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PROPELLERS

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CHAPTER 3
PROPELLERS
SAFETY SUMMARY

GENERAL SAFETY PRECAUTIONS

The following general safety precautions supplement the specific warnings and cautions related to the task of removing and installing propellers. They are precautions that must be understood and applied before and during propeller replacement work. In addition to the following precautions, personnel must be familiar with and observe safety precautions set forth in the following publications:

1. Navy Safety Precautions for Forces Afloat - OPNAV 5100 series
2. Naval Ships Technical Manual (NSTM)
3. Technical/Operating manuals for equipment

Do Not Repair or Adjust Alone

Do not repair or adjust energized equipment alone. The presence of a qualified individual capable of rendering aid is required. Always protect against grounding hazards and make adjustments with one hand free and clear of equipment. Be aware that even after equipment has been de-energized, dangerous electrical hazards can exist due to capacitors retaining electrical charges. Circuits must be grounded and capacitors discharged.

Test Equipment

Make certain electrical test equipment is in good condition and personnel are familiar with its safe operation. Hand-held test equipment should be grounded, if possible, to prevent shock injury. Since some types of equipment cannot be grounded, avoid holding them to prevent injury.

Equipment in Motion

Remain clear of equipment in motion. A safety watch will be posted if equipment requires adjustment while in motion. The safety watch shall have a full view of operations and immediate access to controls which are capable of stopping equipment. If at any time the propeller appears to be moving out of control, stop equipment immediately.

Limit Switches and Interlocks

Limit switches and interlocks are provided to protect personnel and equipment. They should not be overridden or modified except by an authorized person. Do not depend solely upon limit switches for protection. Disconnect power at the power distribution source before adjusting limit switches if possible.
First Aid

Attend to all injuries, however slight, by obtaining first aid or medical attention immediately.

Resuscitation

Personnel working with or near high voltage shall be familiar with approved resuscitation methods. Begin resuscitation immediately if someone is injured and stops breathing. A delay could cost the victim's life. Resuscitation procedures shall be posted where electrical hazards exist.

Minimizing Relative Motion

Relative motion is the movement of two or more objects in relation to each other. This poses unique hazards to divers. A common example is a nest of ships swaying and bouncing against each other due to wind and wave action. This motion would easily crush a diver caught between the two ships. To reduce the hazards of relative motion and to simplify the task, suspend the work platform and rigging from fittings on the ship.

WARNINGS AND CAUTIONS

Specific warnings and cautions related to the task of removing and installing propellers are summarized below for emphasis and review. They should be included, where appropriate, in the step-by-step procedures developed for each propeller replacement task.

**WARNINGS**

Rotating the propeller while divers are in the vicinity may result in a serious injury or death. Ensure that the propeller is rotated only at the direction of the dive supervisor.

(pages 4-6 and 8-2)

Sudden or uncontrolled movement of the propeller may cause serious personal injury. Ensure that divers are positioned forward of the propeller before moving the propeller aft.

(page 5-1 and 6-1)

The inherent danger in using this method is that the lifting device is subject to differences in relative motion between it and the propeller while the propeller is still attached or close to the ship. Damage to equipment or serious injury to divers can occur if these relative motion differences cause impact. For this reason, all divers should remain well forward of the propeller after the balance beam has been connected and lifting has begun.

(page 6-1)

Propeller blade edges are knifelike and very sharp. To prevent injury, divers must wear
gloves while inspecting propeller blades.  
(page 7-1)

CAUTIONS
Slacking the crane hook while the locking key is engaged will cause the nut to retighten. Do not slack the crane hook until the locking nut is removed. (page 5-5)

Chain twist in the working chain loops of manual chain hoists and chain falls will cause chain failure. Chain twist in the working chain loop occurs when the chain has an improper reeve through the chain sprockets OR (more often) the running block has flipped up and through any of the chain loops (see figure 5-4A and 6-8A).

All chain hoists and chain falls issued with NAVSEA SUPSALV Underwater Ship Husbandry equipment kits have been checked for chain twist and the chain hoist/fall has been loosely two-blocked so that the running block can not flip over into the working chain loops during shipment.

OPERATORS must ensure that the running block is not flipped over into the chain loops creating chain twist while deploying and rigging the chain hoists/falls.

To check for chain twist in the chain loop:

Hang the hoist from the top hook in a safe, accessible location. Tighten the hoist until less then one foot of separation exists between the hoist body and the running block. The short throw allows for much easier visual detection of twist in the individual chain reeves. Confirm that none of the chain lengths running from the working chain sprocket to the running chain sprocket (chain reeves) have any twist caused by the running block being flipped over and through the loop of the chain. If ANY chain twist is detected, flip the running block back through the chain loop until the twist is removed. If ANY twist can not be removed by flipping the running block, the hoist chain MUST be removed from the hoist body and re-reeve exercising care not to twist the chain during installation. (page 5-5 and 6-11)

Blade edges are easily damaged. Do not strike blade edges with air cylinders, tools, or other equipment. (page 6-1)

The propeller shaft shall be securely locked.
Otherwise, the torque provided by the propeller nut wrench could be transmitted to the reduction gears and cause considerable damage.

(page 7-9)
CHAPTER 3 PROPELLERS

SECTION 1 - INTRODUCTION

1.1 PURPOSE

This chapter provides Commands with basic guidance in techniques available for performing underwater propeller replacement tasks and for avoiding potential pitfalls while doing so. The chapter may also be used as an on-the-job training supplement.

1.2 SCOPE

While it is impossible to compile into a single document all the information required to successfully replace a propeller, the chapter contains relevant information from numerous technical publications. The chapter provides extensive information, based on past experiences, on the potential problems faced during a task; but, the chapter does not provide step-by-step procedures for performing a propeller replacement task. Differences between ship classes, and often between ships within the same class, require development of step-by-step procedures for individual tasks.

1.2.1 This chapter contains a section that explains the various propeller types and terminology used to describe propellers. The remaining sections each describe a particular phase of a propeller replacement task. Each section generally provides information on the particular phase, different methods available for accomplishing the phase, and the associated pitfalls. Each section also describes the specialized tools and equipment available from NAVSEA 00C5 for each phase. Appendix A outlines in order the phases of a propeller replacement task. The outline can be used to develop step-by-step procedures.

1.3 APPLICABILITY

After carefully reviewing this chapter and assembling the additional reference material required, a Command performing a propeller replacement should be able to use the Propeller Replacement Task Outline (Appendix A) to develop a plan and the step-by-step procedures required to successfully complete the task. NAVSEA 00C5 is available for consultation or technical assistance during propeller replacement planning and execution.

SECTION 2 - PROPELLER TYPES AND TERMINOLOGY

2.1 TERMINOLOGY

Figure 2-1 shows the terminology associated with a typical Navy screw propeller. The following list defines each term shown on Figure 2-1:

- **Hub.** The center section of the propeller bored for a tapered (interference) fit onto the shaft.

- **Blade Fillet.** The radii defined by the transition of the blade faces into the hub. Also referred to as the blade root.

- **Pressure Face.** The aft face of the propeller blade.

- **Suction Face.** The forward face of the propeller blade.

- **Leading Edge.** The blade edge adjacent to the forward end of the propeller hub.
**Trailing Edge.** The blade edge adjacent to the aft end of the propeller hub. A blade knuckle is a sharp, wedge-shaped trailing edge as illustrated in section A-A of Figure 2-1.

**Blade Tip.** The blade edge on the outer most radius of the propeller.

**Emitter Holes.** Holes drilled into a channel near the leading edge that distribute the Prairie masker air.

### 2.2 PROPELLER TYPES

Figure 2-2 shows the various types of propellers used on Navy ships. The Navy generally classifies screw propellers as solid (monobloc), built-up (fixed-pitch), or controllable-pitch. Pitch is defined as the distance that each design section would advance in one complete revolution if there was no slippage. The pitch is usually defined every 10 percent of the propeller radius from the hub to the blade tip and at the 95 percent radius.

#### 2.2.1 Solid Propellers. A single integral casting forms the blades and hub of a solid propeller. Propellers of this type may be further classified as constant pitch or variable pitch.

- **2.2.1.1** On a constant pitch propeller, the pitch at all radii is the same and corresponds to the nominal pitch noted on the propeller drawing.

- **2.2.1.2** On a variable pitch propeller, the pitch at each radius may vary from the nominal pitch to produce a particular distribution of loading and to accommodate the varying inflow to the propeller over the propeller radius. The nominal pitch of the propeller shown on the drawing usually corresponds to the pitch at 0.7 radius.

#### 2.2.2 Built-Up Propellers. The blades and hub of a built-up propeller are cast separately and may be of different materials. Bolts or studs and nuts secure the blades to the hub. The blades must be properly oriented to the hub to produce the designed propeller pitch; the bolts or stud holes in the palms of the blades are usually elongated to permit minor pitch adjustments. Propellers of this type may be either constant or variable pitch also.

#### 2.2.3 Controllable-Pitch Propellers. Controllable-pitch propellers have actuating mechanisms that enable the bridge or engine-room to change the pitch continuously from ahead to astern. Ships fitted with these propellers have operating and maintenance manuals. Planners should consult these manuals before initiating overhaul or repair. Another chapter of this manual covers waterborne repair and blade replacement on controllable-pitch propellers; this chapter covers only solid and built-up propellers. The blades of controllable-pitch propellers may be further classified as constant or variable pitch.

- **2.2.3.1** The Navy further classifies propellers as right hand or left hand, depending on the rotation direction. When viewed from astern, with the ship moving forward, a right hand propeller rotates clockwise and a left hand propeller rotates counterclockwise.

- **2.2.3.2** Planners and divers must be familiar with the blade numbering system to help position the diver at the proper location on the propeller. Figure 2-3 details the blade numbering system.

### SECTION 3 - PLANNING AND PREPARING FOR THE TASK

#### 3.1 GENERAL INFORMATION

This section provides information on the reference material that must be assembled and reviewed before undertaking an underwater propeller replacement task. The key to a successful propeller replacement is to carefully review the applicable reference material before the task and to have that material available for reference during the task.
3.1.1 Later sections give specific examples of applying information found in the reference material listed here to prevent potential propeller removal or installation problems before they occur. These sections also indicate other reference material, and its availability, specific to the particular phase of the task covered by that section.

3.2 REFERENCE DOCUMENTS

Chapter 2 of this manual, General Information and Safety Precautions, provides guidance for locating drawings and reference documents by functional groups in the Ship Drawing Index (SDI), kept in the ship's log room, or from other sources. Planners must extensively research the individual ship's SDI because they may need to consult several drawings to obtain the required information. Many of the drawings indicated will list other helpful drawings in the reference block on the first sheet. Commands performing propeller replacement tasks should note the following reference material.

3.2.1 Naval Ships Technical Manual (NSTM). NSTM Chapter 245, Propellers, provides general information and guidance necessary to clean, inspect, and repair monobloc and controllable pitch propellers (CPP).

3.2.2 Propeller Drawings. The propeller drawings (SDI group 200) specify dimensions, components, materials, and arrangement of the propeller. Important information includes: the weight and diameter of the propeller, the size and location of lifting eye plugs, and the size and number of fastening devices (propeller and fairwater cap studs).

3.2.3 Shafting Drawings. The shafting general arrangement and fabrication drawings (SDI group 200) specify the size of the shaft, amount of taper, and dimensions and fitting details of shaft keys.

3.2.4 Shell Plating Drawings. For some ship classes, the shell plating drawings (SDI group 100) indicate the location of propeller lifting fittings and their arrangement on the hull. Other ship classes have a separate drawing for propeller and rudder lifting fittings in the hull fittings group (SDI group 600 or 800).

3.2.5 Docking Plans. Docking plans (usually SDI group 800) sometimes contain helpful information on propeller rigging requirements.

3.2.6 Rigging Drawings. The SDI does not list propeller rigging drawings. NAVSEA 00C5 has contracted for the development of rigging drawings for several ship classes. If neither the ship or NAVSEA 00C5 has a rigging drawing, a drawing must be prepared that addresses all areas discussed in the rigging section of this chapter.

3.3 REPORTS

Prior to any propeller replacement, IMA divers must inspect the damaged propeller and record the inspection results on NAVSEA form 4730/6 (NSN 0116-LF-047-3035) Propeller Inspection Data. Forward the completed inspection form to NAVSEA 03X73 or 00C5 for repair or replacement recommendation.

3.3.1 Any IMA responsible for propeller replacement is required to have an IMA inspector trained in propeller visual inspection perform a visual preservation inspection upon receipt of the replacement propeller. The results shall be recorded on NAVSEA form 9245/7 (NSN 0116-LF-004-5500) and forwarded to NAVSEA 03X73. Along with the visual preservation inspection, the IMA shall sign the "Visual Preservation Inspection By Installing Activity" section of NAVSEA form 9245/9 (NSN 0116-LF-004-6000).

3.3.2 All ready for issue (RFI) propellers must have a completed NAVSEA form 9245/9 (usually taped to the propeller in a protective plastic pouch) attached. The installing activity must remove the form, sign as indicated above and maintain on file with the controlled work package. A copy of the completed form must be forwarded to NAVSEA 03X73. A sample of a completed NAVSEA form 9245/9 is included in Appendix B so the IMA can readily identify the form.

3.3.3 All reports or records of underwater work or propeller inspection and cleaning may indicate problems in
the propeller or underwater hull configuration that could influence the propeller replacement task.

3.3.4 Docking reports should be reviewed to determine when the propeller was last changed and to obtain any available details of the installation. For example, it would be important to note how much force the propeller was seated with and any problems that were encountered.

3.4 PLANNING

The following paragraphs detail many issues that should be considered in planning for propeller replacement tasks. The requirements discussed are based on actual experience gained through performing propeller replacement tasks.

3.4.1 Commands that perform a propeller replacement must consider all requirements. If shop facilities are not available at the Command with the overall tasking, the Command must arrange for them. A successful propeller change requires 2 to 3 weeks. If this minimum time is not available, highly experienced personnel and support should be used. The ship should have a minimum water depth at the stern of at least 10 feet greater than the ship's draft. Provision should also be made for breasting the ship out so the diving boat and other floating equipment can be positioned between the ship and the pier. Crane service, floating or pier side, must be available for heavy propeller lifting and must have the required reach and angle to handle the propeller. If a smaller service crane at the pier is used during the active operation, the heavy crane will be needed only for the heavy lifting.

3.4.2 While all considerations cannot be covered when planning individual tasks, addressing as many potential problems as possible before beginning the task reduces the chance that problems will occur.

SECTION 4 - FAIRWATER SYSTEM

4.1 GENERAL INFORMATION

Figure 4-1 shows the components of a simple fairwater system and their relation to the propeller. The rope guard is illustrated in Figure 7-1. Figure 4-2 shows a more complex fairwater installation, which incorporates the Prairie air system, a system of air passages that run through the propeller and propeller cap. The presence of a Prairie air system complicates the removal and replacement of the fairwater during a propeller change. For each task, planners should consult the ship's propeller drawing to determine the fairwater system configuration for that particular ship.

4.2 MAJOR COMPONENTS

The major components of a fairwater system are discussed below.

4.2.1 Propeller Cap. The propeller cap, also called the fairwater cap or dunce cap, fits over the end of the propeller shaft and propeller nut (boss nut) and is bolted to the after face of the propeller hub. The cap's conical shape completes the hydrodynamic contour of the hub and protects the threaded shaft end and the propeller nut from damage by contact with seawater. The cap is filled with preservative to prevent seawater from contacting the ferrous shaft and propeller nut. Propeller caps may be one- or two-piece designs. Ships equipped with Prairie air systems can have two-piece propeller caps with Prairie air system components housed in the forward section.

4.2.2 Cover Plates. Cover plates are preformed, semicircular metal plates installed over the juncture between the propeller hub and the propeller cap and between the forward and after sections of a two-piece propeller cap. Cover plates are attached with flat-head screws. When installed, cover plates maintain the contour of the surface of the propeller assembly and prevent fouling by line, wire, or other foreign objects. Cover plates are frequently referred to as fairwater covers, fairwater plates, or fairing plates. On some propellers the juncture is faired with cement grouting material.
4.2.3 Rope Guards. Rope guards are fairwaters attached to the strut bearing housing to protect the area between the forward face of the propeller hub and the strut bearing. Rope guards may be constructed of fiberglass or metal. Fiberglass rope guards are attached with flat-head machine screws. Metal rope guards may be welded in place or they may be attached with flat-head machine screws. Unlike the cover plates attached to the propeller cap, rope guards are stationary and do not rotate with the propeller.

4.3 REMOVAL AND INSTALLATION

During a propeller replacement, the fairwater system must be removed and reinstalled. Tasks include taking accurate measurements, checking preservatives, and removing and replacing components.

4.3.1 Welded Rope Guard Removal. The preferred method of removal is illustrated in Figure 4-3, and can be accomplished if sufficient space exists between the forward face of the propeller hub and the aft face of the strut bearing to leave a 1-1/2 inch overhanging stub from the existing rope guard while still allowing diver access to the propeller gland seal ring studs and nuts. If the entire existing rope guard must be removed, then material sampling of the strut bearing is required to determine weld rod requirements for reattachment. Contact NAVSEA Code 00C for further direction.

4.3.2 Measuring Clearance Dimensions. A major potential problem with the reinstallation of fairwater systems containing Prairie air components is the fit of the propeller cap onto the replacement propeller seated on the shaft. The problem occurs when the clearances between the propeller cap and the end of the shaft have been reduced because the replacement propeller was seated farther onto the shaft than the old propeller. Clearance B in Figure 4-4 illustrates the critical clearance dimension between the fairwater cap and the aft end of the shaft for the fairwater system depicted in Figure 4-2. Figure 4-4 shows that if the replacement propeller seats farther onto the shaft than the old propeller, components in the fairwater cap could potentially contact the end of the shaft before a good seal is established between the fairwater cap and the aft face of the propeller hub.

4.3.2.1 To determine if the fairwater cap will go back on, measure the critical clearance dimension B in Figure 4-4 after the air seal flange is removed and while the propeller cap is still on the old propeller. After the propeller cap and propeller nut have been removed, measure the distance from the aft face of the old propeller hub to the aft end of the shaft taper (dimension A). After the old propeller is removed and the replacement propeller is seated on the shaft, again measure the dimension A from the aft face of the replacement propeller to the aft end of the shaft taper to determine how much farther (if any) the replacement propeller seats farther onto the shaft than the old propeller. If the distance the replacement propeller moved farther up the shaft is less than the critical clearance dimension B, the fairwater cap should fit. If the dimension is greater, the critical clearance dimension may have to be effectively increased by machining down the part of the fairwater cap that interferes. No part may be machined beyond one-half its design thickness.

4.3.2.2 Another potential clearance problem exists with the radial and axial clearance between the rope guard and the forward end of the propeller hub. Radial clearance at the bottom of the rope guard installation will decrease as the strut bearings wear during service and the shaft moves down. Axial clearance is required to allow for forward movement of the propeller when thrust is generated. Always maintain design clearances when reinstalling rope guards.

4.3.2.3 This exercise in carefully maintaining critical dimensions during various phases of the propeller replacement task and comparing the dimensions before reinstalling components (e.g., the propeller cap) ensures a successful reinstallation. The dimensional clearance problem and solution illustrated in Figure 4-4 and stated in the example above is only one example of the type of clearance problems that may be encountered during removal and reinstallation of a fairwater system. Careful review of the particular ship's propeller drawing will point out areas where clearances may be critical, so that similar before and after dimensions can be compared to ensure a successful reinstallation.

4.3.3 Other Problems with Prairie Air Fairwater Systems. Figure 4-4 also illustrates the dimensions and measurements required for fabrication of a new air seal flange. Take the measurements required after installing the forward section of the propeller cap.
4.3.3.1 Some earlier Prairie air fairwater system designs used flexible hose assemblies within the forward propeller cap section. Use extreme care when removing hose assemblies to avoid damage.

**WARNING**

*Rotating the propeller while divers are in the vicinity may cause serious injury or death. Ensure that the propeller is rotated only at the direction of the dive supervisor.*

4.3.4 Draining Preservative Before Removal. If the propeller cap is filled with liquid preservative, the preservative must be removed in the same manner that newly installed propeller caps are dewatered (see Section 8). To check for liquid preservative, jack the shaft until the fill and vent plug (illustrated in Figure 4-1 or 4-2) is at the 12 o'clock position and then open the plug. Since liquid preservative is lighter than seawater, the preservative will escape. Quickly reseal the plug and drain as required.

4.3.5 Removing the Air Seal Flange. In Prairie air systems that have an air seal flange (Figure 4-4), the flange is often difficult to remove. The air seal flange fits tightly and is most easily removed by placing a rolling head pry bar into the center and catching the end of the air seal flange where it rests in the shaft cavity. Exercise caution to prevent cocking the flange.

**CHANGE** 4.3.6 Reattaching Propeller Cap. Clean the threaded holes on the aft face of the propeller hub thoroughly. Seat all studs completely so that they bottom out, measurements should be taken to ensure that the studs are bottomed out. Torque nuts to the values specified in Table 4-1. Figure 4-5 shows the proper method for safety wiring propeller cap studs.

4.3.7 Installing Cover Plates and Rope Guards. Attach the cover plates and rope guards with flat-head screws; stake the screws so that they will not back out during ship operations. Figure 4-5 illustrates the proper method for staking flat-head screws.

SECTION 5 - UNSEATING THE PROPELLER

5.1 METHODS

Two methods for unseating the propeller from the shaft taper are discussed in this section. The two methods involve using a hydraulic Pilgrim nut or ring, or a Charleston gear. A third alternative is the use of explosives. NAVSEA discourages the use of explosives, and does not consider this method a standard method for unseating propellers.

**WARNING**

*Sudden or uncontrolled movement of the propeller may cause serious personal injury. Ensure that divers are positioned forward of the propeller before moving the propeller aft.*

5.1.1 Hydraulic Pilgrim Nut or Pilgrim Ring. Figure 5-1 shows the layout for using a Pilgrim nut for propeller removal. Figure 5-2 shows the layout of the Pilgrim ring configuration. The Pilgrim ring is only applicable to a limited number of ships which have their propeller nuts modified to accept the Pilgrim ring. The Pilgrim ring works on the same principle as the Pilgrim nut.

**CHANGE** 5.1.1.1 The Pilgrim nut works by forcing hydraulic fluid under pressure into the nitrile tire through the hydraulic connection which pushes the loading ring outward against the backing plate. This acts to draw the seated propeller off its seated position. Increased availability of Pilgrim nuts and the relative ease of their application have made this an overwhelmingly preferred method of unseating the propeller. NAVSEA currently
stocks several different types of Pilgrim nuts for use on a variety of ship classes. Each Pilgrim nut is provided with a matching backing plate, withdrawal studs, and all necessary hardware as well as the manufacturer’s technical manual. The manual must be carefully reviewed to determine the maximum pressure that can be applied for the withdrawal stud configuration used. The Pilgrim nut is capable of exceeding the capacity of the withdrawal studs if too much pressure is applied.

5.1.1.2 Most older propellers have been modified with a configuration of more withdrawal studs to withstand the force applied by the Pilgrim nut during propeller removal. In many cases, the original withdrawal stud configuration (usually two larger studs, 180 degrees apart) is left in place on the propeller along with the new stronger configuration. Careful review of the Pilgrim nut technical manual will determine which withdrawal stud configuration is safe to use for the estimated propeller removal loads.

5.1.2 Charleston Gear. The Charleston gear is a hydraulic ram assembly which is so named because it was first developed and used by the Charleston Naval Shipyard. Figure 5-3 shows the layout of the Charleston gear. The Charleston gear works by pressurizing the hydraulic rams so that they lengthen and push against the strongback which is seated on the propeller nut. Since the propeller nut and strongback are stationary, the force is transmitted to the aft end of the hydraulic rams, which push on the withdrawal studs aft, which act to unseat the propeller from the shaft taper. NAVSHIPS Drawing 203-1842704 provides details on the fabrication, application, and use of the Charleston gear for various ship classes.

5.1.3 Explosives. The use of explosives for unseating the propeller should be considered less a method than a potential last-ditch option. With extensive use of the Pilgrim nut for propeller seating, the force required to unseat a propeller is often considerably more than explosives can provide without damaging the shaft, the strut bearing, or some other part of the underwater configuration. For this reason explosives may not be used without the permission of NAVSEA. NAVSEA 00C5 will render a decision after careful evaluation of all available information. NAVSEA 00C5 will provide guidance on the application and quantity of explosives to be used on a case basis if the use of explosives is judged necessary.

Requests for permission to use explosives must include the following information:

a. Name of the ship.

b. Diameter and weight of the propeller.

c. Diameter of the propeller shaft.

d. Details of previous attempts to unseat the propeller including equipment used, number of attempts, and force applied on each attempt.

5.2 POSITIONING PROPELLER NUT OR PILGRIM NUT FOR UNSEATING.

Regardless of the method of propeller unseating used, the propeller nut, Pilgrim nut, or Pilgrim ring must be properly positioned for propeller unseating.

5.2.1 Position the aft face of the propeller nut, Pilgrim nut, or Pilgrim ring flush with the aft end of the shaft. Fill the gap between the hub and the nut with crushing blocks to absorb the shock from the unseating force. Use damage control wedges or two-by-fours for crushing blocks.

5.2.2 Figure 5-4 illustrates the loosening of a propeller nut using the propeller nut wrench. The wrench is provided with a locking key to lock the wrench onto one of the locking key grooves provided on the propeller nut such that an overhead crane can provide a counterclockwise torque to the propeller nut. Remove all propeller cap studs from the after face of the propeller hub before installing the propeller nut wrench to avoid interferences.
5.2.3 Remove the locking key from the propeller nut wrench before the crane hook is lowered after the nut is broken free, so the weight of the wrench will not retighten the propeller nut. Further loosen the propeller nut by hand or by installing a lifting eye in the nut, attaching the hook of an underwater chainfall, and wrapping the chain counterclockwise around the propeller nut so that when the chainfall is taken up on, the chain will act to loosen the nut.

CAUTION
Chain twist in the working chain loops of manual chain hoists and chain falls will cause chain failure. Chain twist in the working chain loop occurs when the chain has an improper reeve through the chain sprockets OR (more often) the running block has flipped up and through any of the chain loops (see figure 5-4A).

All chain hoists and chain falls issued with NAVSEA SUPSALV Underwater Ship Husbandry equipment kits have been checked for chain twist and the chain hoist/fall has been loosely two-blocked so that the running block can not flip over into the working chain loops during shipment.

OPERATORS must ensure that the running block is not flipped over into the chain loops creating chain twist while deploying and rigging the chain hoists/falls.

To check for chain twist in the chain loop:

Hang the hoist from the top hook in a safe, accessible location. Tighten the hoist until less then one foot of separation exists between the hoist body and the running block. The short throw allows for much easier visual detection of twist in the individual chain reeves. Confirm that none of the chain lengths running from the working chain sprocket to the running chain sprocket (chain reeves) have any twist caused by the running block being flipped over and through the loop of the chain. If ANY chain twist is detected, flip the running block back through the chain loop until the twist is removed. If ANY twist can not be removed by flipping the running block, the hoist chain MUST be removed from the hoist body and re-reeve exercising care not to twist the chain during installation.

5.2.4 Some ships have Pilgrim nuts permanently installed as the ship’s propeller nut. The Pilgrim nut must be removed and its orientation on the shaft reversed for the unseating process. The Pilgrim nut will normally be free to manually turn off the shaft. If the Pilgrim nut is too tight against the aft face of the...
propeller hub to loosen manually with a diver held tommy bar inserted in an unthreaded tommy bar hole then the nut must be pressurized to free the binding. (See section 5.1.1, 5.2 and figure 5-1). It is essential that propeller movement be continuously monitored during the process using equipment such as detailed in Appendix C. Utilize the minimum pressure required to move the propeller no more than 5 percent of the total required advance as calculated in Section 7. Never exceed the maximum Pilgrim nut pressure indicated on the Mapeco (original equipment manufacturer) drawing included in the Mapeco manual. The pressurization and relief of the Pilgrim nut should allow the nut to be turned manually.

SECTION 6 - RIGGING THE PROPELLER

6.1 METHODS

Two rigging methods for removing, lifting, and installing propellers and other heavy components are discussed in this section. The two methods are balance beam and yard and stay. Rigging the propeller can be complicated and dangerous if not accomplished in accordance with a detailed rigging drawing and procedure. The rigging of surface ship propellers is complex because the propellers must be rigged clear of the shaft and hull before being lifted to the surface and lowered for seating on the shaft.

WARNING
Sudden or uncontrolled movement of the propeller may cause serious personal injury. Ensure that divers are positioned forward of the propeller before moving the propeller aft.

CAUTION
Blade edges are easily damaged. Do not strike blade edges with air cylinders, tools or other equipment.

6.1.1 Balance Beam Method. The balance beam method combines the horizontal portion of the lift (off the shaft and clear of the hull) with the vertical portion of the lift (up to the surface) into a single lifting device (crane with balance beam attached). Figure 6-1 shows how a balance beam is used to transfer a straight vertical lift into a vertical lift displaced by a horizontal component (1/2 the length of the beam). With this arrangement, the balance beam is able to reach under the ship’s hull to where the propeller is located and move the propeller horizontally out and then straight up once it is clear of the shaft and hull. Figure 6-1 further shows a balanced beam arrangement just after the old propeller has been removed. Before installing the replacement propeller, shift the balancing strap to the old propeller side while both propellers are balancing the beam.

WARNING
The inherent danger in using this method is that the lifting device is subject to differences in relative motion between it and the propeller while the propeller is still attached or close to the ship. Damage to equipment or serious injury to divers can occur if these relative motion differences cause impact. For this reason, all divers should remain well forward of the propeller after the balance beam has been connected and lifting has begun.
6.1.2 Yard and Stay Method. The yard and stay method was developed to help eliminate the inherent relative motion danger of the balance beam method. The yard and stay method uses existing attachment points on the underwater hull surface of the ship to attach underwater chainfalls or chain hoists. These are aligned so the yard and stay principle (Figure 6-2) can be used to lift the propeller clear of the shaft. Once the propeller is lowered clear of the shaft and hull, the single chainfall holding the propeller beneath the hull and a surface crane are used to yard and stay the propeller to the surface. Any relative motion dangers are greatly reduced since the propeller is lowered well clear of the ship before attachment to the surface crane is attempted. Figures 6-3 and 6-4 show how lifting tunnels (some ships have lifting padeyes in place of tunnels) are used to hold wire rope lifting slings to which flounder plates holding chainfalls or chain hoists can be attached. Figures 6-3 and 6-4 also show how to improve the yard and stay rigging equipment by adding underwater hydraulic chain hoists and a support beam with a movable trolley that holds a smaller chain hoist. These modifications have greatly reduced the time and effort required when compared to use of manual chainfalls. NAVSEA representatives experienced with the use of underwater hydraulic chain hoists are required on-site when the chain hoists are to be used because of the relative ease with which the hoists can be overloaded if not properly monitored.

6.2 SELECTION AND INSTALLATION OF UNDERWATER RIGGING MATERIALS

To safely and efficiently remove and replace a propeller, the correct rigging materials must be selected and installed. The configuration of the rigging installation depends upon the weight of the propeller to be handled; the arrangement and type of propeller lifting fittings on the ship's hull; the vertical distance between the shaft and the hull; the size and type of wire rope available for the task; and the dimensions of the hardware and equipment used in the installation. Before a task is started, every aspect of the rigging installation must be considered and a detailed rigging plan developed. Installation of the rigging materials should be accomplished in strict accordance with the rigging plan.

6.2.1 Although specific equipment, materials, and exact dimensions of rigging installations vary between classes and ships, the principle remains the same and general rules apply to all cases. The following paragraphs discuss these rules and provide helpful information applicable to any rigging installation.

6.2.2 Wire Rope. Wire rope is measured by diameter and called out by numbers. For example, 6 x 19 indicates the number of strands (6) and the number of wires per strand (19). The 6 x 19 class of wire rope includes rope with 9 to 26 wires per strand. The 6 x 37 class includes rope with 27 to 49 wires per strand.

6.2.2.1 The strength of a wire rope depends upon its size (diameter) and the material from which it is made. For any particular wire rope, the breaking strength may be obtained from Federal Specification RR-W-410 or in the Catalog of Navy Material, General Stores Section, FSC group 4020. Table 6-1 lists the breaking strengths of 6 x 19 bright (uncoated) wire rope. Bright (uncoated) wire rope is used exclusively in underwater work and 6 x 19 is the most commonly used size. As wire rope gets older, wear and corrosion reduce its strength; therefore new wire rope should be used for all installations.

6.2.2.2 The design of a wire rope installation must include a safety factor, the ratio between the breaking strength of a wire rope, and the total applied load. A safety factor of 5 should be applied to design calculations. For example, if a propeller weighing 15,000 pounds is to be removed and replace, the rigging installation must be capable of handling a total load of 75,000 pounds without exceeding the breaking strength of the wire rope in the particular configuration used.

6.2.2.3 Figure 6-5 shows how the type of termination used in a wire rope affects the strength.

6.2.2.4 Figure 6-6 shows how increasing the number of parts in a wire rope configuration can increase the load handling capacity. This allows smaller diameter (more easily handled) rope to be used.

6.2.2.5 Figure 6-7 shows the general rule for deriving the breaking strength of wire based on the angle it takes from vertical. If a wire rope is loaded at an angle of 45 degrees from vertical, then the effective breaking strength of that wire rope must be reduced by 30 percent. This leaves an effective or "derated" breaking strength of 70 percent of the original breaking strength.
6.2.2.6 Wire rope grommets should be used for all load attachment points so that lifting hooks do not bind in shackles. The task will be easier if the wire rope grommets or soft pendant eyes to be passed through lifting tunnels are compressed and seized as in Figure 6-8. Seize the wire rope grommet so that the wire connectors are at one end and do not have to be passed through the lift tunnel. Make sure that flounder plates and shackles (as seen in Figure 6-3) have compatible pin and pin hole sizes and are able to fit the available rigging space.

CAUTION
Chain twist in the working chain loops of manual chain hoists and chain falls will cause chain failure. Chain twist in the working chain loop occurs when the chain has an improper reeve through the chain sprockets OR (more often) the running block has flipped up and through any of the chain loops (see figure 6-8A).
All chain hoists and chain falls issued with NAVSEA SUPSALV Underwater Ship Husbandry equipment kits have been checked for chain twist and the chain hoist/fall has been loosely two-blocked so that the running block can not flip over into the working chain loops during shipment.
OPERATORS must ensure that the running block is not flipped over into the chain loops creating chain twist while deploying and rigging the chain hoists/falls.
To check for chain twist in the chain loop: Hang the hoist from the top hook in a safe, accessible location. Tighten the hoist until less then one foot of separation exists between the hoist body and the running block. The short throw allows for much easier visual detection of twist in the individual chain reeves. Confirm that none of the chain lengths running from the working chain sprocket to the running chain sprocket (chain reeves) have any twist caused by the running block being flipped over and through the loop of the chain. If ANY chain twist is detected, flip the running block back through the chain loop until the twist is removed. If ANY twist can not be removed by flipping the running block, the hoist chain MUST be removed from the hoist body and re-reeve exercising care not to twist the chain during installation.

6.2.3 Chainfalls and Chain Hoists. When selecting chainfalls or hoists to use in the rigging installation, ensure that they not only can handle the load required but can also move the load the maximum distance required without two blocking (when the running block contacts the standing block) or running out of chain. When using the yard and stay principle, never allow divers to operate more than one hoist or chainfall attached to the same load at a time.

6.2.3.1 Never make substitutions from the rigging drawing and procedure. Always ensure that all components have been properly tested before installation.

6.3 ROTATING THE PROPELLER

During the rigging process, rig the propeller so it can be turned to lay on the forward face of the propeller
hub. Figure 6-9 shows a typical method for rotating the propeller so that it can be set on the propeller hub face. If the propeller blades are highly skewed, the relative position of the rigging attached to the propeller hub face may be adjusted to avoid the blades by adding another shackle to one leg of the rigging. Avoid damage to the blade edges and fillets by ensuring that blade edge guards are installed and wire rope rigging is wrapped. Trident submarine and several HYBRID-type propellers require special turning brackets for rotating.

SECTION 7 - SEATING THE PROPELLER

7.1 PREPARING FOR SEATING THE PROPELLER

Before installing and seating the propeller on the shaft, the condition of the propeller shall be checked, the gland seal fit shall be checked, and the shaft shall be protected from damage.

7.1.1 Gland Seal. Check the fit of the gland seal onto the forward face of the propeller hub (Figure 7-1). Install the gland seal, gland seal O-ring, studs, and nuts on the forward face of the propeller hub while the propeller is still at the surface to check their fit. Bench mark and then remove the gland seal with the gland seal O-ring. Slide the gland seal and O-ring up the shaft to the after face of the strut bearing.

7.1.2 Keys and Keyways. During propeller removal care should be taken to monitor the keys. The keys may be loose in the shaft keyway and remain in the propeller keyway or fall off. To ensure a proper fit of keys into keyways, measure and compare the width and depth of propeller keyways to the width and height of the shaft keys (Figure 7-1). If necessary, shaft keys may be removed and machined down upon approval from NAVSEA.

7.1.2.1 Immediately prior to installing the replacement propeller, thoroughly clean the entire shaft taper area to eliminate residual oils or preservatives.

7.1.2.2 Occasionally new or refurbished ready for issue propellers have gaps in the gland seal O-ring seating surface where the keyways have been cut into the propeller (Figure 7-2). If these gaps exist, they must be filled with weld material and ground smooth to ensure a good seal around the entire circumference of the propeller in accordance with the applicable propeller drawing. A qualified welder trained to weld this material shall perform this repair.

WARNING
Propeller blade edges are knifelike and very sharp. To prevent injury, divers must wear gloves while inspecting propeller blades.

7.1.3 Shaft Protection. After protecting the threaded portion of the shaft from impact damage (wrap with 21 thread), place the propeller as far onto the shaft as the rigging equipment will allow. Figure 7-3 shows a technique that is helpful in restraining wire rig to propeller.

7.2 METHODS

Two methods can be used to seat propellers. A propeller is seated on the shaft taper by using the Pilgrim nut or by tightening the propeller nut with the propeller nut wrench. The propeller nut wrench should be used only in situations where a Pilgrim nut is not available.

NOTE
The procedures detailed in this manual take precedence over the OEM pilgrim nut technical
7.2.1 Pilgrim Nut Method. The Pilgrim nut is the preferred device for seating the propeller on the shaft taper. The original equipment manufacturer (OEM) technical manuals detail the installation and operation of Pilgrim nuts. Mapeco Products, Inc. is the US Navy’s sole source supplier of Pilgrim nuts.

7.2.1.1 To properly seat the propeller on the shaft taper, a specific advance must be achieved. Advance of the propeller is measured using a dial indicator mounted as indicated in Appendix C. Appendix C illustrates two methods for mounting the dial indicator. The primary method (mounted to the shaft) is more accurate and always preferred. The secondary method (mounted to the strut barrel) is only to be used if the dial indicator will not fit between the strut barrel and the propeller hub. Appendix C is developed from NAVSEA drawing # 6697829. The required advance is taken from the ship's propeller drawing. If the required advance is not available on the ship's propeller drawing, the water temperature and uncoated shaft diameter (taken from shaft detail drawing) will be necessary to determine the required advance using the following formula:

a. For bronze propellers advancing on a shaft with a standard taper (1 inch on diameter/foot of length):

\[ A = K \times D \]

Where

- \( A \) = Required Advance (inches)
- \( K \) = coefficient from table 7-1
- \( D \) = shaft design outside diameter (inches) (just forward of the taper, no bearing sleeve or shaft coating considered)

b. For cast iron or cast steel propellers advancing on a shaft with a standard taper:

\[ A = 0.00625 \times D \]

c. For nonstandard tapers:

\[ A = K \times \frac{\text{standard shaft taper (1 inch on dia./ft. of length)}}{\text{actual shaft taper (inches on dia./ft. of length)}} \]

It is essential that the advance achieved versus the pressure applied to the Pilgrim nuts be plotted during the actual seating process. The plot is critical because it allows the installing activity to graphically determine the point at which the actual advance begins. This point is often referred to as the initial seated position. To assist with the required plotting, Figures 7-4 and 7-5 illustrate the initial seated position and the actual advance of fictional propellers initially seated loose during the rigging onto the shaft or initially seated tight during the rigging onto the shaft.

7.2.1.2 Forms for plotting advance for various ship classes are found in Appendix D.

7.2.1.3 With the Pilgrim nut properly in place, slowly pressurize it. Record and plot Pilgrim nut pressure and dial indicator readings at 500 psi increments. Early on in the plotting, the data points will tend to form a straight line (slope). With a loose seated propeller, the plot may run off the paper with considerable advance.
before any pressure is built up. If this occurs, reset the dial indicator, tighten the pilgrim nut, and start over with a fresh plot.

7.2.1.4 After about three data points have been obtained from this straight portion of the plot, project a line back to the zero pressure axis to determine the initial seated position as shown in Figure 7-4 and 7-5. The actual propeller advance is determined from the difference between the advance at the initial seated position and the final advance achieved.

7.2.1.5 Seating of the propeller and plotting of its advance shall continue until the actual advance equals the required advance determined earlier, to within +.005" -.000". Design slope (in psi versus advance) shall be shown on the plot for comparison to actual measured data. Design slope curves are preplotted for selected ship classes in Appendix D. Information on design slopes for ship classes not included in Appendix D can be obtained from NAVSEA 00C5. Because of the lubrication effect of water, waterborne propeller advance curves may be slightly shallower than the design slopes of Appendix D which are based on drydock installation.

7.2.1.6 If the plot does not continue in a smooth, straight line until the required advance is achieved, the propeller has caught on the shaft, shaft keys, or propeller hub keyways, or there is insufficient contact between the propeller hub and shaft taper. The propeller shall be removed and the specific problem corrected before the seating process can continue.

7.2.1.7 OEM Pilgrim nut technical manuals provide push-on pressure charts that supply estimates of the pressure which must be applied to the Pilgrim nut in order to achieve the required advance. The pressure estimates are based on the friction associated with drydock installation. Experience shows that waterborne installations will normally need less pressure to achieve the required advance because of the lubrication effect of the water. Never seat a propeller using applied Pilgrim nut pressure as the only indicator of final seating achieved. Required advance must always be achieved.

7.2.2 Propeller Nut Wrench Method. If a Pilgrim nut cannot be located or provided in time for an emergent job, the propeller nut wrench may be used to seat the propeller on the shaft taper. Details on the propeller nut method of installation are provided on NAVSHIPS dwg 203-1842704. Experience has shown that the thrust bearing specified in NAVSHIPS dwg 203-1842704 should not be used because the propeller nut may not catch sufficient threads if the thrust bearing is installed. Propeller advance torque values for selected ship classes are available and may be obtained from NAVSEA 00C5. Ensure that the shaft locking device is engaged before attempting this seating method. Only the primary method for measuring propeller advance illustrated in Appendix C shall be used for this advance method. The dial indicator must be mounted to the shaft. If the shaft moves based on the high torques required, the advance measurement will not be affected.

7.3 INSTALLING THE PROPELLER NUT

After the propeller is properly seated onto the shaft, install the propeller nut flush with the after face of the propeller hub. If the locking key (see Figure 7-4) will not align with one of the holes in the hub, loosen the propeller nut just enough to achieve alignment. Do not tighten the propeller nut. The friction between the propeller bore surface and the shaft taper is the primary propeller holding force. A balancing key or keys (see Figure 7-4) must be installed opposite the locking key to balance weight on the shaft. The gland seal and gland seal O-ring must also be mounted to the forward face of the propeller hub on the gland seal studs installed on the surface. Torque the gland seal nuts using torque values specified in Table 4-1.

SECTION 8 - FLUSHING AND PRESERVING
8.1 DESCRIPTION

After the fairwater system has been reinstalled on the propeller, the fairwater and the propeller hub must be dewatered, air tested, and then flushed and filled with preservative material. The fairwater system and the propeller hub have threaded holes with installed plugs for use in the above operations (see Figure 8-1). NAVSEA drawing # 6697839, Assembly and Details for Propeller Hub and Dunce Cap Preservation, shows hose attachment configurations and provides specifications for hoses, couplings, nipples and plugs, valves and gauges. Figure 8-1 and this text describe flushing and preserving a configuration with fill and vent plugs at the 12 o’clock and 6 o’clock positions. Some configurations have the plugs only in the 12 o’clock position so the propeller must be jacked to properly position the fitting for flushing or filling as required. Attach surface hoses with the proper fittings and valves to the threaded holes in the fairwater and the propeller hub so that air and preservative can be pumped into the internal voids.

8.1.1 Frequently, the threaded holes provided are poorly threaded or the installed plugs cannot be removed and must be drilled out. After the holes have been properly threaded and the fittings, valves, and hoses have been installed, the fairwater and hub must be dewatered. Air is pumped into the upper fittings and water pushed out of the lower fittings. When all water has been removed, the fitting valves are closed, air pressure applied, and all seal areas inspected to ensure no leaks exist. The void space must hold 10 psi over bottom pressure for at least 10 minutes.

8.1.2 Jacking the shaft can change the relative position of fittings.

8.1.3 After the fairwater and propeller hub are air tested for leaks, fill the voids with the preservative material. Flush preservative through the hub until clear oil, with no signs of seawater contamination or air, is observed. Many propeller drawings specify MIL-C-11796, Class 1A preservative. The preservative must be heated to become a liquid for installation. This heating technique is acceptable in drydock; however, in a waterborne propeller change, unless special equipment is developed to heat the hoses going to the propeller, propeller hub, and the fairwater, the cool water causes the preservative to become solid. For this reason, MIL-L-21260, the highest available grade 40W, minimum grade 30W, is authorized for propeller hub and fairwater preservation.

a.30W preservative, MIL-L-21260, 55 gallon drum, NSN-9150-00-111-0210.

b.40W preservative, MIL-L-21260, 55 gallon drum, NSN-9150-01-293-7697.

8.1.4 After the hub and fairwater are flushed and filled with preservative, remove the fittings and valves from the threaded holes and reinstall the plugs flush with the propeller surface. Each fitting is reinstalled at the 6 o’clock position so that no preservative will be lost (the preservative is lighter than seawater).

8.1.5 When conducting the above operation on propellers with two-piece fairwaters or fairwaters with voids that do not connect with propeller hub voids, shift the fittings and hoses to each void space during each step to ensure complete preservation of the entire system.

SECTION 9 - QUALITY ASSURANCE AND CONTROL

9.1 DESCRIPTION
Firm quality assurance and control of a waterborne propeller replacement is the single most important aspect of the task. NAVSEA has developed quality assurance packages for many ship classes to be used as a basis for ship-specific procedures. Quality control begins with planning detailed ship-specific, step-by-step procedures which must be developed before the task begins so that problems can be anticipated and addressed as early as possible.

9.1.1 Appendix A provides a propeller replacement task outline to aid in the development of detailed procedures.

9.1.2 The procedures should provide for some method of recording any measurements required. Provision should also be made for documenting and assigning accountability (sign-offs) for each phase of the procedure. Quality control is most easily maintained if one individual is solely responsible for recording task sign-offs and associated information. This individual must be trained and knowledgeable in all aspects of performing a waterborne propeller replacement. Appendix E provides a waterborne propeller change data sheet to be completed and forwarded to NAVSEA for every waterborne change.
Figure 2-1. Propeller Terminology.
Figure 2-2. Propeller Types.
VIEW LOOKING FORWARD

Figure 2-3. Blade Numbering System.
Figure 4-1. Simple Fairwater Installation.
Figure 4-2. Complex Fairwater Installation (with Prairie Air System).
Figure 4-3. Welded Rope Guard Removal.
I. ILLUSTRATION OF CRITICAL CLEARANCE:
AS DIMENSION A INCREASES OR DECREASES, LIKewise, CLEARANCE B WILL INCREASE OR DECREASE ACCORDINGLY

II. DIMENSIONS FOR FABRICATION OF NEW AIR SEAL FLANGE (SEE CORRESPONDING NUMBERS ABOVE)
1. MEASURE THIS DISTANCE PLUS 1/16" FOR GASKET
2. ADD 1/2" TO LOCATE O-RING GROOVE CENTER
3. CUT OFF 1/2" PAST O-RING GROOVE CENTER

Figure 4-4. Problems with Propeller Cap interface.
Figure 4-5. Safety Wiring and Staking.
Figure 5-1. Hydraulic Pilgrim Nut Layout for Propeller Removal.
Figure 5-2. Pilgrim Ring Layout for Propeller Removal.
Figure 5-3. Charleston Gear.
Figure 5-4. Loosening Propeller Nut.
Fig. 5-4A Typical Running Block Flip (one or two part Chain Reeve)
Figure 6-1. Typical Balance Beam (Removing Old Propeller).
Figure 6-2. Basic Yard and Stay Principle.
Figure 6-4. Rigging for AOE-1 Class Ship.
<table>
<thead>
<tr>
<th>TYPE</th>
<th>STRENGTH RETAINED*</th>
<th>NOTES</th>
<th>ILLUSTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poured Socket</td>
<td>90-100%</td>
<td>DIFFICULT TO APPLY, BENDING FATIGUE AT SOCKET ENTRANCE, DIFFERENT TERMINATIONS AVAILABLE.</td>
<td><img src="image" alt="Illustration" /></td>
</tr>
<tr>
<td>Swaged Socket</td>
<td>90-100%</td>
<td>SUPERIOR, REQUIRES SPECIAL TOOLS FOR INSTALLATION, DIFFERENT TERMINATIONS AVAILABLE.</td>
<td><img src="image" alt="Illustration" /></td>
</tr>
<tr>
<td>Swaged Soft Eye</td>
<td>90-100%</td>
<td>REQUIRES SPECIAL TOOLS FOR INSTALLATION.</td>
<td><img src="image" alt="Illustration" /></td>
</tr>
<tr>
<td>Clips</td>
<td>80%</td>
<td>TEMPORARY, EASILY APPLIED ON SITE, CAN CAUSE DAMAGE TO ROPE, NEED FREQUENT RE-TIGHTENING DURING USE, NOT RECOMMENDED ABOVE 1½&quot; DIAMETER.</td>
<td><img src="image" alt="Illustration" /></td>
</tr>
<tr>
<td>Grommet w/Swage Clips</td>
<td>90-100%</td>
<td>REQUIRES SPECIAL TOOLS FOR INSTALLATION</td>
<td><img src="image" alt="Illustration" /></td>
</tr>
</tbody>
</table>

*FOR ANY TERMINATION, STRENGTH LOSS WILL BE GREATER ON LARGER DIAMETER WIRE ROPE

Figure 6-5. Wire Rope Terminations and Relative Strengths.
Figure 6-6. Increasing Load Handling Capability by Changing Wire Rope Configuration.
THE ABOVE FIGURE ALLOWS FOR THE FOLLOWING CALCULATIONS:

1. CALCULATING SAFE LOAD FOR GIVEN WIRE ROPE SIZE AND ANGLE WITH VERTICAL A OR HORIZONTAL B:

   SAFE LOAD = RATED BREAKING STRENGTH FOR GIVEN WIRE ROPE x FACTOR IN COLUMN C ÷ SAFETY FACTOR OF 6.

2. CALCULATING REQUIRED ROPE SIZE GIVEN THE LOAD REQUIREMENTS AND ANGLE WITH VERTICAL A OR HORIZONTAL B:

   BREAKING STRENGTH REQUIRED = LOAD APPLIED x FACTOR IN COLUMN D ÷ SAFETY FACTOR OF 6.

Figure 6-7. Derating or Usable Breaking Strength for Various Angles of Lift.
Figure 6-8. Seizing for Passing Through Lifting Tunnel.
Fig. 6-8A Typical Running Block Flip (one or two part Chain Reeve)
Figure 6-9. Typical Rigging for Rotating.
Figure 7-1. Propeller Assembly Components, One Piece Cap.
Figure 7-2. Gaps in Gland Seal O-ring Seating Surface.
Figure 7-3. Restraining Wire Rig to Propeller.
Figure 7-4. Initial Seated Position and Actual Advance - Loose Seated Propeller.
Figure 7-5. Initial Seated Position and Actual Advance - Tight Seated Propeller.
Figure 7-6. Chart for Plotting Advance Versus Pressure Applied.
Figure 8-1. Dewatering, Flushing, and Preserving Configuration.
APPENDIX A

PROPELLER REPLACEMENT TASK OUTLINE

I. PLANNING

A. REVIEW REFERENCE MATERIALS
   3. Ship Drawing Index
      a. Propeller
      b. Shafting
      c. Shell Plating
      d. Docking
   5. Cleaning, work, and inspection reports
   6. Docking reports

B. PREPARE RIGGING PLAN AND DRAWINGS

C. FACILITIES REQUIREMENTS
   1. Shop
   2. Berthing
   3. Crane services

D. PERSONNEL REQUIREMENTS
   1. Dive team
   2. Engineers and planners
   3. NAVSEA support

E. EQUIPMENT REQUIREMENTS
   1. Rigging
   2. Hydraulic gear
   3. Power pack
   4. Air supply
5. Preservative
6. Ancillary tools and equipment

II. TASKS

A. REMOVING FAIRWATER SYSTEM
   1. Rigging
   2. Remove fairwaters and rope guards
   3. Check preservative; flush if liquid
   4. Fairwater cap
      a. One section - remove
      b. Two sections - remove aft cap section
   5. Prairie air components
      a. On end of shaft
         (1) Disconnect flexible hoses
         (2) Remove forward cap
      b. In forward fairwater cap
         (1) Remove components
         (2) Take critical clearance measurement
         (3) Remove forward fairwater cap
         (4) Take end of shaft taper to aft hub face measurement

B. UNSEATING PROPELLER FROM TAPER
   1. Rigging
   2. Removing balance and locking keys
   3. Loosen propeller nut
   4. Install propeller removal equipment and break propeller free of taper
      a. Install wood crush blocks
      b. Pilgrim nut, withdrawal studs, backing plate; or
      c. Pilgrim ring, withdrawal studs, backing plate; or
      d. Charleston gear
   5. Remove unseating equipment and propeller nut
   6. Install shaft thread protection
7. Rig propeller to surface
8. Inspect shaft taper area and report

C. SEATING REPLACEMENT PROPELLER
1. Prepare, inspect, and rig new propeller
2. Place gland ring and packing ring on shaft
3. Install gland studs on replacement propeller
4. Move replacement propeller onto shaft taper
5. Remove shaft thread protection
6. Install seating equipment and seat replacement propeller
   a. Pilgrim nut, or
   b. Propeller nut and wrench, or
   c. Pilgrim ring and modified propeller nut
   d. Propeller Advance Measurement System
7. Record and report seating data to NAVSEA
8. Remove seating equipment and install propeller nut
9. Secure nut in place with locking and balance keys
10. Prepare aft face of propeller hub (i.e., studs)
11. Take end of shaft taper to aft hub face measurement
12. Secure gland and packing ring

D. INSTALLING FAIRWATER SYSTEM
1. Rigging
2. Fairwater cap
   a. One section - install with packing ring
   b. Two sections - install forward cap section with packing ring and O-rings
3. Prairie air components on end of shaft
   a. Connect flexible hoses with O-rings in place
   b. Prepare aft face of forward cap section (i.e., studs)
   c. Install aft cap section with packing ring
4. Prairie air components in forward cap section
   a. Take measurements and fabricate new air seal flange
   b. Install Prairie air components in cap
c. Prepare aft face of forward cap section
d. Install aft cap section with packing ring

E. FLUSHING AND PRESERVING
1. Flush seawater from all voids and pressure test; record results
2. Fill and flush all voids with preservative oil

F. COMPLETING THE TASK
1. Replace fairwaters and rope guards
2. Remove all rigging and equipment
3. Remove protective materials from propeller
PROPELLER CERTIFICATION
This propeller is certified to be in condition A (Ready For Issue).

<table>
<thead>
<tr>
<th>SERIAL NO.</th>
<th>DRAWING NO.</th>
<th>DRAWING REV.</th>
<th>PROPELLER REV.</th>
</tr>
</thead>
<tbody>
<tr>
<td>27939</td>
<td>SSN 58-263-2500465</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

OUT OF TOLERANCE DEVIATIONS

1. Pressure Thrust Center Deviations
   - Blade 1 - 12 Stations, Blade 2 - 6 Stations
   - Blade 3 - 8 Stations, Blade 4 - 13 Stations
   - Blade 5 - 8 Stations, Blade 6 - 9 Stations
   - Blade 7 - 10 Stations

2. Suction Thrust Center Deviations
   - Blade 2 - 6 Stations, Blade 3 - 2 Stations
   - Blade 4 - 6 Stations, Blade 5 - 7 Stations

3. Blade Thickness Plus Deviations
   - Blade 1 - 1 Stations, Blade 2 - 3 Stations
   - Blade 3 - 6 Stations, Blade 4 - 3 Stations

4. Blade Thickness Minus Deviations
   - Blade 1 - 13 Stations, Blade 2 - 23 Stations
   - Blade 3 - 8 Stations, Blade 6 - 15 Stations
   - Blade 7 - 6 Stations

APPROVING CORRESPONDENCE

Approval of discrepancies on November 29, 1989 by NAVSEA Letter 92459 Rev. 113

Approval of discrepancies on February 16, 1990 by NAVSEA Letter 92459 Rev. 227

SIGNATURE & TITLE OF QUALIFIED INSPECTOR
John Doe
DATE: 01/01/90
ACTIVITY: ACME Propeller Shop

SIGNATURE & TITLE
John Doe
DATE: 01/28/90
ACTIVITY: ACME Propeller Shop

IN: 06/15/90
Activity: Propeller Inspection

QUIT: 06/15/90
Activity: Propeller Inspection

DISTRIBUTION: Change the transparent material and add aophilic to the paper. Design by NAVSEA.

NAVSEA 92459 (11/87)  S/N D116-LF-004-0000
APPENDIX C

PROPELLER ADVANCE MEASUREMENT SYSTEM

Figure C-1. Propeller Advance Measurement System.

Primary Method (See Figure C-2)

Secondary Method (See Figure C-3)
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Material</th>
<th>CAGE</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Post, fwd support 3/4” dia. rnd. bar x 6-5/8” Lg</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>10</td>
<td>Clamp, swivel</td>
<td>SST/Brass</td>
<td>ONN18</td>
<td>Gem Instrument Co. #SH-15</td>
</tr>
<tr>
<td>12</td>
<td>Cap screw, hex head 1/4”-20 UNC x 1-1/4” Lg</td>
<td>SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>13</td>
<td>Nut, elastic lock 1/4”-20 Nom.</td>
<td>SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>14</td>
<td>Dial indicator, NSN 5210-00-273-9788 (or equivelent)</td>
<td></td>
<td>05392</td>
<td>Chicago Dial Indicator #J3-B50-1000</td>
</tr>
<tr>
<td>16</td>
<td>Chaffing 4” W x 18” Lg x 1/8” Thk (5000# tensile strength)</td>
<td>Polyester</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>17</td>
<td>Chaffing 4” W x 1” Lg x 1/8” Thk (5000# tensile strength)</td>
<td>Polyester</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>18</td>
<td>Chaffing 2” W x 1” Lg x 1/8” Thk (5000# tensile strength)</td>
<td>Polyester</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>19</td>
<td>Buckle, ratchet type w/ webbing, 2” W x 120” Lg</td>
<td>Galvanized Steel/Polyester</td>
<td>8D865</td>
<td>I&amp;I #RA1-602-2</td>
</tr>
<tr>
<td>20</td>
<td>Mounting shaft, dial indicator</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>21</td>
<td>Grommet, teeth type, 3/8” ID hole size</td>
<td>SST/Brass</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>22</td>
<td>Bolt, flat head, 1/4”-20 x 3/4” Lg</td>
<td>SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>23</td>
<td>Block, 1-1/2” x 1-1/2” x 1-1/2”</td>
<td>CRES</td>
<td></td>
<td>Commercial</td>
</tr>
</tbody>
</table>

Figure C-2. Primary Propeller Advance Measurement System Components.
Figure C-2. Primary Propeller Advance Measurement System Components.
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Material</th>
<th>CAGE</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Base magnetic, 2-3/8” x 2-3/8” x 3”</td>
<td>57163</td>
<td></td>
<td>Starrett #659P</td>
</tr>
<tr>
<td>3</td>
<td>Post, aft support 1” dia. Rnd. bar x 8.782 Lg</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>4</td>
<td>Post, fwd support 3/4” dia. Rnd. bar x 6 5/8” Lg</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>5</td>
<td>Nut, lock 1-1/4” dia. Rnd. bar x 3”</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>6</td>
<td>Fine adjust, housing assembly</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>7</td>
<td>Plate, contact 3” dia. Rnd. bar x 3/4” Lg</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>8</td>
<td>Screw, fine tuning, all thread 3/8” - 16 UNC x 10-1/2” Lg</td>
<td>18-8 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>9</td>
<td>Thumb nut, knurled 1-1/4” dia. Rnd. bar a 1” Lg</td>
<td>SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>10</td>
<td>Clamp, swivel</td>
<td>SST/Brass</td>
<td>ONN18</td>
<td>Gem Instrument Co. #SH-15</td>
</tr>
<tr>
<td>11</td>
<td>Mounting shaft, dial indicator</td>
<td>303 SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>12</td>
<td>Cap screw, hex head 1/4”-20 UNC x 1-1/4” Lg</td>
<td>SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>13</td>
<td>Nut, elastic lock 1/4”-20 Nom.</td>
<td>SST</td>
<td></td>
<td>Commercial</td>
</tr>
<tr>
<td>14</td>
<td>Dial indicator, NSN 5210-00-273-9788 (or equivalent)</td>
<td>05392</td>
<td></td>
<td>Chicago Dial Indicator #J3-B50-1000</td>
</tr>
</tbody>
</table>

**Note:** Setting up the measurement fixture - **CAUTION:** When adjusting the target disk, ensure that the dial indicator plunger is depressed no more then 1/8” (.125). This ensures maximum range of motion for the dial indicator to measure the total advance of the propeller.

**Figure C-3. Secondary Propeller Advance Measurement System Components.**
Figure C-3. Secondary Propeller Advance Measurement System Components.
APPENDIX D

DESIGN SLOPES FOR VARIOUS SHIP CLASSES
Figure D-1. AD-37 Class, MAPECO Nut Drawing D-2613C.
<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

**PROPELLER INSTALLATION DATA**

Date: __________

Temperature ___°
(at propeller)

Figure D-2. AFS-1 Class, MAPECO Nut Drawing D-2346H.
Figure D-3. AGF-3 Class, MAPECO Nut Drawing D-2956C.

PROPELLER INSTALLATION DATA

Ship Name ____________  Required Advance (calculated)  Final Actual Advance  Final Pressure
Hull No. ____________
Propeller Serial No. ____________

Date: ____________
Temperature ____________
(at propeller)
Figure D-4. AOE-1 Class, MAPECO Nut Drawing D-2898E.

PROPELLER INSTALLATION DATA

Ship Name

Hull No.

Propeller Serial No.

Required Advance (calculated)  Final Actual Advance  Final Pressure

Date: 

Temperature (at propeller)

PSI

ADVANCE

1000

1000

ADVANCE

24

22

20

18

16

14

12

10

8

6

4

2

0

0.00

0.02

0.04

0.06

0.08

0.10

0.12

0.14

0.16

0.18

0.20

0.22

0.24

24

22

20

18

16

14

12

10

8

6

4

2

0
<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

**PROPELLER INSTALLATION DATA**

Figure D-5. AOE-6 Class, MAPECO Nut Drawing D-3051C.

Date: 

Temperature (at propeller) 

---

![Graph showing relationship between advance and pressure]
Figure D-6. AOR-1 Class, MAPECO Nut Drawing D-527C.

PROPELLER INSTALLATION DATA

<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller Serial No.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Date: ________
Temperature _______°
(at propeller)
### PROPELLER INSTALLATION DATA

<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

![Graph showing the relationship between ADVANCE and PRESSURE](image)

**Figure D-7. AS-39 Class, MAPECO Nut Drawing D-2564B.**

**Date:** 
**Temperature at propeller:**
Figure D-9. CGN-36 Class, MAPECO Nut Drawing D-2912E.

PROPELLER INSTALLATION DATA

Ship Name

Hull No.

Propeller Serial No.

Required Advance (calculated)

Final Actual Advance

Final Pressure

Date: 

Temperature (at propeller) 

°
PROPELLER INSTALLATION DATA

<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull No.</td>
<td>Temperature</td>
</tr>
<tr>
<td></td>
<td>(at propeller)</td>
</tr>
<tr>
<td>Propeller Serial No.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

![Graph showing the relationship between advance and pressure.]
Figure D-16. LPD-1 Class, MAPECO No. Drawing D-2958C.
### PROPELLER INSTALLATION DATA

<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

Figure D-17: LPH-2 Class, MAPECO No. Drawing D-2946C.
### PROPELLER INSTALLATION DATA

<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Date: 

Temperature °C (at propeller)

---

**Figure D-18. LSD-36 Class, MAPECO Nut Drawing D-2958C.**

![Graph showing relationship between pressure and advance](image)
<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

Figure D-20. SSN-637 and SSBN 608, 616 and 640 Class, MAPECO Nut Drawing D-2629F.
<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Hull No.</th>
<th>Propeller Serial No.</th>
<th>Required Advance (calculated)</th>
<th>Final Actual Advance</th>
<th>Final Pressure</th>
</tr>
</thead>
</table>

![Graph showing propeller installation data](image)
Figure D-22: SSN-688 MOD25 Class, MAPECO Nut Drawing D-3034N.
DRYDOCK/WATERBORNE PROPELLER REPLACEMENT DATA

INFORMATION SHEET

1. DATE OF JOB __________________________________________________

2. ACTIVITY ______________________________________________________

3. SHIP __________________________________________________________

4. REMOVED PROPELLER SERIAL NO. _______________________________

5. REPLACEMENT PROPELLER SERIAL NO. __________________________

6. METHOD USED TO REMOVE PROPELLER (DRYDOCK, WATERBORNE
   HYDRAULIC GEAR, ETC.)
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

7. FOR MULTISHAFT SHIP: FROM WHICH SHAFT WAS PROPELLER REMOVED?
   ______________________________________________________________

8. DESCRIBE ANY PROBLEMS REMOVING PROPELLER (BINDING, GALLING OF
   THREADS, ETC.)
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

9. DESCRIBE CONDITION OF GLAND SEAL, PROPELLER SEATING AREA FOR
   THE GLAND AT THE PROPELLER KEYWAYS, AND O-RING SEALS OF
   REMOVED PROPELLER (BROKEN, NOT SEALING, ETC.)
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

10. DESCRIBE THE CONDITION OF THE SHAFT TAPER AND SHAFT AREA ADJA-
    CENT TO THE END OF THE AFT SLEEVE (PITTING, CORROSION, CRACKS,
    FAIRED OUT AREAS, LOCATIONS, ETC.) DESCRIBE LOCATIONS IN RELA-
    TION TO THE KEYWAYS.
    ______________________________________________________________
    ______________________________________________________________
    ______________________________________________________________
11. WAS THE SHAFT TAPERED AREA AND SHAFT OD, AFT OF THE SLEEVE, MAGNETIC PARTICLE, OR DYE PENETRANT TESTED FOR CRACKS? (MDT only required of damage is located in item 10 above).

______________________________________________________________

______________________________________________________________

WERE ANY CRACKS DETECTED?____________________________________

IF SO, DESCRIBE EXTENT AND REPAIR ____________________________

______________________________________________________________

______________________________________________________________

12. DESCRIBE AND GIVE LOCATION OF ANY KEYS, KEYWAYS, AND THREADS THAT WERE CORRODED, GALLED, RUBBED, ETC.

______________________________________________________________

______________________________________________________________

______________________________________________________________

13. IF ACCESSIBLE, DESCRIBE THE CONDITION OF FIBERGLASS COVERING FORWARD OF THE PROPELLER BEARING SLEEVE (FRACTURED, PEELING, GOOD CONDITION, ETC.)

______________________________________________________________

______________________________________________________________

______________________________________________________________

14. AFTER INSTALLING PROPELLER, WAS FIT AND SEAL OF GLAND SEAL CHECKED BY PRESSURIZING THE FINAL INSTALLATION? RECORD THE PRESSURE ACHIEVED AND MAINTAINED. DID ANY PRESERVATIVE LEAK FROM GLAND OR O-RING SEALS?

______________________________________________________________

______________________________________________________________

______________________________________________________________

15. RECORD FINAL PRESSURE AND ADVANCE OF INSTALLED PROPELLER.
PRESSURE____________________________________________________
ADVANCE____________________________________________________

E-2
16. DESCRIBE ANY PROBLEMS INSTALLING PROPELLER.

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

17. AFTER INSTALLATION WAS COMPLETED, WERE PROPELLER AND DUNCE CAP FLUSHED WITH PRESERVATIVE?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

18. WHAT PRESERVATIVE WAS USED TO FILL PROPELLER AND CAP?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

19. WERE FILL AND VENT PLUGS STAKED? _____________________________
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APPENDIX F

PC CLASS WATERBORNE PROPELLER REMOVAL/REPLACEMENT PROCEDURE

Reference:
(a) NAVSEA DWG 5106760, Patrol Coastal Propeller Details.

F-1 GENERAL
There are 2 types of propellers which may be encountered on these vessels a 5-bladed propeller is the original design and a 6-bladed propeller was installed as a replacement SHIPALT. The 5-bladed version has one central hub lifting fitting attachment point for rigging and the 6-bladed has 2 lifting fitting attachment points (one on the forward (FWD) end and one on the AFT end of the hub). The type of propeller will govern the bellyband arrangement employed for rigging the propeller into position on the shaft taper. In addition, the 6-bladed propeller has a dunce cap covering the propeller nut. The 5-bladed version has no dunce cap.

Ensure full containment measures are in place for any oil lost during propeller removal or replacement. NAVSEA recommended best management practice for this operation is installation of an oil boom around ship and oil absorbent material on hand to collect any oil contained within the oil boom. Ensure that shafts are secured with the hub lifting fitting attachment point(s) at top dead center (TDC).

F-2 PROPELLER REMOVAL

F-2.1. Install Rigging Bellyband on Ship.

For 5-bladed Propeller (1034 lbs)
Secure wire rope (minimum ½ inch diameter) bellyband (Approximately 50 ft) around stern of vessel. Bellyband to be located 12 inches AFT of end of shaft

For 6-bladed Propeller (1,238 lbs without cap)
Secure one bellyband directly above propeller hub FWD lifting fitting attachment point position. Secure second bellyband even with FWD edge of rudder.

F-2.2. Dunce cap removal (6-Bladed Propeller only)
Remove the four (4) dunce cap retaining bolts using a ½ inch Allen wrench. Use a line to lift the dunce cap (88 lbs) to the surface.

F-2.3. Loosen propeller nut
Remove the two (2) locking bolts from the propeller nut using a 7/16-inch wrench. Back off the propeller nut approximately ½ inch using the propeller nut wrench. The propeller nut will now act as a preventer when the propeller is unseated from the shaft taper. If the propeller nut is particularly tight the cheater bar provided with the wrench may be inadequate to remove it. In this case the wrench will need to be modified to accept a stronger cheater bar.

F-2.4. Remove the lifting fitting attachment plug(s) from the propeller using the socket drive screwdriver supplied

F-2.5. Install the hub lifting swivel hoist ring(s) ensuring that they are properly shouldered to the hub.
F-2.6. Attach 2-ton chain hoist(s) to the hub lifting swivel hoist ring(s) and the belly band(s). Appropriate sized wire rope clips are to be attached to the bellybands on both sides of the hoist top block hooks. These clips are to be positioned to maintain the chain hoist vertically in line with the hub centerline. The hook is then to be seized to the bellyband wire so the hook cannot “jump” either of the wire rope clips. In the case of a 6-bladed propeller, ensure that the FWD chain hoist remains slack. This will allow the propeller to move aft during the removal process.

F-2.7. Attach a come-along between the AFT intermediate strut and the propeller hub lifting swivel hoist ring. Ensure that the come-along is slack until the propeller is broken free of the shaft taper. The come-along will serve as a hold back for the propeller loose on the taper while the propeller nut is removed.

F-2.8. Remove the hub hydraulic oil plug using an Allen wrench [5/16-inch (5 blade) and 7mm or ¼-inch (6 blade)] and connect the supplied hydraulic fitting into the hub using an 11/16-inch wrench. Connect the hydraulic oil line from the hub fitting to the pump at the surface. Connect the hydraulic oil line loosely to the hub. Bleed hoses until a steady stream of oil is produced at the propeller hub. Tighten hub hydraulic fitting when oil line has been bled.

**CAUTION**

Because some leakage of hub to shaft taper interface oil is unavoidable, ensure oil containment and collection procedures as recommended earlier are in place.

F-2.9. Slowly pressurize the hub to break the propeller free of the taper. In accordance with Table F-1, PC Class Propeller Removal Data, the maximum removal pressure is 27,000 psi. If no propeller movement is observed within 5 minutes, cycle the hub pressure between zero and max pressure four times with the pressure being maintained for 5 minutes during each cycle. In addition, during this process tapping of the hub with a mallet can assist the unseating process. Table F-2, PC Class Oil Data, recommends the oil viscosity for different temperatures. Higher viscosity oil is ONLY required if the maximum pressure cannot be achieved because too much oil is leaking out of the shaft taper to propeller hub bore interface.

F-2.10. If repeated cycling to the maximum pressure does not break the propeller free, install the special propeller jacking equipment provided by NAVSEA 00C5. The following steps detail the application of the special jacking equipment on a 6-bladed propeller with threaded dunce cap attachment holes in the AFT face of the propeller hub: (All of these steps are to be taken while the hub remains pressurized at 27,000 psi as described in paragraph F-2.9.)

1. Install two 22-inch lengths of Monel 5/8”-11UNC all-thread into two of the oppositely positioned 5/8”-11UNC dunce cap securing holes on the AFT face of the propeller. The all-thread rods are to be screwed into the two holes selected until they are fully seated in the bottom of the threaded hole. One end of each all-thread rod has a screwdriver slot cut in it to allow for tightening the rod into place. The strong back (3” x 3” square steel tube) is then slid over the two all-thread rods and followed by the flat washers and Monel nuts provided. Allow sufficient gap between the FWD face of the strong back and the AFT end of the shaft to fit in the RC-256 ENERPAC (or equal) hydraulic cylinder.

2. Assemble the ENERPAC hydraulic pump, RC-256 cylinder and 50-foot hose per the manufacturer's assembly instructions (hydraulic cylinder and pump of equal capacity by another manufacturer may be used). The heavy black end plates are not required on the RC-
256 cylinder and should not be used to ensure the assembled cylinder will fit between the AFT end of the shaft and the FWD face of the strong back. Ensure the hand pump reservoir is filled to the proper level. Test operate the assembled unit on the surface ensuring that there are no leaks and that the pressure gauge is working. Add additional hydraulic oil as needed to maintain a properly filled sump level. Fully seat the piston in the cylinder and ensure the pump is aligned to pressurize the cylinder when ready.

(3) Position the ENERPAC RC-256 hydraulic cylinder between the AFT face of the propeller shaft and the FWD face of the strong back. Divers should secure the hydraulic cylinder to one of the bellybands rigged for propeller removal with a suitable piece of small line. This is done to assist the diver in handling its 22-lb. weight and to prevent it from falling free when the propeller breaks loose from the taper. Diver is to tighten the all-thread nuts using hand-tools so that the cylinder is held in position between the AFT face of the propeller shaft and the FWD face of the 3" x 3" strong-back. It is essential that the cylinder be positioned perpendicular to both these faces and as near as possible to the center of each surface in order to effectively and safely apply an AFT-ward pulling force to the propeller.

(4) With the divers observing from a close distance, but clear (hands, umbilical, etc.) of the pulling device, topside slowly pressurizes the RC-256 hydraulic cylinder until approximately 50-75 psi is indicated at the pump. The divers are to ensure that the hydraulic cylinder remains perpendicular to both the strong back and AFT face of the propeller shaft. If the divers notice that the cylinder begins to shift out of such an orientation immediately inform topside; the cylinder is to be depressurized and step (3) is to be repeated. Once it is established that the pulling device and hydraulic cylinder are securely in proper position, the divers are to swim clear of the propeller and jacking equipment to observe propeller coming loose of the shaft taper.

(5) Topside pressurizes the RC-256 hydraulic cylinder while maintaining and monitoring the 27,000 psi applied to the propeller hub. The maximum allowed pressure to be applied to the hydraulic cylinder is 3,400 psi. Do NOT exceed this pressure at the hand pump connected to the RC-256. (Note: For the RC-256 Cylinder, a hydraulic pressure of 3,400 psi equates to 17,500 lbs. of pulling force applied to the pulling device.) The cylinder should be steadily pressurized to the maximum value while monitoring the 27,000 psi propeller hub pressure. If at any time while pressurizing the hydraulic cylinder, the propeller hub pressure is observed to relieve appreciably, the propeller has broken free from the taper and no more pressurization is required. If the maximum pressure is obtained at the pulling device cylinder and the propeller hub pressure has not relieved, maintain the maximum pressure at the pulling device for 5 minutes or until the propeller breaks free from the taper. Once the propeller breaks free, remove all components of the pulling device from the propeller AFT face prior to rigging the propeller off the shaft.

F-2.11. If maximum propeller hub pressure combined with maximum jack pressure does not break the propeller free of the taper, contact NAVSEA 00C5 for additional specific direction.

F-2.12. After unseating the propeller the chain hoists and propeller holdback come-along are to be tightened to take the weight and prevent further movement down the shaft taper. Remove the hydraulic oil line from the hub.

F-2.13. Ensure that the propeller holdback come-along is acting as a preventer. Remove the propeller nut. Install the thread protector onto the end of the shaft.
F-2.14. Yard and stay the propeller from the shaft to the pier.

F-2.15. Thoroughly clean the shafts taper with greenie pads and inspect for imperfections. Shaft taper must be smooth with no burrs, raised spots, or other damage.

F-3 PROPELLER REPLACEMENT

F-3.1. In addition to a normal installation activity propeller receipt inspection:
   a) Inspect the bore of the replacement propeller. Confirm that the helical oil distribution and drainage grooves are as shown in ref (a).
   b) Confirm the bore is free of burrs, raised spots, or other damage. Clean the bore with greenie pads.
   c) Check that the AFT hub face of the propeller has been drilled and tapped with two ¼-20 holes, 180 degrees apart to accept the propeller nut locking bolts.
   d) Confirm the rope guard connection ring (see reference (a)) is installed on the FWD propeller hub face. The rope guard connection ring fasteners should be weld locked/loctited in place at time of OEM installation.

If any problems are detected with the supplied propeller it shall be rejected and returned to the procuring activity to be repaired.

F-3.2. On the surface, install the propeller lifting swivel hoist ring(s), ensuring that they are properly shouldered. Install the hydraulic oil fitting into the hub

F-3.3. Divers coat the shaft taper with a light coat of oil (see Table F-2 for correct oil).

FZ-3.4. Yard and stay the replacement propeller onto the shaft. Employ the propeller holdback come-along to help pull the loose propeller well onto the shaft taper.

F-3.5. Remove the shaft thread protector.

F-3.6. On the surface ensure that the propeller hydraulic nut is fully retracted (de-pressurized) and measure and record the extension of the hydraulic nut gland from the nut body in the fully retracted position. This will enable the divers to be able to confirm by measurement when the nut is or is not fully retracted.

F-3.7. Thread the nut onto the shaft threads until it is snug against the AFT face of the hub.

F-3.8. Slacken the chain hoist(s) and holdback come-along.

F-3.9. Allow propeller, shaft, and hydraulic nut to soak for 12 hours to come to the same temperature.

F-3.10. Measure the temperature at the propeller and select the proper oil from Table F-2.

   CAUTION
   Because some leakage of hub to shaft taper interface oil is unavoidable ensure oil containment and collection procedures as recommended earlier are in place.

F-3.11. Connect the hydraulic oil lines loosely to the hub and the hydraulic nut. Bleed hoses until a steady stream of oil is produced at the propeller hub and nut fittings. Tighten hub and nut hydraulic fittings when oil lines are bled.
F-3.12. Pressurize nut to 200 psi to achieve a seal between shaft and hub. Do not pressurize hub at this stage. Do not exceed one-inch extension (as measured by a ruler) of the nut gland from the nut body.

F-3.13. Depressurize nut, disconnect hydraulic hose at the nut, and rotate nut body up the shaft until it is once again snug against the AFT face of the hub with the nut gland fully retracted. Full retraction of the nut gland is confirmed by the measurements taken in paragraph F-3.6.

F-3.14. Connect the hydraulic oil line loosely to the hydraulic nut. Bleed hose until a steady stream of oil is produced at the nut fitting. Tighten nut hydraulic fitting when oil lines are bled.

F-3.15. Pressurize nut to 200 psi to achieve a seal between shaft and hub. Do not pressurize hub at this stage.

F-3.16. Install the dial indicator as detailed in Figure F-1, PC Class Dial Indicator Mounting. The propeller will be moving away from the dial indicator as the propeller advances up the shaft taper. Therefore, it is necessary to pre-set 0.500-inch movement of the dial indicator plunger when setting up the dial indicator plunger against the AFT face of the propeller. The 0.500 inch pre-set is ½ the total range of measurement (1 inch) available on the dial indicators supplied in the PC propeller dial indicator equipment kit. Advance will be measured as the amount of plunger movement reduced from the original pre-set 0.500 inch as the propeller is advanced up the shaft taper.

F-3.17. Select one topside person to operate the hub pressure pump and another to operate the nut pressure pump.

F-3.18. Diver will confirm that oil is bleeding from between hub and shaft when the hub pump operator pressurizes to approximately 1,000 psi.

F-3.19. Once confirmed that oil is bleeding from between shaft and hub increase nut pressure to achieve 0.050-inch total advance of the propeller up the shaft taper.

F-3.20. Topside apply additional pressure to the propeller hub until pressure will not maintain (approximately 5,000 psi).

F-3.21. Topside apply additional nut pressure to achieve 0.100-inch total advance as read by the diver.

F-3.22. Topside apply additional pressure to the propeller hub until pressure will not maintain (approximately 7,000 psi).

F-3.23. Topside apply additional nut pressure to achieve 0.150-inch total advance as read by the diver.

F-3.24. Topside apply additional pressure to the propeller hub until pressure will not maintain (approximately 10,000 psi).

F-3.25. Topside apply additional nut pressure to achieve 0.200-inch total advance as read by the diver.

F-3.26. Topside apply additional pressure to the propeller hub until minimum “Propeller Pressure”
from Table F-3, PC Class Propeller Assembly Data, is achieved or pressure will not maintain.

F-3.27. Topside apply additional nut pressure to achieve the mean draw for the existing temperature as indicated on Table F-3.

**NOTE**
No maximum nut pressures from Table F-3 shall be exceeded.
All minimum draw values from Table F-3 shall be achieved.

F-3.28. If required, topside apply additional pressure to the propeller hub to achieve minimum interface pressure from Table F-3.

F-3.29. When the required advance has been achieved, stop increasing but maintain final hydraulic nut pressure while the propeller hub pump operator de-pressurizes the hub. Maintain the final hydraulic nut pressure for 20 minutes to permit any residual hub pressure to relieve from the propeller hub/shaft taper interface.

F-3.30. After 20 minutes, slowly vent the hydraulic nut pressure and confirm by observation of the dial indicator that the propeller does not lose any advance. The final advance MUST be within the specified maximum and minimum draw range detailed in Table F-3.

F-3.31. If the propeller does not mount or maintain the minimum draw indicated in Table F-3, remove the propeller from the shaft taper, thoroughly clean the shaft taper and hub bore and repeat the propeller installation as detailed above. If after the second attempt the propeller will not maintain the required minimum advance contact NAVSEA 00C5 for further guidance. Be prepared to provide the following information from prior installation attempts:

a) Component temperatures
b) Oil weight used in the hub interface hydraulic pump
c) Pressures used on the hub interface pump and hydraulic nut
d) Propeller advance (draw) achieved.

F-3.32. Remove all hydraulic hoses, hydraulic fittings, and propeller advance measurement equipment. Replace and stake the seal plugs where hydraulic fittings are removed from the hub.

F-3.33. Remove the hydraulic nut and replace the propeller nut. Hand tighten the nut against the AFT face of the propeller hub, then back off the nut as required to allow for installation of the two (1/4-20) propeller nut locking bolts with a 7/16 inch wrench. A particular solid thread lock compound applied to the fasteners prior to sending underwater has worked well in past experience to hold fasteners in place. The particular thread lock compound is Loctite 248 Threadlocker Blue, Model # 37684.

F-3.34. Remove the propeller hub lifting swivel hoist ring(s) and install lifting fitting attachment plug(s).

F-3.35. For a 6-bladed propeller, install the propeller dunce cap and torque the four bolts to 66 ft-lbs. A particular solid thread lock compound applied to the fasteners prior to sending underwater has worked well in past experience to hold fasteners in place. The particular thread lock compound is Loctite 248 Threadlocker Blue, Model # 37684.

F-3.36. Remove bellyband(s) and all rigging gear.
FIGURE F-1: PC CLASS DIAL INDICATOR MOUNTING

DIAL INDICATOR MOUNT ASSEMBLY

- Eye Bolt, Shoulder Pattern 5/8 - 11 UNC X 2 long
- Nut 5/8 - 11 UNC
- Angle, 2 X 2 X 1/4 2 1/2 long
- 3/16 V
- Flat Washer, 5/8 X 1 3/4 OD

PROPELLER HUB REF

DIAL INDICATOR MOUNT ASSEMBLY

HYDRAULIC NUT
Table 4-1. Torque Specifications for Propeller Cap and Gland Studs and Nuts.

<table>
<thead>
<tr>
<th>Stud Diameter</th>
<th>Torque (ft-lbs)</th>
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<tr>
<td>1&quot;</td>
<td>345</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
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NOTES
1. Tolerance is ± 5 percent.
2. Torque is for QQ-N-281, Class A (Monel), Nickel-Copper alloy wrought material.
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<tr>
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<td></td>
<td>(Plow Steel)</td>
<td>(Plow Steel)</td>
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**Note:** 6 x 19 classification/bright (uncoated) wire rope
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<tbody>
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<td>REMOVAL INTERFACE PRESSURES</td>
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<tr>
<td>PROPELLER ABSOLUTE MAXIMUM</td>
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<td>GEARBOX COUPLING ABSOLUTE MAXIMUM</td>
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Table F-1. PC Class Propeller Removal Data
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<th>MINERAL MOTOR OIL</th>
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Table F-2. PC Class Oil Data
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Table F-3. PC Class Propeller Assembly Data