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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 245

PROPELLERS

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CHAPTER 245

PROPELLERS

SECTION 1.

INTRODUCTION

245-1.1 SCOPE

245-1.1.1 This chapter provides the general information, guidance, and requirements necessary to clean, inspect, and repair monobloc, built-up, and controllable-pitch propellers (CPP). It also includes procedures for removing and installing blades for CPP; both drydock and waterborne. Removal and installation information for monobloc, built-up , and controllable-pitch propellers can be found in reference (a). Points of contact are:
• NSWCCD- SSES 9323 - technical
• NAVICP MECH 05822 - non – technical (inventory)

245-1.2 REFERENCES

a. **NSTM Chapter 243, Propulsion Shafting**

b. NAVSEA S9245-AR-TSM-010/PROP, **Technical Manual for Marine Propeller Inspection, Repair, and Certification**

c. MIL-DTL-2845 (SH), **Propulsion Systems, Boat and Ship; Main Shafting, Propellers, Bearings, Gauges, Special Tools, and Associated Repair Parts; Preservation, Packaging, Packing and Storage of**

d. NAVSEAINST 9245.1A, **Ship Propeller and Propulsion Shafts; Procedures for Maintaining**

e. NAVSEA 9245/3, **Propeller Visual Inspection Form**

f. NAVSEA 9245/4, **Propeller Dimensional Inspection Form**

g. NAVSEA 9245/1, **Propeller Certification Form**

h. **NSTM Chapter 081, Waterborne Underwater Hull Cleaning of Navy Ships**

i. MIL-PRF-6799, **Coatings, Sprayable, Strippable, Protective, Water Emulsion**

j. NAVSEA S0600-AA-PRO-000, **Underwater Ship Husbandry Manual**

k. DOD-P-24562A(SH) , **Propeller, Ship, Controllable Pitch**

l. PMS OPNAV Form 4790/7B, **Technical Feedback Report**

m. OPNAVINST 4790.4, **Ship Maintenance and Material Management**

n. NAVSEA S6430-AE-TED-010, **Technical Directive for Piping Devices, Flexible Hose Assemblies**

o. MILPRE-17331, **SYM 2190 TEP, Hydraulic Fluid**

p. OPNAV 4790/CK, **Configuration Change Form**

q. OPNAVINST S5513.5B , **Submarine Propulsor Security Classification Guide, Encl 56.2**

r. OPNAVINST S5513.3C , **Surface Ship Propeller Security Classification Guide, Encl 52.2**

245-1.3 PROPELLER DESCRIPTION

245-1.3.1 GENERAL REQUIREMENTS

245-1.3.1.1 Propellers are designed and manufactured to meet specific operating requirements such as speed, rpm, endurance, vibration, and noise for a particular ship class. To meet these requirements the propeller must achieve a minimum efficiency, absorb available shaft horsepower at a specific rpm or various rpms for controllable-pitch propellers (CPP), operate within specified vibration and noise criteria, and withstand hydrodynamic loads and stresses during all operating conditions.

245-1.3.1.2 To achieve the required performance, propeller geometry must conform to the design hydrodynamic contours. Propeller performance can be sensitive to small geometric changes and defects in hydrodynamic contour, in turn affecting the flow of water over the blade surfaces. Small geometric changes and defects can cause vibration and cavitation problems, which can result in unsatisfactory performance. Use extreme caution when working with, inspecting, preserving, and handling propellers to ensure that the critical hydrodynamic surfaces are maintained within specified tolerances and remain free of defects.

245-1.3.1.3 Because propeller performance is sensitive to damage and geometric changes, propeller inspection, repair, and certification requirements and procedures have been developed to ensure that propellers can meet ship operating requirements.

245-1.3.2 PROPELLER TYPES

245-1.3.2.1 Monobloc Propellers. The blades and hub of a monobloc propeller are formed of a single integral casting.

245-1.3.2.2 Built-up Propellers. The blades and hub of a built-up propeller are manufactured separately and in some cases are of different materials. The blades are secured to the hub with fasteners.

245-1.3.2.3 Controllable-Pitch Propellers. Controllable-pitch propellers have actuating mechanisms that pivot the blades on the hub. The operator can therefore adjust the pitch from full ahead to full astern without reversing the direction of rotation of the propeller shaft.

245-1.3.3 PROPELLER TERMINOLOGY. A propeller is a complex, three-dimensional geometric shape that must be defined in space. To properly understand the propeller information in this chapter, it is important to understand propeller terminology. This terminology is described and defined in reference (b).

245-1.3.4 PRAIRIE SYSTEM. Some surface ship propellers have a prairie (propeller air internally emitted) system for noise reduction. This system has machined channels in the propeller blades and holes in the pressure and suction faces near the leading edge and tip of the propeller. The prairie system emits air through these holes to provide propeller quieting. Details and requirements can be found in the applicable ship class technical manuals, technical repair standards, and reference (b).

245-1.3.5 PROPELLER HANDLING. Most monobloc propellers have threaded holes on their forward and aft faces and on the outside diameter of the propeller hub for installing eyebolts used for handling the propeller. Before handling the propellers, protect the blade edges with edge guards in accordance with reference (c). Screw in the eyebolt(s) until the eyebolt shoulder firmly contacts the propeller hub. To prevent blade edge damage when handling the propellers, do not allow the lifting slings and cables to rub the blade edges. To prevent fillet damage, protect the blade fillet with chafing gear or soft wood blocking. If the propeller does not have eyebolt holes on the outer diameter of the hub, the propeller will require special handling fixtures, or lifting arrangements. The appropriate fixture or lifting arrangement may be identified on the applicable propeller drawing. Methods of turning propellers are described in reference (b).

245-1.4 PROPELLER REPAIR AND SPARING PROGRAM

245-1.4.1 SPARE INVENTORY MANAGEMENT. Propeller sparing requirements are developed for all ship classes. They are based on the number of ships, ship's mission, deployment strategy, depot strategy, repair time, and service experience. Spare propellers, blades, and hubs are managed by NAVICP MECH for the Naval Sea Systems Command (NAVSEA) for most ships and are designated as 2S Cog propellers. Propellers managed by NAVICP MECH, including hubs, oil distribution boxes and blades of built-up and CPPs, have a serial number, in addition to the stock number, for identification. Procedures for maintaining propellers in ready-for-issue condition, and for controlling the issue of propellers and associated special tooling can be found in reference (d). Reference (d) also provides requirements for inducting propellers into the repair program.

245-1.4.2 INSPECTION, REPAIR, AND CERTIFICATION REQUIREMENTS FOR PROPELLERS

245-1.4.2.1 Propellers that have been removed from ships during overhauls and restricted availabilities and have been determined not to be acceptable for service will be repaired in accordance with reference (b) upon induction into the 2S Cog repair program, or will be placed in storage pending repair. The types of propeller inspections (visual preservation, visual technical, and dimensional) and when they are to be performed are defined in references (b) and (d). Monobloc propellers, built-up propellers, and CPP blades do not have specified overhaul cycle requirements. Required repair actions are based on propeller condition and the results of propeller inspections.

245-1.4.2.2 Most monobloc propellers, built-up propellers, and CPP blades are Navy designed. Some of these propellers may have design features which are proprietary to the commercial vendor and some designs are classified in accordance with references (q) and (r). Inspection and repair of monobloc propellers, built-up propellers, and CPP blades shall be performed only by qualified repair facilities. Facilities (government or commercial) are qualified to perform repairs based on the results of a facility assessment conducted by NAVSEA. Evidence of facility qualification and qualification limitations, if any, shall be available upon request. Commercial facilities with propeller repair contracts issued by Naval Inventory Control Point Mechanicsburg, PA are considered evidence of qualification. Certification of repaired propellers is required when repairs are completed to ensure that the propeller meets specifications. Only government personnel who have successfully completed the NAVSEA Propeller Certification Course or persons designated by NAVSEA are qualified to certify propellers.

245-1.4.2.3 CPP hubs and oil distribution boxes have specified overhaul cycle requirements defined in the applicable CPP technical manuals and technical repair standards. NAVSEA has transitioned from a time-based approach to a condition based approach (CBA) for CPP systems. Section 5 provides specific periodicities for maintenance inspection for all CPP systems to support CBA inspections. CPP equipment is generally proprietary to the original equipment manufacturer (OEM) and shall be repaired by the OEM. If the CPP blades are determined to be in acceptable condition based on a visual technical inspection, and acoustic performance is satisfactory (if applicable), it is not necessary to have the blades repaired, regardless of the need to repair the hub and oil distribution box. If this is the case, remove the blades from the hub and store or preserve, as required, until replacement hubs are received. If CPP blades require repair, they may be repaired at any qualified Navy repair facility.

245-1.4.3 INSPECTION, REPAIR, AND CERTIFICATION REQUIREMENTS FOR PROPELLERS REMOVED FROM A SHIP AND INDUCTED INTO THE 2S COG REPAIR PROGRAM

245-1.4.3.1 Upon receipt of a propeller for repair, the repair facility shall perform and document a visual technical and dimensional inspection of the propeller in accordance with reference (b). The repair facility shall submit the inspection reports, references (e) and (f), proposed repairs, and anticipated departure from specification requests to the contracting activity with a copy to NSWCCD-SSES 9323. Prior to data submission, a qualified government propeller certification official shall verify that the inspection data accurately represents the actual condition of the propeller and shall review the data to confirm completeness.

245-1.4.3.2 Upon completion of propeller repair, the repair facility performs a final visual technical and dimensional inspection in accordance with reference (b) and submits the inspection reports, references (e) and (f), to the contracting activity with a copy to NSWCCD-SSES 9323. Prior to data submission, a qualified government propeller certification official shall verify that the inspection data accurately represents the actual condition of the propeller and shall review the data to confirm completeness.

245-1.4.3.3 The contracting activity is responsible to have the inspection reports reviewed by the appropriate technical personnel. The inspection reports are evaluated on the basis of completeness and conformance to specification requirements. Disposition on departures from specification requirements shall be provided on all departures. Upon satisfactory disposition of all departures and approval by the contracting activity, the qualified propeller certification official shall sign the Certification Document (reference (g)). The original certification document is sent to the contracting activity, a copy is attached to the propeller in accordance with reference (c) and a copy to NSWCCD-SSES 9323 and NAVICP 05822.

245-1.4.3.4 Propellers shall not be shipped or installed until the propeller certification process is complete.

245-1.4.3.5 Contact NAVICP MECH and NSWCCD-SSES 9323 if propeller repairs cannot be completed during the scheduled availability. Replacement propellers may be issued from stock.

245-1.4.4 EXCEPTIONS to INSPECTION, REPAIR, AND CERTIFICATION REQUIREMENTS

245-1.4.4.1 Minor Damage. In cases of minor visible damage (e.g., small nicks, dents in localized areas, etc.), light grinding, filing, or sanding can be done with the propeller installed on the ship by qualified personnel who are familiar with reference (b) specifications and the propeller geometry. However, this is not routinely recommended. Approval for any work on submarine tips must be obtained from NSWCCD-SSES 9323. Always consider the following before deciding whether to repair a propeller in place:

a. The condition of the propeller based on a visual technical inspection. The propeller may have to be removed if there are bends requiring straightening or cracks requiring welding.

b. Reports, if any, of operational problems (e.g., cavitation, vibration, noise, etc.) related to the installed propeller.

c. The time required to remove and repair the propeller relative to the ship's availability schedule.

d. The availability of a replacement propeller from stock and the time to ship and install it relative to the ship's schedule.

e. The effect on propeller balance. Any work that will significantly affect balance will require removal of the propeller for rebalancing.

f. Ship operational requirements (e.g., submarine, noise-critical combatant, auxiliary, etc.).

g. The likelihood of creating additional damage while performing the repair.

h. The location of the defect and the potential for further damage during subsequent operation.

245-1.4.4.2 Post Repair Visual Technical Inspection. After minor in-place repair, conduct a final visual technical inspection. Submit a report documenting the work performed on the propeller to the contracting activity. Provide a copy of the report to NSWCCD —SSES 9323. A dimensional inspection and recertification of the propeller is not required.

245-1.4.4.3 It should be stressed that repairing a propeller without the appropriate equipment (e.g., blade gages, pitchometer, etc.) and markings (e.g., radius lines, chord-wise stations, etc.) increases the risk of not achieving satisfactory performance because the actual propeller geometry cannot be compared and corrected to the intended design geometry; only approximations can be made. Although the guidelines presented above are to be used in determining the feasibility of making minor repairs while taking exception to requirements, be careful not to exploit this shortcut for the repair of propellers.

SECTION 2.

TYPICAL PROPELLER AND PROPELLER-RELATED PROBLEMS

245-2.1 VIBRATION, CAVITATION, AND NOISE

245-2.1.1 VIBRATION. The shape of the hull influences the fluid flow into the propeller and may result in periodic forces on the propeller that cause blade frequency vibration. Blade frequency vibration is equal to the number of blades times the propeller rpm. Blade frequency vibration problems are normally a function of the hull, propeller, and appendage design. It cannot be corrected by repairing the shaft or propeller. Defects, such as damage, propeller unbalance, and runout in the shafting, can cause shaft rate vibration. Shaft rate vibration occurs at a frequency equal to or in multiples of the propeller rpm. It can be caused by mechanical unbalance of the shaft, propeller, or cap; improper propeller installation; a bent shaft; or geometric discrepancies between the propeller blades.

245-2.1.2 CAVITATION. Water flow across the blades of an operating propeller causes pressure to vary across the blade surfaces. These pressure variations result from high velocities caused by local curvature of the blades. When the pressure at any location falls below the vapor pressure of the water, vapor cavities (cavitation bubbles) are formed that later collapse as they move into areas of higher pressure. The collapse of the cavitation bubbles can erode the blade surface. This erosion begins as a roughening of the surface and develops into craterlike pits that continue to enlarge. Propeller cavitation decreases as the shaft rpm decreases or the depth of operation increases. The areas most likely to cavitate are the suction side of the outer radii and areas near the leading edge. Physical damage and improper repairs to the blades changes of geometry of the blade and as a result increase the probability of cavitation. Since the leading edges are the most susceptible to damage, they are the prime sources of cavitation. Cavitation results in noise that is often sharp, random, and crackling when it starts. When the cavitation is further developed, at higher speeds or shallower depths, the noise becomes periodic at shaft frequency and has a variety of sounds. Cavitation noise covers a broad frequency range.

245-2.1.3 SINGING NOISE. Propeller singing is another type of propeller noise. It is characterized by a tone at a relatively constant frequency. Singing is blade vibration at a natural frequency. At a given speed the singing tone may include more than one frequency. It may occur on one or several blades simultaneously. Singing is caused by vibration excited by vortex shedding from the trailing edge or tip of the blade. Propeller blade singing has been significantly reduced by propeller blade design improvements (e.g., trailing edge or tip knuckles, thicker trailing edges, etc.).

245-2.1.4 MECHANICAL NOISE. Another source of noise in the propeller system can be a lack of clearance for rope guards and fairwaters, causing mechanical rubbing between the rotating and stationary elements. Wire, cable, or rope wrapped around the propeller; loose propeller cap bulkhead plates; loose propeller cap studs or nuts; and loose gland studs or nuts can also cause noise in the propeller system.

245-2.2 FOULING AND ROUGHNESS

245-2.2.1 The efficiency of a propeller is affected by the drag and hydrodynamic shape of the blade sections. Roughening by cavitation erosion or by fouling with marine growth will increase the power required for a given speed over that required by a smooth propeller.

245-2.3 LOSS OF SEAWATER SEALING INTEGRITY

245-2.3.1 LOSS OF FAIRWATER CAP. Loss of a fairwater cap device or tail cone in service is a significant casualty. With the cap gone, the corrosion preventive compound will wash away and subject the propeller nut locking key and shaft to seawater. Shaft corrosion and failure could ultimately result. Divers shall inspect the propeller nut locking key, retaining screw, propeller nut, and shaft threads monthly until the fairwater cap is replaced. Install a replacement cap device or tail cone at the earliest opportunity.

245-2.3.2 LOSS OF SEALING RING INTEGRITY. Seawater exposure can lead to early failure of the shaft and loss of the propeller. Give special attention to the integrity of the cap and gland sealing rings and seating areas. An assembly pressure test, in accordance with reference (b), can identify a loss of seal integrity. The voids in the propeller assembly should be completely filled with corrosion preventive compound at all times.

SECTION 3.

PROPELLER AND BLADE CLEANING, INSPECTION, REPAIR, AND REPLACEMENT WHEN SHIP IS DRYDOCKED

245-3.1 GENERAL

245-3.1.1 This section provides cleaning, inspection, and repair requirements for monobloc propellers, built-up propellers, and the blade and hub surfaces of controllable-pitch propellers (CPPs) while the ship is in drydock. Information on propeller and CPP blade replacement is also provided. Additional information on the CPP servo control assembly, oil distribution box, hydraulic oil power module assembly, and valve rod assembly can be found in Section 5.

245-3.2 CLEANING

Marine growth can affect the efficiency of a propeller and cause propeller cavitation. Cleaning should be performed at every drydocking to remove all sea growth (e.g. calcium deposits, sea grass, barnacles, etc.). Cleaning propellers by processes other than those described herein will damage critical propeller surfaces degrading acoustic performance or causing conditions favorable for cavitation inception. Only experienced personnel who are familiar with navy propeller critical geometries and characteristics should clean naval ship propellers. All personnel performing propeller cleaning must complete both academic and hands-on training in accordance with a NAVSEA approved program. Academic refresher training is required annually. A propeller cleaning shall not result in damage to the propeller or the removal of blade material. The following methods are acceptable for cleaning propeller and fairwater caps in drydock and are listed in order of precedence. When propeller cleaning is in progress, maintain an air supply to the prairie system to prevent foreign material from entering the emitter holes. Note that blade surface polishing shall follow the same cleaning process outlined herein in order to produce the required surface finish.

245-3.2.1 HYDROBLASTING. Hydroblasting (high pressure water jet cleaning) may be used on all propeller and fairwater surfaces. For best results, perform hydroblasting on propeller surfaces immediately after drydocking and before marine growth has dried. At NO TIME shall hydroblasting on propeller or fairwater cap surfaces exceed 10,000 pounds per square inch.

245-3.2.2 HAND CLEANING (SCRAPING, WIRE BRUSHING, ETC,) Scraping and wire brushing is more effective if performed prior to drying of marine growth. Use hard plastic or wood scraper or soft bronze or brass wire brushes to clean all propeller surfaces. DO NOT use metallic scrapers or scrapers impregnated with abrasive material. Scraping and wire brushing must be performed by hand and not powered. The final cleaning operation of propeller blade edges (within 3 inches of the edges and tips) shall be cleaned by hand with plastic surface conditioning material (e.g. Scotch-Brite ″greenies″ or equivalent).

245-3.2.3 POWERED CLEANING PROCESSES. Powered cleaning methods with surface conditioning discs shall only be used on propeller surfaces of minimal curvature and shall not be used within 6 inches of propeller blade edges, tips, cusps, fillets (excluding hub to blade interface) or other sensitive areas of a propeller. Powered surface conditioning discs shall only be utilized by experienced personnel who are familiar with navy propeller critical geometries and characteristics. However, the use of powered nylon or plastic brushes is acceptable for cleaning edges and tips, providing proper care is taken to avoid removal of metal. When cleaning the outer periphery of the propeller blades, the brushes and disks must be kept flat on the propeller surface. Do not attempt to round the edges of the propeller blade with brushes and disks.

245-3.3 PREREPAIR INSPECTION

245-3.3.1 VISUAL INSPECTION. Perform a visual technical inspection of propellers at every drydocking in accordance with reference (b). If a propeller has been in service for more than 5 years, inspect the entire hub, blade , and fillet surfaces with liquid penetrant in accordance with reference (b). Use liquid penetrant testing only as an aid in locating discontinuities. Visually inspect or apply low-pressure air to the prairie-type propellers to determine the condition of the prairie system. Silt, preservative, weld deposits, check-valve rubber, and marine growth can block prairie system air holes and air channels. Flow tests, in accordance with reference (b), are required on the prairie system to verify that the holes are clear. Upon completion of a visual technical inspection submit a propeller visual inspection report (reference (e)) to the type commander or the ship's commanding officer with a copy to NSWCCD —SSES 9323. If the ship is to be inactive for longer than 30 days after undocking, coat the propellers with a strippable compound specified by reference (i) in accordance with reference (c). Cover prairie air holes prior to coating in accordance with reference (c). If no repairs are required and the ship is to return to immediate service, coating is not required.

245-3.3.2 MINOR DEFECTS. If the inspection in drydock reveals only minor defects, repairs may be performed in accordance with paragraph 245-3.4.2. If the inspection in drydock reveals defects that cannot be repaired in place, submit findings to NSWCCD 9323 and NAVICP. A determination will be made if the propeller should be removed and inducted into the 2S COG program in accordance with reference (d).

245-3.4 REPAIR

245-3.4.1 LEVEL OF REPAIR. Acceptable performance of a propeller is based on structural integrity, vibration characteristics, powering performance and acoustic performance, all of which vary in importance depending upon ship class. Defects, which have compromised or degraded the operational performanoe of a propeller as determined from operational reports, visual inspection results, machinery operation logs, instrumented evaluations, etc., should be repaired to reestablish an acceptable level of performance based upon engineering assessment consistent with the performance and operational requirements for the ship class. Additional information is provided in paragraph 245–1.4.4.

245-3.4.2 REPAIR OF MINOR DEFECTS. Minor defects (e.g., small nicks, dents in localized areas, small bends, etc.) may be repaired in place by light grinding, filing, sanding, minor welding, or minor straightening by qualified personnel familiar with reference (b) specifications and the propeller geometry. Limit metal removal to that necessary to make the repairs.

245-3.4.3 ADDITIONAL REPAIR. When propeller deficiencies require additional repair such as welding of major defects or straightening of large bends, etc., repairs must be accomplished with the propeller removed from the ship. Based on the propeller's performance deficiency, the engineering assessment, and the characteristics of the physical defects, an authorized repair facility shall perform a pre-repair dimensional inspection to determine the extent of the damage and/or deficiencies. Repair of bronze propellers shall be performed in accordance with reference (b). Additional repair requirements can be found in paragraphs 245–1.4.2 and 245–1.4.3. Procedures for repairing propellers of other materials shall be approved by the Naval Sea Systems Command. Post -repair dimensional inspection shall be performed. The extent of this inspection, determined by the engineering assessment, shall he sufficient to ensure that a satisfactory level of propeller performance will be reestablished. In circumstances where propeller certification is required, paragraphs 245–3.5 and 245–3.6 apply.

245-3.5 FINAL INSPECTION

245-3.5.1 Upon completing repairs, perform final visual and dimensional inspections of the propeller in accordance with reference (b). Additional inspection information can be found in paragraphs 245-1.4.2 and 245-1.4.3.

245-3.6 CERTIFICATION

245-3.6.1 Upon completing the final visual and dimensional inspections, a qualified propeller certification inspector shall verify that the inspection data accurately represent the actual condition of the propeller and shall review the data to confirm completeness. Additional certification information can be found in paragraphs 245-1.4.2 and 245-1.4.3.

245-3.7 REMOVAL AND INSTALLATION

245-3.7.1 Removal and installation requirements for monobloc and built-up propellers are defined in reference (a). Guidance for replacement of CPP blades is provided in the CPP technical repair standards, shipyard procedures, and drawings. Refer to the class maintenance plan for appropriate documents.

SECTION 4.

PROPELLER AND BLADE CLEANING, INSPECTION, REPAIR, AND REPLACEMENT WHEN SHIP IS WATERBORNE

245-4.1 GENERAL

245-4.1.1 This section provides cleaning, inspection, repair, and replacement information for monobloc propellers and the blade and hub surfaces of both built-up and controllable-pitch propellers (CPPs) while the ship is waterborne. Propeller and blade inspection and repair shall be performed only by qualified divers; i.e., divers who have satisfactorily completed the Propeller Visual Inspection Course or divers designated by NAVSEA. NSWCCD —SSES PHILA 9323 can provide assistance to activities performing approved waterborne propeller and blade maintenance and replacement.

245-4.2 CLEANING

245-4.2.1 Waterborne propeller cleaning shall be performed in accordance with reference (h).

245-4.2.2 All personnel performing propeller cleaning waterborne must complete both academic and hands-on training in accordance with a NAVSEA approved propeller training program. Academic refresher training is required annually.

245-4.3 INSPECTION

245-4.3.1 Qualified divers shall inspect propeller blades and hubs, propeller caps, devices, and rope guards at regular intervals. The interval should not exceed 6 months for any waterborne ship. Inspect the propeller immediately when abnormal noise or vibration is observed. If oil spots (slick or sheen) are seen off the stern of the vessel, examine the blade and hub seals for oil leaks. If the propellers have been operated dockside (training or testing) for periods longer than those associated with normal ship arrival and departure, inspect the propellers, caps, devices, and rope guards before getting under way. Examine them for damage, fouling, roughness, nicks, dents, and loose or missing parts. Also inspect for items such as wire, rope, hose, or cable that may be entangled or wrapped around the propeller or shaft, or under the rope guards or fairwaters. For propellers with prairie systems, apply low-pressure air and visually inspect the prairie emitter holes propeller to determine the condition of the prairie system. Silt, preservative, weld deposits, check-valve rubber, and marine growth can block air holes and air channels. Flow tests, in accordance with reference (b), are required on the prairie system to verify that the holes are clear.

245-4.4 REPAIR

245-4.4.1 If possible, avoid waterborne propeller repairs. When necessary, repairs shall be performed in accordance with reference (j) procedures by qualified divers who are familiar with reference (b) specifications and the propeller geometry . The following minor repair actions may be taken to improve propeller performance and prevent further damage:

a. Nicks and dents on blade edges may be filed smooth , while ensuring that the design contour of the blade edge is maintained (i.e., No flat spots are introduced). Do not perform repairs on submarine tips unless authorized by NSWCCD 9323.

b. Small bends or curled edges may be tapped back to the correct shape, taking care not to cause further damage. The use of wood blocking is recommended rather than impacting the blade directly. Take care on leading edges not to create ridges and flat spots.

c. On trailing edges take care to prevent rounding off the break of the knuckle.

d. Edge cracks may be temporarily stopped from further growth by drilling a 1/4-inch-diameter hole in the blade at the end(s) of the crack.

e. Secure rope guards or fairwaters that have loosened. If this is impossible, remove them to prevent their coming off when underway and damaging the propeller.

245-4.5 REMOVAL AND INSTALLATION

245-4.5.1 Removal and installation requirements for monobloc and built-up propellers are defined in reference (a). Waterborne removal and installation procedures for monobloc and built-up propellers shall be in accordance with reference (j). Waterborne replacement of CPP blades shall be in accordance with reference (j).

SECTION 5.

CONTROLLABLE-PITCH PROPELLER SYSTEMS

245-5.1 GENERAL

245-5.1.1 INTRODUCTION. This section provides an overview and general information on the various types of controllable pitch propeller (CPP) systems. Refer to the applicable technical manuals listed in Table 245-5-1 for more detailed information on specific CPP systems. Although the terms CPP, controllable reversible pitch (CRP), and controllable pitch (CPCH) are sometimes used interchangeably, the term ″CPP″ will be used throughout this section to identify controllable-pitch propeller systems. Definitions are provided in the glossary for terms directly associated with CPP systems or where a particular term has a specific meaning within this chapter.

245-5.1.2 BASIC DESIGN. A CPP system consists of a CPP with associated mechanical, hydraulic, pneumatic, or electronic pitch controls. Controllable-pitch propeller systems are used on surface ships, where rotation of the propulsion shaft is usually limited to one direction, either by design or by necessity. Controllable-pitch propeller systems are also designed so that rotation of the propulsion shaft in a direction opposite the normal should not result in damage to the propeller. Such rotation can occur when using a jacking gear, when wind milling, or under abnormal circumstances.

245-5.1.3 BASIC CONTROL SYSTEM. The control system positions the propeller blades, permitting a range of thrust from full ahead to full astern while the main propulsion machinery continues to operate in the same direction of shaft rotation. Pitch commands can be made from various locations and may be electrical, mechanical, or pneumatic.

245-5.1.4 BASIC PRINCIPLES OF OPERATION. The pitch command signal (Figure 245-5-1) is translated by the pilot or control valve to hydraulic pilot or auxiliary servo control pressure that positions the servo valve. The servo valve ports high-pressure (HP) hydraulic fluid to the servomotor. The resultant servo piston linear movement is mechanically translated to rotation of the propeller blades by the blade-turning mechanism, creating the corresponding change in pitch ordered by the pitch command. The system is designed to hold any pitch setting from full ahead to full astern under all operating conditions within the limits imposed by the main engines.

245-5.2 CONTROLLABLE-PITCH PROPELLER SYSTEM TYPES

245-5.2.1 VARIATIONS. The U.S. Navy uses various designs of CPP systems for a variety of ship missions. The CPP system specification, reference (k), covers general requirements and lists the various styles, types, and blade designs of CPP systems. In this chapter, conventional CPP systems, such as the ″hub servomotor″ type and the ″push rod″ type will be discussed. Though these will be the focus of this section, CPP systems such as the ″aviation″- and ″cycloidal″-type systems are briefly discussed below.

a. Hub Servomotor-Type CPP System. In this type of CPP system, the blade pitch is actually changed by a servomotor in the hub assembly. Paragraph 245-5.2.2 discusses this type of CPP system in more detail.

b. Push-Rod-Type CPP System. In this type of system, the blade pitch is changed by the action of a mechanical push rod (or actuating rod) that is controlled by a servomotor fitted inboard, inside the propeller shaft, and generally immediately forward of the tailshaft. Paragraph 245-5.2.3 discusses this type of CPP system in more detail.

c. Aviation-Type CPP System. Certain specialized Navy craft, such as landing craft air cushions, use a CPP system to control the pitch of high-speed blades in a large, fanlike unit that is similar to an aviation propeller. Refer to the applicable technical manuals noted in Table 245-5-1 for information on this type of CPP system.

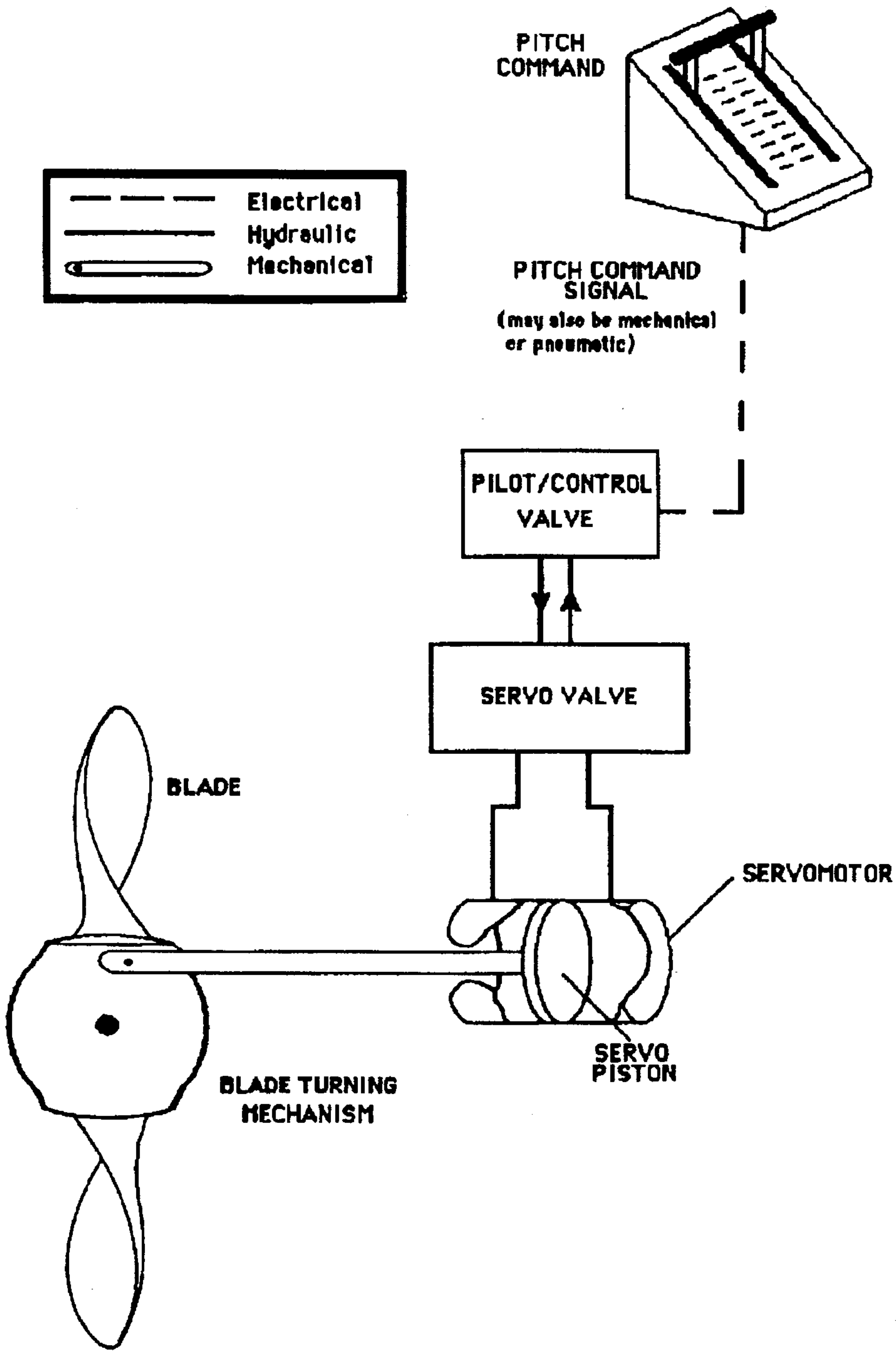


Figure 245-5-1 Controllable-Pitch Propeller - Functional Diagram.

Table 245-5-1 CONTROLLABLE-PITCH PROPELLER SYSTEM DOCUMENTATION

Ship Class/ Group	Manufacturer	Publication Number/Title
ARS 50 CLASS	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-AJ-MMM-010, CONTROLLABLE PITCH PROPELLER SYSTEM-MODEL NO. 79 S9245-BK-TRS-010, TRS PROPELLER HUB ASSEMBLY AND BLADES, ARS 50 CLASS
CG 47 — 65	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-AH-MMA-010, CONTROLLABLE REVERSIBLE PITCH PROPELLER FOR CG 47 CLASS SHIPS S9CGO-BP-POG-010/CG 47, PROPULSION SYSTEM OPERATING GUIDE S9262–AF-MMA-010, CRP PROPELLER OIL COOLER
CG 66 & FOLLOW	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-AV-MMA-010, CONTROLLABLE REVERSIBLE PITCH PROPELLER FOR CG 66 AND FOLLOW SHIPS
DD 963/DDG 993 Class	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-BF-MMM-010, CONTROLLABLE PITCH PROPELLER IN DD 963 CLASS, DDG 993 CLASS, AND DD 997 (THIS MANUAL SUPERSEDES S9245-AC-MMA-010, S9245-AL-MMA-010, AND 0944-LP-006-3010) S9245-AE-TRS-010 /DD-963/DDG-993 CL , TRS PROPELLER HUB ASSEMBLY AND BLADES DD 963 CLASS AND DDG 993 CLASS TRS OIL DISTRIBUTION BOX ASSEMBLY 0944-LP-006-3011 INSTRUCTIONS FOR CHANGING BLADES UNDERWATER, CONTROLLABLE REVERSIBLE PITCH PROPELLER FOR DD 963 CLASS SHIPS
DDG 51 Class	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-AM-MMA-010, CONTROLLABLE PITCH PROPELLER SYSTEM, DDG 51 CLASS, MODEL 156, TYPE S1/5 S9245-AT-TRS-010, TRS OVERHAUL PROCEDURES PROPELLER HUB & BLADE ASSEMBLY S9245-AU-TRS-010, TRS OIL DISTRIBUTION BOX ASSEMBLY & TEMPERATURE COMPENSATED PITCH INDICATOR ASSEMBLY OVERHAUL PROCEDURES
FFG 7 CLASS	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	0941-LP-053-7010, FFG 7 CLASS CP PROPELLER AND PROPULSION SHAFTING SYSTEM 2451-086-607, TRS OIL DISTRIBUTION BOX ASSEMBLY 2451-086-608, TRS PRESSURE CONTROL ASSEMBLY S9245-AF-TRS-010/FFG-7 CL, TRS PROPELLER HUB ASSEMBLY AND BLADES FFG 7 CLASS
LCAC Class	DOWTY ROTOL (aviation)	S9245-BA-MMA-010, MAINTENANCE MANUAL FOR CONTROLLABLE PITCH PROPELLER PART NO. 660000033 S9LCA-AA-SSM-010, SAFE ENGINEERING AND OPERATIONS (SEA OPS) TECHNICAL MANUAL
LSD 41 Class	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-AD-MMA-010, CP PROPELLER AND PROPULSION SHAFTING SYSTEM FOR LSD 41 CLASS SHIPS

Table 245-5-1 CONTROLLABLE-PITCH PROPELLER SYSTEM DOCUMENTATION - Continued

Ship Class/ Group	Manufacturer	Publication Number/Title
LST 1179 Class	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (KAMEWA)	0944-LP-007-2010, CONTROLLABLE PITCH PROPELLERS LST 1179, LST 1180, LST 1181 0944-LP-007-1010, CONTROLLABLE PITCH PROPELLERS LST 1182 THROUGH LST 1198 S9245-AG-TRS-010, TRS PROPELLER HUB ASSEMBLY AND BLADES LST 1179 CLASS 0905-LP-485-8010, PROPULSION SYSTEMS INFORMATION AND TROUBLESHOOTING GUIDE FOR LST 1182-1198
MCM 1 Class	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	S9245-AE-MMO-010, NON-MAGNETIC CONTROLLABLE PITCH PROPELLER SYSTEM S9245-BJ-TRS-010, TRS PROPELLER HUB ASSEMBLY & BLADES, MCM 1 CLASS OVERHAUL PROCEDURES
MHC 51 Class	Voith Schiffstechnik GmbH & Co. KG (cycloidal) (CAGE D8829)	S9245-BM-MMA-010, CYCLOIDAL PITCH PROPELLER MODEL 21GS-MC-1600; S9245-BM-TRS-010, CYCLOIDAL PROPELLER OVERHAUL PROCEDURES S9241–CA-MMA-010, OPERATION AND MAINTENANCE MANUAl FOR MHC-51 CLASS SHIP PROPULSION UNIT
MSO 421-518	ROLLS ROYCE NAVAL MARINE INC. (CAGE 07309) (Bird-Johnson Co.)	0944-LP-007-5010, DESCRIPTION, INSTALLATION AND OPERATION, CONTROLLABLE PITCH PROPELLERS MSO 421 THROUGH 518 MINE SWEEPERS 0944-LP-007-6010, CONTROLLABLE PITCH PROPELLERS MSO 421 THROUGH 518 MINE SWEEPERS 0344-LP-002-2000, PROPELLER PITCH CONTROL EQUIPMENT 0344-LP-002-0000, PROPELLER INSTALLATION 0344-LP-002-7000, CONTROLLABLE PITCH PROPELLER CONTROL 0344-LP-002-5000, CONTROLLABLE PITCH PROPELLER CONTROL MSO 488 CL 0944-LP-000-6010, PROPELLER CONTROL SYSTEM
MSO 421-518	NORFOLK NAVAL SHIPYARD	0344-LP-003-0000, CONTROLLABLE PITCH PROPELLER, MSO 421, 488, 498, 508 & 512 CLASS MINE SWEEPERS (NORFOLK NSY DESIGN) 0344-LP-003-4000, CONTROLLABLE PITCH PROPELLER, NORFOLK CONTROLS
PG 92-101	LIAAEN PROPULSION SYSTEMS, INC.	0944-LP-004-3010, INSTRUCTION MANUAL FOR LIAAEN PROPULSION CONTROLLABLE PITCH PROPELLER, DOUBLE CRANK, SERIAL NUMBER 185-204, FOR MOTOR GUNBOAT PG CLASS VESSEL
YFY 91 CLASS (EX-LCU 1625 CLASS)	Voith Schiffstechnik GmbH & Co. KG (cycloidal) (CAGE D8829)	0344-LP-005-0000, 340 HP VOITH— SCHNEIDER PROPELLER

d. Cycloidal-Type CPP System. The cycloidal-type CPP system is a vertical axis propulsor that uses a bevel gear or a worm gear mechanism to transmit power to the blades. The propeller consists of four or more blades projecting from a circular disk whose axis is vertical. This disk is geared to the propulsor drive shaft, and, as it rotates, the blades are rotated separately by cam action to create thrust. The position of the cam with respect to the disk can also be varied to produce thrust in any direction. The magnitude of thrust can also be varied from zero to maximum design thrust. This propeller system eliminates the need for a rudder and has superior maneuverability characteristics, but it is less efficient than a screw-type propeller. Refer to the applicable technical manuals noted in Table 245-5-1 for information on this type of CPP system.

245-5.2.2 HUB SERVOMOTOR-TYPE CPP SYSTEM. The most common CPP system in the U.S. Navy is the ″hub servomotor″ type (Figure 245-5-2). This type of system is described in the following paragraphs. The major components of the hub servomotor-type CPP system are:

- Electrohydraulic servo control assembly
- Oil distribution (OD) box
- Hydraulic system (including hydraulic oil power module [HOPM])
- Valve rod assembly
- Hub assembly and propeller blades.

a. Electrohydraulic Servo Control Assembly. This unit electronically controls, monitors, actuates, and displays propeller pitch settings and changes. It receives pitch commands from the ship control console in the pilot house through the propulsion auxiliary control console in the central control station or from the propulsion local control console and provides electrical pitch commands to the OD box (specifically, the electrohydraulic servo valve on the manifold block assembly). It also receives pitch position input from the feedback potentiometer on the local pitch indicator at the OD box, displays pitch position, and provides pitch position input to the control consoles.

b. Oil Distribution Box. The OD box is usually mounted on the forward side of the reduction gear and is connected by hydraulic piping to the head tank, sump tank, and HOPM. Attached to the OD box are the local pitch indicator and the manifold block assembly (which consists of the remote operation servo valve, the manual control valve, and the manual changeover valves). The OD box receives electrical pitch control commands from the electrohydraulic servo control assembly. The command signal activates the electrohydraulic servo valve on the manifold block assembly. This valve directs the flow of auxiliary servo oil (control) pressure to and from the auxiliary servo pistons (forward and aft pistons), which change the position of the valve rod; this arrangement is sometimes referred to as the valve rod actuating mechanism. Pitch position feedback is provided to the electrohydraulic servo control assembly from the feedback potentiometer located on the local pitch indicator. Additionally, the OD box directs high pressure (HP) (hub servo) oil to, and low-pressure (LP) (return) oil from, the hub assembly through the propeller shaft and provides a passage for prairie system tubing. Major components of the OD box are:

- Manifold block assembly
- Forward and aft pistons
- Single-row bearing assembly
- Emergency pitch lock
- Housing
- Thrust bearing
- LP oil seals
- HP oil seals
- Local pitch indicator and follow-up rod assembly.

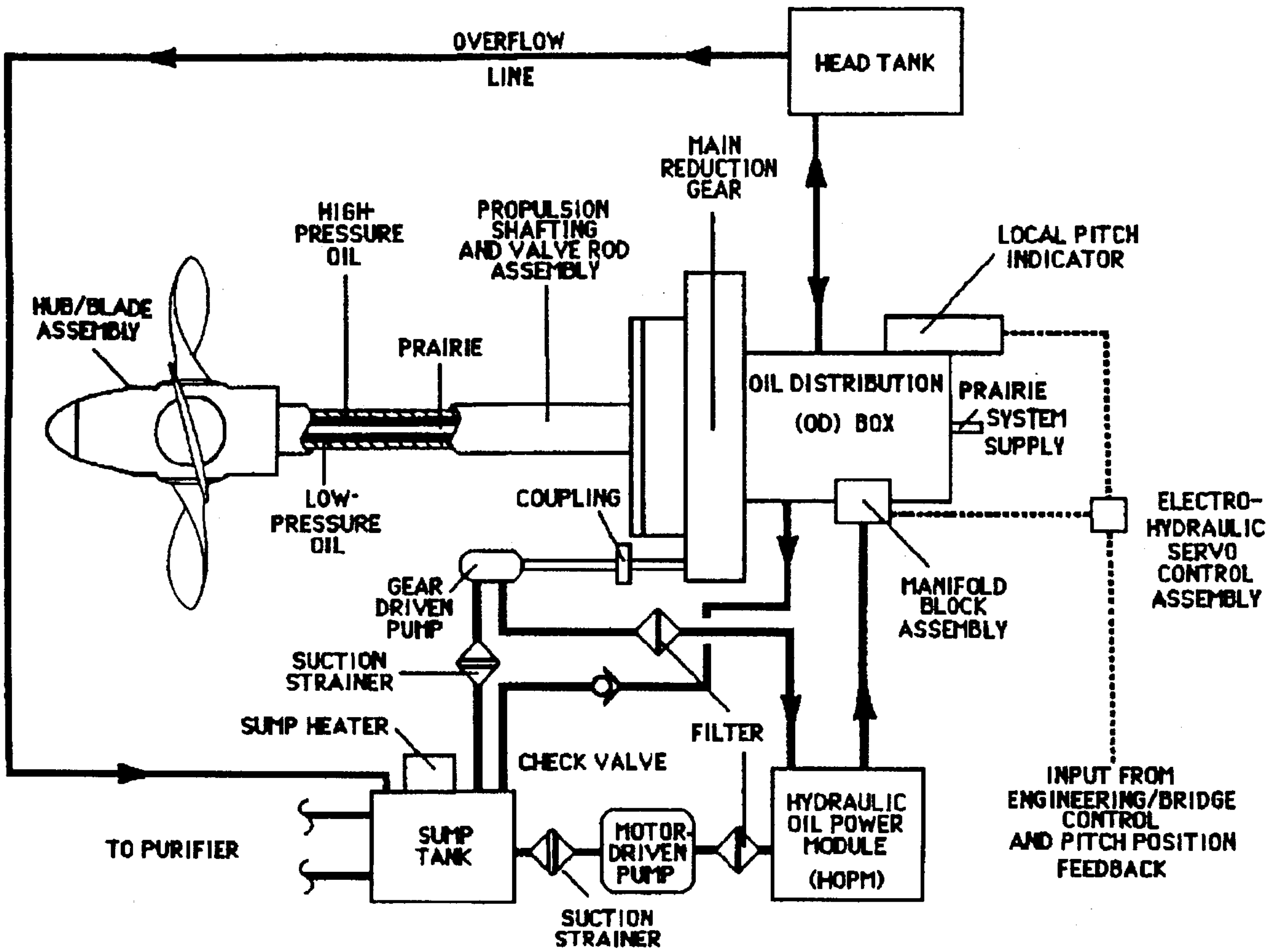


Figure 245-5-2 Hub-Servomotor-Type (CG 47 Class) CPP System.

c. Hydraulic System. The hydraulic system provides control (auxiliary servo) fluid pressure and flow to the OD box to operate the valve rod actuating mechanism. It also provides HP fluid to the hub servomotor through the OD box and valve rod to operate the blade-turning mechanism. The system includes a HOPM connected by hydraulic piping to the sump tank, head tank, OD box, and manifold block assembly. Gear- and motor-driven pumps provide a flow of hydraulic fluid, which is regulated at the pressure control assembly, to achieve operating (high) and control (auxiliary) fluid pressure and flow to the OD box. Major components of the hydraulic system and HOPM are:
- Motor - ac
- Motor-driven pump
- Suction (inlet) strainers
- Oil cooler (if installed)
- Gauge panel assembly
- Gear-driven pump
- Oil filters
- Bypass valve
- Pressure control assembly
- In-line check valves
- Unloading valve
- Pressure-reducing valve

- Auxiliary servo relief valve
- Sequencing valve
- Main relief valve.

d. Valve Rod Assembly. The valve rod assembly provides passage for HP hydraulic fluid from the OD box to the hub assembly and mechanically translates hydraulic pitch control commands in the OD box into valve rod movement. The regulating-valve pin, attached to the aft end of the valve rod, moves with the valve rod and carries HP oil through the hub regulating-valve liner to the servomotor (in the hub assembly). Guides support the valve rod in the center of the propeller shaft bore. The forward end attaches to the OD box distance tube. Prairie system tubing is mounted in the bore of the valve rod. Low-pressure hydraulic fluid returns to the OD box from the hub assembly through the cavity between the valve rod assembly and the inside surface of the main propulsion shaft.

e. Hub Assembly and Propeller Blades. The hub assembly is attached to the aft end of the propulsion shaft. Propeller blades are bolted symmetrically around the circumference of the hub. A blade port cover and blade seal base ring prevent seawater from entering the hub and pressurized hydraulic fluid from leaking out around each blade. The position of the blades is set and maintained by the hub servomotor assembly through the blade-turning mechanism. Pitch commands from valve rod and regulating-valve pin movement port HP hydraulic fluid to the servomotor through the regulating-valve liner. When the desired pitch is reached, the regulating-valve liner acts as a follow-up mechanism, closing servo piston HP hydraulic fluid supply ports to restrict the flow through metering reliefs in the valve liner. This balances the forces on the servo piston, holding the pitch in the desired position. The prairie system tube ends at the hub, where air is carried internally to the blade edges. Major components are:
- Hub cone and cover
- Blade-turning mechanism:
  - Crosshead
  - Sliding block
  - Crank pin ring
  - Eccentric pin
- Prairie system check valve (where applicable)
- Purge valve assembly
- Safety relief valves
- Propeller blades
- Regulating valve liner
- Servomotor (piston or cylinder assembly)
- Blade seals and bearing rings.

f. Other Components and System Interfaces.

1. Sump Tank. The sump tank is the hydraulic fluid reservoir for the CPP system. It supplies hydraulic fluid for the main and standby pumps and is connected to the head tank and OD box through piping. The major components of the sump tank are:
   - Thermostat
   - Low oil level sensor
   - Immersion heater
   - Temperature gauge
   - Sounding tube or tank level indicator.
2. Head Tank. The head tank stores system hydraulic fluid and is installed above all other CPP components and above the ship’s waterline. The head tank maintains a static hydraulic fluid pressure in the hub greater than the ambient water pressure on the blade seals to prevent seawater from entering when the system is secured or when there is damage to a blade seal.
3. Circulating Pump. Some ships have a separate pump that provides hydraulic fluid to replenish the head tank when the fluid level falls below a specified level. Other ships use the motor-driven pump to replenish the head tank. Refer to the system technical manuals for specific instructions on replenishing the head tank hydraulic fluid level.
4. Prairie System Interface. A prairie system is installed on some ships to reduce propeller noise. Prairie system tubing enters the CPP system through the forward end of the OD box and travels through the bore of the valve rod to the propeller hub, where the air is carried to the blades. The prairie system should be operated in accordance with the engineering operational sequencing system (EOSS) and type commander’s instructions.

5. Lube Oil Purifier Interface. The lube oil purifier is hard-piped to the CPP system sump tank and is shared with other propulsion and auxiliary systems. It is used to remove water and particulate contamination from lube oil and hydraulic fluid. Piping is interconnected with storage and settling tanks for sump tank replenishment or fluid replacement, as well as for recirculating through the purifier. Some systems may use the purifier as a heater for the hydraulic fluid during startup.
6. Propulsion Control System Interface. The normal operating mode for most ships is automatic remote operation from the pilot house (bridge) or central control station. Throttle and pitch control are integrated in a single handle on the control consoles for normal combinations of shaft rpm and pitch. Additionally, control on most ship classes can be split at certain stations to allow an infinite combination of rpm and pitch (within engine overload and overspeed limits). Pitch system alarms and indicators are also found together on propulsion system control consoles.

g. Variations.

1. Bird-Johnson Design. The basic Bird-Johnson Co. components and system configurations are the same, with the size of the components being the primary variation between the hub servomotor-type systems. In addition, the DDG 51 class CPP system is the first to feature a different OD box design and improvements to the pitch-indicating system. It is equipped with a temperature-compensated pitch indicator (TCPI) assembly and an electronic pitch indicator (EPI) assembly. The TCPI measures the actual valve rod movement while it adjusts for changes in the valve rod and propeller shaft length due to changes in propeller load, hydraulic fluid pressure, and hydraulic fluid, sea, and air temperature. The EPI provides pitch measurement by generating an electrical signal corresponding to the displacement of the hub servo piston. In support of these indicating devices, a wire carrier inside the prairie system tube facilitates component wiring from the hub to the OD box.
2. KAMEWA Design. The KAMEWA (AB Karlstads Mekaniska Werkstad) CPP design is a smaller hub servomotor system with a different OD box design and no blade port covers (to facilitate underwater blade changeout). Rights to the design are now owned by Bird-Johnson Co.

245-5.2.3 PUSH-ROD-TYPE CPP SYSTEM. The second major type of CPP system found on Navy ships is the push-rod type. Figure 245-5-3 is a simplified diagram of such a system. The primary components of the push-rod system are:

- Pitch controller and transmitter arrangement
- Actuating unit
- Hydraulic system
- Double oil tube assembly
- Servomotor
- Actuating rod
- Hub assembly and propeller blades

a. Pitch Controller and Transmitter Arrangement. This is an electromechanical device that transfers electrical pitch signals from the control stations to the command shaft and clamping lever of the actuating unit. The primary components of this arrangement are:
   - Pitch controller output shaft
   - Carrier
   - Catch plate

b. Actuating Unit. The actuating unit housing is usually bolted to the forward face of the reduction gearbox. The command shaft receives a remotely transmitted pitch signal that is transmitted to the pilot piston. Movement of the pilot piston results in corresponding movement of the control piston. The movement of the control piston causes HP hydraulic fluid to be carried to one of the passages of the double oil tube assembly. The major components of the actuating unit are:
   - Servo box housing
   - Control body
   - Control lever
   - Connecting rod
   - Command shaft

c. Hydraulic System. The hydraulic system is made up of the various components required to supply pilot pressure and control HP hydraulic fluid to the actuating unit. The primary components are:

- Sump tank
- Gear-driven pump
- Motor-driven pump
- Circulating pump
- Filters
- Strainers
- Relief valves
- Oil cooler

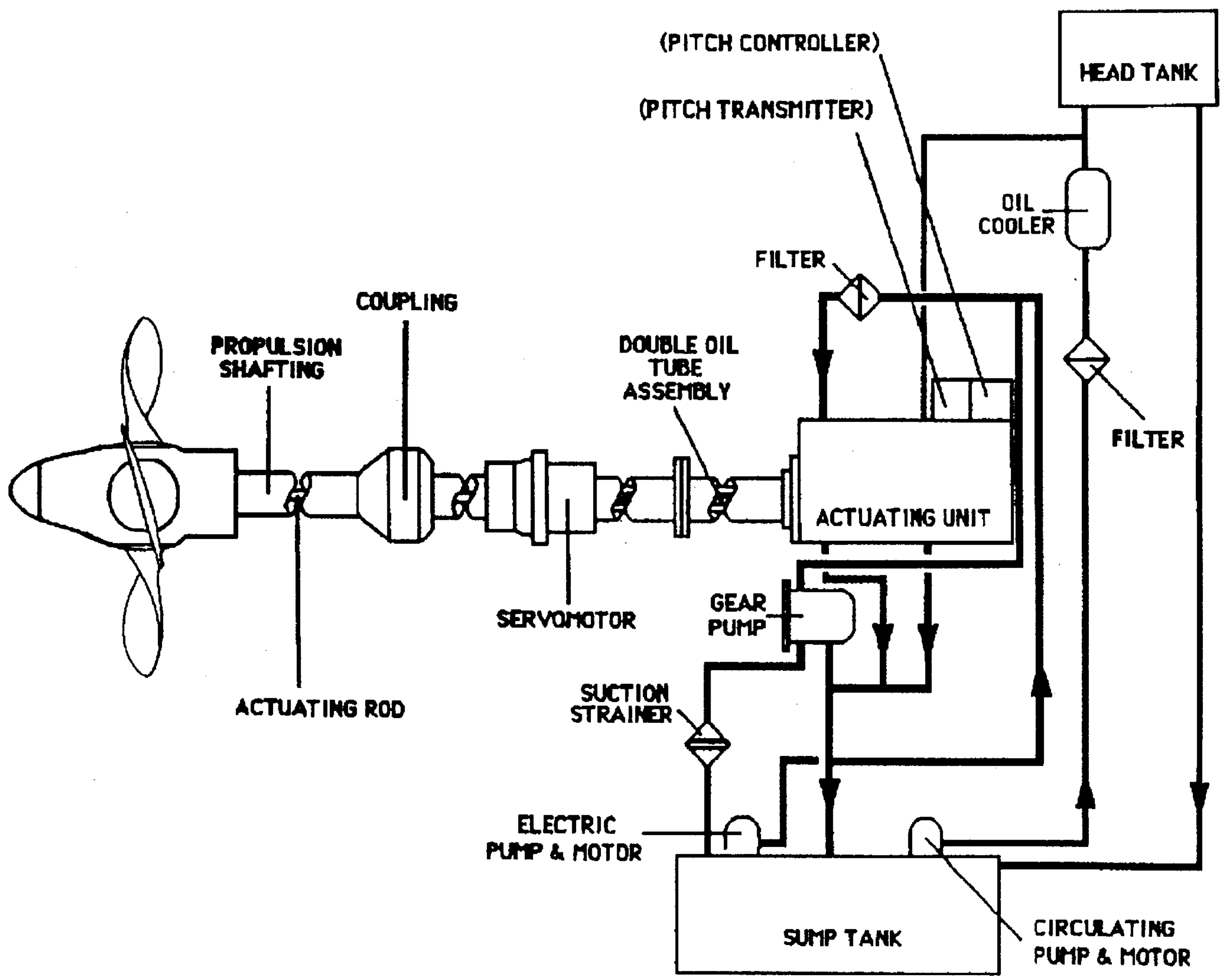


Figure 245-5-3 Push-Rod-Type (ATS 1 Class) CPP System.

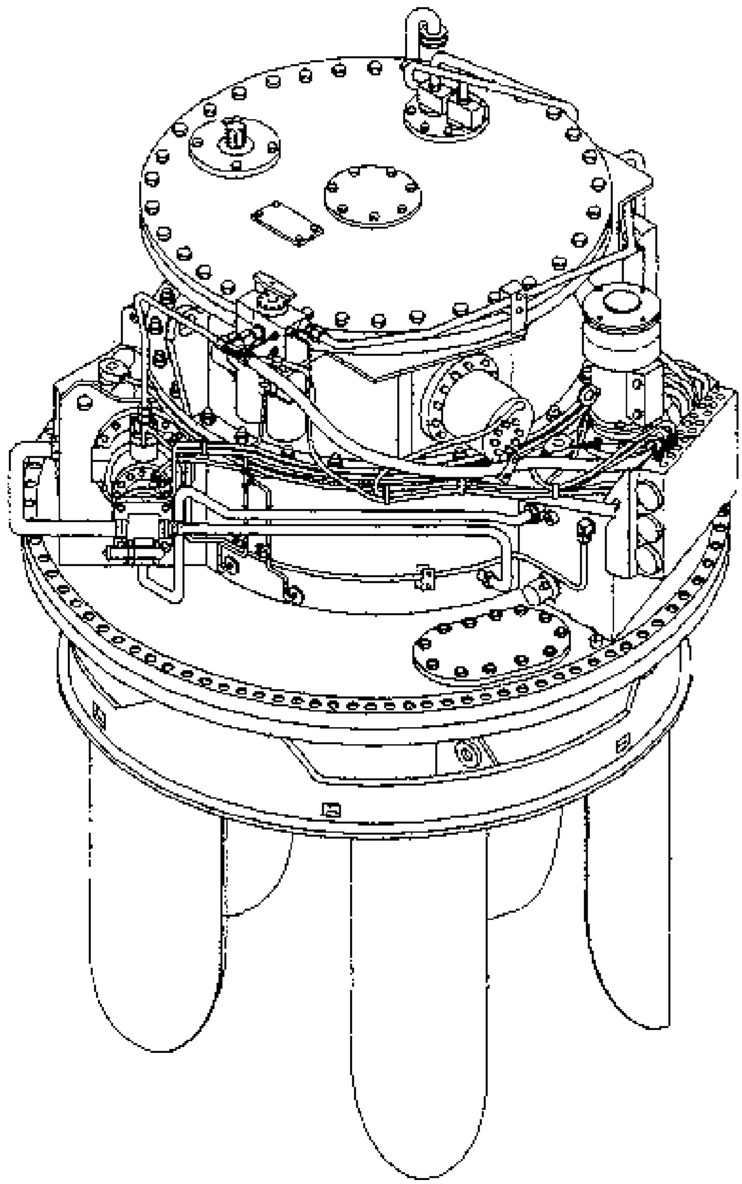
d. Double Oil Tube Assembly. The double oil tube assembly consists of two concentric tubes bolted to the forward face of the servomotor piston. From the servomotor piston, the double oil tube assembly runs inside the lineshaft and the low-speed gear shaft. It ends within the guide pipe of the actuating unit. The assembly is free to rotate with the lineshaft and the low-speed gear shaft, as well as to move linearly within the guide pipe. In this way, the double oil tube assembly supplies paths for HP and return hydraulic fluid to the servomotor in addition to transmitting the motion of the servomotor piston to the actuating unit feedback system.

e. Servomotor. The servomotor is in the propulsion shafting, forward of the stern tube shaft. The servomotor uses the HP control fluid supplied through the actuating unit to provide linear motion to the actuating rod.

f. Actuating Rod. The actuating rod is in four sections and connects the aft end of the servomotor to the crosshead inside the hub. Movement of the actuating rod (induced by the servomotor) causes corresponding linear movement of the crosshead.

g. Hub Assembly and Propeller Blades. The four-bladed propeller hub is bolted to the after propeller shaft flange. The hub contains the mechanism for converting the linear motion of the actuating rod into the rotary motion of the blade trunnions, which is then transmitted to the propeller blades. The components that make up the hub are:
   - Cap (cone)
   - Housing
   - Double joint bars
   - Cranks
   - Blade trunnions

245-5.2.4 CYCLOIDAL PROPELLER SYSTEMS. The Navy utilizes cycloidal propeller units on MHC-51 Class vessels (Figure 245-5-4). This system allows a ship to propel or turn in any direction. This type of CPP system is described in the following paragraphs. The major components of the cycloidal propeller system are:
- Upper Propeller Casing
- Lower Propeller Casing
- Rotor Casing
- Hydraulic (Control) Oil System
- Lubricating Oil System
- Propeller Worm Gear Interval Drive
- Blade Control (Kinematic) Elements and Propeller Blades



CHANGEDFIGURE

Figure 245-5-4 Cycloidal Propeller (MHC-51 Class)

a. Upper Propeller Casing. The upper propeller casing is a welded structure that houses the hydraulic actuator cylinders, lubrication oil head tank with level sensors, the upper portion of the control rod and the pitch indicator plate.

b. Lower Propeller Casing. The lower propeller casing is a welded structure that houses the worm and wheel gear components, driving sleeve, main seals, and the upper and lower thrust ring bearings.

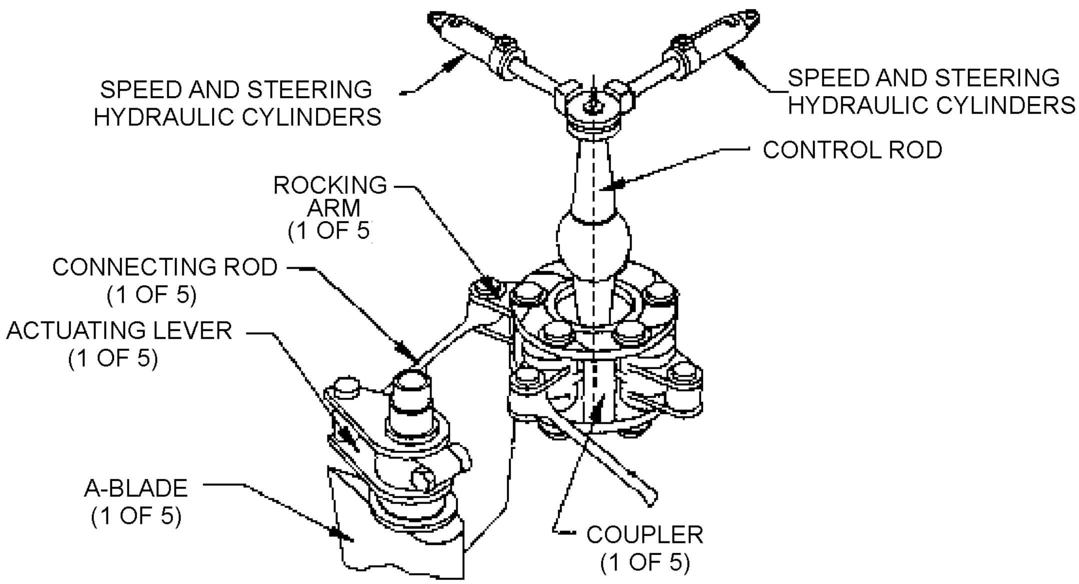
c. Rotor Casing. The rotor casing is the lowest casing and rotates during operation. It is the only portion of the propeller assembly that contacts the water, and only the blades extend beyond the ship's hull. This casing houses the blade control (kinematic) elements, the propeller blade shafts, and the propeller blade bearings and seals.

d. Hydraulic (Control) Oil System. The hydraulic fluid system is used to manipulate the blade control (kinematic) elements in order to change the direction of thrust and amount of speed of the vessel. This is accomplished by supplying high pressure hydraulic fluid to the hydraulic actuator cylinders. This hydraulic fluid system is comprised of a main gear driven pump, standby pump, control valves, filters, measuring and monitoring devices, an oil sump tank, and the hydraulic cylinders.

e. Lubricating Oil System. The lubrication oil system is a low pressure system that supplies lubrication and cooling to the propeller components. Lubrication oil flows from a sump tank via the main or standby pump to the worm and wheel gear, thrust ring bearings, and worm shaft bearings. The oil then flows to the head tank and then returns to the sump tank. If the lubricating oil rises to a specific temperature, a thermostatic valve opens and directs a portion of the flow into the rotor casing for cooling where it will then flow into the head tank and back to the sump tank. This lubricating oil system is comprised of a main gear driven pump, standby pump, valves, filter, indicator, oil cooler and heater, temperature regulators, a sump tank and a head tank.

f. Propeller Worm Gear Internal Drive. The main propulsion shaft is connected to the propeller worm gear shaft by a mis-alignment coupling. The propellers employ a single stage, cylindrical gear drive which consists of a worm and wheel gear. The worm gear meshes horizontally with the wheel gear and changes the axis of drive rotation from horizontal to vertical. A thrust plate transmits thrust from the wheel gear to the drive sleeve. The outer flange of the thrust plate rotates between the upper and lower thrust ring bearings which are bolted to the propeller lower casing. The drive sleeve is bolted onto the rotor casing which sequentially rotates the blades.

g. BLADE CONTROL (KINEMATIC) ELEMENTS AND PROPELLER BLADES. The ships speed and direction are a result of the pitch angle of the propeller blades. The pitch angle can be modified via the blade control (kinematic) elements (Figure 245-5.5). The two hydraulic cylinders are connected to the upper portion of a control rod. The cylinders move the upper portion of the control rod which pivots at a central spherical bushing about its central axis. The control rod pivots but does not rotate with the propeller. The coupler is connected to the lower portion of the control rod and consists of 5 couplings. These couplings move with the lower portion of the control rod and rotate with the rotor casing via bearing surfaces. Each of the couplings are pinned to a rocking arm which is then pinned to a connecting rod. The connecting rod is pinned to an actuating lever which is clamped to the propeller blade shaft. When the coupler is moved off center, via the control rod, the connecting rods will push or pull the actuating lever depending on their location relative to the coupler. Since the actuating lever is clamped to the blade shaft this motion will constantly change the propeller blade pitch angle as it rotates about its center axis. Although the propeller blades constantly change pitch angles as they rotate about the center axis of the propeller, the direction of thrust will remain constant with respect to the ship's hull for a particular setting.



CHANGEDFIGURE

Figure 245-5-5 Blade Control (Kinematic) Elements

245-5.2.5 SPECIAL COMPONENT FEATURES. The following are special component features that may be found on CPP systems:

a. Pitch-Locking Device. This device provides a means to mechanically lock the OD box, piston, valve rod, and propeller blades in the emergency-ahead pitch position. This position allows the propeller to operate in the event of loss of pitch control through hydraulic or electrical failure.

b. Emergency Pitch-Positioning Equipment. In the event of hydraulic or electrical system failure, this equipment provides a means to mechanically position the propeller blades using a hand-operated hydraulic pump to provide hydraulic fluid under pressure to the OD box piston.

c. Pump Drive Assembly. The pump drive assembly is mounted on the reduction gear and contains gears and shafting for driving the CPP system gear-driven pump. This assembly includes a sliding tooth clutch that permits engaging the gear-driven pump at rest and disengaging the gear-driven pump during operation.

245-5.3 CPP SYSTEM OPERATION

245-5.3.1 OPERATIONAL REQUIREMENTS. The EOSS provides ship-specific written procedures, charts, and diagrams that allow watch-standers to operate the CPP system and handle casualties in a safe, orderly, and controlled manner. The EOSS consists of two parts: engineering operating procedures (EOP) and engineering operational casualty control (EOCC). The EOP consists of sequential actions required for CPP alignment and operation; it includes system diagrams to support these procedures. EOCC consists of casualty response procedures for watch standers to implement in order to control casualties. Casualty responses include loss of CPP control, loss of oil pressure, and major oil leakage. Carderock Division/Naval Surface Warfare Center, Philadelphia (NSWCCD-SSES 9323) is responsible for developing and maintaining the applicable Ship's Information system EOSS. Refer to the applicable Ship's Information Books (SIB) for specific descriptions of operating stations and capabilities.

245-5.3.2 OPERATING MODES. There are two types of operating conditions for CPP systems, normal operation and emergency operation. Several facets of normal operation correspond to operation from the various control consoles; control alignment varies with ship type. Refer to the Ship Information Book (SIB) and control technical manuals for information on specific ship controls. Additionally, refer to the system manuals and the EOSS for further information and procedures for normal and emergency operation. If the automatic or manual controls fail, most ships are able to set and lock blade pitch in an emergency-ahead position to permit limited operation. Refer to the system manuals (Table 245-5-1) for specific information on this capability.

245-5.4 MATERIAL CONDITION AND MAINTENANCE

245-5.4.1 OVERVIEW. This section provides requirements, instructions, and information to aid in the performance of preventive and corrective maintenance.

245-5.4.2 PLANNED MAINTENANCE. The planned maintenance system (PMS) requirements shall be performed according to the instructions provided on the applicable maintenance requirement cards (MRC). NSWCCD-SSES is responsible for developing and maintaining the PMS for these systems.

245-5.4.2.1 A report [reference (l)] is to be submitted in accordance with reference (m) requesting coverage for the equipment. The following standard maintenance items shall be included in each CPP system PMS package:

a. Hydraulic Fluid Maintenance. Perform the following steps: take samples, provide samples for analysis, clean or renew contaminated fluid, inspect filters and strainers, clean or replace filters and strainers, and strip bottom sediment and water from the head tank.

b. Lubrication. Lubricate moving parts such as the linkages, bearings, and couplings.

c. Test Operation. Test operate the pitch control system (cycle times), test the emergency pitch positioner, test the alarms, and test the hydraulic pump output.

d. Heat Exchanger. Clean and inspect the heat exchanger (if installed).

e. Mounting Bolts. Check for mounting bolt presence, condition, and torque.

f. Hoses. Inspect the hoses for cracking, wear, and age. For further guidance on hose inspection, replacement, and testing, refer to reference (n).

g. Adjustment and Alignment. Certain electrical, hydraulic, pneumatic, and mechanical components require periodic adjustment and alignment. The periodicity of these actions are specified on the applicable MRC’s. Procedures for making the adjustments and alignments are found in the appropriate component technical manuals. These adjustments and alignments include calibrating pitch indication, testing the relief valves, testing the sequencing valves, testing the control valves, checking the electrical enclosures and motors, checking pitch cycle times, and aligning the control circuits.

245-5.4.2.2 If the MRC’s are incorrect or do not exist for a particular piece of equipment or component, institute interim maintenance according to the manufacturer’s recommendations.

245-5.4.3 SYSTEM MAINTENANCE. Common or recurring problems associated with CPP system components and guidance for resolving or correcting problems where available are discussed in the following paragraphs:

245-5.4.3.1 Calibration and Alignment. The mechanical pitch indicator shall be calibrated following repair or replacement of major components in the hub, valve rod, shafting or OD box. Refer to the applicable system technical documentation for specific instructions. This alignment ensures that the local pitch-indicating assembly accurately reflects the actual pitch position of the blades at the hub. Calibration should be done with the hydraulic fluid at normal operating temperature to avoid inaccuracies due to thermal growth or contraction of the valve rod. Significant changes in ambient seawater temperature will result in variations in the normal operating temperature of the hydraulic fluid. Since this will cause thermal growth or contraction of the valve rod, ships should recalibrate after changing operating areas where differences in seawater temperature are significant.

245-5.4.3.2 System Fluid Condition. Controllable-pitch propeller systems are considered hydraulic systems, even though most systems use lubricating oil, reference (o), as the hydraulic fluid. The most common cause of problems with the hydraulic system is fluid contamination.

a. Particulate Contamination. Hydraulic system particulate contamination may be the result of component catastrophic failure, component wear, or entry from some external source. To prevent system damage, carefully keep the system hydraulic fluid (and filters) as clean as possible (see PMS requirements). Some servo valves have tiny screen filters in the pilot stage of the valve body that are often overlooked and can become clogged and affect (slow) blade slew rates.

b. Wear Metals. Compare current wear metal analysis results to subject system's historical trend. Significant variations from the system norm for a given wear metal(s) is indicative of accelerated deterioration. NSWCD 9323 and NSWCCD 622 should be notified of instances of wear metal contamination. NSWCCD will use wear metal analysis results to identify likely sources of subject material and direct targeted troubleshooting efforts.

c. Water Intrusion. CPP systems are subject to seawater and freshwater contamination. The ″clear and bright″ criteria and the bottom sediment and water (BS & W) tests have been adapted from lubricating oil testing to provide a shipboard capability for evaluating the contamination of CPP system hydraulic fluid. CPP hydraulic fluid, however, is evaluated under different criteria than lubricating oils. The following is a discussion of the various contamination ranges for CPP hydraulic fluid and the required maintenance actions.

   1. The operating goal for water contamination is ″clear and bright″ . If the hydraulic fluid sample appears ″clear and bright″ (free of visible contaminants), the fluid is satisfactory for continued use. As part of standard preventive maintenance, the CPP system fluid should be purified for 4 hours per day while at sea to maintain ″clear and bright″ . Since the ″clear and bright″ goal is not always achieved in practice, refer below for additional requirements.

   2. If the hydraulic fluid sample appears hazy or cloudy or if sediment is present on the bottom of the sample bottle, perform a BS & W test.

      (a) If results indicate less than or equal to 0.1 percent BS & W, the hydraulic fluid is satisfactory for system operation. Purify the system fluid for 12 hours per day. Obtain and analyze samples daily until ″clear and bright″ fluid is achieved.

      (b) If the BS & W results indicate contamination is greater than 0.1 percent, but less than or equal to 0.4 percent, purify system for the maximum hours purifier is available, for the next 48 hours. Inspect system for leaks and source of contamination. Every 12 hours of the 48-hour purification period, take fluid samples and perform BS & W tests on them. Record the results obtained. At the end of the 48-hour purification period, review the BS & W results recorded above.

         (1) If there is no reduction of or if there is an increase in the BS & W level as shown by the above results, request technical assistance. Continue to purify system for maximum hours per day and monitor hydraulic fluid until the problem is resolved.

         (2) If the results indicate that the BS & W level is decreasing, control of the contamination problem

has probably been established. Continue purifying the system for the maximum number of hours that purifier is available until BS & W test indicates water contamination of 0.1 percent or less. Continued unrestricted operation is acceptable with water content greater than 0.1 percent and less than or equal to 0.4 percent, provided control of water content can be maintained within this range. Inability to purify to 0.1 percent or less may be due to fluid additive oxidation and/or system leak and should be corrected as soon as possible.

(c) If the results of the BS & W test indicate a BS & W level greater than 0.4 percent, the potential for system component damage and fluid degradation exist.

(1) Report the system degraded and request technical assistance. Prolonged operation of CPP systems with high levels of water contamination can result in system corrosion and damage.

(2) Inspect system for leaks and/or source of contamination.

(3) Continue to purify the system the maximum number of hours the purifier is available and monitor the hydraulic fluid until the problem is resolved.

3. MHC 51 Class Ships:

(a) MHC 51 VSP units do not have access to on-line purification. System lubricating oil and hydraulic fluid should be maintained in the best possible condition in order to protect the equipment and reduce the effects of wear and corrosion. Historically, water contamination has been the result of seawater ingress into the system via the rotor casing blade seals or system oil cooler failures (though other sources are possible). Testing for water contamination yields information critical to evaluating the integrity of the system, as well as preventing irreparable fluid degradation.

(1) Sampling: In order to ensure a representative sample, operators should ensure that the system oil is at operating temperature, and the subject VSP unit(s) has been spun for a minimum of 15 minutes prior to taking samples. This ensures complete mixing of oil between the lower and rotor casing (controlled by a thermostatic valve), and that the oil of the rotor casing is agitated sufficiently to raise any settled water into solution.

(2) Criteria: Oil that is clear and bright with no indication of free water or sediment is considered uncontaminated. If the oil is cloudy water content shall be evaluated. The allowable range of water contamination is:

(a) 0.0 - 0.1% H2O fluid is considered satisfactory for system use.

(b) 0.1 - 0.4% H2O fluid is considered satisfactory for system use, however equipment operators should recognize that an adverse machinery operating condition exists and the cause shall be identified and corrected. Oil shall be filtered/purified/replaced as soon as operationally practical.

(c) Greater than 0.4% H2O fluid is considered at a condemning limit and the system must be secured unless operational requirements dictate continued use. Technical assistance must be requested upon reaching this threshold to ensure continued safe operation of the equipment whether the unit is operated or secured.

(3) Shipboard Analysis: Pending the development of a suitable shipboard testing methodology, if the oil sample has a uniform milky appearance, the water content is approximately 0.4 percent or greater. A sample must be taken for laboratory analysis.

245-5.4.3.3 Gear-driven Pump Vibration. Couplings and mounting bolts may loosen, causing vibration and eventual pump failure. Routine inspection and maintenance, in accordance with PMS requirements, should eliminate this problem.

245-5.4.3.4 Head Tank Drain Down. With the CPP system secured, the head tank should maintain a static fluid pressure for approximately 12 hours without replenishing.

a. Head tank drain down within approximately 20 minutes after system shutdown indicates that a valve is open that bypasses the return line check valve. The correct valve alignment should be identified in the EOSS procedures.

b. Significant decreases in the head tank fluid level may be experienced during the initial stages of system shutdown due to fluid cooling. This is a direct result of the cooling contraction of the warm hydraulic fluid in the hub and propulsion shafting. It is more apparent on systems with large quantities of fluid. In a CPP system with 2300 gallons of fluid, for example, a change from an operating temperature of 110°F to an ambient temperature of 60°F may cause an apparent volume loss of approximately 45 gallons. This phenomenon is normal but could be misconstrued as a leaking hub oil seal or return line check valve. Volume loss due to cooling is dependent upon temperature change and the quantity of fluid in the system. Figure 245-5-6 is provided for estimating the amount of volume loss that will occur for a specific temperature change and a specified volume of system fluid. The capacity is the volume of hydraulic fluid pressurized by the head tank; the fluid in the sump tank and associated piping must be discounted.

c. A slow head tank drain down after system cool down, with a corresponding rise in sump tank level, commonly indicates a leaking return line check valve; the leak may also be through another component, however, such as the isolation valves, foot valve, or manifold block assembly.

d. Hydraulic oil leaks through the blade seals (as evidenced by an oil slick astern) or into the engine room bilges are less common occurrences but may contribute to head tank drain down.

245-5.4.3.5 Emergency Ahead Pitch Lock. The pressure required to move the OD box piston to the emergency ahead pitch lock position is much higher than normal auxiliary servo pressure and may stretch the valve rod and OD box. This may deform (overstress) the attached assemblies if operated improperly. While operating in emergency ahead pitch lock, closely monitor the shaft rpm and oil temperature, as this mode of operation generates considerable heat. Refer to the operating instructions for restrictions and operating parameters.

245-5.4.3.6 Obsolete Parts. One of the recurring problems for CPP systems is the need to replace components that are no longer available in the supply system. Obtaining obsolete replacement parts becomes increasingly difficult, especially for older CPP systems. Manufacturers are constantly modifying their equipment to improve component efficiency and keep pace with industry standards. Modifications are occasionally needed to accommodate new components. When a ship receives a replacement part that has been modified in some way or modifies the system, the ship shall document the configuration change as in reference (p) (to update the Weapon System File and Coordinated Shipboard Allowance List), and to submit technical manual, PMS, and EOSS changes (feedback reports) as applicable.

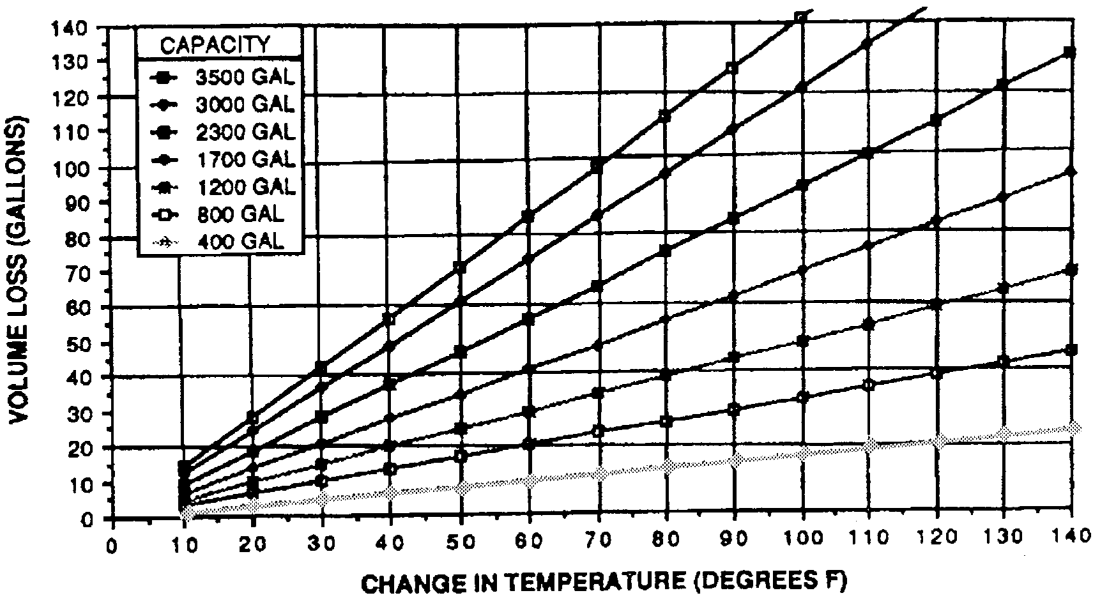


Figure 245-5-6 Controllable-Pitch Propeller Hydraulic Fluid (MIL-L-17331) Volume Loss due to Thermal Contraction

245-5.4.3.7 Mechanical Seal Leakage Criteria.

a. New Seal Installations: Zero measurable dripping leakage is permitted over a 30 minute operating period for satisfactory new seal installation.

b. In-Service seals shall be replaced when:

   (1) Seal is removed for any reason.

   (2) Seal leakage rate exceeds 5 drops per minute.

245-5.4.4 CONDITION BASED DOCKING DETERMINATION CRITERIA.

245-5.4.4.1 Background. Under the Condition Based Assessment (CBA) approach, the following periodic inspections and tests of the CP propeller system are provided to assess the material condition of the system and permit a determination to be made concerning the need for depot level maintenance. Applicable technical manuals and technical repair standards are identified in Table 245-5-1 .

245-5.4.4.2 Periodicities. After the first six years of CP propeller hub operation, CBA procedures/inspections are required. Evaluation of the periodic inspection results will be compared to inspection records from the last inspection and CP propeller system installation or the last major system overhaul to identify deteriorating trends and/or departures from allowable operating conditions. If the six year inspection does not identify material deficiencies requiring drydocking to correct, the CP propeller system is acceptable for continued operation for an additional two years. At the end of two years, repeat the CBA inspection process and every two years thereafter until the next drydocking, at which time, the CP propeller blades and blade port covers (as applicable) shall be removed and blade ports shall be inspected, critical dimensions taken, and the hubs repaired or replaced as required during the availability.

245-5.4.4.3 Condition Based Assessments. The following condition based assessment procedures/inspections shall be conducted in accordance with the periodicities discussed above.

245-5.4.4.3.1 Visual Inspection For Oil Leaks:

a. Shipboard.

1 Action: Inspect shipboard system piping and equipment for leakage.

2 Criteria: No Leakage Permitted.

3 Corrective Actions: Troubleshoot and correct leakage in accordance with applicable system technical manual.

b. Waterborne.

1 Action: Qualified divers shall inspect the CP propeller system waterborne. The diver shall inspect the hub for oil leaks from the following locations while the system is pressurized and placed on purge via applicable MRC card.

(a) Blade Ports (including blade bolts).

(b) Hub Body (Plugs, Joints, etc).

(c) Prairie Air Emitter Holes

2 Criteria: No Leakage Permitted.

3 Corrective Actions:

(a) Blade Ports: When waterborne inspections reveal oil leaks indicative of blade port seal deterioration, the blade and blade port seals shall be replaced waterborne in accordance with system technical manuals and procedures contained in reference (j). After seal replacement, the system shall be re-inspected as specified above. If the system continues to leak after seal replacement, the ship must be drydocked, the CP propeller hub shall be opened and inspected, and associated components repaired or replaced in place during the availability.

(b) Hub Body.

(1) Plugs. Leakage from hub body plugs can be corrected by tightening and re-staking of subject plug in accordance with procedures contained in reference (j).

(2) Joints. Leakage located at hub body to hub cone, or hub body to propeller shafting joints requires drydocking to correct.

(c) PRAIRIE Emitters. Oil leakage from PRAIRIE emitter holes is indicative of damage to PRAIRIE tubing. Temporary repairs are possible (eliminating PRAIRIE function), but full correction requires drydocking. Temporary Repairs:

(1) Onsite technical assistance conduct system inspection and Qualified Navy divers conduct a waterborne inspection of the subject hub in an effort to determine if the PRAIRIE tube is parted, or is simply leaking.

(2) If the PRAIRIE tube is leaking but not parted, the hub PRAIRIE check valve is replaced with a plug in order to block flow of oil to the blade emitter holes in accordance with procedures contained in reference (j). This eliminates PRAIRIE function.

(3) If the PRAIRIE tube is parted in the vicinity of the hub section of PRAIRIE tube flange weld (usual case), the PRAIRIE flange and attached section of the tube is removed and a blank is installed on the end of the valve pin liner in accordance with procedures contained in reference (j). The PRAIRIE check valve is also removed and replaced with a plug as in item (2) above. This returns operation of the CPP system, but eliminates PRAIRIE function

245-5.4.4.3.2 Blade Bolt & Blade Bolt Cap Inspection:

a. Action: Qualified divers shall inspect the CP propeller blade bolts and blade bolt caps (as applicable) for tightness.

b. Criteria: No loss of preload, as measure by qualified Navy diver using ultrasonic blade bolt stretch measurement device in accordance with Navy Underwater Ship Husbandry Manual (Chapter 12) Procedures, reference (j)

c. Corrective Action: If a loose bolt is found, the subject bolt must be removed, inspected, and reinstalled or replaced in accordance with the Navy Underwater Ship Husbandry Manual (Chapter 12) Procedures, reference (j). Additionally, in order to ensure that the joint integrity is not compromised as a result of the change in load distribution due to the loose bolt, measure stretch (preload) of all blade bolts on affected blade port after the loose bolt has been satisfactorily re-installed.

245-5.4.4.3.3 System Fluid Inspection.

a. Action: Take system fluid samples in accordance with applicable Sample For Chemical Analysis MRC Card, and have samples tested for wear metals, particulate count, and water. NSWCCD 9323 will evaluate current sample against established criteria and historical trend for subject ship and system, observing for variations that would be indicative of component/subcomponent deterioration.

b. Criteria: See Paragraph 245-5.4.3.2 b and c for system fluid characteristic criteria.

c. Corrective Action:
   1 Water: Identify the source of water contamination and correct
   2 Wear Metals & Particulate Count: High particulate count and wear metals are indicative of component/subcomponent deterioration. Using wear metal analysis in accordance with the Sample For Chemical Analysis MRC Card, identify likely sources of subject material and determine if waterborne or drydock repair is required based on applicable system technical manual and class maintenance plan

245-5.4.4.3.4 Evidence of Oil Consumption.

a. Action: Verify no loss of system fluid is observed during operation.

b. Criteria: No Oil Consumption Permitted.

c. Corrective Action: Perform detailed system inspection in accordance with applicable system technical manual.

245-5.4.4.3.5 System Pressures and Temperatures.

a. Action: Observe system pressures and temperatures at system Hydraulic Oil Power Module (HOPM), pier side and underway.

b. Criteria: System pressures and temperatures at HOPM are within allowable values in accordance with applicable system technical manual.

c. Corrective Action: Troubleshoot in accordance with applicable system technical manual.

245-5.4.4.3.6 Slew Rate.

a. Action: Cycle propeller blade pitch, Full Ahead to Full Astern in manual mode (from oil distribution box). Observe and record time required. Cycle pitch, Full Astern to Full Ahead in manual mode (from oil distribution box). Observe and record time required.

b. Criteria: 30 Seconds (Maximum).

c. Corrective Action: Troubleshoot in accordance with applicable system technical manual.

245-5.4.4.3.7 Hub Servo Stall Check.

a. Action: Slew propeller blade pitch, pier side in manual mode (from oil distribution box) while manipulating the pressure control manifold valves on the Hydraulic Oil Power Module (HOPM) to affect a reduction in hub servo pressure until the hub servo piston in the propeller hub stalls. Record the pressure at which hub servo stall occurs. Evaluate current pressure against historical trend for subject ship and system, observing for variations in the trend which would be indicative of component/subcomponent deterioration.

b. Criteria: Variance of + 50 psi from original install.

c. Corrective Action: Correlate results of hub stall check with fluid chemical analysis and other system inspection results. Conduct further troubleshooting in accordance with applicable system technical manual to isolate root cause and determine course of repair.

245-5.4.4.3.8 Valve Rod Stall Check.

a. Action: Slew propeller blade pitch pier side in manual mode (from oil distribution box) while manipulating the pressure control manifold valves on the Hydraulic Oil Power Module (HOPM) to affect a reduction in auxiliary servo pressure until the OD Box piston stalls. Record the pressure at which the auxiliary servo stall occurs. Evaluate current pressure against historical trend for subject ship and system, observing for variations in the trend which would be indicative of component/subcomponent deterioration.

b. Criteria: Variance of + 50 psi from original install.

c. Corrective Action: Correlate results of valve rod stall check with fluid chemical analysis and other system inspection results. Conduct further troubleshooting in accordance with applicable system technical manual to isolate root cause and determine course of repair.

245-5.4.4.4 Emergent Casualties. At any time if there is a loss of pitch, unusual noise or vibration (not due to valve rod guide wear), or a significant variation in operating oil pressure during ship operations, the propeller system shall be inspected immediately by qualified technicians. If the CP propeller system components within the hull are determined not to be the source of the problem, the ship must be drydocked, the CP propeller hub shall be opened, and associated equipment shall be inspected and repaired or replaced. Noise associated with valve rod guide wear is not considered a cause for an emergent drydocking, unless the ship's mission is considered noise critical, because it does not pose an immediate threat to continued CPP system operation. The valve rod guides shall be repaired at the ship's next availability. If the CP propeller hub is repaired, the ship will return to the two-year pressurized inspection cycle until the next drydocking, at which time, the CP propeller hub shall be opened and inspected, and repaired or replaced if required during the availability. If the CP propeller hub is replaced, pressurized inspection of the CP propeller system shall be performed after six years of operation and at two year intervals thereafter until the next drydocking, at which time, the CP propeller blades and blade port covers (as applicable) shall be removed and blade ports shall be inspected, critical dimensions taken, and the hubs repaired or replaced as required during the availability.

245-5.4.4.5 Emergent Drydockings. In the event that the ship is drydocked for non CP propeller system related reasons after six years of CP propeller operation, the CP propeller blades and blade port covers (as applicable) shall be removed and blade ports shall be inspected, critical dimensions taken, and the hubs repaired or replaced as required during the availability. The ship will return to the two-year pressurized inspection cycle after the CP propeller hub is repaired in drydock. If the CP propeller hub is replaced, pressurized inspection of the CP propeller system shall be performed after six years of operation and at two year intervals thereafter until the next drydocking, at which time, the CP propeller hub the CP propeller blades and blade port covers (as applicable) shall be removed and blade ports shall be inspected, critical dimensions taken, and the hubs repaired or replaced as required during the availability.

245-5.4.4.6 Reporting. The results of all inspections, tests and repairs shall be forwarded to the In-Service Engineering Agent (ISEA), NSWCCD-SSES Code 9323.

245-5.4.5 PROPELLER INSPECTION AND MAINTENANCE WHEN SHIP IS DRYDOCKED. Drydocking presents the only opportunity to inspect the internals of the CPP hub. CPP hub inspections during drydock availabilities should be conducted in accordance with the periodicities defined in paragraphs 245-5.4.4.2 and 245-5.4.4.5. Standard (baseline) inspections should be done in accordance with applicable technical manuals, technical repair standards, and drawings; and the results reported to the ship's commanding officer, TYCOM and NSWCCD— SSES 9323. In addition to the requirements of Section 3, the following minimum standard work item inspections shall be in the applicable CMP's and scheduled during drydocking inspections:

a. Inspect the propeller blade bolts for residual stretch.

b. Inspect the internal condition of the hub at one blade port and measure the critical clearances and dimensions.

c. Inspect the blade ports.

d. Test and verify pitch alignment. Verify alignment using hub bench marks.

e. Remove, test, and reinstall the hub body safety valves.

f. Tighten the hub and tailshaft bolts to the specified torque.

g. Inspect the propeller bearing rings and skim-cut the ring to the maximum depth tolerance before reassembling it (if disassembled).

h. Clean the prairie system emitter holes.

i. Clean and inspect the after prairie system check valve.

j. Inspect and check the tightness of the retaining setscrews on the prairie system adapter plug and retaining plate.

245-5.4.6 HUB ASSEMBLY AND BLADE REPAIR AND REPLACEMENT WHEN SHIP IS DRYDOCKED. Results of the blade and hub assembly inspections, discussed in paragraphs 245-3.3 and 245-5.4.5, are used to determine if the assembly will operate satisfactorily until the next scheduled dry docking. If the inspection results are unsatisfactory, hub and blade removal, disassembly, repair or replacement, and reinstallation are required. Guidance for repair and maintenance actions is provided in paragraph 245-1.4 and the CPP technical repair standards. CPP blade replacement information is provided in paragraph 245-3.7.

245-5.4.7 PROPELLER CLEANING, INSPECTION, REPAIR, AND BLADE REPLACEMENT WHEN SHIP IS WATERBORNE. See Section 4.

245-5.4.8 BLADE BALANCE REQUIREMENTS. Blades are repaired and balanced as a hub set, to the requirements of reference (b) and (k). The blade position, as installed on the hub, is identified by the blade serial number stamped on each blade. Sometimes blade sets are separated as a result of individual blade replacements. In these cases contact NSWCCD —SSES 9323 to identify replacement blades that can be properly matched to the remaining blades to achieve a balanced set. NAVSEA maintains a record of all CPP blade weights and centers of gravity.

245-5.5 POSTREPAIR INSPECTIONS AND TESTS

245-5.5.1 When the overhaul (or other industrial availability) has been completed, all CPP system repairs and maintenance shall be proved by performing a complete series of inspections and tests. Component inspections and tests provide assurance that the CPP system is operating properly, obvious deficiencies were corrected, and adjustments critical to safety and reliability were made. The shipyard or industrial activity should provide documentation for retention on the ship, including the equipment replacements, equipment settings, and test results obtained in support of all the overhaul maintenance performed on the CPP system. The appropriate technical manuals, TYCOM instructions, the total ship test program (TSTP) procedures, and PMS and EOSS for each specific piece of equipment should be reviewed for detailed information on appropriate inspections and testing procedures. Test procedures for some ships are formalized in the TSTP documentation maintained by Planning, Engineering, Repairs, and Alterations, planning yards and building yards (new construction).

APPENDIX A

GLOSSARY

Actuating rod - A linkage that connects the servomotor piston to the blade-turning mechanism in push-rod systems.

Actuating unit - A type of rotary hydraulic valve manifold in push-rod systems that directs high-pressure oil to and return oil from the servomotor through the double oil tube assembly.

Attached pump - Same as gear-driven pump.

Blades - Part of the propeller hub assembly that cuts through the water, creating thrust. On controllable-pitch propeller (CPP) systems, changes in the angle or pitch of the blades create changes in thrust. The blades are attached to the hub individually.

Blade trunnion - The rotating bearing connected to the blade that translates linear motion of the crosshead through the connecting pin to blade rotation in the hub of push-rod systems.

CCS - Central control station

CPCH - Controllable pitch, same as CPP.

Conning station - Location where the ship's course and speed are controlled.

CPP - Controllable-pitch propeller. A type of propulsor system in which the propeller blade pitch can be continuously changed to provide thrust in the ahead or astern direction or any intermediate position, including zero thrust, without changing the direction of shaft rotation.

CRP - Controllable reversible pitch, same as CPP. This term may also be used in some applications to indicate contrarotating propellers, two sets of propeller blades on a common shaft rotating in opposite directions.

Double oil tube assembly - A tube inside a tube for carrying high-pressure oil to and return oil from the servomotor in push-rod systems.

Electric pump - Same as motor-driven pump.

Emergency ahead pitch - This is a device to mechanically lock the oil distribution (OD) box piston, valve rod, and propeller blades in the emergency ahead position. The emergency pitch positioner assembly is a portable, hand-operated hydraulic pump that provides hydraulic oil pressure to the OD box when auxiliary servo pressure is unavailable from main or standby pumps.

EOCC - Engineering operational casualty control. Written procedures for recognizing, controlling, isolating, and recovering from certain propulsion plant casualties.

EOP - Engineering operating procedures. Written, step-by- step procedures, charts, and diagrams used for normal lighting off, operating, and securing the propulsion plant.

EOSS - Engineering Operational Sequencing System. Provides written procedures, charts, and diagrams that fit the individual ship's configuration. It allows watchstanders to carry out major plant evaluations and correct casualties in a safe, orderly, and controlled manner.

EPI - Electronic pitch indicator.

Gear-driven pump - Hydraulic pump driven by the reduction gear or propulsion shaft through a flexible coupling or splined shaft connection. Depending upon the type of system, a gear-driven pump may be either the main or the standby pump.

GSO - General Specification for Overhaul of Surface Ships, NAVSEA S9AAO-AB-GOS-010/GSO. The document that contains the requirements for overhaul and repair of propellers, including CPP's.

Head tank - Tank used to maintain a constant static pressure greater than the ambient water pressure on the hub assembly when the CPP hydraulic system is secured. The head tank is installed above the ship's waterline at a higher level than other hydraulic components of the CPP system.

HOPM - Hydraulic oil power module. A self-contained unit consisting of various hydraulic components that provides low-pressure (LP) oil to the OD box and high-pressure (HP) oil, through the OD box, to operate the hub assembly.

HP - High pressure.

Hub assembly - Attached to the aft end of each propulsion shaft. Provides a mounting base for attaching the propeller blades. Houses the blade-turning mechanism for changing the pitch of the propeller blades.

IMA - Intermediate Maintenance Activity; such as Shore Intermediate Maintenance Activity (SIMA), or a tender.

LCAC - Landing craft air cushion.

LP - Low pressure.

Main pump - The hydraulic pump that provides primary hydraulic fluid power for maintaining or changing pitch. Depending on the type of system, the main pump may be either gear or motor driven.

MIP - Maintenance index page.

Motor-driven pump - A hydraulic pump driven by an electric motor. Depending on the type of system, the motor-driven pump may be either the main or a standby pump.

MRC - Maintenance requirement card.

NAVSEA - Naval Sea Systems Command, Washington, D.C.

NAVICP MECH - Naval Inventory Control Point, Mechanicsburg, PA.

NOAP - Navy Oil Analysis Program.

NSWCCD —SSES - Naval Surface Warfare Center, Carderock Division / Philadelphia, Pa.

OD box - The oil distribution box is a type of rotary hydraulic manifold that directs HP (control) oil to and LP (return) oil from the hub assembly through the propeller shaft, and positions the valve rod assembly.

PACC - The propulsion and auxiliary control console located in the CCS.

PERA - NAVSEA Detachment, Planning, Engineering, Repairs and Alterations, Surface.

PLCC - Propulsion local control console.

PMS - Planned maintenance system.

Prairie system - The propeller air internally emitted (prairie) system is used to lessen the underwater sound level of the propeller. Air flows through tubing in the center of the valve rod assembly to drilled passages in the hub and is emitted from each blade through small holes near the leading edge of the blades.

Purifier - A device for removing water and other contaminants from lube oil and hydraulic fluid. It is connected with piping to the CPP system sump tank. In some systems it is also used as a heater for the hydraulic fluid.

Return line check valve - Located in the hydraulic oil return line between the OD box and the sump tank, it provides a back pressure to prevent drain down of the head tank to the sump.

SCC - The ship control console located in the pilot house.

Servomotor - The assembly that drives the blade-turning mechanism. It may include the servo piston and valve, or the actuating rod and servo piston, depending on the type of CPP system.

SIMA - Shore Intermediate Maintenance Activity.

Standby pump - The hydraulic pump that provides secondary hydraulic fluid power for the CPP system. Depending on the type of system, the standby pump may be either gear- or motor-driven.

Sump tank - The main tank used for holding the hydraulic fluid used throughout the CPP system.

TCPI - Temperature-compensated pitch indicator.

TLI - Tank level indicator.

TRS - Technical repair standard.

TSTP - Total ship test program.

TYCOM - Ship type commander (i.e., COMNAVSURFLANT).

Valve rod assembly - The fabricated sections of seamless steel tubing joined by couplings and supported in the center of the propeller shaft by guides. It provides passage for HP hydraulic fluid from the OD box to the hub assembly and mechanically translates hydraulic pitch control commands in the OD box into servo valve movement in the hub. High-pressure hydraulic fluid is thus carried to the hub servomotor, resulting in corresponding pitch changes at the blade-turning mechanism in the hub assembly.

APPENDIX B

TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT(TMDER)

NOTE

Ships, training activities, supply points, depots, Naval Shipyards, and Supervisors of Shipbuilding are requested to arrange for the maximum practical use and evaluation of NAVSEA technical manuals. All errors, omissions, discrepancies, and suggestions for improvement to NAVSEA technical manuals shall be reported to the Commander, NAVSURFWARCENDIV, 4363 Missile Way, Port Hueneme, CA 93043-4307 in NAVSEA/SPAWAR Technical Manual Deficiency/ Evaluation Report (TMDER), NAVSEA Form 4160/1. To facilitate such reporting, print, complete, and mail NAVSEA Form 4160/1 below or submit TMDERS at web site http://nsdsa.phdnswc,navy.mil/tmder/tmder.htm. All feedback comments shall be thoroughly investigated and originators will be advised of action resulting therefrom. Extra copies of NAVSEA Form 4160/1 may be requisitioned from DDSP Susquehanna Pennsylvania, 05 E Street, Mechanicsburg, PA 17055-5003. (S/N 0116-LP-019-5300)

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