard shall be installed over that section of piping.

3.4.48.27 Gaskets. Gaskets used in oil systems shall be of plant fiber with no wire or asbestos filler.

3.4.49 Grease lubrication. Where grease lubrication is required, design shall be such that required lubrication is obtained with grease conforming to MIL-L-15719. Commercially available grease of a type compatible with that complying with the Government specifications may be used during shop tests. Grease fittings conforming to geometry of MS15003 shall be provided with the turbine.

3.4.50 Control systems. Auxiliary steam turbines shall be equipped with speed control systems in accordance with 3.4.50.1 through 3.4.50.2.7.4.

3.4.50.1 Control systems for forced draft fan turbines. Forced draft fan turbine control systems, including normal speed control, pre-emergency speed control and emergency control, shall be in accordance with the requirements of MIL-F-18602.

3.4.50.2 Control systems for pump turbines. Control systems for pump turbines shall be furnished as required by table VII and 3.4.50.2.1 through 3.4.50.2.7.4.

TABLE VII. Tabulation or turbine governing requirements.

Application of turbine	Normal speed control			Pre-emergency control		Emergency controls		
						Automatic		
	Type required	Setting	Regulation	Type required	Setting	Type required	Setting	Manual trip
Feed pumps	Pump pressure regulating governor	See applicable pump specification for requirements		Hydraulic relay (see 3.4.50.2.2)	Set at maximum operating speed (see 3.4.50.2.2.1)	Overspeed trip (see 3.4.50.2.3)	Set at 15 percent above operating speed (see 3.4.50.2.3)	Required
Fire and flushing pumps Fuel oil service pumps Lubricating oil pumps	Same as for feed pumps			Hydraulic relay or mechanical (see 3.4.50.2.2)	Same as for feed pumps			

TABLE VII. Tabulation of turbine governing requirements. Continued

Application of turbine	Normal speed control			Pre-emergency control		Emergency controls		
						Automatic		Manual trip
	Type required	Setting	Regulation	Type required	Setting	Type required	Setting	
Fuel oil transfer pumps Condensate pumps Feed booster pumps Circulating pumps[1/] Bilge pumps Cargo pumps Miscellaneous pumps	Hand-throttle	As required by operator	No requirements	Same as for fire and flushing pumps				
Forced draft fans (blowers)	See MIL-F-18602 for requirements							
Compressors	See specification for driven unit							

[1/] Overspeed or manual trip systems are not required for circulating pumps that have rigid couplings or continuous shafts between the following:

(a) Turbine and the gear.
(b) Gear and the pump.
(c) Turbine and the pump, if not geared

Where a flexible coupling is used in any of the above, an overspeed trip system is required on the turbine.

3.4.50.2.1 Normal speed control. Normal speed control requirements are covered by the applicable pump specification.

3.4.50.2.2 Pre-emergency control. Pre-emergency control of pump turbines shall be by means of a speed-limiting governing system consisting of.

(a) Speed governor in accordance with 3.4.50.2.2.4.
(b) Speed control mechanism in accordance with 3.4.50.2.2.5.
(c) Governing or nozzle control valves in accordance with 3.4.50.2.2.6.

3.4.50.2.2.1 Definition of speed-limiting governing system. A speed-limiting governing system is defined as a system which, by control of the steam to turbine, will not permit the turbine to operate at a speed in excess of that to which the governing system is adjusted, but will permit the turbine to continue in operation at this speed. It is fundamentally a safety device, the required normal speed control being obtained by manual control, pressure-regulating governor, or other means. This type of governor, being adjusted to the maximum operating speed of the turbine, shall have no control of the steam to the turbine until this speed is approached, regardless of load, steam, exhaust, or other conditions.

3.4.50.2.2.2 General requirements for speed-limiting governing systems. Speed-limiting governing systems shall be as follows:

(a) System shall be as defined in 3.4.50.2.2.1.
(b) System shall be designed to withstand the shock requirements of 3.4.9. In addition, the system shall be designed so that, under the shock conditions specified in 3.4.9, the system shall not be actuated unintentionally, but shall function properly if the turbine speed increases to the set point.
(c) System shall control the flow of all steam to the turbines.
(d) Hydraulic relay type systems shall be designed so that loss of oil pressure shall shut off all steam to the turbine.

(e) Mechanical relay type systems shall have balanced levers, linkages, etc. to prevent malfunction when subjected to shock (see 3.4.9).
(f) Governor fly-weights shall be mounted so that they will not be dislodged when subjected to shock (see 3.4.9).
(g) Cadmium plating is not permitted on parts which will be in contact with oil.
(h) Speed-limiting governing system and the pump normal speed control system may actuate the same governing valve, but the speed-limiting governor shall be overriding in the event of overspeeding, also the speed-limiting governor shall not interfere with the normal speed control at any speed up to the maximum operating speed.

3.4.50.2.2.3 Performance requirements for speed-limiting governing systems. Performance requirements of speed-limiting governing systems shall be as follows (see note):

(a) Speed regulation. Speed regulation, from specified maximum load to no load ~~ the driven equipment, shall not exceed 6 percent of the speed setting. For -bine driven centrifugal (not propeller) pumps the "no-load" condition shall be considered as the lowest load attainable with the pump operated at shut-off condition, that is, with the pump discharge valve closed.
(b) Adjustable speed range. Adjustable speed range shall be from 5 percent above to 50 percent below the speed at which the turbine will deliver rated power.
(c) Maximum speed variation. Maximum speed variation shall not exceed plus or minus 0.5 percent of the speed setting.
(d) Maximum speed rise . Maximum speed rise, when the turbine is developing rated power, at rated speed, and the load is suddenly reduced to zero, shall not exceed 7 percent of rated speed.

NOTE: These requirements apply only to turbines combatant and non-combatant ships. The requirements for submarines and contatant turbines shall be as specified (see 6.2.2(p)).

3.4.50.2.2.4 Speed governors. Speed governors shall be of the flyweight type. Governor weights shall be positively secured to prevent dislodging under shock. Knife edges are not permitted on pump turbines of 501 hp and above.

3.4.50.2.2.5 Speed control mechanisms. Speed control mechanisms shall include all the necessary relays, servo-motors, pressure or power amplifiers, accumulators, valve actuators or operators, piping and fittings, orifices, levers and linkages between the speed governor and the governing valves. Speed control mechanisms shall be as follows:

(a) For main feed pump turbines, the speed control mechanisms shall be of the hydraulic relay type using lubricating (or control) oil as the relaying medium.
(b) For pump turbines, other than main feed, the speed control mechanism may be either the hydraulic relay type as in (a), or a mechanical type. Where a mechanical type is used, the levers, linkages, etc. shall be balanced so that the system will not be rendered inoperative when subjected to shock (see 3.4.9).

3.4.50.2.2.6 Governing (or nozzle control) valves. Governing valve materials and construction details shall be in accordance with 3.4.50.2.7 through 3.4.50.2.7.4. Governing valves which depend on differential steam pressure for positioning are not acceptable.

3.4.50.2.2.6.1 Governing valves for hydraulic relay type system. Governing valves for hydraulic relay type governing systems shall be designed so that the valves are opened either by a start valve or lever (see 3.4.50.2.5) and are held open by control oil pressure which is opposed by the valve operator or actuator spring. Loss of oil shall cause the valve to close.

3.4.50.2.2.6.2 Governing valves for the mechanical relay type system. Governing valves for the mechanical relay type system shall be held open by the governor spring and action of the fly-weights will tend to close the valves when the speed reaches the speed-limiting governor setting.

3.4.50.2.2.6.3 Governing valves for pump turbines of 501 hp and above. Governing valves for pump turbines of 501 hp and above shall be designed so that inlet steam is above the valve seat and steam pressure tends to close the valve.

3.4.50.2.2.6.4 Governing valves for pump turbines of 500 hp and below. The preferred design of governing valves for all pump turbines shall be as required by 3.4.50.2.2 6.3, however, for pump turbines of 500 hp and below, the inlet steam may be below the seat, where it is impracticable, or would unduly complicate the design, to have the steam inlet above the seat.

3.4.50.2.2.7 Provision for adjusting and testing onboard ship. The speed-limiting governing system shall be capable of being adjusted and tested onboard ship by shipboard personnel at a range of 95 to 105 percent of rated speed. The test procedure shall be described in the technical manual.

3.4.50.2.3 Emergency controls. Pump turbines, except for circulating pumps that comply with footnote 1 of table VII, shall be provided with an emergency control that is completely independent of the normal speed control or the pre-emergency control systems, that is it shall have separate sensing, relaying and shut-down devices. The emergency control system shall include a manual trip to actuate the overspeed trip system.

3.4.50.2.3.1 Definition of overspeed trip system. An overspeed trip system is defined as a system that will shut off all steam to the turbine governing (or nozzle control) valves, to fully stop the turbine in the event a pre-determined speed is exceeded.

3.4.50.2.3.2 Trip system basic design. Overspeed trip system shall be reliable, positive and quick acting, of simple and rugged design and construction.

3.4.50.2.3.3 Shockproofness. Trip system shall be designed to withstand the shock requirements of 3.4.9. In addition, the system shall be designed so that, under shock conditions specified in 3.4.9, the system will not be actuated unintentionally to shut down the set, but will function properly if overspeeding occurs.

3.4 50.2.3.4 Operation during sudden speed or load change. Overspeed trip system shall not be actuated unintentionally by sudden changes in speed or sudden removal of any load within rated operating conditions.

3.4.50.2.3.5 Speed setting. Overspeed trip system shall function automatically at 113 to 117 percent of rated speed.

3.4.50.2.3.6 Maximum speed after tripping. Overspeed trip system shall be designed so that tripping by overspeeding or manually, at any possible load or speed or during start-up or shut-down, shall safely limit the speed of the turbine to 125 percent of rated speed. The maximum speed that the turbine could attain after tripping and the conditions under which this speed would occur shall be determined by the turbine manufacturer and furnished to NAVSEC for information.

3.4.50.2.3.7 Provision for adjusting and testing onboard ship. The overspeed trip system shall be capable of being adjusted and tested onboard ship by shipboard personnel at a range of 113 to 117 percent of rated speed. It shall be possible to test the overspeed trip by uncoupling the pump from the turbine. Pump or turbine shall not be moved to accomplish this test. Coupling halves shall be secured in such a way that they are not a safety hazard and turbine balance is not adversely affected. Test procedure shall be described in the technical manual.

3.4.50.2.3.8 Speed-sensing devices. Speed-sensing devices shall be any of the following:

(a) Centrifugal (bolt, plunger, belleville spring or two interconnected eccentric rings).
(b) Magnetic proximity pick-up.
(c) Permanent magnet generator (frequency responsive type only).

3.4.50.2.3.9 Relaying mediums. Relaying mediums shall be any one, or any combination, of the following types:

(a) Mechanical.
(b) Hydraulic.
(c) Electrical/electronic.

3.4.50.2.3.10 Shut-down device. Shut-down device shall be as follows:

(a) A trip throttle valve in accordance with 3.4.50.2.6.1 and 3.4.50.2.6.3 for main feed pump turbines.
(b) Either a trip throttle valve in accordance with 3.4.50.2.6.1 and 3.4.50.2.6.3 or a trip valve in accordance with 3.4.50.2.6.2 and 3.4.50.2.6.3 for pump turbines other than for main feed pumps.

3.4.50.2.3.10.1 Valves specified in 3.4.50.2.3.10 shall be independent of any other control or governing valve and shall control all steam to the turbine governing or nozzle control valves.

3.4.5.2.3.11 Resetting. System shall be designed to reset as follows:

(a) Speed-sensing devices shall reset automatically.
(b) Relaying mediums shall reset automatically.
(c) Shut-down devices shall require manual resetting (see 3.4.50.2.6.1 and 3.4.50.2.6.2).
(d) Resetting shut-down device shall not require shut-down of lube oil system.

3.4.50.2.3.11.1 Resetting speed. Resetting speed for the system shall be not less than 50 percent of rated speed. Resetting speeds above 50 percent of rated speed are acceptable, however the system shall be capable of being reset at any speed between zero speed and the maximum resetting speed. Technical manuals shall indicate the maximum resetting speed.

3.4.50.2.3.12 Electrical/electronic system gageboard. When the electrical/electronic system is used, the following shall also be furnished on a gageboard:

(a) A switch to turn power on.
(b) A white indicator light to show "power-on". The "power-on" light shall indicate that the overspeed trip system is energized, including power to the trip valve or trip throttle valve.
(c) A red indicator light to show that unit has tripped (solenoid energized).
(d) Test buttons for each indicator light to establish that the light bulbs are good. The button shall be spring backed to break contact when released.
(e) A warning plate, mounted prominently, stating the following. "Caution - If overspeed trip system is not energized, there is no overspeed trip protection."
(f) A tachometer type IC/EFC or IC/EFD in accordance with MIL-T-16049.

3.4.50.2.3.13 Electrical/electronic system additional requirements. Additional requirements for electrical/electronic systems shall be as follows:

(a) Components shall be solid state.
(b) No electrical relays are permitted.
(c) Components shall be in accordance with MIL-T-16049, type IC/EFC or IC/EFD as applicable.
(d) Loss of electrical power shall in no way interfere with starting, stopping or operating the turbine, however failure to energize the overspeed trip system will result in no overspeed trip protection.

3.4.50.2.3.14 Manual trip. Means shall be provided for manual tripping at any speed. Manual trip shall be located so that it is readily accessible to the man at the trip throttle or trip valve, but cannot be tripped accidentally. If necessary to avoid accidental tripping, a guard shall be installed around the trip button, lever or handle.

3.4.50.2.4 Hand valve. Each turbine shall have one hand-controlled valve to meet emergency conditions (see 3.4.5.2). Valve materials and construction shall be in accordance with 3.4.50.2.7. Steam through the hand valve shall be under control of the governing valve.

3.4.50.2.5 Start valve or lever. A starting valve or a lever shall be installed for opening the governing valves, to start turbines, if required by the design.

3.4.50.2.6 Trip throttle valve or trip valve. Trip throttle or trip valves shall be furnished as required by 3.4.50.2.3.10. Valve materials and construction shall be in accordance with 3.4.50.2.7. Valves shall be installed between the steam strainer and the turbine governing or nozzle control valves and shall be supported to withstand the shock requirements of 3.4.9.

3.4.50.2.6.1 Trip throttle valves. Trip throttle valves shall be of the plug (or disc or poppet) type. Butterfly or gate valves are not permitted. Valves shall be of the hydraulic type, being opened and held open by oil pressure, opposing a spring, and inlet steam pressure, which will close the valve upon loss of oil pressure. Oil pressure shall be furnished from the units lubricating oil pump Valves shall be equipped with a handwheel for opening the valve slowly, during start-up, and for controlling steam to the turbine until the governing valves take control. Valves shall be designed so that they will be tripped shut by either the overspeed trip or the manual trip. When the valve has functioned to stop steam to the turbine, it shall be necessary to manually turn the handwheel to the completely closed position, to reset the valve, before reopening to again admit steam to the turbine. The automatic operation of the valve shall be entirely independent of the degree of opening of the valve.

3.4.50.2.6.2 Trip valves. Trip valves shall be in accordance with the requirements of 3.4.50.2.6.1 for trip throttle valves, except that the valve may be either mechanical or hydraulic and a handwheel is not required. If a handwheel is not furnished, the valve shall have a starting lever for opening the valve. Trip valves will normally be fully opened or completely closed. The design shall be such that when the valves have been tripped shut, it shall be necessary to reset them manually before steam can be admitted to the turbine. Automatic reopening of the valves is prohibited.

3.4.50.2.6.3 Trip throttle valve or trip valve for turbines of 151 hp and above. For turbines of 151 hp and above the trip throttle valve or the trip valve shall consist of a main outer valve with an inner pilot valve, which shall lift first to partially relieve the pressure on the valve, thereby reducing the effort required to open the main valve. The pilot valve will also eliminate the need for a bleed-off connection in the main steam line between the root valve and the turbine trip throttle valve, or trip valve, to reduce the steam pressure on the valve.

3 4.50.2.6.4 Resetting force for trip throttle valves and trip valves. The force required to reset valves, after tripping, with full steam pressure on the valve, shall not exceed 50 pounds on the rim of the wheel for trip throttle valves or 50 pounds at the center of the hand grip on the handle of trip valves

3.4.50.2.7 Valves. Valves shall be in accordance with 3.4.50.2.7.1 through 3.4.50.2.7 4.

3.4.50.2.7.1 Valve materials. Valve materials shall be in accordance with table I The body for the trip throttle valve shall be of material as specified for the steam chest or casing for comparable operating conditions.

3.4.50.2.7.2 Valve seats. Valve seats shall be removable from the valve body or steam chest. Threaded connections are not permitted. Provision shall be made for expansion between seat and body or chest. Annulus between valve seat and body or chest shall be seal welded to prevent leakage. For saturated steam applications, expansion lips or rings used for absorbing expansion between seat and body shall be constructed of nickel-chromium-iron alloy (73-15-7 nominal).

3.4.50.2.7.3 Valve contact area (disc and seat). Valve contact area of disc and seat shall be hard-faced with chrome-cobalt material, MIL-R-17131, type MIL-RCoCr-A, to a minimum thickness of 3/32 inch and approximate width of 1/4 to 1/2 inch.

3.4.50.2.7.4 Valve stems and bushings. Soft packing shall not be used. Stems and bushings shall be nitrided or otherwise hardened.

3.4.50.2.8 Filters for control oil. Where any element of the governing system, including speed-limiting governor or overspeed trip, is hydraulic, a duplex filter shall be installed in the control oil line to filter all oil to all parts of the system. The filter shall be of the replaceable element type capable of removing particles of 25 micron size or larger and also capable of withstanding, without collapsing the elements, the pressure imposed on the element when starting the turbine with 60 degree oil.

3.5 Onboard tools and maintenance parts. Items listed in table VIII shall be furnished as applicable.

TABLE VIII. Onboard tools and maintenance parts.

Item	Quantity per ship	Reference
1. Special tools (as applicable)[1/] For. (a) Measuring crown thickness	1 set	3.4.35.2.5.12
(b) Removing and setting overspeed devices	1 set	3.4.50.2.3.7
(c) In-field balancing (weights not included)	1 set	3.4.24
(d) Alinement of spherical seating b[illegible]ngs	1 set	3.4.35.2.4.9
(e) Removing thrust collar	1 set	3.4.35.2.7.5
(f) Taking thrust clearance	1 set	3.4.35.3.2
(g) Unbolting and remaking casing flanges	1 set	3.4.25.3.10 and 3.4.40.4.1
(h) Replacing stub shafts	1 set	3.4.35.2.7.5
(i) Charging apparatus and gage for accumulator, if used	1 set	3.4.50.2.2.5
(j) Pulling anti-friction bearings	1 set	3.4.35.2.6.2.1
2. Bearing yokes and jack	1 set	3.4.35.3.1
3. Bolt heaters and extensiometers	2 each size	3.4.25.3.9
4. Clearance gage	1 each	3.4.33.12
5. Lifting gear	1 set/turbine and gear, up to maximum of 4 sets	3.4.40.11
6. Turning tool	2 sets	3.4.32

[1/] Special tools are defined as those items not listed in the Federal Supply Catalog (copies of this catalog may be consulted in the office of the DCAS).

3.6 Repair parts.

3.6.1 Onboard and stock repair parts. Onboard repair parts shall be in accordance with table IX and shall be either furnished with the turbine and gear or procured separately by the inventory control point. Stock repair parts (shore-based) shall be handled in accordance with procedures of MIL-P-15137 (see 6.5). Stock (insurance) repair parts to be recommended are shown in table X.

TABLE IX. Onboard repair parts for turbines and reduction gears.

Item	Part, as applicable to the turbine and gear furnished (A "set" means quantity required for 1 turbine and gear)	Number of turbines and gears of same design per ship							Factor code (For Government use only)
		1	2	3	4	5-8	9-20	21-50	
1	Accumulator bladder and wearing parts including springs	1	1	1	1	2	3	4	G
2	Basket, oil strainer, each size and type	2	3	4	4	5	6	8	C
3	Basket, steam strainer, each size and type	1	1	1	1	1	1	1	K
4	Bearings, complete all types, except thrust bearings, sets[1/]	1	2	3	3	4	6	7	D
5	Bearing parts, thrusts, including collars, complete sets	1	1	1	1	2	3	4	G
6	Bellows assemblies complete sets[1/]	1	1	1	1	2	3	4	G
7	Cartridge, oil filter, each size and type	6	9	12	12	18	24	36	A
8	Deflector or seal rings, complete sets	1	2	3	3	4	6	7	D
9	Fasteners, self locking, threaded, complete sets	1	2	3	3	4	6	7	D
10	Gaskets which cannot be fabricated from standard Navy gasket material, complete sets	1	2	3	3	4	6	7	D
11	Glasses for oil sight flow fittings and gages, complete sets	1	1	1	1	2	3	4	G
12	Governor parts, overspeed, complete sets	1	1	1	1	2	3	4	G
13	Governor assemblies, mechanical/ hydraulic, self-contained type similar to Woodward	1	1	1	1	2	3	4	G
14	Governor system parts, speed limiting, including operating cylinder, pilot valve, bushings, servo-mechanism, linkages, drive gears, and so forth, complete sets	1	1	1	1	2	3	4	G
15	Nozzles for centrifugal oil filters	2	3	4	4	5	6	8	C
16	O-rings, complete sets	1	2	3	3	4	6	7	D
17	Orifices, removable, complete sets	1	1	1	1	2	3	4	G
18	Packing, gland, including springs, complete sets	1	1	2	2	3	4	5	E
19	Packing, valve, and so forth, (other than standard Navy packing carried onboard), complete sets	1	2	3	3	4	6	7	D
20	Pump parts, lube oil, including drive gears, if not included under item 14, gaskets, bearing bushings, or body when bushings are not used, complete sets	1	1	1	1	2	3	4	G
21	Springs, not including gland springs, complete sets[1/]	1	1	1	1	2	3	4	G
22	Switches, pressure alarm, each type, range and design	1	1	1	1	1	1	1	K
23	Trip parts, back pressure and lube oil, complete sets	1	1	1	1	1	1	1	K

See footnote at end of table.

TABLE IX. Onboard repair parts for turbines and reduction gears. Continued

Item	Part, as applicable to the turbine and gear furnished (A "set" means quantity required for 1 turbine and gear)	Number of turbines and gears of same design per ship							Factor code (For Government use only)
		1	2	3	4	5-8	9-20	21-50	
24	Trip parts, overspeed governor, complete sets	1	1	1	1	2	3	4	G
25	Turning device parts, complete sets	1	1	1	1	1	1	1	K
26	Valve parts, nozzle complete, including lift rods, bushings, valves and seats, linkages not included [illegible] em 14, complete sets	1	1	1	1	1	1	1	K
27	Valve, complete relief, oil and steam, each size and type	1	1	1	1	1	1	1	K
28	Valve parts, trip throttle, or trip, including pilot valve, main valve and seats, snap rings, valve stem with bushings, and screw spindle with nut, complete sets	1	1	1	1	2	3	4	G

1/ Quantities of bearing, item 4; bellows, item 6; and springs, item 21, are in addition to any such parts being furnished as component parts of other items.

TABLE X. Stock (insurance) repair parts.

Item part(s)		Number of turbines and gears using part(s)	Stock recommended 1/
(1)	(2)	(3)	(4)
1	Trip throttle valve	Any quantity	0
2	Turbine rotors 2/ and gear main rotating elements 3/	1 2 to 10 (incl.) 11 to 30 (incl.) 31 to 50 (incl.) 51 to 70 (incl.) 71 and up	1 2 3 4 5 6
3	Intermediate segments 4/	1 2 to 10 (incl.) 11 to 25 (incl.) 26 to 40 (incl.) 41 to 55 (incl.) 56 to 70 (incl.) 71 to 85 (incl.) 86 and up	1 2 3 4 5 6 7 8
4	Turbine blading 5/	1 2 to 10 (incl.) 11 to 20 (incl.) 21 to 30 (incl.) 31 to 40 (incl.) 41 to 50 (incl.) 51 to 65 (incl.) 66 to 80 (incl.) 81 to 95 (incl.) 96 and up	1 2 3 4 5 6 7 8 9 10
5	Labyrinth packing 6/ and seal strips 7/	1 2 3 4 5 to 10 (incl.) 11 to 20 (incl.) 21 to 35 (incl.) 36 to 50 (incl.) 51 to 65 (incl.) 66 to 80 (incl.) 81 to 95 (incl.) 96 and up	1 2 3 4 5 6 7 8 9 10 11 12

See footnotes on next page.

1/ Where the identical part is used more than once in one turbine and gear, multiply the quantity shown in column 4 by the quantity required per turbine and gear.

2/ Spare turbine rotors shall be completely bladed and be ready for installation without further machining. Thrust collar, coupling and overspeed sensing devices shall be included. Balancing is required and, unless specifically waived in the contract, the shop operating test of 4 5.9 shall be performed either in a casing for which rotor is intended or by use of a special testing facility.

3/ Spare gear main rotating elements shall be furnished as matched sets. Thrust collars, couplings and all shafts, including quill or flexible shafts, where used, shall be included. Balancing is required.

4/ Each stock-numbered intermediate segment consists of all material necessary to effect replacement. Included, as applicable, are the segment, bolts, seal strips and calking. Blading shall also be included.

5/ Each stock-numbered item of blading consists of 105 percent of all materials necessary to replace one row of rotating or stationary blading. Included, as applicable, are blades, shroud bands, calking, seal strips (if inserted in blade or shroud) locking pieces, screws, pins and any other necessary parts.

6/ Each stock-numbered item of packing consists of one complete replacement metallic labyrinth packing ring for use in gland. Included as applicable, are a ring, spring(s), retaining ring(s), screws, pins and retaining plates.

7/ A stock-numbered set of seal strips consists of 105 percent of all renewable calked-in seal strips and lock strips in way of rotating and stationary blading, and nozzle blocks for a complete turbine.

3.6.1 1 Inventory control point Ships Parts Control Center (SPCC), Mechanicsburg, Pennsylvania is the Inventory Control Point (ICP) for all repair parts

3 6 2 Interchangeability. Repair parts shall be identical and interchangeable with their respective standard-installed parts on all turbines and gears of the same design, and shall be capable of being installed without any special fitting, machining, running-in, or other work, except as allowed below.

(a) Exceptions on approved drawings. Exceptions to above interchangeability requirements are permitted, if approved by NAVSEC and so noted on applicable drawings.
(b) Blading exception. All blading material, except shrouding, shall be furnished completely finished and ready for use, except for design allowance if any on blade roots for fitting. Blade material which is to be installed in segmental form shall be furnished assembled in segments.
(c) Shrouding exception. Shrouding shall be furnished out to length. Surplus stock for axial trimming to obtain specified clearances is acceptable. Shrouding shall be undrilled and unpunched for blade tenons.
(d) Diaphragm crush pins. Crush pins shall be fitted at installation.
(e) Shims. Shims for bearings, oil pump drive, turning gear, etc., may be fitted at installation.
(f) Double seated valves. Double seated valves shall be lapped to fit at installation.
(g) Nozzle control valve exception. Nozzle control valves, of the button head type, furnished for stock shall have 1/16 inch extra material on the head to permit fitting at installation.
(h) Dowels. Components utilizing dowels will require locating and redowelling with the next larger size dowel.
(i) Gears. In order to obtain the contact pattern area designated in 3.4.45.12.1, it may be necessary to realine the equipment and rebore or rescrape the bearings as determined by the installing activity.
(j) Governors and overspeed trips. Settings of governors and overspeed trips must be rechecked after installing replacement parts.
(k) Bearings, casings, oil seals, packing. Upper and lower halves of bearings casings, oil seals and packing rings (gland) are manufactured together as complete circles and must be furnished and installed as complete assemblies rather than in halves or segments.

3.6.3 Provisioning list. Provisioning lists are required for all repair parts and shall be prepared in accordance with contract data ordering documents (see 6.2.3) except that the turbine manufacturer shall include in the lower right hand margin a drawing title block and revision column. The provisioning list shall be used as a drawing of onboard parts and may be used as packing and shipping list. Applicability of parts shall be indicated in remarks column.

3.7 Drawings. Drawings shall be in accordance with data ordering documents included in the contract or order (see 6.2.3).

3.7.1 The modifications and clarifications specified in 3.7.1.1 through 3.7.1.4 shall apply.

3.7.1.1 The drawings required to manufacture the turbine, gear and components furnished therewith plus the drawings required by 3.7.4 herein constitute the total number of drawings involved in meeting intended use categories. Clarification of categories is as follows:

(a) Category A (Design evaluation). Those drawings specified herein for use at the design approval conferences and those requiring NAVSEC approval.
(b) Categories B (Interface control) and G (Installation). Those drawings required to provide the shipbuilder with sufficient information to design support systems and to install the equipment. Included are the following drawings:
  (1) [illegible]ine and arrangement.
  (2) [illegible] and drain.
  (3) Pneumatic or electric power or signal for governor.
  (4) Instrumentation.
  (5) Lifting arrangement.
  (6) Low lube oil pressure alarm switch.
  (7) Piping.
  (8) Subbase.
(c) Category D (Logistic support). Provisioning list and other drawings required by MIL-P-15137 (see 6.5).
(d) Categories H (Maintenance) and I (Government manufacture). Drawing shall contain sufficient information to permit manufacture and maintenance of all parts by a Naval activity. Submission of microfilm in accordance with 3.8 herein will fulfill requirements for these categories.

3.7.1.2 Contractor drawing numbers and code identification shall be used.

3.7.1.3 Identification of interface, specification, and source control drawings is optional.

3.7.2 In addition to the drawing content required by the data ordering document, for unique technical features (see 6.3).

3.7.2.1 Marking. Drawings shall specify marking detail (where and how) when purchase specifications contain marking requirements and when marking to be done by the manufacturer requires control to prevent stamping on highly stressed parts.

3.7.3 Material identification. Material for all parts shall be identified on detail drawings or parts list as applicable. Material may be defined by manufacturer's specifications for non-specified parts and for principal parts when approved in accordance with 3.2.8; however, double identification is required. This may be on the same drawing by a reference to a government or national society specification which identifies an equivalent material for use in conducting repairs or in manufacturing the part. An alternate method that will be accepted is to provide a separate drawing (A size), to be called a "Material List", which contains a complete list of the manufacturer's specifications in numerical order with equivalent government or national society specification indicated for each manufacturer's material. If the alternate method is used, reference to the "Material List" shall be shown on all drawings which require material identification. Existing drawings used for new contracts need not be revised solely to reflect changes in Government material specifications referenced thereon, however when drawings require revision for other reasons, the referenced specifications shall be updated at the same time.

3.7.4 Special drawings. Drawings specified in 3.7.4.1 through 3.7.4.15 are required in addition to all drawings required by the applicable pump or fan specification and all drawings required for manufacture, assembly, installation and maintenance of the turbines and gears including the following:

(a) Outline and arrangement (see 3.7.4.1).
(b) Turbine and gear assembly (see 3.7.4.2).
(c) Subassembly (see 3.7.4.3).
(d) Detail (see 3.7.4.4).
(e) Clearance diagram (see 3.7.4.5).
(f) Control system diagram (see 3.7.4.6).
(g) Oil system diagram (see 3.7.4.7).

(h) Lifting and handling arrangement (see 3.7 4.8).
(i) Insulation and lagging (see 3.7.4 9).
(j) Gland leak-off diagram (see 3.7.4.10).
(k) Instrumentation drawing (see 3 7.4.11).
(l) Drawing list (see 3.7.4.12).
(m) Machinery variation summation drawing (see 3.7.4.13).
(n) Welding and non-destructive testing (see 3.7.4.14).
(o) Piping diagram (see 3 7 4.15).

3.7.4.1 Outline and arrangement (or installation) drawing. In addition to the requirements of the applicable pump or fan specification. The outline and arrangement drawing shall contain, as applicable, the following, except that no information with a security classification shall be included:

(a) Plan, side elevation and end views of completely assembled turbine, gear (if used) and driven equipment, including overall dimensions.
(b) Complete performance data.
(c) Complete equipment performance curves.
(d) Table of weights, showing individual weights of equipment components and weight of complete set of onboard repair parts. Include weights of major parts (rotors, casings, and other parts) for lifting and handling purposes.
(e) A graphic presentation of the range of allowable forces and moments on the steam inlet and exhaust connections. The graph shall be constructed in such a manner that the shipbuilder can compare various combinations of calculated forces and moments of the external piping systems with the allowable values on the graph and readily arrive at a piping layout which will not impose undue strain on these connections. Outline drawing shall also specify the thermal movement of the steam inlet and exhaust connections (see 3.4.18).
(f) List of shipbuilder's connections, showing size, type and dimensions of flanges (including outside diameter, thickness number of holes, bolt diameter, bolt circle and face) (see 3 7.4.15).
(g) Estimated quantities of steam and air leakages at each leak-off connection include pressure, temperature and flow for the following
    (1) Gland leak-off with design gland packing clearance.
    (2) Gland leak-off when gland packing is worn to maximum clearance designated by manufacturer.
    (3) Trip valve or trip throttle valve leak-off
    (4) Governor valve leak-off.
    (5) Any other leak-offs or open drains.
(h) Critical speed.
(i) Center-of-gravity of major components and center of gravity of the combined unit (wet and dry). (For small units, (100 hp or less) turbine and gear may be considered as one component.)
(j) List of gages and thermometers (showing range).
(k) Dismantling dimensions.
(l) Bearing data, including loads, surface and pressure angle and surface speed.
(m) Manufacturer's drawing number and revision symbol.
(n) Data required by MIL-D-1000/2.
(o) The WR^2 of the major rotating parts.
(p) An outline of the identification plate showing all plate markings and the location of the plate. (For small units (100 hp or less) only the outline and location need be shown.)
(q) Type, number, ratings (volts, amperes r/min, kW, etc.) and name of manufacturer of all electric equipment.
(r) Attached instrumentation and fittings such as bearing sight flow fittings, thermometers, sections for same.
(s) Openings for examination or clearance measurement.
(t) The maximum amount of heat in British thermal units (Btu) per hour dissipated by the turbine and gear into the space where installed, assuming turbine is is insulated in accordance with specification requirements and is operating at rated load and speed with rated steam inlet and exhaust conditions.
(u) Maximum thrust load on each main shaft.
(v) Areas where insulation should be shielded from oil drips.
(w) Low oil pressure alarm setting.
(x) Alinement requirements.
(y) Show all drains with a table or notes to indicate when drain is to be open, when to be closed or if continuous, also indicate whether continuous drains are orificed or need traps.
(z) Any other information for proper installation, operation or maintenance of turbine and gear.

(aa) For turbines and gears that have been shock tested and found satisfactory, the drawing shall contain the following note: "This turbine (or gear) has satisfactorily passed shock tests as recorded in (show shock test activity) test report number (show test report number) dated (show date of test report) under Government contract number (show Government contract number).
(bb) Show pneumatic and electric requirements that shipbuilder should furnish.
(cc) Identify application (i.e., main feed pump, etc.).
(dd) Table of reference drawings, at least the first generation breakdown.
(ee) Compliance note stating: "Turbines, gears and equipment shown hereon conform to MIL-T-17523, as amended in the applicable ship specification, purchase order, or contract."

3.7.4.2 Turbine and gear assembly drawings. Turbine assembly drawings and gear assembly drawings are required. They may be furnished either separately or as a combined drawing and shall include the following:

(a) Side elevation of upper and lower half turbine and gear sectioned longitudinally, with enlarged view of casing strength stay rods, tie webs, ribs and other parts provided for positioning and strength.
(b) End elevation (upper and lower-half) with transverse section (facing nozzle block) through valve control gear, nozzle control valves, and steam chest. Also gear end elevations.
(c) Principal parts shall be identified by name and material in a list of material which may be integral with, or referenced on, the assembly drawing.
(d) Special views of valve control parts are required to indicate details of all parts, including lift bar, control valve (with adjusting nut or button head), discs, seats, bushings, seals and method of retaining parts.
(e) Rotor bore, if applicable.
(f) All planes for shop and in-field balancing shall be shown and identified, and method of attaching balance weights or limits of grinding or drilling for balancing shall be indicated.
(g) Gland packing rings shall be numbered consecutively (preferable beginning at the thrust end), geometry, construction and installation clearance of a representative ring of each category shall be indicated by special enlarged views and sections.
(h) Blade clearance (representative radial and axial values) shall be indicated.
(i) Journal and thrust bearing clearances (and thrust collar position) shall be indicated.
(j) Detail of thrust nut locking feature.
(k) Detail of overspeed protective devices.
(l) Nozzle block support and retention features shall be shown by enlarged view or section.
(m) Identification of gland leak-off connections. (Unless identified in outline.)
(n) Identification of oil supply and return connections. (Unless identified in outline.)
(o) Identification of oil deflector, waste oil-and-water pockets (if any) and drainage of same.
(p) Water-removal features and casing drains shall be indicated, along with representative dimensions involved, and whether or not drain is continuous.
(q) Representative views of threaded fasteners shall be included, along with means of securing and retaining same.
(r) Dowels locating major subassemblies shall be shown by enlarged view or section.
(s) Flange stud and bolting schedule, giving size, projection, and whether or not heater hole is provided.
(t) Means of providing for longitudinal and radial expansion (flex-leg, keys, clearance bolts, etc.) of casing shall be shown or described in a note.
(u) Attached instrumentation and fittings shall be clearly shown or enlarged.
(v) Miscellaneous small or loose parts not covered or specifically referenced on other drawings.

3.7.4.3 Subassembly drawings. Drawings shall be provided as necessary to show details of subassemblies not included in the cross-sectional assembly. Included in these drawings shall be one drawing or drawing list to describe the completely bladed and assembled turbine rotor with all necessary rotating parts such as thrust collar, oil pump drive gears and overspeed trip bolt or plunger (if installed). Drawing is required for ordering stock rotors.

3.7.4.4 Detail drawings. Details of all parts including identification plates, shall be delineated, except that details of standard commercial items such as nuts, bolts, anti-friction bearings, and other similar items shall not be furnished when they can be described by catalog number, size, and so forth, on the cross-sectional assembly drawing or a subassembly drawing.

3.7.4.4.1 Pinion and gear detail drawings. Pinion and gear detail drawings shall include all gear cutting data, shall show the amount of any helix angle or crown modification and shall show the method of finishing pinion and gear teeth. Minimum allowable tooth thickness, at the pitch circle, shall be shown, for rehobbing purposes.

3.7.4.4.2 Limiting reduction in journal diameters. Detail drawings of turbine rotor, pinion and gear shall show the limit below which bearing journals and packing areas shall not be reduced in diameter, when effecting repairs to shafts damaged in service.

3.7.4.4.3 Turbine rotor detail drawing. The turbine rotor detail drawing shall include an inset or by other means show details of securing blades and shrouding. The drawing shall show number and location of steam balance holes. Also the method of mechanical balance shall be shown, indicating the number, size and location balance weights, or if balance is to be by grinding, show location and limit of grinding permitted.

3.7.4.5 Clearance drawing and overhaul report form. A combined clearance and overhaul report drawing shall be prepared for each turbine and gear design; the drawing shall contain a longitudinal assembly view of the rotors with detail views indicating "cold" clearances for parts as listed in 3.7.4.5.1 through 3.7.4.5.7 in tabular form with columns entitled "design" (values filled in) and blank spaces for "as found" and "as closed" clearances for use by repair activities. Drawing shall indicate tolerances for installation and maximum allowable clearances for which replacement or reconditioning of parts is recommended.

3.7.4.5.1 Blading clearances. Clearances (radial and axial) shall be shown for rotating blading at its closest approach to casing, nozzle block, seal strips and other non-rotating parts.

3.7.4.5.2 Bearing clearances. Diametral clearances shall be shown for journal bearings. The clearance or fit between each bearing shell and its cap shall be indicated Axial float of the thrust collar shall be shown with the rotor hard up against either set of shoes.

3.7.4.5.3 Gland packing clearance. Axial and radial clearances shall be shown for each labyrinth packing ring. Provision for recording axial clearances is not required.

3.7.4.5.4 Oil seal clearance. Radial clearances shall be shown for each oil ring.

3.7.4.5.5 Rotor radial position setting. Where reference measurements are used for checking radial position of rotors utilizing bearings with adjustable seating pads, the radial reference measurements to be used as constants and method of measurement shall be shown.

3.7.4.5.6 Axial position. Provision for determining axial position of rotor (see 3.4.42.12) shall be indicated.

3.7.4.5.7 Notes. There shall be notes on the drawing similar to the following:

Note 1 - Radial and diametral clearances shown are with the rotor journals---(manufacturer shall state here whether journals are concentric with casing bore or resting in the bottoms of bearings). Two or more radial clearances shall be shown for parts having their axes eccentric with rotor axis.

Note 2 - Clearances shown are "installation clearances", which should be used as a guide when blading, bearings, thrust shoes, packing rings or oil seals are reconditioned or replaced.

Note 3 - If applicable, include caution note regarding taking total float measurements which can damage packing teeth. If total float can be taken, show expected value.

3.7.4.6 Control system diagram (drawing). A schematic drawing of the control system shall be furnished. Drawing shall indicate valves and linkages and include information for setting and adjusting control mechanisms. The control system diagram shall contain a description of how the control system operates and procedures for start-up, operation, and shut-down.

3.7.4.7 Oil system diagram. Drawing may be combined with the control system diagram for those turbines having hydraulic governors.

3.7.4.7.1 Schematic. The drawing shall indicate schematically bearing inlet and drain connections and, as applicable, oil connections to overspeed mechanisms and control mechanisms. Piping shown, but not furnished by the turbine manufacturer, shall be dotted or phantomed, while solid lines represent items and connections furnished with turbines and gears. Size of each connection shall be shown.

3.7.4.7.2 Flow data. Values of oil flow (gal/min) shall be shown at each connection. Direction of flow shall be indicated by an arrow. By note or table, drawing shall also indicate conditions for which oil flows apply (state percent power, and pressure).

3.7.4.7.3 Bearing orifices. Size and location of bearing orifices shall be indicated. Where orifices are integral with bearing shell, a note to this effect (giving a size) is acceptable.

3.7.4.7.4 Heat rejection. Drawing shall show heat rejection data used in sizing the lube oil cooler.

3.7.4.8 Lifting and handling arrangement drawings. Drawings shall illustrate the use of lifting and handling gear furnished for rotor and casing. Weights of parts to be lifted or handled shall be shown.

3.7.4.9 Insulation and lagging. The turbine manufacturer shall furnish a drawing showing the application of insulation and lagging (see 3.4.34).

3.7.4.10 Gland leak-off diagram.

3.7.4.10.1 Schematic. Drawing shall indicate schematically the turbine connections for leak-offs from glands and valve steams, and casing and chest drains. Piping shown, but not furnished by turbine and gear manufacturer, shall be dotted or phantomed, while solid lines represent items and connections furnished with turbines.

3.7.4.10.2 Direction of flow. Direction of flow in each line shall be indicated by an arrow or other means.

3.7.4.10.3 Connection sizes. Size of each line and connection shall be indicated.

3.7.4.10.4 Flow data. The values of steam flow, air flow and temperature at each gland seal shall be tabulated for specified full load and standby conditions with normal clearances. Capacity of regulator and dump valve shall be shown. An ambient air temperature of 120°F shall be used for calculations.

3.7.4.10.5 Notes. There shall be notes on the drawing similar to the following:

Note 1 - The capacity of the gland exhauster system, and leak-off piping shall be based upon "maximum clearance" flows: (corresponding to "maximum clearances" which require replacement of packing due to excess leakage); these maximum flows, calculated for 2 lb/in^2 in the seal pocket and 5 inches of water vacuum in the leak-off pocket, are as follows: (manufacturer shall indicate values here).

3.7.4.11 Instrumentation drawing. An instrumentation drawing shall be prepared and shall contain an outline of the turbine and gear (with cut-out views as necessary) indicating all points of instrumentation either furnished with the turbine and gear or by shipbuilder. A table showing maximum expected values of temperature and pressure shall be included. Relief valves (with settings given), rotor position indicator and sight flows shall be included. In lieu of preparing a separate instrumentation drawing the information required above may be shown on the outline drawing providing the drawing is not unduly cluttered.

3.7.4.12 Drawing list. A drawing list shall be prepared for each turbine and gear and all drawings applicable to equipment furnished shall be listed thereon. List shall provide a complete breakdown with an alphabetized index thereunder by major assemblies. It is the intent of this requirement to carry part generation breakdown to the detail drawings which support the subassemblies even though the detail parts may lose their identity in the assembly. The list of preferred materials and comparison sheets are not included in the drawings to be listed

3.7.4.13 Machinery variation summation drawing. A machinery variation drawing shall be provided for each class of ships. (Class of ships as used here refers to those units covered by the same technical manual.) Drawing shall contain a post production summation of all variations which involve special repair parts or affect maintenance actions (see 3.12) and shall indicate for each variation a brief description of the deviation from the basic drawing, the serial number of unit affected, the hull number of the ship to which assigned, and the necessary correlation with special parts and repair parts which result from the variation.

3.7.4.14 Welding and nondestructive testing (NDT) information. Drawings shall show all essential welding fabrication details and areas requiring nondestructive testing. Welding and NDT symbols shall comply with ANSI Y32.3 and AWS A2.2 respectively. Fabrication drawings shall reflect the kind of weld and shall state that welding is in accordance with MIL-STD-278.

3.7.4.15 Piping drawing. A piping drawing shall be prepared showing all piping furnished with the turbine and gear. This includes turbine and gear self-contained piping and connections to shipbuilders piping. The drawing shall show all connections necessary for proper installation and maintenance of the turbine and gear. The size, type and dimensions of all flanges, such as outside diameter, thickness, number of holes, bolt hole diameter, bolt hole circle diameter and flange face shall be shown. For other connections, complete details or description shall be shown. Drawing shall show the following connections as applicable:

(a) Control oil supply.
(b) Lubricating oil supply.
(c) Oil drains
(d) Steam inlet.
(e) Steam exhaust.
(f) Steam drains.
(g) Steam leak-offs.
(h) Air supply.
(i) Sea water inlet and exhaust.
(j) Fresh water inlet and exhaust.

3.7.5 Drawing approval.

3.7.5.1 Drawings requiring approval: (categories are those of MIL-D-1000).

(a) Category A The following drawings require NAVSEC approval.
  (1) Assembly drawing(s) (see 3.7.4.2).
  (2) Clearance drawing (see 3.7.4.5).
  (3) Applicable drawings indicating radiographic inspection (see 4.4.4).
  (4) Onboard repair parts list (see 3.6.3).
  (5) Instrumentation drawing (see 3.7.4.11).
  (6) Welding drawings (only those drawings of welds that require radiography) (see 3.7.4.14).
(b) Categories B and G. For shipbuilder-furnished equipment, the following drawings require approval by the cognizant supervisor.
  (1) Outline and arrangement drawing(s).
  (2) Lifting arrangement drawing.
  For government-furnished equipment, the above require procuring activity approval.
(c) Categories H and I. Except for the above, other drawings in these categories shall be self-approved by the turbine or gear manufacturer.
(d) Revisions to any category drawing. Revisions to drawings which have been approved by the Government require acceptance of NAVSEC when the revision affects either installation, performance, maintainability, or stock repair parts.

3.7.5.2 Approval procedure. Detailed procedure for submitting original and revised drawings for approval shall be established subsequent to award of contract and will be dependent on the activities involved. A drawing submittal schedule shall be prepared by the turbine and gear manufacturer within 60 days after contract award. The following general requirements apply.

(a) The schedule shall be arranged so that sections pertaining to each item of equipment can be easily identified, and, as a minimum, the schedule shall contain the following information.
  (1) Contract number.
  (2) Rating of turbine or gear.
  (3) Title of each drawing.
  (4) Drawing number for each drawing (including revision identification data).
  (5) Whether preliminary or revised version which reflects approval comments.
  (6) Scheduled submission date for each drawing.
(b) Drawings which have been revised solely to reflect approval comments shall be resubmitted for information only.
(c) Previously approved drawings which apply without change do not require reapproval. Such drawings shall be submitted for information only.

3.7.5.3 Approval responsibilities. Approval action taken by NAVSEC, NAVSEA, or its authorized representative shall not be construed to relieve the contractor from any contractual obligations regarding performance, reliability or other specification requirements.

3.8 Final drawings (microfilm). Final drawings shall be in accordance with the data ordering document (see 6.2.3) and 3.8.1 through 3.8.6.

3.8.1 Drawings shall be photographed one sheet per frame in an upright position where possible.

3.8.2 A set of cards shall consist of all drawings shown on the drawing list (see 3.7.4.12).

3.8.3 Revisions. If drawing revisions occur after cards have been distributed and within the guarantee or warranty period, replacement cards shall be furnished.

3.9 Technical manuals. Technical manuals shall be prepared in accordance with the data ordering documents included in the contract or order (see 6.2.3) except that the unique features of 3.9.1 through 3.9.7 shall apply (where there are any contradictions the requirements of 3.9.1 through 3.9.7 shall apply).

3.9.1 Validation. Validation is required only for those items specified hereinafter. Once a procedure has been validated, re-validation is required only when the design of the part and the arrangement of parts has been changed. Re-validation when only the part number designation has been changed is not required. The manufacturer shall make every effort to complete validation prior to submission of preliminary manuals for approval. Where such validation is not completed, correspondence forwarding preliminary manuals shall show the portions of the manual which have not been validated. All validation shall be completed prior to printing of final manuals.

3.9.1.1 Items which require validation. Items which require validation shall be as follows:

- (a) Procedure for determining whether the equipment is properly alined
- (b) Procedure for examination and replacing all journal bearings (including checking bearing clearance).
- (c) Procedure for examination, determining clearances and replacement of all seals.
- (d) Procedure for taking thrust clearance, installing thrust locking device, examination and replacement of thrust shoes and for taking total float clearance on thrust bearings.
- (e) Procedure for checking axial clearance of turbine rotor.
- (f) Procedure for examination, testing, adjusting, replacement, and setting of parts in the overspeed trip assembly, the low bearing oil pressure assembly, the back pressure trip assembly and the speed-limiting governing system.
- (g) Procedure for examination of control valves and linkages including setting instructions.
- (h) Procedure for examination and replacement of parts in the attached lube oil pump and the associated drive assembly.
- (i) Procedure for examination and replacement of parts in the motor driven oil pump.
- (j) Procedure for examination and replacement of parts in the throttle valve (or trip valve).
- (k) Procedure for examination of lube oil coolers and replacement of zinc, as applicable.
- (l) Procedure for balancing the rotating elements (turbine rotor, pinion and gear, as applicable).
- (m) Confirm that lubrication characteristics and procedures (pressures, temperatures, areas to be lubricated and frequency of lubrication, as applicable) agree with information in the technical manual.

3.9.2 Outline of manual. The manual may be sectionalized as necessary to provide major divisions under each chapter, each covering one unit such as governor, reduction gear, turbine, lube system, and special devices and systems. The format and content of the manual shall be in accordance with 6.2.3.

3.9.3 General requirements.

3.9.3.1 Where the manual consists of more than one volume in order to meet the specification limit on maximum thickness, chapter 8 shall be contained in the last volume.

3.9.3.2 Photography. Use of photographs to supplement description and maintenance coverage shall be required. As a minimum, photographs or sketches of the following items shall be included.

(a) Completely assembled turbine, gear and driven equipment. One view each from the right and left hand sides of the set.
(b) Turbine assembly with upper half casing removed.
(c) Reduction gear assembly (if reduction gear furnished) with upper half casing removed.
(d) Method of taking crown thickness.
(e) Thrust bearing showing leveling plates and pads.
(f) Lube oil system pressure control valve.
(g) Special couplings such as those with resilient composition inserts.
(h) Trip throttle valve or trip valve.
(i) Overspeed trip assembly.
(j) Thrust collar locking device.
(k) Speed-limiting governor assembly.
(l) Typical gland packing assembly.
(m) Low bearing oil pressure and manual trip assembly.
(n) Typical nozzle support.
(o) Typical turbine and gear journal bearing.
(p) Turbine rotor assembly.
(q) Lube oil pumps and drives (attached and motor driven).

3.9.4 Detail requirements. Detail requirements for manual contents are specified in 3.9.4.1 through 3.9.4.8. These requirements take precedence over 6.2.3 otherwise specified.

3.9.4.1 Chapter 1 - General information and data. Chapter 1 shall consist of the following.

(a) Section 1 - Section 1 shall briefly describe the turbine and gear and detached accessories showing physical characteristics (size and weight, and so forth) of these items and showing general performance characteristics under steady state and transient load conditions and under the specified steam and exhaust conditions Any special features such as noise reduction shall be covered
(b) Section 2 - Section 2 shall briefly describe physical and operating characteristics, and manufacturer's type or model designations for the turbine, lubricating oil pumps and motor (if provided), lube oil cooler, reduction gear (if provided) speed-limiting governors and overspeed trip systems.

3.9.4.2 Chapter 2 - Installation. Chapter 2 shall consist of the following:

(a) Section 1 - Reference shall be made to installation drawings for the turbine and gear and detached accessories. Installation information, as necessary, shall be added to supplement these drawings.
(b) Section 2 - Section 2 shall cover the following as a minimum requirement.
    (1) Show procedure for handling equipment prior to unpacking.
    (2) Show procedure for unpacking equipment.
    (3) Show procedure for handling equipment after it is unpacked.
    (4) Show tools required and step by step procedure for attaching units to the turbine and gear where these units have been removed for shipping purposes.
    (5) Show step-by-step procedure for checking alinement of turbine and gear after it has been secured to ships foundation.
    (6) List safety precautions.
    (7) Show procedure for any inspections to be made prior to starting the turbine and gear or detached units for the first time onboard ship.
    (8) Show step-by-step procedure for starting, operating, and securing the turbines and gears for the first time onboard ship. This procedure shall show the normal readings for all indicating devices (gages, meters, and so forth) during the starting, operating and securing phases of the turbines and gears and all accessories. In addition, this procedure shall show the operating sequence for all devices requiring adjustment (such as valves, switches) during the starting, operating and securing phase.

3.9.4.3 Chapter 3 - Operation. Guidance for operating the turbine and gear shall be provided for the areas listed below. Information on all operational limitations such as maximum back pressure, allowable bearing temperatures, minimum and maximum oil pressures, minimum and maximum oil inlet temperatures, maximum ambient compartment temperatures and other parameters to provide specific guidance for operation of the turbine and gear including detached accessories shall be provided.

(a) Safety precautions.
(b) Examinations and checks to be made prior to starting. Information should include data to show the correct position of adjusting devices (such as valves, switches, and so forth) prior to starting the unit.
(c) Step-by-step procedure for starting the unit including the sequence of opening and closing valves and the sequence of operating and the setting of all switches, rheostats and circuit breakers (including those associated with electric overspeed governors). Procedure shall also show details of the warming up period including rate of increase in speed, the speeds in r/min where the turbine and gear is operated during the warm up period and the time involved at each speed.
(d) Step-by-step procedure for operation of the turbine and gear as a single unit after the warm-up period has been completed and is operating at rated speed.
(e) When to clean, replace or switch strainer and filter elements (maximum allowable pressure drop).
(f) Step-by-step procedure for paralleling.
(g) Step-by-step procedure for securing, including the sequence of opening and closing and closing valves and so forth.

3.9.4.4 Chapter 4 - Preventative maintenance. The intent of this chapter is to show information on routine maintenance procedures to prevent unscheduled shut-down due to failure of units, or where units deteriorate to the point where they will not meet the performance requirements of this specification during the operating time between ship overhaul periods. Routine maintenance shall not involve alinement or complex adjustments as the equipment shall be designed to eliminate the need for accomplishing such items during the operating time between ship overhaul periods. This chapter shall include a list of planned maintenance actions based on those shown in table III and the following information for accomplishing each action.

(a) Step-by-step procedure (including procedure for disassembly and assembly of units or parts, as applicable).
(b) Tools and instruments needed.
(c) Estimated time.
(d) Details of any minor adjustments and minor parts replacement (brushes, fuses, gages, thermometers, and so forth) involved.

3.9.4.5 Chapter 5 - Overhaul maintenance. The intent of this chapter is to show information on inspections, and the criteria for adjustment, repair or replacement of parts resulting from the inspections during the ships overhaul period so that when overhaul work is completed, the turbine and gear will operate for the specified hours between ships overhaul periods without unscheduled shut-downs for corrective maintenance when the preventative maintenance items in Chapter 4 are accomplished. Procedures and instructions related to overhaul maintenance actions which will be performed by shipyard personnel shall cover the following items.

(a) Safety precautions.
(b) Removal of upper turbine casing and bearing brackets for examination of turbine blades, packing, valves, seals, bearing journals, bearings and associated clearances.
(c) Removal of upper gear casing (where gear is furnished) for examination of tooth contact, bearing journal surfaces, bearings and associated clearances.
(d) Criteria for determining whether a part is in need of repair or replacement.
(e) Disassembly and reassembly procedures including sequence of removing and tightening bolts, pattern for stretching bolts and securing joints and a torque table for tightening critical bolts and nuts, where applicable.
(f) Acceptable range of clearances between all rotating parts and between all rotating and stationery parts.
(g) Cleaning procedures for units and parts after they are disassembled.
(h) Procedures for measuring bearing wear.
(i) Procedure for examination and replacing turbine blades.
(j) Procedure for examination and replacing gland packing rings.
(k) Procedure for examination, testing, adjusting, repairing and replacing parts in the overspeed trip assembly.

(l) Procedure for examining, repair and replacement of parts in the bearing low oil pressure and manual trip assembly.
(m) Procedure for examination, repair and replacement of parts involved in the steam chest, valves and linkages.
(n) Procedure for examination, repair and replacement of parts in the throttle valve.
(o) Procedure for examination, repair and replacement of parts in the lube oil cooler.
(p) Procedure for examination, repair and replacement of parts in the turbine driven oil pump and drive assembly.
(q) Procedure for examination, repair and replacement of parts in the electric motor and lube oil pump assembly (when this assembly is furnished).
(r) Procedure for examination, repair and replacement of parts in strainers and filters.
(s) Procedure for examination, testing, adjusting, repair and replacement of parts in the speed-limiting governor.
(t) List of special tools, lifting slings and guides provided and indicate where these items are used.
(u) Procedure for checking alinement of turbine, reduction gear (if reduction gear furnished) and driven equipment.
(v) Procedure for checking alinement of internal shafting, couplings and bearings in turbine or gear accessories.
(w) Procedure for examination, repair and replacement of parts in the governor assembly.
(x) Procedure for adjusting all protective devices.
(y) Procedure for balancing the rotating elements that the complete equipment will meet the vibration limits specified herein.
(z) Procedure for checking performance of complete equipment after all adjustments, repairs, balancing and alinement has been completed during this ships overhaul period. This procedure should include reference to the test data shown under chapter 8 of the manual as a means of comparison to determine whether the equipment performance is optimum.

3.9 4.6 Chapter 6 - Trouble shooting. The intent of this chapter is to show a detail functional description of each unit furnished with the turbine and gear, a step-by-step explanation of the operation of the turbine and gear to show how each unit is involved, why adjustment are required to maintain optimum performance and trouble shooting information for isolating the unit or part which has failed or which is functioning improperly. Chapter 6 shall consist of the following sections.

(a) Section 1 - Section 1 shall show the step-by-step sequence of operation of all units of the turbine and gear (during the start up, operation and securing phases) and shall include block diagrams, simplified schematic diagrams, performance curves, and so forth as necessary, and reference to these items made in the write up, so that the function of each unit and its affect on the performance of the turbine and gear may be clearly understood. The minimum items to be covered shall be as follows:
  (1) Governor system including any linkage involved.
  (2) Lube oil system.
  (3) Gland leak-off system.
  (4) Turbine steam chest valves and linkage.
  (5) Turbine throttle valve (or trip valve).
  (6) Safety and alarm devices.
  (7) Indicating devices.
  (8) Control devices.
  (9) Bearings.
(b) Section 2 - Section 2 shall be arranged in table form with three vertical columns. The first column shall be titled "Symptom"; the second column shall be titled "Probable Cause", and the third column shall be titled "Remedy". Items under the "Remedy" column which involve checks, inspections, repairs, replacement of parts, cleaning and adjustments shall refer to the section and paragraph in the manual where detail procedures for accomplishing these items may be found. Where the "Remedy" column for electrical items involves checking voltages, wave forms and current in circuits, information shall be added to identify the specific points in the circuit where measurements are made by appropriate reference to drawings included in the manual. As a minimum, the trouble shooting table shall show probable causes and remedies for the following symptoms.
  (1) Loss of lubrication oil pressure.
  (2) Bearing temperatures abnormally high.
  (3) Vibration abnormally high.

(4) Speed varies with constant load.
(5) Recovery of speed abnormally slow after sudden application or removal of load.
(6) Low lube oil pressure.
(7) Low control oil pressure.
(8) High lube oil pressure.
(9) High control oil pressure.
(10) Turbine trips of line inadvertently when operating personnel do not initiate action to trip unit off the line.
(11) Turbine fails to trip when tripping device operated by personnel.
(12) Steam chest linkage operation sluggish.
(13) List of special tools and all instruments required for trouble shooting.

3.9.4.7 Chapter 7 - Parts and special tools list. Chapter 7 shall consist of the following:

(a) Section 1 - Section 1 shall contain a list of all units and their maintenance parts. The listing shall be arranged by units and the basis of the items and quantities specified as repair parts in individual equipment specifications plus any other parts which the manufacturer considers necessary to support the turbines and gears during the hours of operation between ships overhaul periods specified herein. Further the list of parts shall include those additional parts which the manufacturer recommends the Navy have on hand for use during the ships overhaul period. The list of parts shall consist of the following data.
(1) Name of unit and name and description of part.
(2) Identify part location by referencing applicable drawing and piece number.
(3) Quantity of each part contained in one turbine and gear.
(4) Identification of manufacturer of each part (if this data not shown on referenced drawings).
(b) Section 2 - Section 2 shall include a list of special tools supplied with the turbine and gears.

3.9 4.8 Chapter 8 - Appendix. Chapter 8 shall consist of the following:

(a) Section 1 - Section 1 shall consist of a list of the following drawings:
(1) Major assembly drawings of all units.
(2) Installation drawing or drawings.
(3) Drawings which are referenced on the installation drawing or drawings.
(4) Detail drawings, as necessary, to supplement operating, preventative maintenance, overhaul maintenance and trouble shooting instructions in the manual, and to identify repair parts.
(b) Section 2 - Section 2 shall include legible fold-out copies of the approved versions of drawings required by Section 1 of this chapter.
(c) Section 3 - Section 3 shall contain information on the results of tests on the unit subjected to the performance test required by 4.5.21.3.

3.9.5 Acceptance procedures for preliminary manuals.

3.9.5.1 Preliminary draft of the technical manual shall contain all the information which the manufacturer proposes for the final manual except for photographs and results of tests.

3.9.5.2 Preliminary drafts of the manual shall be submitted for approval in the quantity, on the date and to destinations as specified (see 6.2.2(q)).

3.9.6 Final manuals. Responsibility for preparing final manuals, quantity of manuals required, date manuals are required and distribution of final technical manuals shall be as specified (see 6.2.2(r)).

3.10 Technical data requirements. Data shall be prepared as indicated by X's in table XI, columns (5), (6) and (7). Table XI also shows the interrelationship of ordering data, bid data, technical manual data and data for the technical data books.

TABLE XI. List of technical data requirements.

Data category	Item number	Data description	Ordering data	To be furnished by manufacturer in: Bid or proposal	Technical manual	Tech data book	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I	1.	Nozzle block					
		(a) Number of groups	-	-	-	X	
		(b) Number of nozzles per group	-	-	-	X	
		(c) Throat area per group	-	-	-	X	
		(d) Active arc	-	-	-	X	
	2.	Diaphragms (by stage)					
		(a) Nozzle height	-	-	-	X	
		(b) Nozzle throat area	-	-	-	X	
		(c) Active arc	-	-	-	X	
		(d) Number of nozzles	-	-	-	X	
	3.	Blading (by stage)					
		(a) Blades per row indicating number of gaps	-	-	-	X	
		(b) Mean diameter	-	-	-	X	
		(c) Blade height (excluding root and tenon)	-	-	-	X	
	4.	Reduction gears					
		(a) Gear efficiency	-	-	-	X	
		(b) Bhp	-	-	X	X	
		(c) Pinion r/min	-	-	X	X	
		(d) Gear r/min	-	-	X	X	
		(e) Reduction ratio	-	-	X	X	
		(f) Pitch diameter (inches)	-	-	X	X	
		(g) Number of teeth (pinion)	-	-	X	X	
		(h) Number of teeth (gear)	-	-	X	X	
		(i) Addendum (inches) (pinion)	-	-	-	X	
		(j) Addendum (inches) (gear)	-	-	-	X	
		(k) Dedendum (inches) (pinion)	-	-	-	X	
		(l) Dedendum (inches) (gear)	-	-	-	X	
		(m) Diametral pitch	-	-	-	X	
		(n) Helix or lead angle (degrees)	-	-	X	X	
		(o) Normal pressure angle (degrees)	-	-	-	X	
		(p) Normal pitch	-	-	-	X	
		(q) Tooth thickness on pitch diameter	-	-	-	X	
		(r) Face width	-	-	X	X	
		(s) Pitch line speed (ft/min)	-	-	-	X	
		(t) Total load (pounds)	-	-	-	X	
		(u) Tooth pressure per inch of face	-	-	-	X	
		(v) "K" factor	-	-	X	X	
	5.	Bearing journals and packing areas Furnish a table listing all bearing journal and packing areas and show design diameters and limiting minimum diameter when reduced to effect repairs of shafts damaged in service.	-	-	X	X	

TABLE XI. List of technical data requirements. Continued

Data category	Item number	Data description	Ordering data	To be furnished by manufacturer in: Bid or proposal	Technical manual	Tech data book	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
II	1.	Material tabulation	X	X	-	X	Principal parts
	2.	Size and space	X	X	X	-	Outline drawing
	3.	(a) Weight target (total)	X	-	-	-	
		(b) Weight estimate (component) (specific weight)	-	X	-	X	
		(c) Final weights (total and of principal parts)	-	-	X	-	
	4.	Curves for correcting operating (trial) conditions to design conditions	-	-	-	X	See figure 6
	5.	Nomograph, relating expected variations in hp, r/min, pressure, temperature, vacuum	-	-	X	-	
	6.	Rotor criticals (rigid bearing and running)	-	-	X	X	
	7.	Tabulation of the following design data for specified steady state conditions	-	-	X	X	
		(a) R/min (rated)					
		(b) Hp output					
		(c) Throttle flow (lb./hr)					
		(d) Inlet steam conditions pressure and temperature					
		(e) Steam rate (lb./hp-hr)					
		(f) Calculated maximum speed after actuation of overspeed trip					
		(g) Stage pressure and temperatures at measured points					
		(h) Exhaust pressure, temperature, moisture content and enthalpy					
	8.	Tabulation of following data for each bearing:	-	-	-	X	
		(a) Size (diameter and active length)					
		(b) Projected area (in^2) (inside drain grooves)					

TABLE XI. List of technical data requirements. Continued

Data category	Item number	Data description	Ordering data	To be furnished by manufacturer in			Remarks
				Bid or proposal	Technical manual	Tech data book	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
II	8.	Tabulation of following data for each bearing continued:	-	-	-	X	
		(c) Bearing load (lb/in) on projected area, at 25, 50, 75 and 100 percent of rated load					
		(d) Direction of bearing loading at 25, 50, 75 and 100 percent of rated load					
		(e) Oil required (gal/min and press) at full load					
		(f) Surface speed (ft/s) at rated speed					
		(g) Diametral clearance (minimum and maximum)					
		(h) Location and size of orifices					
	9.	Operational limitations for principle parameters for which instrumented (pressure, temperature, r/min and so forth) include curves of stage pressures (where measured) versus load	-	-	X	-	
	10.	Curves, on a base of hp over entire operating range, showing: (a) Turbine steam rates (including all losses) and flow indicating, valve points and assumed gear efficiencies at design points	-	-	-	X	Include Willans line
		(b) Maximum exhaust pressure the turbines can usefully (and safely) employ	-	-	X	-	
		(c) Gland leakoff quantities (design and worn conditions)	-	-	X	X	See 3.7.4.1(g) (1) and (2)
		(d) Hp output at turbine coupling or at gear coupling (if gear is used)	-	-	-	X	

TABLE XI. List of technical data requirements. Continued

Data category	Item number	Data description	Ordering data	To be furnished by manufacturer in: Bid or proposal	Technical manual	Tech data book	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
II	11.	Curves, on the base of r/min. over entire operating range showing:					
		(a) Rate of lube oil circulation required and as estimate of the required pressure at the bearing inlet connections	-	-	-	X	
		(b) Rate of heat removal required from the lubricating oil	-	-	-	X	
	12.	Torsional vibration analysis, curves and data (including speed, highest shaft stress relative to design stress for high and low speed spans, WR^2 and stiffness values used in calculations)	-	-	-	X	
	13.	Curves, valve lift versus load	-	-	X	X	
	14.	Mollier charts (full load and 60 percent load)	-	-	-	X	Show actual state lines
III	1.	Curve of turbine efficiency versus turbine hp	-	-	-	X	
	2.	Curves of blade and rotor material rupture strength and creep (0.1 percent) strength versus temperature for 1,000, 10,000, 40,000, 60,000 and 100,000 hours	-	-	-	-	Include with material comparison sheets
	3.	Blade and rotor tabulation (by stages) including:					
		(a) Stage temperature (metal)	-	-	-	X	
		(b) Material strength at temperature					
		(c) Minimum factor of safety					

TABLE XI. List of technical data requirements. Continued

Data category	Item number	Data description	Ordering data	To be furnished by manufacturer in: Bid or proposal	Technical manual	Tech data book	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
III	3.	Blade and rotor tabulation (by stages) including: continued					
		(d) Maximum or limiting value and direction of stress in rotor section (groove, disc, wheelneck, etc.) and blading (tenon, vane, tang, hook, neck, shank, etc.)	-	-	-	X	
		(e) General notes stating: (1) Stresses are direct centrifugal unless otherwise indicated					
		(2) Limiting or maximum stress and safety factors indicated are for rated kW and r/min unless otherwise stated					
		(3) Ratio of allowable sheer stress to tensile stress					
	4.	Tabulation (by stages) of the following (0 to 125 percent rated speed) for blading	-	-	-	X	Number of blades per shrouded group and number of shrouded groups shall be indicated.
		(a) Frequency evaluation of tangential, axial and torsional modes	-	-	-	-	
		(b) Maximum vibration stress and location (tenon, vane, etc.)	-	-	-	-	
		(c) Steam bending stress	-	-	-	-	
		(d) R/min at which resonance occurs	-	-	-	-	
		(e) Centrifugal stress	-	-	-	-	

3.10.1 Data categories. Technical data shall be categorized as shown in 3.10.1.1 through 3.10.1.3.

3.10.1.1 Category I data. Category I data covers design details.

3.10.1.2 Category II data. Category II data covers performance.

3.10.1.3 Category III data. Category III data shall be submitted to NAVSEC only and shall be safeguarded as proprietary data to protect the manufacturer's commercial interests. Each data sheet in this category shall contain "CAUTION: FOR NAVSEC USE ONLY - DO NOT MICROFILM OR OTHERWISE REPRODUCE WITHOUT CONSENT OF (NAME OF MANUFACTURER)--".

3.10.2 Technical data books. The manufacturer shall prepare technical data books in accordance with the data ordering documents included in the contract or order (see 6.2.3) except that the unique requirements of 3.10.2.1 through 3.10.3 shall apply.

3.10 2.1 Data book format and identification.

3.10.2.1.1 Data book covers. Data books may be paper-back. Covers shall show the following:

Name of component

for

Name of equipment (See note)

Hull numbers of ships, i.e., DLG 10-15

Manufacturer's name

Note: Examples -

Turbine

for

Main feed pump

Gear

for

Main circulating pump

3.10.2.1.2 Title page. Title page shall include information shown on the cover plus the following:

Manufacturer's address
Name and address of manufacturer of gear or turbine, as applicable, if different.
Name and address of pump or fan manufacturer.
Name and address of purchaser, i.e., commercial shipyard, Naval shipyard, NAVSEA, etc.
Purchaser's contract or order number and date

3.10.2.1.3 Table of contents. A table of contents shall be included.

3.10.2.1.4 Identification plate data. Following the table of contents, identification plate data for the turbine, the gear, if one is used, the pump or fan and major subcomponents, such as motor driven oil pumps, strainers, filters, coolers, governors (if self-contained), etc., shall be included.

3.10.2.1.5 Serial numbers. Serial numbers of turbines and gears shall be included. If known, and if practicable, list serial numbers by ship name and hull number.

3.10.2.1.6 Technical data. Technical data required by column (7) of table XI shall be included. The data may be typewritten or hand written on sheets. Wherever practicable, the data shall be in the same order as listed in table XII. Each sheet shall be dated. If data is shown on the outline or assembly drawings (see 3.7.4.1 and 3.7.4.2), it is not necessary to repeat the information, however there should be a note, opposite the item listed in table XI, stating "see outline drawing" or "see assembly drawing".

3.10.2.1.7 Campbell diagram. Campbell diagrams shall be included for each row of blading, showing natural blade frequency and exciting frequencies as a function of speed.

3.10.2.1.8 Drawings. At the back of the book, fold-outs of turbine and gear outline and assembly drawings shall be included. Drawings shall be legible and shall be similar to or identical with those included in the technical manual.

3.10.3 Submittal of data. Data books shall be submitted for information as soon after award of contract as available, (but no later than 120 days) and shall be as complete as practicable. Thereafter, data sheets (or pages) shall be submitted as prepared or revised. Distribution shall be in accordance with table XII.

TABLE XII. Distribution of data books.

Data category	NAVSEC (6145) (direct mail)	Each building shipyard	Cognizant SUPSHIPS (for info)	NAVSEC Division Phila. Pa.
I	3	0	0	1
II	3	3	1	1
III	3*	0	0	0

*Denotes use of registered mail.

3.11 Reports. A schedule for submission of the items listed below shall be prepared by the turbine and gear manufacturer in accordance with the data ordering documents included in the contract or order (see 6.2.3) except that the following unique requirements shall apply. The schedule shall be forwarded to the following within 90 days after award of contract.

NAVSEC - 3 copies
Each shipyard concerned - 3 copies
Each supervisor involved - 3 copies

The schedule shall list each item, indicate expected date for submission, and contain a column to be filled in when the item has been completed. Schedule shall be revised as necessary with final submittal to be used as a check on completion of the items involved. Items to be included, as applicable, are as follows:

(a) Drawings listed by title and drawing number, if available (see 3.7).
(b) Blade stress data (see 3.2.5.2).
(c) Technical data books (see 3.10).
(d) Microfilm (see 3.8).
(e) Vibration test report (see 4.5.10).
(f) Blade vibration test agenda and report (see 4.5.12).
(g) As-shipped clearances (see 4.5.3).

3.12 Equipment variations. Equipment which does not conform to contractual requirements shall be handled in accordance with the provisions of the contract. Other variations, which result in conforming equipment but constitute deviations from the approved configuration, materials or processes, shall be handled in accordance with the data ordering documents (see 6.2.3) and the procedures set forth herinafter. Specific examples of these variations are as follows:

(a) Manufacturering errors which necessitate special repair procedures or the use of non-standard repair parts.
(b) An improperly-applied process procedure or a substitute process which does not adversely affect the end use of the part or assembly involved.

3.12.1 Disposition. Variations which affect installation, operation, performance, reliability, maintainability, stock repair parts (onboard and ashore), or interchangeability of parts that would be repaired or replaced during maintenance of the equipment require Government approval.

3.12.2 Conditions for acceptance of parts having variations. Variations will be approved under the following conditions:

(a) The effect of the variation either in the as-is conditions or with the part modified is technically acceptable to the Government.
(b) The nature of the part involved is such that replacement is not economically justified.
(c) Where parts involved are normally onboard repair parts, three of each such non-standard parts or sets of parts shall be furnished at contractor's expense, consisting of one of each as onboard repair parts and two of each as stock repair parts.
(d) Where parts involved are normally stock repair parts, but not onboard repair parts, two of each such special parts or sets of parts shall be furnished at contractor's expense as stock repair parts.

(e) The repair parts furnished in accordance with (c) and (d) shall consist of the lowest echelon of the parts required to compensate for the variation. For example, the major parts in which the basic error is made need not necessarily be furnished; if a rotor bearing journal is machined undersize necessitating the installation of a non-standard bearing, spare non-standard bearings shall be furnished, but a spare non-standard rotor need not be furnished.

(f) Separate provisioning documentation for non-standard repair parts shall be submitted in accordance with MIL-P-15137 (see 6.5). The component involved shall be identified by ship, unit, component serial number, and shown at "NO CHARGE" in the documentation.

(g) An equipment variation summary drawing (see 3.7.4.13) together with certification that resultant special parts have been furnished, shall be submitted for all variations permitted herein under each contract.

(h) Where the variation results in additional cost to the Government to accommodate a non-standard GFM item, such as additional shipyard costs for installation, the contractor shall reimburse the Government for the total amount of such costs involved.

(i) The requirements of (c) and (d) apply only where the variation affects interchangeability.

3.12.3 Procedure for approval of variations. The following procedure shall be used for approval of variations:

(a) Variations shall be referred to NAVSEA/NAVSEC as applicable, for approval, via the local Defense Contract Administration Services (DCAS) within thirty days after occurrence. Submittals shall be in the same manner as established for obtaining drawing acceptance which, on shipbuilder furnished equipment, will require submittal via the shipbuilder and cognizant supervisor. Any work done on equipment with variations prior to obtaining Government approval shall be at the contractor's risk.

(b) Copies of all correspondence involving repair parts shall be forwarded to Ships Parts Control Center, Mechanicsburg, Pennsylvania.

3.13 Quality control records. Machining errors and equipment variations which are not covered in 3.12.1 (such as non-significant and non-critical deviations from drawing dimensions or tolerances for castings, forgings, weldments, connections, or machine-processed parts) do not require approval by either NAVSEA/NAVSEC or DCAS; however, each such deviation shall be documented, and a copy shall be furnished to the local DCAS. If the DCAS considers that the deviation involves contractual requirements or meets criteria in 3.12.1, NAVSEC and the manufacturer shall be notified. If NAVSEC agrees with the DCAS, the deviation shall be treated in accordance with 3.12.2 and 3.12.3. When a repair restores a part to original drawing dimensions, but involves no change of materials and uses a previously-approved repair process, the local DCAS shall approve such repair.

3.14 Design approval. As indicated within this specification, NAVSEC approval is required for a number of general design details and for other specific areas applying to a particular design of turbine and gear to be furnished for a given application. Approval required and procedures for obtaining approval shall be as specified in 3.14.2.

3.14.1 Summary of approvals required.

3.14.1.1 General design practices.

(a) Substitute materials (see 3.2.8).
(b) Exceptions to spare part interchangeability (see 3.6.2).
(c) Repair procedures (equipment variations) (see 3.12).
(d) Welding procedures (see MIL-STD-278).
(e) Instrumentation system for blade tests (see 4.5.12).

3.14.1.2 NAVSEC approval required for each design.

(a) Exceptions to specifications (see 3.4.8).
(b) Drawings specified by 3.7.5.
(c) Blade vibration test agenda (see 4.5.12).
(d) Equipment variations (see 3.12).

3.14.1.3 NAVSEC review-required for each design. NAVSEC review is required for each design for preliminary technical manuals (see 3.9.5).

3.14.2 Approval procedures.

3.14.2.1 General design practices. Approval of the items listed in 3.14 1.1 are required once and do not require re-approval under each contract. Accordingly, the manufacturer may prepare a booklet of "design practices" and obtain across-the-board approval from NAVSEC for these items.

3.14.2.2 Specific turbine and gear designs. Design approval conferences shall be held to review the overall design. It is intended that drawing approvals be handled concurrently at the conferences to minimize delays and repeated exchange of letters.

3.14.3 Design release conferences. As soon as practicable after award of contract, the manufacturer shall request a conference at NAVSEC (request to be forwarded via shipbuilder and cognizant supervisor if applicable) for the purpose of obtaining approval of basic design and ordering of material. Areas to be covered at the conference include but are not necessarily limited to the following; however, partial coverage of these items will be considered if necessary to grant timely approval of long lead time components.

(a) Interchangeability of design or parts therof to previously furnished designs.
(b) Materials of principal parts (minimum of items listed in table I) including identification of acceptable substitute materials proposed.
(c) Basic design features.
(d) Predicted performance.
(e) Arrangement.
(f) Weights.
(g) Specification clarifications if applicable.
(h) Control system.
(i) Need for stellite shields on blades.
(j) Lubricating oil system.

3.14 3.1 Data to be furnished prior to conference. At least 2 weeks prior to the conference, the manufacturer shall forward a proposed agenda in accordance with the contract data ordering document (see 6.2.3). Preliminary drawings (such as the outline and arrangement drawing and assembly drawing) material lists, technical data and other documentation as necessary to permit review by NAVSEC prior to conference shall be included.

3.14.4 Design review conferences. Other conferences shall be held as necessary to review the final design and to discuss progress or problems that have arisen. As in the case of the design release conference, request for conference shall be made at least 2 weeks prior to the desired date and shall include a proposed agenda similar to the requirement of 3.14.3.1. It is also intended that NAVSEC comments on drawing submittals be discussed at these conferences.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract 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 Records. Records shall be maintained of results of all tests, checks and examinations. When required herein or by the applicable pump or fan specification, results shall be forwarded as indicated. Where not specified, records shall be retained by the manufacturer and be available, at all times, for review by the DCAS and copies shall be furnished upon request. Test reports shall be in accordance with the data ordering documents included in the contract (see 6.2.3).

4.1.2 Use of mercury. Turbines and gears shall be free of mercury contamination. During the manufacturing processes, checks, examinations and tests, the product being offered for acceptance shall not come in direct contact with mercury, any of its compounds nor with any mercury containing device, such as gages and thermometers. The manufacturer shall certify that the product, when shipped, is free from mercury contamination.

4.2 Inspection system. The inspection system which the contractor is required to maintain, as provided in the inspection clause of the contract or order, shall be in accordance with MIL-I-45208 (see 6.2.2(v) and 6.5).

4.2.1 Product inspection type A (PIT-A) requirements. The PIT-A requirements which will be imposed are as follows:

(a) Overspeed test - (each unit) (see 4.5.16 and 4.5.17).
  (1) Verify that contractor's test procedures and instrumentation are adhered to.
  (2) Verify vibration data.
(b) Post-test examination (each unit) (see 4.5.2.4, 4.5.3, 4.5.4 and 4.5.7).
  (1) Rotor assembly.
    a. Verify that blades are properly installed; check conformance to drawing requirements on alinement, pitch and tightness.
    b. Verify tenon peening for conformance to requirements; assure absence of cracks and overworked material.
    c. Verify radial and end gaps of shrouds for conformance to drawing requirements.
  (2) Verify proper assembly of seals and examine for condition.
  (3) Examine each row of blades for shroud lift.
  (4) Examine throughout for rubbing and damage to internal parts.
  (5) Verify that all balance weights are staked in accordance with drawings.
  (6) Examine all journals for scoring.
  (7) Examine all bearings for damage.
(c) Radiography (each unit) (see 4.4.4).
  (1) Review each NDT (radiography) result and submit those required by 4.4.4 to the contractually-designated Government representative for approval.

4.3 Material examination. Where substitute materials have been approved, examination requirements of the substitute specification shall apply. Examination of materials for parts not specified in table I shall be to the company's specification or standard even though identification by Government or technical society specification is required (see 3.7.3). The use of materials other than those called for on drawings is permitted on a case basis subject to review and acceptance by the local DCAS. For parts listed in table I, alternate material shall have been approved by NAVSEC, and in every case, the material to be used shall be such that required factors of safety are met and where applicable, the essential variables of repair welding procedures for the material called for by the drawing remain applicable to the alternate material.

4.4 Nondestructive testing. Nondestructive tests shall be conducted as required by:

(a) Applicable material specification.
(b) MIL-STD-278, Appendices A, B or C as applicable.
(c) Table XIII.

TABLE XIII. Additional nondestructive testing requirements.

Part or service	MT/PT	HT	UT	LT	Visual	Remarks
1. Thrust bearing collar	X-2	-	-	-	-	
2. Blades and locking pieces	X-VA	-	-	-	-	
3. Nozzle partitions	-	-	-	-	X	
4. Packing and packing springs	-	-	-	-	X	
5. Packing casings	X-3	-	-	-	-	
6. Pins (notch block and locking pieces)	X-1	-	-	-	-	
7. Rotors, turbine	X-VA	-	X-VA	-	-	
8. Shrouding	-	-	-	-	X	
9. Control valves						
(a) Poppets and seats, lift rods, valve stems, bushings and lift bars	-	-	-	-	X	
(b) Seal welds and expansion rings	X-2	-	-	-	-	

TABLE XIII. Additional nondestructive testing requirements. Continued

Part or service	MT/PT	HT	UT	LT	Visual	Remarks
10. Gear, main elements, forgings for						
(a) Pinions	X-VA	-	X-VA	-	-	
(b) Gears	X-VA	-	X-VA	-	-	
(c) Gear rims	X-VA	-	X-VA	-	-	
(d) Shafts (pinion, gear or quill)	X-VA	-	X-VA	-	-	
11. Pinion and gear teeth (main elements)	X-VA	-	-	-	-	
12. Flexible couplings	X-VA	-	X-VA	-	-	
13. Piping (steam)						
(a) Below 300 lb/in	-	X	-	-	-	See 4.4.6
(b) 300 lb/in and above	-	X	X-VA	-	-	
14. Piping (control oil)						
(a) Below 300 lb/in	-	X	-	X	X	See 4.4.6
(b) 300 lb/in and above	-	X	X-VA	X	X	
15. Piping (lubricating oil)						
(a) Supply	-	X	-	X	X	See 4.4.6
(b) Drain	-	-	-	X	X	
16. Lubricating oil sumps	-	-	-	X	X	See 4.5.13

MT - Magnetic particle
PT - Dye penetrant test
HT - Hydrostatic test
UT - Ultrasonic test
LT - Leak test (gravity)

X - Indicates test required
X - Followed by number indicates acceptance level
X - Followed by VA indicates vender levels as approved by NAVSEC

NOTES:
1. Inspections required in table XIII do not eliminate requirements of applicable material specifications.
2. Inspections required in table XIII are in addition to the requirements in MIL-STD-278, Appendicies A, B or C, as applicable, and apply to all pump and fan turbines and gears.

4.4.1 Test methods. Nondestructive test methods shall be in accordance with the methods of MIL-STD-271.

4.4.2 Hydrostatic test. Hydrostatic tests shall be performed for the items shown in table XIII. Test pressure shall be determined as follows:

(a) All turbine casings other than steam chests, including all fittings and connections subject to steam pressures shall, unless otherwise specified herein or in the contract or order, be tested hydrostatically to a pressure at least 50 percent greater than the maximum working gage pressure, but in no case less than 50 lb/in^2.
(b) All inlet steam fittings and connections, such as steam chests, throttle valves, and nozzle chambers shall be tested hydrostatically after assembly to a gage pressure of 2060 lb/in^2 for turbines operating on 1200 lb/in^2 (nominal) steam inlet gage pressure and 1000 lb/in^2 for turbines operating on 600 lb/in^2 (nominal) steam inlet gage pressure.
(c) All installed lubricating oil supply piping shall be tested under a hydrostatic pressure of at least 150 pounds gage; five times the maximum working pressure for piping close to hot surfaces. Examination shall be made for leakage at joints and fittings. Drainage piping may be tested at the same pressure or separately at 100 pounds gage.
(d) Oil cooler circulating piping shall be tested with the cooler, or separately at 100 pounds gage.

4.4.3 Magnetic particle and dye-penetrant tests. There shall be 100 percent magnetic particle or dye penetrant testing of all accessible areas for the items shown in table XIII. Acceptance standards shall be in accordance with NAVSEA 0900-LP-003-8000 except that note 1 of table II therein does not apply.

4.4.4 Radiography. Radiographic inspection shall be conducted for the items shown in table XIII and Appendicies A, B and C of MIL-STD-278. Extent of coverage shall be as follows:

(a) Casings and steam chests.
  (1) External pressure boundary walls above valve seats (nozzle control and by-pass) 2-1/2 inches and larger.
  (2) Steam inlet - 2-1/2 inches and larger.
  (3) Steam chest flange and cover (castings only).
  (4) Front wall and first stage shell area (horizontal flange excluded) where inlet pressure to chest is 900 lb/in or greater.
  (5) All fabrication welds in the above areas.

(b) Piping welds. 100 percent coverage is required.

Acceptance standards shall be in accordance with table XIV for castings and NAVSEA 0900-LP-003-9000 for welds except that incomplete fusion and penetration is not acceptable. Drawings showing extent of coverage and RT symbols shall be submitted for NAVSEC approval (a separate sketch or drawing properly referenced on the engineering drawings is also acceptable).

TABLE XIV. RT inspection standards.

Thickness	Shrinkage			Porosity		Inclusions		Unfused chaplets
	ASTM standard	Type	Reference radiograph	ASTM standard	Reference radiograph	ASTM standard	Reference radiograph	
Less than 1 inch	E186	1 2 3	CA 2 CB 2 CC 2	E186	A2	E186	B2	None acceptable
1 inch up to 3 inches	E186	1 2 3	CA 3 CB 3 CC 3	E186	A3	E186	B3	None acceptable
3 inches and over	E280	1 2 3	Ca 2 Cb 2 Cc 2	E280	A3	E280	B3	None acceptable

NOTES:
Where ASTM E186 is specified, use the following:
(a) 1 to 2 MEV x-ray films for x-ray sources in this range and lower and for iridium 192.
(b) Gamma ray films for cobalt 60 sources (and radium if any).
(c) 10 to 24 MEV x-ray films for x-ray sources in this range.
Where ASTM E280 is specified, use the following:
(a) 10 to 24 MEV x-ray films for x-ray sources in this range.
(b) Cobalt 60 films for other sources.

4.4.4.1 Radiographic standard shooting sketches. Shooting sketches in accordance with MIL-STD-271 shall be provided to assist in interpretation of the applicable radiographs; however, approval of the sketches is not required.

4.4.5 Ultrasonic test. Ultrasonic test shall be conducted for the items shown in table XIV. Acceptance standards shall be prepared and submitted for approval in accordance with the contract data ordering document (see 6.2.3).

4.4.6 Exception for piping. All piping which is furnished in sections which will be fitted and welded to form final assembly by the shipbuilder and which will be hydrostatically tested by the shipbuilder does not require hydrostatic tests by the turbine or gear manufacturer. Drawings shall clearly indicate which piping is to be tested in the field. Small sections of low pressure piping (such as gland seal vent lines, valve stem leakoffs, and lube oil connections) which are to be welded to nipples on turbine or gear casing do not require hydrostatic tests. MT/PT to class 2 acceptance standards may be substituted.

4.5 Other examination and tests.

4.5.1 Heat stability test. Requirements of MIL-S-860 apply for turbine rotors except that the maximum deviation (following the second cold reading) of turbine rotors for submarine applications shall not exceed 0.0005 inch.

4.5.2 Blading. Geometry checks of tenons, vane and roots shall be performed to ensure conformity to drawing requirements.

4.5.2.1 After assembly before shrouding. After assembly of blading in rotor and before shrouding, blades shall be checked to ensure that they are installed to drawing requirements.

4.5.2.2 After shrouding. End gaps between shrouded groups and radial gaps (clearance between shroud and blade measured parallel to tenon axis) shall be checked for conformance to drawing requirements. The shroud shall bear against some portion of the vane of every blade being shrouded. Approval of the manufacturer's engineering department is required for either acceptance or re-peening of blading where radial gaps are in excess of 0.010 inch for cylindrical shrouds and 0.015 inch for conical (slant) shrouds. If clearances larger than these values are accepted, the maximum value for each stage so affected shall be recorded on the machinery variation summation drawing (see 3.7.4.13).

4.5.2.3 Acceptance test for tenon peening. Turbine or gear manufacturer shall prepare and submit for information a tenon peening procedure in accordance with the requirements in the contract data ordering document (see 6.2.3). Procedure shall include the standards acceptance including sectioned pieces showing acceptable and nonacceptable peening. Workmen who will do peening shall each be qualified to the procedure by demonstrating that they can produce a minimum of 5 test pieces representative of normal blade/tenon design in accordance with the standards of acceptance.

4.5.2.4 After shop operating test (see 4.5.9). On each unit, all blading shall be examined for indications of deformed tenons, shroud lift (see 4.5.2.2) and other damage. On all turbines or gears, the blading shall be examined, for tightness and damage.

4.5.3 As shipped clearances. After completion of the shop operating test (see 4.5.9), complete clearance data shall be taken and recorded on the overhaul report form (see 3.7.4.5). Bearing crown thickness measurements and depth gage constants are not required to be included since they are stamped on the bearing shells and bearing cap respectively. One copy each shall be forwarded to the cognizant Supervisor and building yard (for the applicable ship).

4.5.4 Bearings and journals. After completion of the shop operating test (see 4.5.9), bearings (journal and thrust), thrust collar, thrust shoes, oil deflectors and journals shall be examined for damage. Journals shall not be reworked for appearance only, when it is evident that performance is not affected. Minor scraping of bearings is acceptable. During load or overspeed tests, temperature readings shall be recorded for information and for confirmation of proper installation. Temperature limits of 3.4.48.6 do not apply to the overspeed condition.

4.5.5 Onboard tools. Special tools which involve critical fits for proper usage shall be demonstrated on the first unit of each contract or order, by actual use on the turbine and gear for which they are intended unless acceptability can be verified by dimensional checks of the applicable parts. Where special tools involve a procedure not previously used, such procedure shall be demonstrated on the first unit of a given design by using the tools provided.

4.5.6 Threaded fasteners and dowels. It shall be verified that steam joint bolting has been tightened to specified values in accordance with documented procedures. The use of helical screw thread inserts in accordance with MS21208 to compensate for damaged threads is acceptable.

4.5.7 Gland packing. After completion of the shop operating test (see 4.5.9), gland packing rings shall be examined for damage. If damaged, they shall be either repointed or replaced as necessary. If examination of the packing rings during the manufacturing process reveals surface porosity or defects that are not detrimental to the service of the packing, such rings may be accepted on a case basis by the local DCAS.

4.5.8 Steam valve tightness test. Turbine or gear manufacturer shall demonstrate by contract dye checks that valves and seats have a continuous line contact within the seating area.

4.5.9 Shop operating test. Each turbine and gear shall be subjected to an operating shop test to check the operating dynamic balance of rotating parts and the strength and rigidity of all parts of the completed assembly, as well as the adequacy of internal clearances. Lubricating oil used during the test shall have the same viscosity as oil in accordance with MIL-L-17331. Tests may be run either with or without the driven pump or fan.

4.5.9.1 Duration of test. Test shall be conducted for a period of at least 30 minutes continuous operation. The rotors shall run in their own casings.

4.5.9.2 Test speed. Test shall be conducted at rated speed to demonstrate that the speed regulating mechanisms operate properly.

4.5.9.3 Overspeed test. Shop operating test shall also include operation to demonstrate the ability of the rotor to be safely overspeeded for 3 minutes to 120 percent of rated speed or to the maximum speed expected after actuation of the overspeed trip and trip throttle valve or trip valve, if such speed is calculated to be greater than 120 percent of the rated speed.

4.5.10 Vibration test. Vibration amplitudes shall be recorded during the shop operating test (see 4.5.9) at various speeds up to and including rated speed. Amplitude and frequency measurements shall be made with instruments having sensitivity consistent with figure 1. The maximum acceptable reading, as measured on the bearing journal or adjacent part of rotor at each end of each turbine, at rated speed shall not exceed the allowable amplitudes shown on figure 1. If shaft motions are measured directly by probes on journal or other means data shall be included in report of vibration results to be submitted to NAVSEC for information. Vibration levels shall be such that testing of overspeed devices can be safely conducted without damage to the units.

4.5.11 Lifting gear. Lifting gear for the first turbine and gear of each contract or order shall be fitted and demonstrated by the manufacturer before delivery to the ship. Inclining of machinery to obtain list or trim effects is not required.

4 5.12 Blade vibration test. When specified (see 6.2.2(t)), a blade vibration test shall be conducted to determine frequencies and stresses of one selected stage. Stage to be tested shall be acceptable to NAVSEC and will be chosen considering calculated stresses, type of vibration mode, size, and similarity to other stages or designs. Test shall be conducted using either the actual turbine or a special test vehicle. Test agenda and instrumentation used shall be as accepted by NAVSEC.

4.5.13 Sumps. All oil sumps shall be tested by filling with water or clean hot oil (160°F) and carefully examined for leakage, any slight leakage shall be corrected. Any visual leakage shall result in rejection of the sump

4.5.14 Test of speed-limiting governing system. Speed-limiting governing systems shall be tested to assure conformance with the requirements of 3.4.50.2.2.3 as follows:

(a) Speed regulation - 6 percent.
(b) Adjustable range - plus or minus 5 percent minimum
(c) Speed variation - plus or minus 0.5 percent maximum
(d) Speed rise, sudden load loss - 7 percent maximum

4.5.14.1 Steam conditions for test. Any available steam inlet and exhaust, capable of operating the turbine at the speed-limiting governor setting, may be used.

4.5.15 Check of trip valves and trip throttle valves. Trip valves and trip throttle valves shall be checked by tripping manually. Trip valves shall be tested, at least twice, by tripping from the fully opened position to assure that the valve closes completely. Trip throttle valves shall be tested at least twice from each of at least three positions, i.e., barely open, approximately half open and fully open, to assure that the valve closes completely regardless of the degree of opening before being tripped.

4.5.16 Check of overspeed trip settings. Overspeed trip settings shall be checked at actuating speeds. Trip shall be checked 5 times and tripping speed shall be repeatable within plus or minus 2 percent of trip setting (115 percent of rated speed).

4.5.17 Test of overspeed trip system. The overspeed trip system of the first turbine under a contract shall be tested, with the trip throttle or trip valve in the wide-open position, by suddenly opening the governing valves while the unit is operating at no load and at rated speed. The turbine shall not exceed the design maximum overspeed. This speed shall be listed in the technical manual and the technical data book. During this test the time for the trip throttle or trip valve to close shall be ascertained. For turbines with hydraulic speed control mechanisms, a test shall be made to simulate loss of oil supply to the governing system with full steam flow through the turbine. During this test, the time for the trip throttle or trip valve to close shall be ascertained, also the maximum turbine speed attained after loss of oil shall be determined.

4.5.17.1 Steam conditions for test. Maximum specified design steam inlet pressure and temperature and minimum specified design exhaust pressure shall be used for overspeed test.

4.5.18 Check of oil system. During performance tests required by the applicable pump or fan specification, the adequacy of the oil system shall be demonstrated to show that there is no detrimental effect on the bearing lubrication as a result of governor transients. Special attention shall be given to the thorough cleanliness of all parts of the integral lubricating system, and care shall be taken to ensure that full flow can be circulated throughout the entire system.

4.5.19 Check of drains. Careful visual examination and checking of all details in connection with the drainage system shall be made to ensure that all turbines and gears are properly and completely drained. This requirement includes drainage of turbine casing, casing drain manifolds, oil and water pockets of bearings and gland housings, and oil drainage from bearings.

4.5.20 Checks of gear main rotating elements.

4.5.20.1 Forgings.

4.5.20.1.1 Forgings for gear shafts and pinions over 3 inches in diameter shall be subjected to ultrasonic test and surface defects examination.

4.5.20.1.2 All teeth of main elements shall be examined for surface defects by magnaflux.

4.5.20.2 Main pinions and gears (accuracy).

4.5.20.2.1 The manufacturer shall prepare a technical report containing the procedure for coating teeth with copper or layout lacquer in accordance with the requirements of the contract data ordering documents (see 6.2.3) and the special requirements specified in 4.5 20.2.2 through 4.5.20.2 6. The procedure shall provide objective evidence that it produces the desired film thickness.

4.5.20.2.2 Tooth geometry errors (see 3.4 45.14) shall be measured on main elements produced on each contract in accordance with the following sampling plan:

- (a) First gear of each design and first pinion of each design produced.
- (b) From each succeeding lot of 5 to 10 elements of each design, one such element randomly selected.

4.5.20.2.2.1 Pitch diameter runout, pitch variation, total accumulated pitch error and profile error (relative to design profile) shall be measured.

4.5.20.2.3 Each set of meshing elements shall show design tooth contact and relative helix angles when meshed on true centers and when assembled in the gear case. For these purposes, a light coating of pigment in oil may be transferred between teeth, and feeler gages may be used (see 3.4.45.12).

4.5.20.2.4 Hardness for through-hardened elements shall be determined after final heat treatment. For pinions, the hardness readings shall be taken at 4 points on the outside diameter of each helix approximately 90 degrees apart, before rough machining. For gear rims, readings shall be taken at 4 points on the end of each helix, approximately 90 degrees apart and slightly below the root diameter of the teeth but before teeth are cut.

4.5.20.2.5 Surface hardness of case-hardened elements shall be determined after final heat treatment. Hardness readings shall be made by the superficial method when feasible on flanks of teeth. Otherwise indentations may be made on ends slightly below the root diameter. Readings shall be taken at 4 points at each end, approximately 90 degrees apart. The case depth and core hardness shall be determined from coupon samples.

4.5.20.2.6 Tooth surface finish shall be checked either by comparator block or by measurement, on at least one tooth in each quadrant of each helix of each pinion of each gear (see 3.4.45.13) as follows:

- (a) First pinion and gear of each design.
- (b) One of each element, randomly selected, from each succeeding lot of 5 to 10 elements of each design.

4.5.21 Performance tests. Performance tests of turbines and gears shall be performed as required by 4.5.21.1 through 4.5.21.3.7.

5.1.2 Painting. Turbines and gears shall be painted as required by MIL-P-17286, except that, for turbine parts that never exceed 250°F, such as support members, bases or bedplates, one coat of aluminum paint, conforming to TT-P-28 is acceptable.

5.1.3 Packing. Packing shall be as follows:

(a) Turbines and gears, level C of MIL-P-17286.
(b) Electrical units, level C of MIL-E-16298 or MIL-E-17555 as applicable.
(c) Motor driven oil pumps, level C of MIL-P-16789.
(d) Accessories, level C of applicable specification.
(e) Instrumentation, such as gages and thermometers shall be removed from the turbine and gear, cleaned, preserved and packaged in accordance with 5.1.1(e) and packed level C of MIL-P-17286.

5.1.4 Marking. Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, National stock number or manufacturer's part number, contract or order number, contractor's name and destination.

5.2 Onboard and stock repair parts and special tools. Onboard and stock repair parts and special tools shall be processed as specified in 5.2.1 through 5.2.3.

5.2 1 Mechanical repair parts. Mechanical onboard and stock repair parts shall be cleaned, preserved and packaged level A, packed level C and marked in accordance with MIL-P-17286.

5.2.2 Electrical repair parts. Electrical repair parts shall be cleaned, preserved and packaged level A, packed level C and marked in accordance with MIL-E-17555.

5.2.3 Special tools. Special tools shall be cleaned, preserved, packaged and packed level C and marked in accordance with MIL-B-17286.

5.3 Shipping of onboard repair parts. Onboard repair parts shall be packed separately and shipped concurrently with the turbines and gears.

5 4 Unpacking instructions. In addition to any special marking required by the contract or order, unpacking instructions for equipment, assembled or disassembled, shall be provided to prevent possible damage during removal from the shipping container. When practicable, one set of these instructions shall be placed in a sealed waterproof envelope prominently marked "Unpacking Instructions" and securely attached to the outside of the shipping container in a protected location. If the instructions cover a set of equipment packed in multiple containers, the instructions shall be attached to the number one container of the set.

5.5 Technical manuals.

(a) Preliminary technical manuals shall be packaged and packed in accordance with Postal regulation of the U.S. Postal Service or other carrier regulations, as applicable.
(b) Final technical manuals which are not packed with turbines and gears shall be packaged and packed in accordance with Postal regulations of the U.S. Postal Service or other carrier regulations and in accordance with the requirements of MIL-M-15071, as applicable.
(c) Technical manuals which accompany shipments of equipment shall be packaged in transparent plastic bags of minimum 0.004 inch thickness. Closure shall be by heat sealing. Manuals shall not be placed within the sealed water vaporproof barrier material used to enclose the equipment. Manuals accompanying equipment shall be packed in the shipping container housing the main unit. The shipping containers which house the manuals shall be marked "Manual Enclosed" and the approximate location of the manual. Packing lists shall also indicate which container the manual(s) are located within.

5.6 Drawings. Drawings shall be folded not to exceed 8-1/2 by 15 inches. Packaging and packing shall be to Postal regulations of the U.S. Postal Service or other carrier regulations, as applicable.

5.7 Microfilm. Microfilm mounted in aperture cards and tabulating index cards shall be packaged in accordance with commercial practice and in a manner which will afford protection against physical damage during shipment. Cards shall be packed within a close-fitting fiberboard box. Packaging and packing shall also be in accordance with Postal regulations of the U.S. Postal Service or other carrier regulations, as applicable.

5.8 Marking. Marking shall be as follows:

(a) Interior packages and exterior shipping containers shall be marked for shipment in accordance with the requirements of the applicable equipment specification and MIL-STD-129.
(b) Shipping containers for equipment shall be stenciled as follows: "CAUTION - THIS EQUIPMENT MAY BE DAMAGED UNLESS UNPACKING INSTRUCTIONS ARE CAREFULLY FOLLOWED. UNPACKING INSTRUCTIONS ARE LOCATED (state where located)". Where practical, this marking shall be applied adjacent to the identification marking on the side of the container.

5.9 Subcontracted material, parts and units. The preservation, packaging, packing and marking requirements of referenced specifications do not apply for materials, parts and units shipped to the contractor from the subcontractor which are used to produce the complete turbine generator set. Preparation for delivery of such materials, parts and units is the responsibility of the contractor. However, prior to shipment of turbines and gears and detached accessories by the contractor, preparation for delivery shall be specified herein.

6. NOTES

6.1 Intended use. This equipment is intended for service in Naval ships where it is expected to withstand continuous use for long periods, without benefit of overhaul. The equipment is vital; failure can result in serious interruption of ship and fleet operating schedules.

6.2 Ordering data.

6.2.1 Specific application. Since this specification is general in scope, the details listed in 6.2.2 should be specified in the contract or order. (It is not necessary to delete inapplicable portions of the basic specification.)

6.2.2 Detail requirements.

(a) Title, number and date of this specification.
(b) Materials, if other than specified in 3.2 and required changes (if any) to List of Preferred Materials.
(c) Quantity (see 3.3.1).
(d) Normal rated steam inlet and exhaust conditions (see 3.3.1.1.1, 4.5.21.3.3 and 4.5.21.3.4).
(e) Maximum and minimum steam inlet and exhaust conditions (see 3.3.1.1.2, 3.4.5.1(b), 4.5.21.3.2 and 4.5.21.3.3).
(f) Any other items to be furnished with turbines and gears, in addition to those listed in 3.3.2.
(g) Weight and space limits, if any (see 3.4.6 and applicable pump or fan specification).
(h) Required steam economy including method of evaluation (see 3.4.11).
(i) Pitch and roll time, if required (see 3.4.12, table V).
(j) Specify airborne and structureborne noise levels over noise frequency range and vibration targets or limits (see 3.4.24.1, 3.4.24.4, 3.4.35.2.11, 3.4.40.9, 3.4.41.8 and applicable pump or fan specification if more stringent than 4.5.10 and figure 1).
(k) If quietness of operation is a requirement (see 3.4.37.9.3 and 3.4.41.8).
(l) Location of steam inlet connection (see 3.4.40.6).
(m) If other than nitriding or carburizing is to be used on pinions and gears (see 3.4.45.1.2).
(n) Specify method of gear hardening, if other than as specified in 3.4.45.2, 3.4.45.3, 3.4.45.4 and 3.4.45.5.
(o) Specify gear accuracy, if other than as specified in 3.4.45.14.
(p) Requirements for speed-limiting governing systems (see 3.4.50.2.2.3).
(q) Quantity of preliminary technical manuals (see 3.9.5.2).
(r) Quantity of final technical manuals (see 3.9.6).
(s) Quality assurance requirements (see 4.2).
(t) If a blade vibration test is required (see 4.5.12).
(u) Information required with bid or proposal (see 6.4.1 and 6.4.4).

4.5.21.1 General requirements. General requirements for all performance tests of turbines and gears shall be as follows:

(a) During the performance tests, the turbine and gear shall be carefully checked to assure satisfactory operation of all control, governing and regulating devices, when operating at all loads, speeds and steam inlet and exhaust conditions (see 4.5.21.3 2 and 4.5.21.3.3).
(b) During the tests, the lubricating oil sump shall be filled to the maximum operating level and the unit shall be checked for adequate lubrication of bearings, gears, etc. and to assure that there is no leakage (see 4.5 18)
(c) During the tests, checks shall be made of all oil, water and steam drains to confirm that drain connections are sized properly and that there is no "back-up" into the turbine or gear (see 4.5.19).

4.5.21.2 Performance tests of forced draft fan turbines Turbines for forced draft fans shall be tested with the driven fan in accordance with the requirements of MIL-F-18602.

4.5.21.3 Performance tests of assembled turbines and gears for pumps. One turbine, with gear, if used, of each size on contract, or contracts in effect at the same time for identical units with identical contract requirements, assembled complete, shall be subjected to a performance test to determine the overall power consumption of the assembled unit throughout its entire operating ranges of speeds and loads, as specified in the contract or order, or as dictated by the service for which intended. This test shall be made under steam, exhaust, and temperature conditions as specified in 4.5.21.3.2 and 4.5.21-3.3 and shall demonstrate compliance with this specification, regarding governing, balance and lubrication, at rated output and overload operating speeds and loads, as well as throughout the normal operating range. This test may be made with any loading facility available, including the driven unit for which intended, water brake, or dynamometer. Test conditions shall be governed by the requirements of the ASME PTC 6.

4.5.21.3.1 Duration of test. Assembled turbine and gear shall be operated under rated output conditions to permit a careful check of all operating characteristics, including temperature rise of bearings and lubricating oil, both with oil coolers in use and out of commission, governing, including speed-limiting and overspeed governors and overall efficiency. During observations each operating run shall be continued until stable conditions are obtained, but in no case shall such periods be less than 2 hours duration, except as otherwise indicated herein.

4.5.21.3 2 Steam conditions for performance test of turbines Steam conditions for performance tests of turbines shall be as follows.

(a) 2 hours minimum (see 4.5.21.3.1) at minimum specified inlet pressure and maximum specified exhaust pressure (see 6.2.2(e)).
(b) 30 minutes at maximum specified inlet pressure and minimum specified exhaust pressure.
(c) 30 minutes at a combination of inlet and exhaust pressures approximately half way between the two extremes of (a) and (b).

4.5.21.3.3 Steam conditions for performance test of turbines Steam conditions for performance tests of turbines shall be as follows:

(a) 2 hours minimum (see 4.5.21.3.1) at specified normal rated inlet steam pressure and temperature and exhaust pressure (see 6.2.2(d)).
(b) 30 minutes at maximum steam inlet pressure (see 3.4.5.1(a) and 6.2.2(e)), other conditions normal (see 6.2.2(d)).
(c) 30 minutes at minimum inlet pressure (see 3.4.5.1(b) and 6.2.2(e)), other conditions normal (see 6.2 2(d)).
(d) 30 minutes at maximum exhaust pressure (see 3 4.5.1(c) and 6.2.2(e)), other conditions normal (see 6.2.2(d)).

4.5.21.3.4 Steam consumption test. A test shall be conducted, during performance tests, to determine steam consumption with normal rated steam inlet and exhaust conditions (see 6.2.2(d)) and at rated power and speed, by measuring the condensate, either by weighing or by using water meters calibrated to the satisfaction of the DCAS.

4.5.21.3.5 Inclined operation test. Turbines and gears shall be tested for satisfactory inclined operation as follows:

	Surface ships Degrees	Submarines Degrees
(a) Horizontal units.		
(1) Shaft inclined forward end down	5	30
(2) Shaft inclined forward end up	5	30
(3) Shaft horizontal, turbine base inclined to left	15	15
(4) Shaft horizontal, turbine base inclined to right	15	15

	Surface ships Degrees	Submarines Degrees
(b) Vertical units.		
(1) Shaft inclined forward	15	30
(2) Shaft inclined backward	15	30
(3) Shaft inclined to the left	15	30
(4) Shaft inclined to the right	15	30

4.5.21 3 5.1 Conditions during inclined operation test. Inclined operation tests shall be conducted as follows:

(a) Turbine and gear, if used, shall be tested assembled, at rated speed, with or without load, with any available steam inlet and exhaust for at least 30 minutes in each of the positions listed in 4.5.21.3.5.
(b) Any other conditions as specified in the applicable pump specification.

4.5.21.3.6 Use of hand-controlled nozzle valve. The hand-controlled nozzle valve (see 3.4.5.2) shall be closed for tests at rated power and speed with normal rated steam inlet and exhaust conditions.

4.5.21.3.7 Exceptions. Any of the tests of 4.5.21.3 through 4.5.21.3.6 that have been or will be conducted as part of the tests required by the applicable pump specification need not be repeated.

4.5.22 Shock, noise and vibration tests. Shock, noise and vibration tests of the completely assembled turbine driven pump or fan, with gear, if used, shall be in accordance with the requirements of the applicable pump or fan specification.

4 5.23 Check of back pressure trips. Each back pressure trip shall be tested at least twice. Testing may be with either steam or air. Bench testing is acceptable.

4.6 Inspection of preparation for delivery. Packaging, packing and marking shall be inspected for compliance with section 5 of this document.

5. PREPARATION FOR DELIVERY

(The preparation for delivery requirements specified herein apply only for direct Government procurements. For the extent of applicability of the preparation for delivery requirments of referenced documents listed in section 2, see 6.7.)

5.1 Turbines, gears, accessories and instruments.

5.1.1 Cleaning, preservation and packaging. Cleaning, preservation and packaging shall be as follows:

(a) Turbines and gears shall be cleaned, preserved and packaged in accordance with level A requirements of MIL-P-17286, except that Tectyl 511M, or equivalent, shall be used to preserve the steam side of turbines. All turbines shipped to the shipbuilder shall have the steam side preservation identified by a tag or stenciled note, such as "STEAM SIDE PRESERVED WITH (Commercial name)" on the turbine or shipping container.
(b) Electrical units shall be cleaned, preserved and packaged in accordance with the level A requirements of MIL-E-16298 or MIL-E-17555, as applicable.
(c) Motor driven lubricating oil pumps shall be cleaned, preserved and packaged in accordance with the level A requirements of MIL-P-16789.
(d) Accessories shall be cleaned, preserved and packaged in accordance with level A requirements of the applicable specification.
(e) Instrumentation such as gages and thermometers shall be cleaned, preserved and packaged in accordance with the level A requirements of MIL-P-17286.

(v) In the event turbines and gears are purchased separately, not as part of a complete pump or fan, the applicable items under ordering data of the applicable pump or fan should also be specified.
(w) Specify waivers, revisions and additional requirements.

6.2.3 Data requirements. When this specification is used in a procurement which invokes the provision of the "Requirements for Data" of the Armed Services Procurement Regulations (ASPR), the data identified below, which are required to be developed by the contractor, as specified on an approved Data Item Description (DD Form 1664), and which are required to be delivered to the Government, should be selected and specified on the approved Contract Data Requirements List (DD Form 1423) and incorporated in the contract. When the provisions of the "Requirements for Data" of the ASPR are not invoked in a procurement, the data required to be developed by the contractor and required to be delivered to be developed by the contractor and required to be delivered to the Government should be selected from the list below and specified in the contract.

Paragraph	Data requirements	Applicable DID	Option
3.2.8.1, 3.2.8.1.2, 3.11, 4.4.5, 4.5.2.3, and 4.5.20.2.1	Report, Technical/ Engineering/ Scientific	UDI-S-23272	------
3.6.3	Provisioning List	DI-V-2078	Option 4
3.7	Drawings, Engineering and Associated List	UDI-E-23174	------
3.8	Microfilm, Aperture/ Tabulating Cards and Listing	UDI-E-23140	------
3.9	Manual, Technical, Preliminary	DI-M-2043	------
3.9	Manual, Technical, Standard Basic Issue	DI-M-2043	MIL-B-15071
3.10.2	Manual With Supplementary Data, Technical (Tech Data Books)	DI-M-2050	------
3.12	Report, Variation Transmittal/Referable Letter	UDI-E-23216	------
3.14.3.1	Agenda, Meeting	UDI-A-23531	------
4.1.1	Reports, Test	DI-T-2072	------

6.3 The following notes apply to the preparation, approval and distribution of drawings (see 3.7):

Notes:

1. Preparation of engineering drawings to cover items which could be described by reference to Government or industry specifications is acceptable when identification of the item is thereby improved.
2. Subcontractor drawings. Subcontractor's drawing number of finished items shall be used as the single reference identification in all cases where the part(s) delineated thereon is (are) produced by the subcontractor. Turbine or gear manufacturer shall not add his drawing number to the drawing, except as an unofficial reference outside the drawing border or margin.
3. Parts list. Each assembly and subassembly drawing shall have a parts list (either on the drawing or on a separate drawing properly referenced) which shall include the following:

   (a) Item or find number.
   (b) Quantity required for one equipment, assembly or subassembly.
   (c) Part identification.
   (d) Nomenclature or description.
   (e) Unit weight, if weight is over 10 pounds. Unless shown on detail drawing of equipment or part.)
   (f) Material identification (unless shown on detail drawing of the equipment or part).

4. Drawing approval. Two copies of each drawing shall be forwarded to NAVSEC and each shipyard involved and one copy of each drawing to each Supervisor involved. Thirty days (from receipt of the drawing by the approval activity) should be allowed for approval action.
5. Quantity of final drawings to be furnished shall be as follows:

   (a) One set of microfilm mounted in aperture cards and one set of tabulating index cards conforming to MIL-M-38761/2 to Navy Publication and Printing Service, Washington, D.C.
   (b) Three sets of microfilm mounted in aperture cards conforming to MIL-M-38761/2 except that microfilm shall be type 2, class 2 of MIL-M-9868. Distribution shall be one set to each of the following activities:

      (1) Naval Ship Engineering Center, Code 6145, Center Building, Prince George's Center, Hyattsville, Maryland 20782.
      (2) Naval Ship Engineering Center, Philadelphia Division, Philadelphia, Pennsylvania 19112.
      (3) Ships Parts Control Center, Mechanicsburg, Pennsylvania 17055.

6.4 Information required with proposal or bid.

6.4.1 Quantity of bids or proposals. For NAVSEA and NAVSEC procurement 5 complete copies of bid shall be submitted, unless otherwise stated (see 6.2.2(x)).

6.4.2 Drawings. The bid or proposal shall include an outline drawing with dimensions and preliminary turbine and gear longitudinal sectional assembly drawings with materials for principal parts. Drawings shall be to scale.

6.4.3 Other data and statements. The bid or proposal shall include curves, tabulations, sketches, diagrams, statements and such other data as is indicated in column 5 of table XI.

6.4.4 List of items to be furnished. A list of items being furnished is not required if in accordance with the specifications, however, if such a list is included in the proposal or bid, it is mandatory that each item listed be identified with the applicable part of 3.3.2 and 6.2.2(x).

6.5 Management control system documents. The following management control system documents should be included on DD Form 1660:

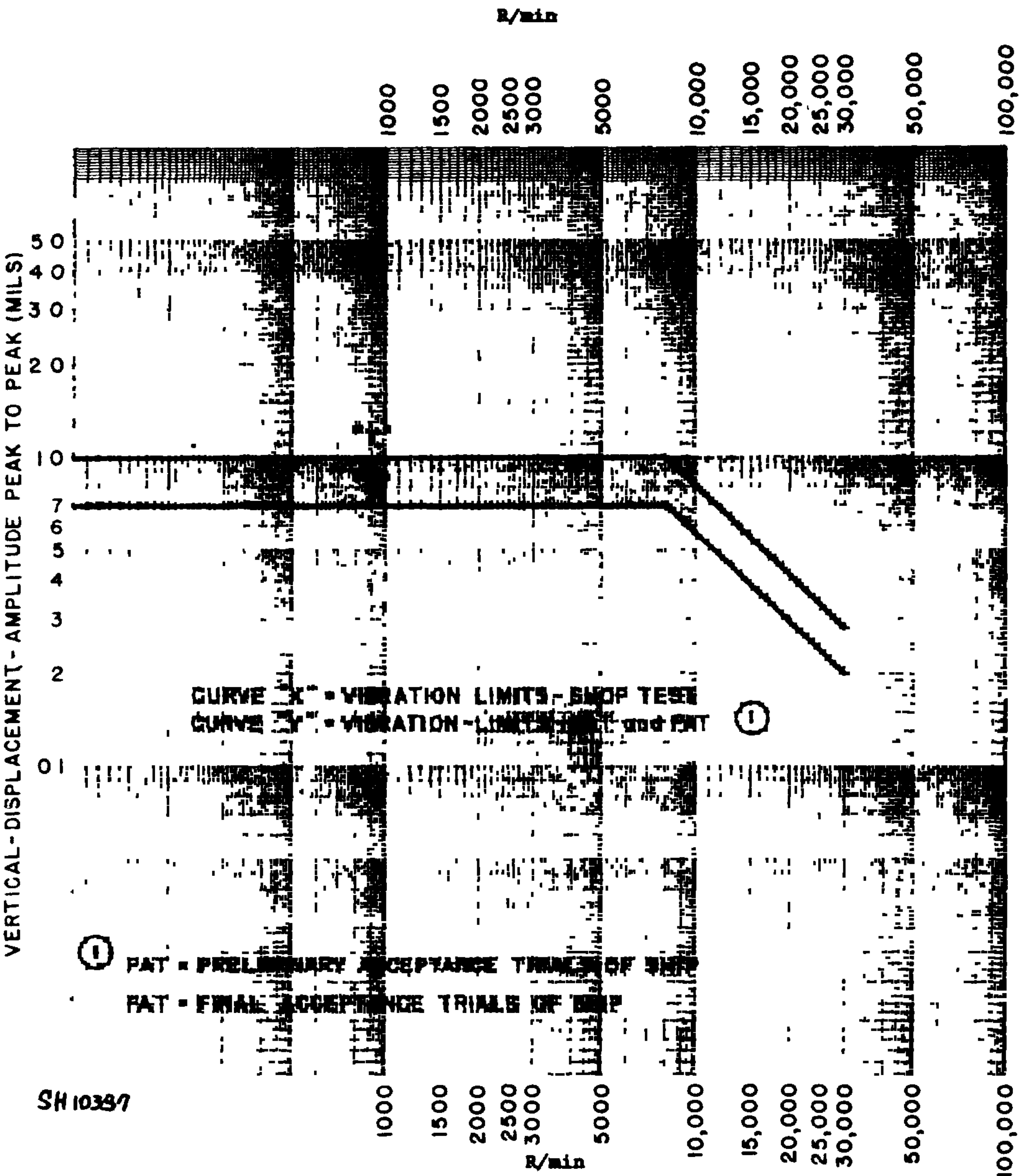
(a) MIL-P-15137 (see 3.6.1, 3.7.1.1(c) and 3.12.2(f)).
(b) MIL-I-45208 (see 4.2).

6.6 Supersession data. This specification supersedes that part of MIL-T-17523C(SHIPS) for auxiliary steam turbines and gears other than generator turbines and gears. MIL-T-24398 (SHIPS) supersedes that part of MIL-T-17523C(SHIPS) for generator turbines and gears.

6.7 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 procured by the supplier for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.8 Changes from previous issue. The extent of changes (additions, modifications, corrections, deletions) preclude the annotation of the individual changes from the previous issue of the document.

Preparing activity:
Navy - SH
(Project 2825-N009)



NOTE: Rotational (filtered) vibration readings shall not exceed the above limits for any operating condition within speed ranges from idling speed to 125 percent of rated speed.

Figure 1 - Turbine and gear vibration limits - bearing cap.

NAME OF PUMP OR FAN

TO BE USED ON

TURBINE FOR (   )

SERIAL NO. [- -]

MANUFACTURED BY

[- - - - - - - - - - - - - - - - - -]
[- - - - - - - - - - - - - - - - - -]

[INSP] TECH. MANUAL

NAVSEA [- - -]

TYPE [- -]

MAX RATED R/min [- -] INLET LB/IN^2 [-]

MAX RATED BHP [- -] INLET TEMP °F [-]

EXH PRESS [-]

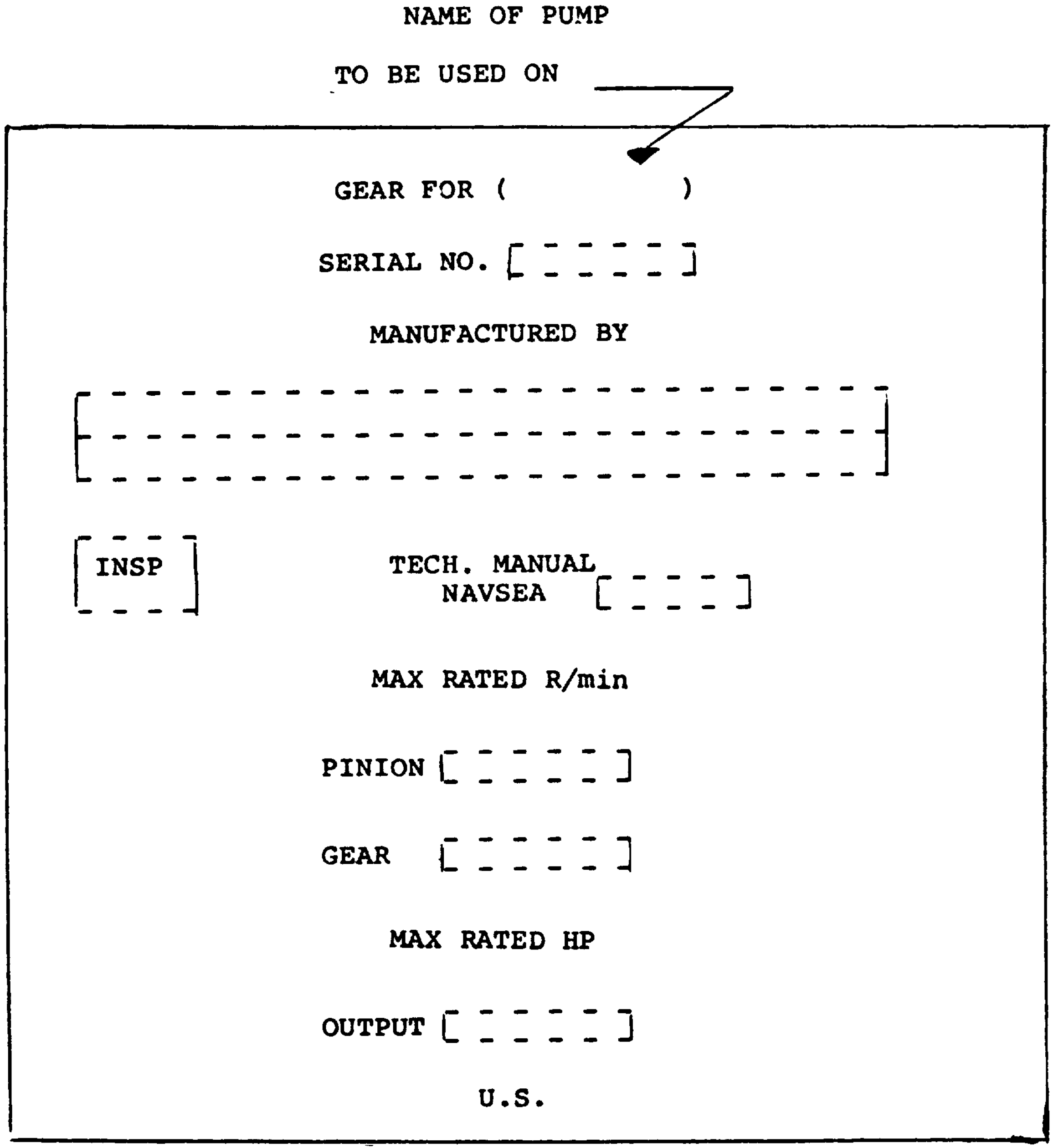
SPEED-LIMITING GOVERNOR SETTING [- -]

OVERSPEED TRIP SETTING [-]

U.S.

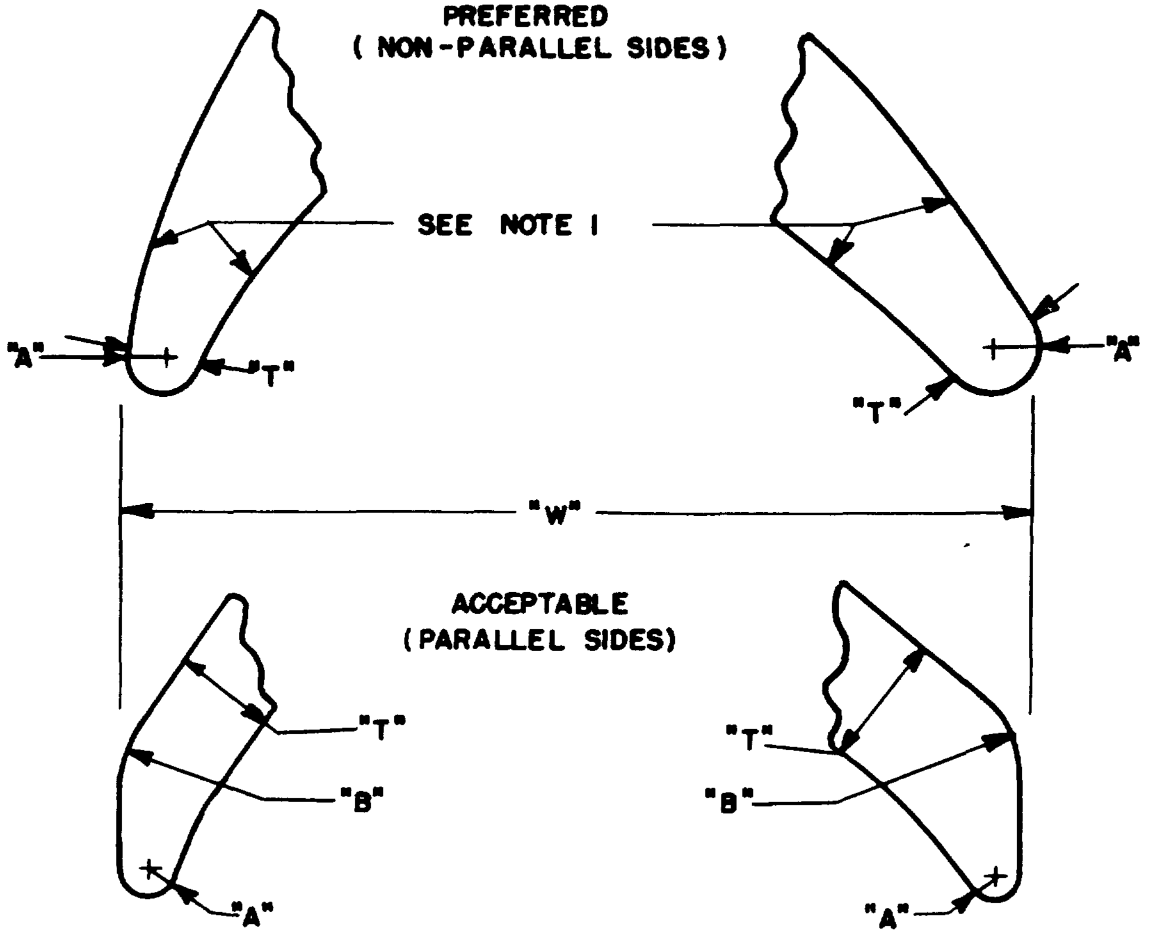
NOTE: Classified information shall not be shown on identificat plates. Either leave applicable block blank or insert "Conf" or "See Tech. Man".

Figure 2 - Typical identification plate for pump or fan turbines.



NOTE: Classified information shall not be shown on identificatio plates. Either leave applicable block blank or insert "Conf" or "See Tech. Man.".

Figure 3 - Typical identification plate for pump gear.



Vane width "W"	Min. value of "T"	Min. value of "A"	Radius "B"
Less than 1	0.010	0.005	See note 2
Above 1	.020	.010	

Notes to figure 4:

1. Concave and convex surfaces of nozzle partition shall not be parallel at any point.
2. Radius "B" is not specified quantitatively, but this area shall be polished smooth. A definite break between planes will not be acceptable.

Figure 4 - Vane metal section (blading and partitions).

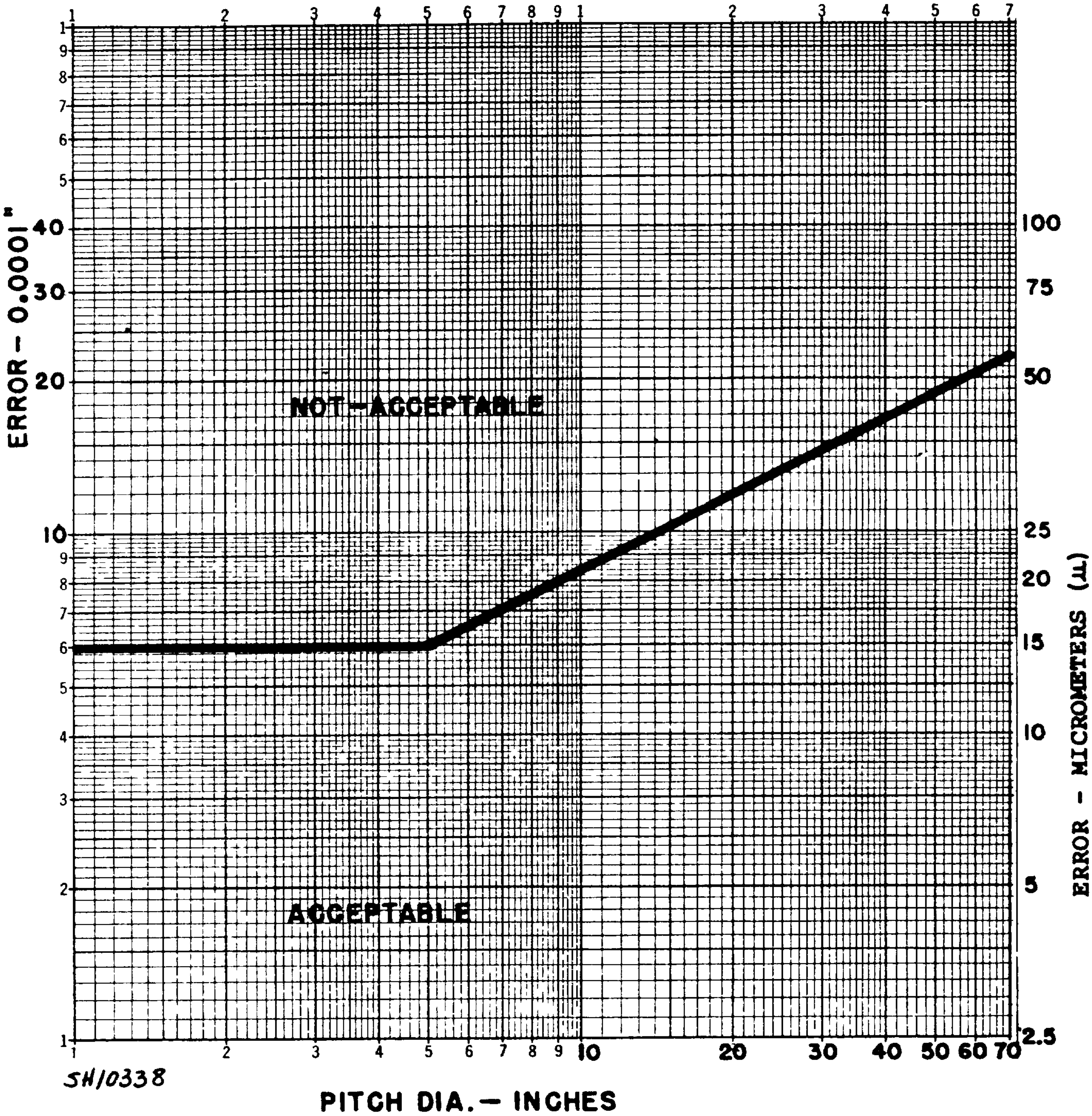
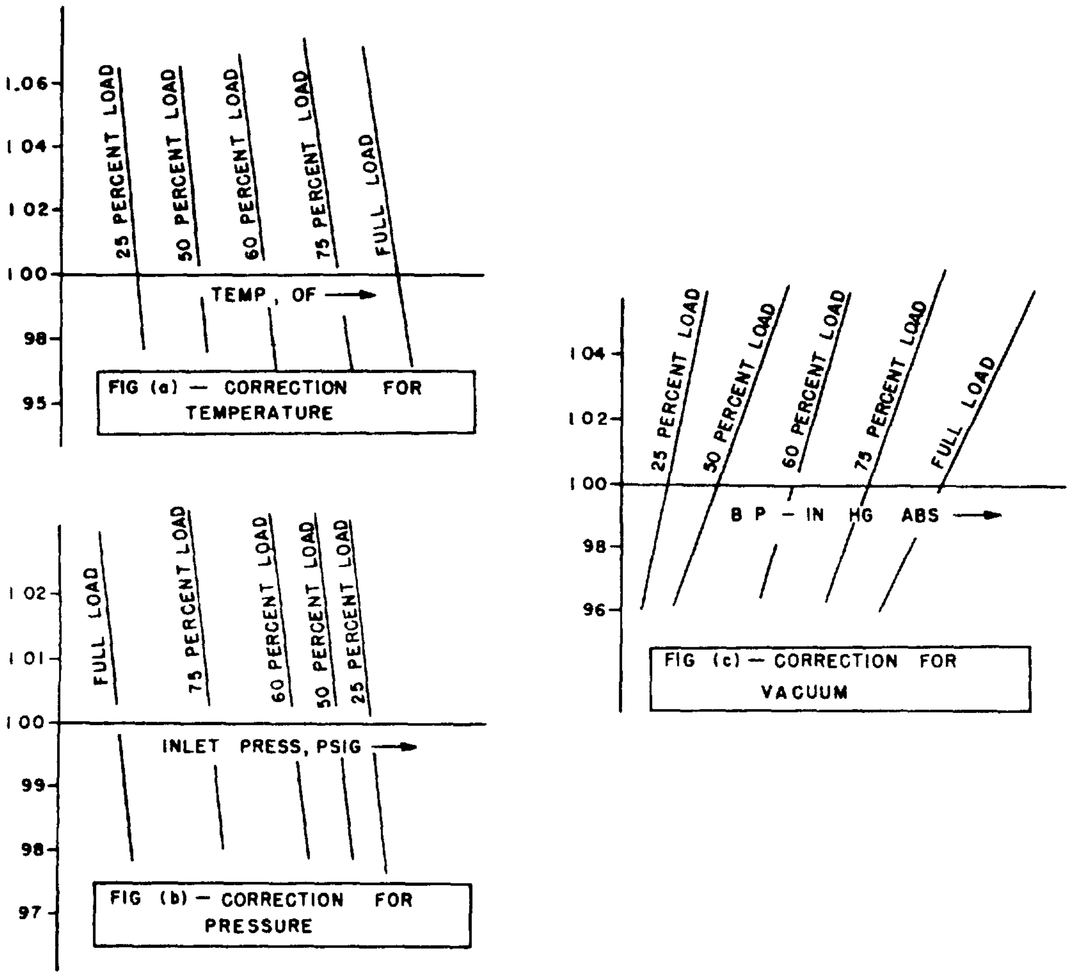


Figure 5 - Adjacent tooth spacing error limit



SH 9847

Figure 6 - Correction factors at constant valve settings.

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b. Recommended Wording

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