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CHAPTER 244

PROPULSION BEARINGS AND SEALS

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CHAPTER 244

PROPULSION BEARING AND SEALS

SECTION 1

BALL AND ROLLER BEARINGS (ROLLING-ELEMENT TYPE)

244-1.1 GENERAL

244-1.1.1 INTRODUCTION Rolling-element bearings are used to guide and support rotating and oscillating members. The rolling-element bearing, except for special designs, consists of two rings, a set of balls or rollers, and a cage. The cage maintains even spacing of the balls or rollers and prevents them from falling out of the bearing during handling. The rolling-element bearing has many uses in shipboard machine elements. Rolling-element bearing design is based on the principle that rolling friction is much less than sliding friction. These bearings are commonly called antifriction bearings. Reasonable changes in load, speed, and operating temperature have no effect on their satisfactory performance.

244-1.1.2 AVAILABLE TRAINING FILMS. The following films are available for training:

a. MN-10343 - **Replacement of Ball Bearings for Quiet Operation**

b. MN-11128A - **Interpretation of Service Damage in Rolling Contact Bearings**

244-1.2 COMMON BEARING DESIGNS

244-1.2.1 BALL BEARINGS. Ball bearings are not widely used in main propulsion machinery but are found in all types of auxiliary machinery.

244-1.2.1.1 Type. The type designations of ball bearings common to shipboard applications are as follows:

a. Type 111. Single-row, radial, nonloading groove, both rings same width, metric
   1. Class 1. Open
   2. Class 2. Single-shield
   3. Class 3. Double-shield
   4. Class 4. Open, snap ring
   5. Class 5. Single-shield, snap ring
   6. Class 6. Double-shield, snap ring
   7. Class 7. Single-seal
   8. Class 8. Double-seal

b. Type 115. Single-row, radial, nonloading groove, both rings same width, inch
   1. Class 1. Open
   2. Class 2. Single-shield
   3. Class 3. Double-shield

c. Type 120. Single-row, radial, nonloading groove, both rings same width, sealed (cartridge type without grease plug), metric bore and outer diameter (OD), inch width

d. Type 123. Internal self-aligning, double-row, both rings same width, metric

e. Type 131. Single-row, counterbore (primarily radial), self-contained, both rings same width, metric
   1. Class 1. Single bearing
   2. Class 2. Duplex pair, faces ground for face-to-face (DF), back-to-back (DB), or tandem (DT) mounting

f. Type 133. Single-row, angular contact (contact angle 25° or less), self-contained, both rings same width, metric
   1. Class 1. Single bearing
   2. Class 2. Duplex pair, faces ground for DF, DB, DT mounting

g. Type 134. Single-row, angular contact (contact angle greater than 25°), self-contained, both rings same width, metric
   1. Class 1. Single bearing
   2. Class 2. Duplex pair, faces ground for DF, DB, or DT mounting

h. Type 143. Double-row, nonloading groove, vertex of contact angle outside of bearing, metric bore and OD, inch or metric width

i. Type 145. Double-row, loading groove, vertex of contact angle inside of bearing, metric bore and OD, inch or metric width

j. Type 146. Double-row, loading groove, vertex of contact angle outside of bearing, metric bore and OD, inch or metric width.

244-1.2.1.2 Precision. Three grades of precision are available. The standard grade of precision is grade 00 standard tolerance. This level is satisfactory for most designs and therefore has the widest use. Bearings having closer tolerances on dimensions are manufactured to grade 50 precision tolerances or grade 70 super-precision tolerances. Most ball bearings are purchased in accordance with FF-B-171, **Bearings, Ball, Annular (General Purpose).** Ball bearings for Navy noise-critical applications are purchased under a special Naval Sea Systems Command (NAVSEA) specification, MIL-B-17931, **Bearings, Ball, Annular, For Quiet Operation.** Dimensional tolerances for these bearings are similar to grade 50 and 70 limits. Additional strict requirements are imposed on these bearings to ensure a minimum of bearing noise and vibration. Such bearings are marked with the symbol NT followed by the number designated to the latest noise requirement in MIL-B-17931 and will be referred to throughout this NSTM chapter as quiet bearings.

244-1.2.1.3 Limitations. Unless otherwise specified or approved by NAVSEA, ball bearings for shipboard use are limited to the grade, type, and class specified for the original equipment. Quiet bearings are not intended for general use and are restricted to low-noise applications.

244-1.2.2 ROLLER BEARINGS. Roller bearings are used in main propulsion machinery only to a limited extent, but are widely used in auxiliary machinery. As generally used in the Navy, they are described by type, grade, and nomenclature designations in the following paragraphs.

244-1.2.2.1 Cylindrical Roller Bearings. The type designations of cylindrical roller bearings common to shipboard applications are as follows:

a. Class 1. Radial, cylindrical, nonlocating, single-row, metric
   1. Type 211. Two-lip inner ring, cylindrical outer ring with two roller retainment rings, nonseparable
   2. Type 212. Two-lip inner ring, cylindrical outer ring, separable
   3. Type 214. Cylindrical inner ring, cylindrical outer ring with two roller retainment rings, separable
   4. Type 215. Cylindrical inner ring, two-lip outer ring, separable

b. Class 2. Radial, cylindrical, one-directional locating, single-row, metric
   1. Type 231. Two-lip inner ring, one-lip outer ring, separable
   2. Type 232. Two-lip inner ring, one-lip outer ring with one roller retainment ring, nonseparable
   3. Type 233. One-lip inner ring, two-lip outer ring, separable

c. Class 3. Radial, cylindrical, two-directional locating, single-row, metric - Type 237. Two-lip inner ring, two-lip outer ring, nonseparable

d. Class 5. Radial, cylindrical, nonlocating, single-row, inch
   1. Type 251. Two-lip inner ring, cylindrical outer ring, separable
   2. Type 252. Cylindrical inner ring, two-lip outer ring, separable.

NOTE

Class 4 is intentionally omitted

244-1.2.2.2 Spherical Roller Bearings. The only type designation of spherical roller bearings common to shipboard applications is the class 6, self-aligning (spherical), radial-thrust double row, metric - Type 264. It is self-aligning (spherical), with angular contact, inner and outer raceways concave, and nonseparable.

244-1.2.2.3 Tapered Roller Bearings. The type designations of tapered roller bearings common to shipboard applications are as follows:

a. Type 751. Single-row, straight bore, normal angle, (TS)

b. Type 753. Single-row, straight bore, steep angle

c. Type 755. Single-row, straight bore, flanged cup, normal angle, (TSF)

d. Type 757. Double-row, straight bore, one double cone, two single cups, normal angle, (TDI)

e. Type 759. Single-row, straight bore, flanged cup, steep angle, (TSSF)

f. Type 761. Double-row, straight bore, two single cones, one double cup with lubrication holes and groove, normal angle, (TDO)

g. Type 763. Double-row, straight bore, two single cones, one double cup with lubrication holes and groove, steep angle, (TDOS)

h. Type 764. Double-row, straight bore, nonadjustable, two single cones (with front faces contacting), one double cup with lubrication holes and groove, normal angle, (TNA)

i. Type 765. Double-row, straight bore, nonadjustable, two single cones with (contacting front) faces slotted and chamfered for lubrication, one double cup with lubrication holes and groove, (TNASW)

j. Type 767. Double-row, straight bore, nonadjustable, two single cones (with front faces contacting), one double cup with lubrication holes and groove, steep angle, (TNAS)

k. Type 768. Two single-row bearings, straight bore, unit assembly, nonadjustable, with cone and cup (snap ring) spacers, (2TS-lMSS ASSEMBLY)

l. Type 770. Double-row, straight bore, one double cone, two single cups, steep angle, (TDIS).

244-1.2.2.4 Precision. Roller bearings of the types listed in paragraphs 244-1.2.2.1 and 244-1.2.2.2 are purchased to FF-B-185, **Bearings, Roller, Cylindrical and Self-Aligning,** which requires grade 00 tolerances. Tapered roller bearings of the types listed in paragraph 244-1.2.2.2 are purchased to FF-B-187, **Bearings, Roller Tapered,** with tolerances conforming to class 4 of ANSI/AFBMA Std 19, **Tapered Roller Bearings - Radial Inch Design.** These precision grades are satisfactory for most designs and therefore have the widest use. Use of special higher precision bearings, however, when previously approved by NAVSEA, is acceptable.

244-1.2.2.5 Limitations. Unless otherwise specified or approved by NAVSEA, all roller bearings for shipboard use are limited to the grade, type, and class specified for the original equipment.

244-1.3 IDENTIFICATION

244-1.3.1 NATIONAL STOCK NUMBERS. In the National Supply System, rolling-element bearings are identified by National Stock Numbers (NSN). Each bearing NSN has an item description that lists the bearing design features peculiar to that NSN. This item description is used to procure new bearings from government-qualified manufacturers, ensuring interchangeability. All bearings should have the NSN marked on the outer unit package.

244-1.3.2 ALLOWANCE PARTS LIST. In support of the National Supply System, NAVSEA has established the Coordinated Ship Allowance List (COSAL) and the Allowance Parts List (APL). The COSAL identifies specific equipment by the Component Identification Number (CID). The APL is a ready reference that lists onboard replacement parts by name and NSN for specific equipment as identified by the CID's. Bearing NSN's should always appear on the APL as onboard replacement items. Procurement requests shall specify the NSN.

244-1.3.3 BEARING TYPE. The bearing types as listed herein are in accordance with MIL-STD-102, **Anti-Friction Bearing Identification Code.** The code is descriptive and consists of 12 digits broken down into three groups. The first 3 digits classify the bearing type. The following 5 digits code the principal boundary dimensions of bore, OD, and width. The last 4 digits code variations such as precision, internal clearance, seals, shields, lubricant, cages, or preload. This numbering system has been superseded by the NSN numbering system. It is still widely used, however, on equipment drawings, in technical manuals, and by the Defense Industry Supply Center.

244-1.3.4 BASIC BEARING NUMBER. The list of government-qualified bearing suppliers is lengthy and each supplier has its own identification system. Manufacturers' identification numbers usually consist of a three-digit **basic bearing number.** The first digit of the basic bearing number codes the bearing OD or width series (duty) as extremely light (900), extra light (100), light (200), medium (300), heavy (400), type 120 light (500), and type 120 medium (600). The second and third digits of the basic bearing number are the **bore code.** The bore code is 1/5 the bore dimension in millimeters, with the exception of bore codes 00 through 03. For example, a basic bearing number of 318 tells the user that this is a medium duty bearing with a bore of 90 mm. A combination of numbers or letters are used as prefixes or suffixes to the basic bearing number to code bearing type and special features.Table 244-1-1 is an interchangeability list of manufacturers' basic bearing numbers (bore code

09 only) for the most commonly used shipboard machinery ball bearings. The table is provided only for guidance. Manufacturers' basic bearing numbers as they appear stamped on ball bearings, and cylindrical and spherical roller bearings are helpful in determining bearing nominal size. This information will provide easy entry into the fitup tables contained here, eliminating the need to measure the bearings. Do not use bearing manufacturers' numbers for procurement, however, because:

a. Bearing identification is not standard. Different manufacturers use the same numbers and letters to mean different things. For example, with Koyo 7309 is an open angular-contact bearing with a large contact angle conforming to Navy type 134, but with Marlin Rockwell Corporation (MRC) 7309 is an open angular-contact bearing with a small contact angle conforming to Navy type 133.

b. Only the basic bearing number is usually stamped on the bearing. This number does not give information about such important features as lubricant, internal clearance, cage material, precision, preload, seals, or shields. This information, however, may be marked on the bearing package. MIL-L-HDBK-203, **Manufacturers Symbols and Designations for Anti-Friction Bearings,** has been prepared to help translate such information.

c. Many original equipment manufacturers assign their own part numbers to bearings, instead of the bearing manufacturer's number. When such part numbers appear on drawings, only the original equipment manufacturer can decipher this code. Many drawings that do list bearing manufacturers' numbers list only the basic numbers.

d. Bearings procured outside the National Supply System may not have been subjected to quality control on a par with government standards or manufactured by a government-qualified supplier. This could result in procuring an inferior product.

244-1.4 BEARING DESIGN

244-1.4.1 GENERAL. All bearings of the same type and size are dimensionally interchangeable regardless of precision. In addition, ball, and cylindrical and spherical roller bearings manufactured to the same boundary plan dimensions in metric units are interchangeable. This of course does not mean that all types will perform equally well, or for that matter, work at all. In general, not more than two bearings are permitted on rigidly mounted shafts required to run in line.

244-1.4.2 BALL BEARINGS. Standard grade ball bearings are precision ground machine elements. Grade 00 bearings are manufactured under very close control of dimensions and finish. For example, the bore of a type 111, size 320 bearing with a diameter of 3.9370 inches must be round within 0.0008 inch. Each 1.5-inch-diameter ball in this bearing must be round within 0.000025 inch and have a surface finish better than 1.5-microinch RA. Higher-precision bearings have proportionally tighter tolerances. Most ball bearings are dimensioned in the metric system. The most common ball bearing designs are discussed in paragraphs 244-1.4.2.1 through 244-1.4.2.5.

244-1.4.2.1 Type 111 is the most versatile of bearings, as it is capable of supporting radial loads and two-directional thrust loads combined in any proportion. This bearing is not self-aligning and therefore requires accurate parallelism between the shaft and the housing bore.

244-1.4.2.2 Types 115 and 120 are similar in design to type 111 with the following exceptions:

a. Type 115 is dimensioned in inches.

b. Type 120 is termed a cartridge bearing since it is as wide as a double-row bearing but has only one row of balls.

c. Type 120 bearings are double sealed or double shielded and lubricated for life by the bearing manufacturer.

Table 244-1-1 BALL BEARING INTERCHANGEABILITY DATA FOR GRADE 00 BEARINGS (BORE CODE 09)

MIL-STD-102 Type Class	MRC	New Departure	Norma Hoffman	NTN	SKF	Industry Series	Barden	Fafnir	Koyo
111 1	109KS	3L09	6109	6009	6009X	Extra Light	109	9109K	6009
111 1	209S	3209	209	6209	6209	Light	209	209K	6209
111 1	309S	3309	309	6309	6309	Medium		309K	6309
111 1	409S	3409	409	6409	6409	Heavy		409K	6409
111 2	209SF	7509	209P	6209Z	6209Z	Light	209S	209KD	6209Z
111 3	309SFF	77609	309PP	6309ZZ	63092Z	Medium		309KDD	6309ZZ
111 4	309SG	43309	4309	6309NR	6309NR	Medium		309KG	6309NR
111 5	309SFG	47609	4309P	6309ZNR	6309ZNR	Medium		309KDG	6309ZN
111 7	209SZ	9509	209K		6209RS	Light		209KP	6209RS
111 8	309SZZ	99609	309KK	6309LLU	63092RS	Medium		309PP	63092RS
120	309SZZC			63309LLU	462309	Medium		W309PP	N63092RS
120	309SFFC		S3609			Medium		W309KLL	
120	309SRRC		FL3609	63309LLB		Medium			
131	309R	20309	L7309			Medium		7309W	
133	7309	20309	7309	7309C		Medium		7309W	
134	7309	30309		7309	7309B	Medium		7315PW*	7309

NOTE:
This table is not all inclusive. The numbers shown are for a bore code 09 bearing. For other size bearings substitute the appropriate bore code.
* Not available in 09 bore code.

244-1.4.2.3 Type 123 are useful mainly where housing alignment is uncertain. They will support moderate radial loads and light two-directional thrust loads. They are internally self-aligning.

244-1.4.2.4 Types 131, 133, and 134 are angular-contact ball bearings designed to support thrust loads in one direction, possibly in combination with radial loads. All three types are similarly designed in that the direction of load through the balls forms an angle, known as the contact angle, with a plane perpendicular to the bearing axis. The thrust capacity increases with increasing contact angle. These bearings usually have a greater number of balls than type 111 bearings. Type 134 has a range of contact angles larger than type 133, which in turn has a range of contact angles larger than type 131. Angular contact bearings are frequently made so that they can be mounted in pairs, back-to-back, tandem, or face-to-face, which enables them to carry radial, thrust, or combined loads in any direction (paragraph 244-1.8.5.7). These arrangements are called duplex pairs. In these arrangements bearing ring side surfaces are ground so that when the assembled bearings are clamped together, the desired internal clearance, or preload, is obtained. For general purpose applications duplex pairs are designed as flush-ground bearings. This means they will not have a significant preload or measurable end play. For specialized applications varying degrees of preload, or end play, may be desirable. In these cases, the bearing ring side surfaces are ground to give the desired loading condition.

244-1.4.2.5 Types 143, 145, and 146 are double-row, angular-contact ball bearings. Although the two rows of balls provide greater radial load capacity than equivalent sizes of single-row bearings, the thrust capacity is limited to that of one row of balls since the contact angles are not parallel.

244-1.4.3 ROLLER BEARINGS. Cylindrical and spherical roller bearings are usually manufactured to basic boundary dimensions in the metric system. Tapered roller bearings are usually manufactured to basic boundary dimensions in inches. Unless otherwise specified, the following discussion applies accordingly. Roller bearings provide a greater degree of surface contact than ball bearings and can therefore withstand comparatively heavy radial or thrust loads, and shock loads, depending on bearing design. The most common roller bearing designs are discussed in paragraphs 244-1.4.3.1 through 244-1.4.3.3.

244-1.4.3.1 Cylindrical Roller Bearings. Cylindrical roller bearings are designed to carry primarily radial loads and are categorized, first by their ability to provide endwise location, secondly by their separable or nonseparable characteristics, and finally by the dimensional system employed. The component parts of separable types should not be interchanged. Types 212, 214, and 215 are separable and free floating in both directions and are incapable of supporting any thrust load. Type 211 is nonseparable but is not intended to carry thrust loads. Types 231, 232, and 233 are one-directional-locating types and will support light thrust loads against the single lip. Types 231 and 233 are separable. Type 232 is nonseparable but is not intended to carry thrust load against the roller retainment ring. Type 237 will support light thrust load in either direction. This type has low load capacity, however, because of the reduced number of rollers that can be installed. Types 251 and 252 are manufactured to inch dimensions and are functionally identical to types 212 and 215, respectively.

244-1.4.3.2 Spherical Roller Bearings. Self-aligning spherical roller bearings of type 264 have a double row of rollers with angular-contact internal design. This type can support light to moderate thrust loads in both directions in combination with radial loads. The self-alignment feature is of value where housing misalignment or shaft deflection cannot be avoided.

244-1.4.3.3 Tapered Roller Bearings. Two basic types of tapered roller bearings are used on naval ships: single and double row. These two types are divided into normal- and steep-angle constructions. Double-row bearings are manufactured in two basic styles: those with separate cups and double cones, and those with separate cones and double cups. Double-row types have two-directional thrust load capability, and single-row types have only one-directional thrust load capability. Normal-angle construction is designed for use where the loading is primarily radial. Steep-angle construction is designed for use where the loading is primarily axial. Types 751, 753, 755, and 759 are single-row bearings and require adjustment at installation to achieve the correct amount of running clearance. Types 757, 761, 763, and 770 are double-row types that may be procured with appropriate spacers to achieve a pre-set clearance. These types will otherwise require adjustment at installation. Types 764, 765, 767, and 768 are manufactured with a pre-set clearance and are nonadjustable. In addition, types 761, 763, 764, and 767 can be used to float axially in the bearing housing where temperature differentials result in unequal relative expansion.

244-1.4.4 BEARING CAGES. Cages are made to many different designs and of several different materials. The cage separates the rolling elements, spacing them evenly around the periphery and preventing them from falling out of the bearing during handling. In addition, in some roller bearing designs, the cage guides the rollers, preventing them from skewing. The cage is not designed to help carry the load. It can be subjected, however, to considerable inertial forces due to acceleration, shock due to extreme service, and centrifugal force due to high speed. Cages are either machined or stamped, usually from steel, brass, bronze, phenolic, or plastic material. The cage may pilot or ride on the balls, rollers, inner ring lands, or outer ring lands. In general shipboard applications all cage types perform equally well. Standard cage materials of brass, bronze, phenolic, and plastic are restricted to operational temperatures below 110°C (230°F).

244-1.4.5 SEALS AND SHIELDS. Seals and shields integral to the bearing are incorporated to prevent the entry of foreign matter and to retain lubricant. Shields are usually defined as circular closures affixed to one bearing ring and disposed radially toward the other ring but not in contact with it. Seals are similarly defined except they have rubbing contact lips or overlapping elements that form a labyrinth. It may not be outwardly possible to distinguish between a seal or shields as mounted in the bearing. Use of seals and shields has not been standardized by the bearing industry. Many designs are available, and it has therefore been necessary to group together those types that function similarly. Rubbing contact seals generate heat, however, and are therefore limited by bearing size and rotational speed. In addition, all standard seal materials manufactured of rubber, felt, or leather are restricted to operational temperatures below 110°C (230°F).

244-1.4.6 RADIAL INTERNAL CLEARANCE. Radial internal clearance is the distance the inner ring can be displaced radially from one extreme position to the other in relation to the outer ring. Mounted radial internal clearance is of primary importance, and as a general rule, a small clearance is desirable during operation. Bearings of types 111, 115, 120, 211, 212, 213, 215, 231, 232, 233, 237, 264, 764, 765, 767, and 768 are available with various degrees of radial internal clearances as standardized by the bearing industry. For unlisted types, the internal clearances are either determined by adjustment or fitted to the manufacturer's standard practice.

244-1.4.6.1 Shipboard applications generally use bearings with standard clearance. Under ordinary operating conditions and with one bearing ring mounted with an interference fit, this clearance is adequate. When severe operating conditions require an extra tight fit for the interference-fitted ring, when both rings must be mounted with a press fit, or when thermal expansion of the inner ring is considerably more than the outer ring, a loose clearance may be required. The degree of bearing internal clearance necessary is generally specified by the original equipment manufacturer and is indicated on the equipment master drawing if other than standard.

244-1.4.6.2 Type 111 and 120 quiet ball bearings have stricter limits on radial internal clearance than those standardized by the bearing industry.

244-1.4.6.3 Separable-type bearings that are nonadjustable must be installed as originally matched by the manufacturer to maintain the required radial internal clearance. Mismatching of such types will usually result in premature failure.

244-1.4.7 DIMENSIONAL STABILITY. Bearing rings and rolling elements as usually manufactured may retain a small percentage of the austenite phase of steel after hardening. This austenite is unstable and with time at room temperature, and more rapidly with a rise in temperature, changes to the harder, less dense martensite phase, which causes the bearing components to grow. The bearing industry has therefore established levels of dimensional stability.

244-1.4.7.1 The maximum temperature of nonstabilized bearings in service should not exceed 110°C (230°F). Bearings that exceed this temperature may grow, affecting the fit of the bearing on the shaft and in the housing. The radial internal clearance may also be reduced. Seizure and galling may ensue, with eventual failure.

244-1.4.7.2 When operating temperatures are above 110°C (230°F), use bearings that have been heat stabilized. Heat stabilization will significantly reduce the level of retained austenite. It is not a cure-all, however, because the stabilizing process reduces material hardness and therefore shortens fatigue life. In addition, heat stabilization does not guarantee that the bearing components will not grow. Rather, it establishes a level of stability that must be considered in equipment design.

244-1.4.8 MOUNTING DESIGN. Bearing mounting designs are of the opposed-shoulder method, or the fixed-free method (Figure 244-1-1 and Figure 244-1-2). A single-row bearing, a double-row bearing, or a duplex pair of bearings can be used at each bearing location. In the opposed-shoulder method, the end play necessary to allow for thermal differential expansion shall be designed into the bearing mounting. Opposed-shoulder mounts can be designed using all types of bearings, except for types 211, 212, 214, 215, 251, and 252. The fixed-free method is the most popular in naval shipboard applications. The fixed bearing is secured on the shaft and clamped axially in the housing by housing and end cap shoulders. The fixed bearing must be suitable for supporting radial loads and two-directional thrust loads. The floating bearings can be of any type as long as design requirements are satisfied. If the floating bearing is a cylindrical roller bearing of type 212, 214, 215, 251, or 252, the outer rings will be clamped axially and the bearing will float internally. If any other type of bearing is used, one ring will be clamped axially and the other will float. For rotating shafts, the inner ring will be clamped axially, requiring that the outer ring have room to move axially in the housing. The clearance required depends on the bearing span, the machining tolerances on all joints and surfaces affecting the span, and the shaft-to-housing temperature differential expected in service. When a bearing capable of only one-directional thrust is used as the floating bearing, thrust load arising from dead weight, axial spring preload, or other loading must always be present to prevent the bearing from separating. For duplex pairs the back-to-back pair can be allowed to float in the housing. Quite the contrary, the face-to-face pair cannot be allowed to float in the housing, since the nonthrusted outer ring will separate from the bearing. Such duplex pairs shall be installed as originally designed.

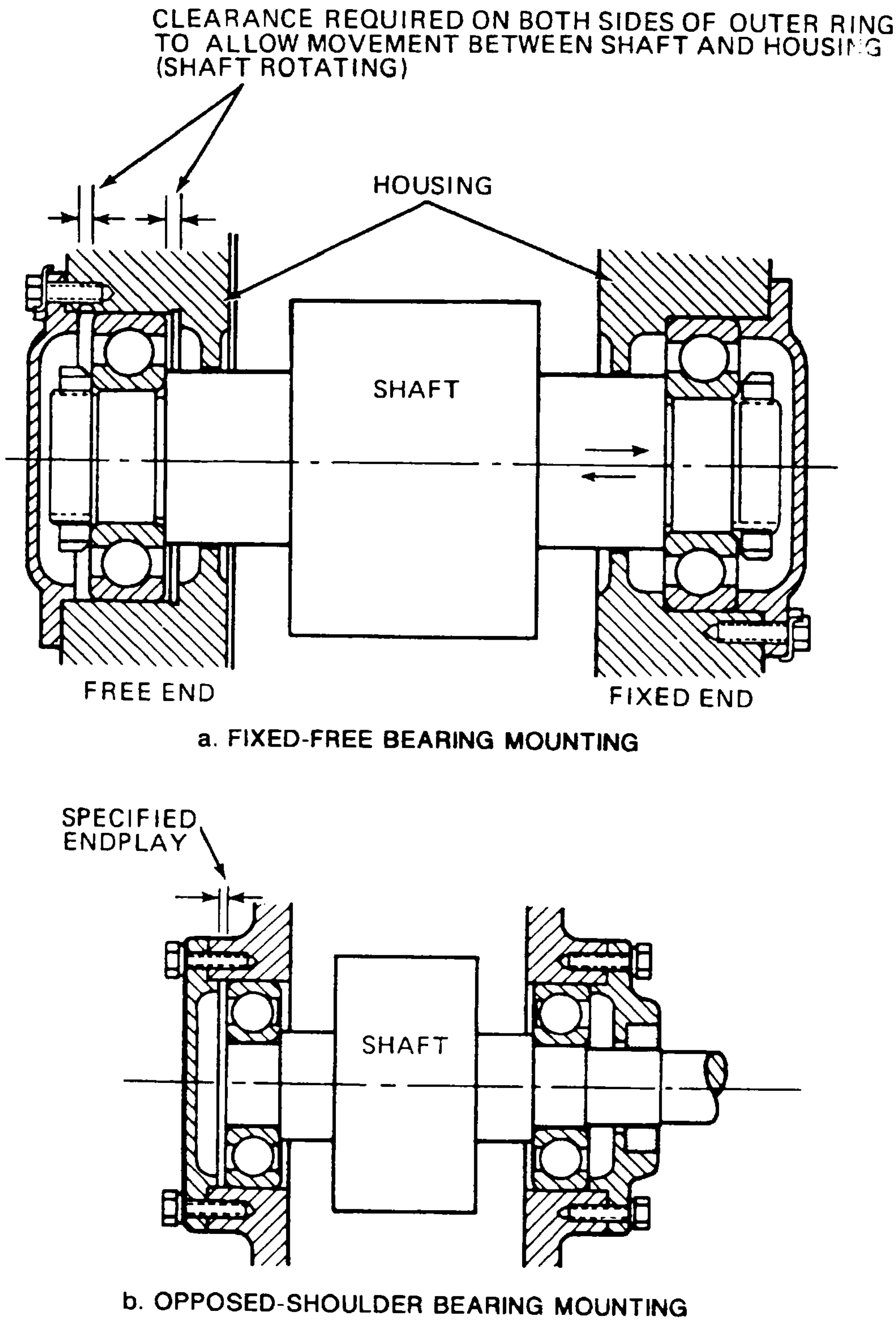
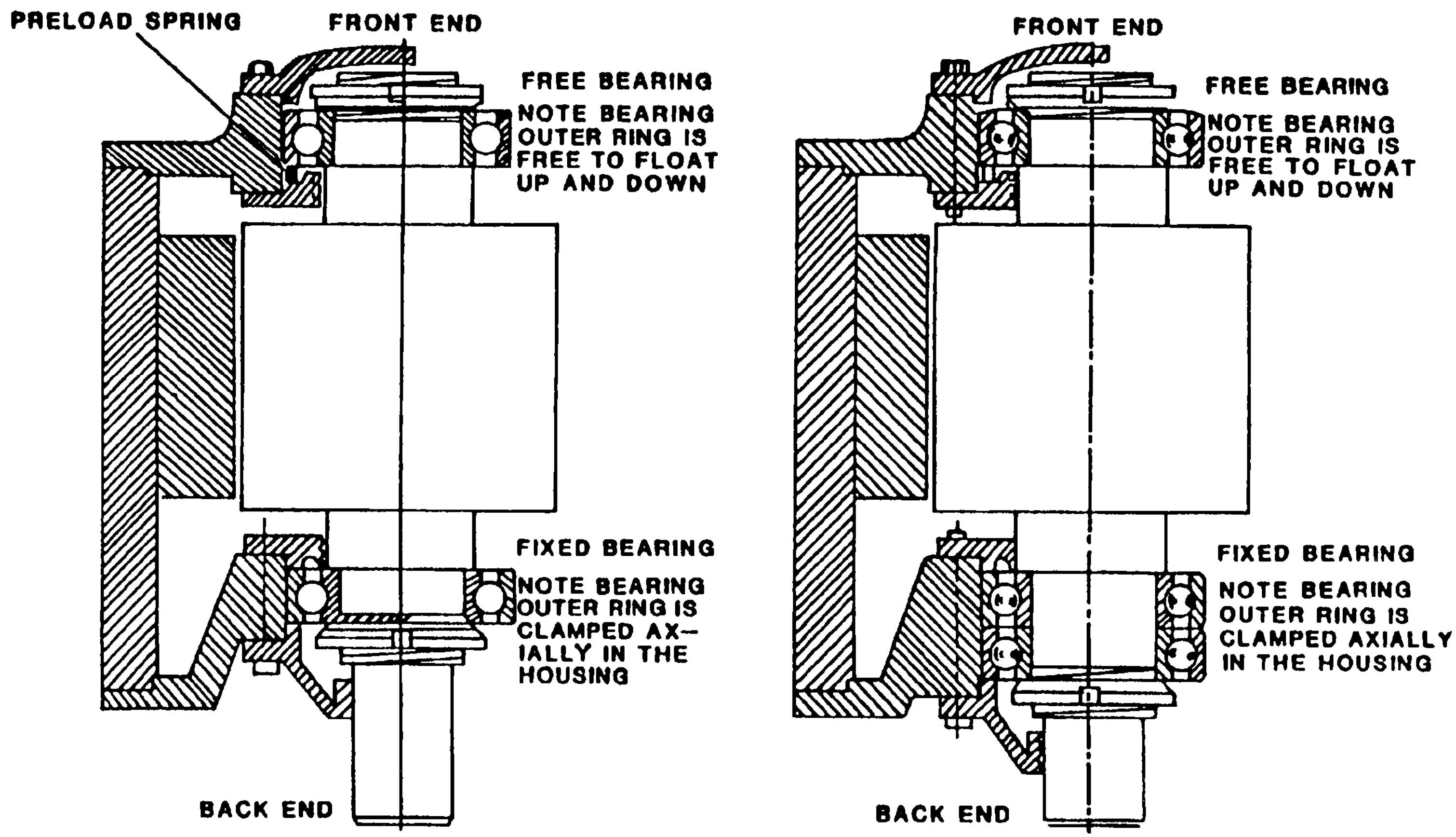


Figure 244-1-1 Mounting Methods for Horizontally Mounted Ball Bearings



a. DEEP-GROOVE FIXED BEARING

b. DUPLEX-PAIR FIXED BEARING

Figure 244-1-2 Mounting Methods for Vertically Mounted Ball Bearings

244-1.4.9 SHAFT AND HOUSING DESIGN. Rolling-element bearing bores and outside diameters are held within certain defined tolerances, depending on precision grade. In turn, shaft and housing diameters must be held to comparable limits in accordance with bearing precision grade. Limits and fits are ordinarily determined by the equipment manufacturer to satisfy the design requirements. During overhaul, it is important to maintain the limits and fits best suited for the application. The shaft and housing fitups herein are therefore provided for use where specific instructions are unavailable. These tables are intended for the precision grades, bearing types, and dynamic conditions as indicated, which are characteristic of most naval shipboard applications. Shaft and housing seats and shoulder surfaces should be ground. The machining tolerances specified in Table 244-1-2 through Table 244-1-6 are the minimum requirements for reliable bearing life. Use these limits when other information is unavailable or when such other limits exceed the limits herein.

NOTE

NT 4 is the latest noise requirement as of this printing.

244-1.5 CARE OF UNMOUNTED BEARINGS

244-1.5.1 HANDLING AND STORAGE. Many bearings are rendered unsuitable for use by improper storage and handling. Although bearings are designed to be extremely rugged, they are very sensitive to corrosion, dirt, and abusive handling. Safe storage for any length of time requires that the storage area be dry. Do not store bearings in unheated areas, because condensate may form on cold surfaces. Likewise, avoid storing in temperatures above 120°F, as the preservative will oxidize more rapidly. Apply the first-in, first-out rule of storage. Place frequently used or heavy bearings on lower shelves. Heavy bearings requiring mechanical handling should be placed on pallets to simplify handling and to keep the bearing off the floor in case of flooding. Do not throw or drop bearings. This may scuff or dent the raceways and rolling elements, resulting in noisy operation. Keep bearings in their original packing until they are ready for installation. If a new bearing is accidentally exposed to dirt, clean it thoroughly as indicated in paragraph 244-1.5.4.

Table 244-1-2 SHAFT AND HOUSING BEARING SEAT AND SHOULDER TOLERANCES

	Shaft		Housing	
	General	**Quiet**	**General**	**Quiet**
Seat Diameter	Table 244-1-3 and Table 244-1-6	Table 244-1-3 [1]	Table 244-1-5 and Table 244-1-6	Table 244-1-5[2]
Seat Roundness[3]	1/2 diameter limit	1/2 diameter limit	1/2 diameter limit	1/2 diameter limit
Seat Surface Finish	63AA	32AA	125AA	63AA
Shoulder Squareness	0.001 in/in diameter	0.0003 in (maximum)	0.001 in/in diameter[4]	0.0002 in/in diameter[4]

NOTES:
1. Enter Table 244-1-3 with bearing bore code as stamped on the bearing.
2. Enter Table 244-1-4 with the basic bearing number as stamped on the bearing. Enter Table 244-1-5 with nominal metric bearing OD as determined from Table 244-1-4 .
3. Seat roundness applies to diameter measurement with a two-point gage. If seat roundness is measured with a dial indicator with shaft or housing on center, tolerance is 1/2 that listed.
4. This applies only where housing shoulders clamp bearing outer ring or thrust load pushes outer ring against housing shoulder.

244-1.5.2 INSPECTION. All bearings procured through the military supply system are manufactured by government-qualified firms. Boundary dimensions and tolerance grades standardized by the bearing industry and adopted by the government and material control information are constant sources of quality control demanded by government source inspectors. Because of the critical dimensional and vibrational requirements of quiet bearings, a sample from every bearing procurement lot is checked on a continuous basis at the Carderock Division, Naval Surface Warfare Center (CDNSWC), Annapolis, Maryland. Bearings marked with the NT symbol followed by the noise requirement number have passed the requirements for quiet bearings.

244-1.5.2.1 Inspection procedures should consist of the following:

1. Inspect the bearing packaging date which is recorded on the individual box of every bearing or set of duplex bearings. If the packaging date is 10 years or older, file a Quality Deficiency Report and return the bearings to the issuer. Grease degradation in older bearings can result in reduced bearing life and early equipment failure. This procedure is applicable to both Grade 00 and noise tested bearings.
2. Make sure that you have the correct bearing before removing the packing.
3. If the package has been broken but the bearing appears usable, clean the bearing.
4. Examine the bearing for corrosion, dirt, and dents. Do not use externally corroded bearings except in emergencies.
5. Rotate the bearing by hand to determine freedom of rotation.

Table 244-1-3 SHAFT DIAMETER LIMITS FOR GRADE 00 AND QUIET BEARINGS

Bore Code			Shaft Diameter Limits[2] (inches)									
			Shaft Rotating								Shaft Stationary[1]	
	Nominal		Ball		Quiet		Cylindrical		Spherical			
Bore Code	MM	Inch	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	4	0.1575	0.1576	0.1574							0.1573	0.1570
5	5	0.1969	0.1970	0.1968							0.1967	0.1964
6	6	0.2362	0.2363	0.2361							0.2360	0.2357
7	7	0.2756	0.2758	0.2755							0.2754	0.2750
8	8	0.3150	0.3152	0.3149							0.3148	0.3144
9	9	0.3543	0.3545	0.3542							0.3541	0.3537
00	10	0.3937	0.3939	0.3936	0.3940	0.3938					0.3935	0.3931
01	12	0.4724	0.4726	0.4723	0.4727	0.4725	0.4728	0.4725			0.4721	0.4717
02	15	0.5906	0.5908	0.5905	0.5909	0.5907	0.5910	0.5907			0.5903	0.5899
03	17	0.6693	0.6695	0.6692	0.6696	0.6694	0.6697	0.6694			0.6690	0.6686
04	20	0.7874	0.7879	0.7875	0.7877	0.7875	0.7879	0.7875			0.7871	0.7866
05	25	0.9843	0.9848	0.9844	0.9846	0.9844	0.9848	0.9844			0.9840	0.9835
06	30	1.1811	1.1816	1.1812	1.1814	1.1812	1.1816	1.1812			1.1808	1.1803
07	35	1.3780	1.3785	1.3781	1.3783	1.3781	1.3785	1.3781			1.3776	1.3770
08	40	1.5748	1.5753	1.5749	1.5751	1.5749	1.5753	1.5749	1.5753	1.5749	1.5744	1.15738
09	45	1.7717	1.7722	1.7718	1.7720	1.7718	1.7725	1.7721	1.7725	1.7721	1.7713	1.7707
10	50	1.9685	1.9690	1.9686	1.9688	1.9686	1.9693	1.9689	1.9693	1.9689	1.9681	1.9675
11	55	2.1654	2.1660	2.1655	2.1657	2.1655	2.1664	2.1659	2.1664	2.1659	2.1650	2.1643
12	60	2.3622	2.3628	2.3623	2.3625	2.3623	2.3632	2.3627	2.3632	2.3526	2.3618	2.3611
13	65	2.5591	2.5597	2.5592	2.5594	2.5592	2.5601	2.5596	2.5601	2.5596	2.5587	2.5580
14	70	2.7559	2.7565	2.7560	2.7562	2.7560	2.7569	2.7564	2.7571	2.7564	2.7555	2.7548
15	75	2.9528	2.9534	2.9529	2.9531	2.9529	2.9538	2.9533	2.9540	2.9533	2.9524	2.9517
16	80	3.1496	3.1502	3.1497	3.1500	3.1497	3.1506	3.1501	3.1508	3.1501	3.1492	3.1485
17	85	3.3465	3.3472	3.3466	3.3469	3.3466	3.3476	3.3470	3.3479	3.3470	3.3460	3.3451
18	90	3.5433	3.5440	3.5434	3.5437	3.5434	3.5444	3.5438	3.5447	3.5438	3.5428	3.5419
19	95	3.7402	3.7409	3.7403	3.7406	3.7403	3.7413	3.7407	3.7416	3.7407	3.7397	3.7388
20	100	3.9370	3.9377	3.9371	3.9374	3.9371	3.9381	3.9375	3.9384	3.9375	9.3965	3.9356
21	105	4.1339	4.1346	4.1340	4.1343	4.1340	4.1350	4.1344	4.1358	4.1349	4.1334	4.1325
22	110	4.3307	4.3314	4.3308	4.3311	4.3308	4.3318	4.3312	4.3326	4.3317	4.3302	4.3293
24	120	4.7244	4.7251	4.7245	4.7248	4.7245	4.7255	4.7249	4.7263	4.7254	4.7239	4.7230
26	130	5.1181	5.1189	5.1182	5.1186	5.1182	5.1194	5.1187	5.1203	5.1193	5.1175	5.1165
28	140	5.5118	5.5126	5.5119			5.5131	5.5124	5.5140	5.5130	5.5112	5.5102
30	150	5.9055	5.9063	5.9056			5.9071	5.9061	5.9083	5.9073	5.9049	5.9039
32	160	6.2992	6.3000	6.2993	6.2997	6.2993	6.3008	6.2998	6.3020	6.3010	6.2986	6.2976

Table 244-1-3 SHAFT DIAMETER LIMITS FOR GRADE 00 AND QUIET BEARINGS - Continued

Bore Code			Shaft Diameter Limits[2] (inches)									
			Shaft Rotating								Shaft Stationary[1]	
	Nominal		Ball		Quiet		Cylindrical		Spherical			
Bore Code	**MM**	**Inch**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
34	170	6.6929	6.6937	6.6930			6.6945	6.6935	6.6957	6.6957	6.6923	6.6913
36	180	7.0866	7.0874	7.0867			7.0882	7.0872	7.0894	7.0884	7.0860	7.0850
38	190	7.4803	7.4813	7.4805			7.4821	7.4809	7.4835	7.4823	7.4797	7.4785
40	200	7.8740	7.8750	7.8742			7.8758	7.8746	7.8772	7.8760	7.8734	7.8722
44	220	8.6614							8.6646	8.6634	8.6608	8.6596
48	240	9.4488							9.4520	9.4508	9.4482	9.4470
52	260	10.2362							10.2396	10.2384	10.2355	10.2343
56	280	11.0236							11.0270	11.0258	11.0229	11.0277
60	300	11.8110							11.8157	11.8145	11.8103	11.8091
64	320	12.5984							12.6043	12.6029	12.5977	12.5963

NOTES:
1. Does not apply to quiet bearings.
2. These tolerances apply to all points along the length of the bearing seat.

244-1.5.2.2 Bearings packed in grease that have been on the shelf for some time may at first resist hand rotation. This resistance has resulted in the disposal of many good bearings that were reported to be defective for having dried grease or flat balls. This resistance to rotation is common and will clear up as the grease is worked. Work the bearing by hand for several minutes. Allow it to sit a short time and then check it again. If it has not cleared up, a problem may indeed exist.

244-1.5.2.3 If the bearing had been preserved in grease and the application uses oil, remove the grease as indicated in paragraph 244-1.5.4.

244-1.5.3 CLEANING. Do not clean bearings as a routine procedure, since foreign matter can easily enter a bearing. Ordinary airborne dust, paint chips, metal filings, brush bristles, cigarette ash, and other foreign objects can severely damage a bearing. Double-seal and double-shield bearings cannot be cleaned unless manufactured with removable closures. Normal practice is to inspect these bearings and accept or reject them on the basis of rotational smoothness and appearance. Single-seal and single-shield bearings can be cleaned satisfactorily by the methods outlined here if cleaning operations are repeated enough to ensure that all contaminant has been removed.

244-1.5.4 NEW BEARINGS. If a new bearing is exposed to any contaminant or grease must be removed, clean the bearing as follows:

Table 244-1-4 COMMON BALL AND CYLINDRICAL ROLLER BEARING OUTSIDE DIAMETERS CROSS REFERENCED TO MANUFACTURERS' BASIC BEARING NUMBERS

Basic Bearing Numbers					Nominal Bearing OD (millimeters)
Extremely Light Series	**Extra light Series**	**Light Series**	**Medium Series**	**Heavy Series**	
			34		16
		36	35		19
900	38	37			22
901					24
	100	39			26
902	101				28
903		200			30
	102	201			32
	103	202	300		35
904			301	400	37
		203			40
905	104		302	401	42
906	105	204	303		47
		205	304	402	52
907	106				55
908	107	206	305	403	62
909	108				68
910		207	306	404	72
	109				75
911	110	208	307	405	80
912		209			85

Table 244-1-4 COMMON BALL AND CYLINDRICAL ROLLER BEARING OUTSIDE DIAMETERS CROSS REFERENCED TO MANUFACTURERS' BASIC BEARING NUMBERS - Continued

Basic Bearing Numbers					Nominal Bearing OD (millimeters)
Extremely Light Series	**Extra light Series**	**Light Series**	**Medium Series**	**Heavy Series**	
913	111	210	308	406	90
	112				95
914	113	211	309	407	100
916	114	212	310	408	110
	115				115
917		213	311	409	120
918	116	214			125
919	117	215	312	410	130
920	118	216	313	411	140
921	119				145
922	120	217	314	412	150
	121	218	315	413	160
	122	219	316		170
926	124	220	317	414	180
928		221	318	415	190
	126	222	319	200	200
930	128			417	210
		224	320		215
932					220
	130		321	418	225
934	132	226			230
			322	419	240
936		228		420	250
938	134		324	421	260
		230			270
940	136		326	422	280
	138	232			290
			328		300
	140	234		424	310
		236	330		320
		238	332	426	340
		240	334	428	360
			336	430	380
			338	432	400
			340	434	420

1. Secure a clean, dry container and fill it with clean, filtered MIL-L-17331, **Lubricating Oil, Steam Turbine and Gear, Moderate Service, Military Symbol 2190 TEP**.

2. Heat the oil to 60° + 5°C (140° + 10°F).

3. Immerse the bearing in the oil and rotate and agitate it until all the dirt or grease is washed out. Do not use a brush.
4. Repeat step 3 in a second container of clean, filtered oil.

Table 244-1-5 HOUSING BORE LIMITS FOR GRADE 00 AND QUIET BEARINGS

Bearing Outside Diameter		Housing Bore Limits[5] (inches)							
		Housing Stationary			Housing Rotating			Special[4]	
Nominal		All[1]	Quiet		Ball	Cylindrical Spherical		Cylindrical Spherical	
MM	Inch	Max	Max	Min	Min	Min	Max	Min	Max
16	0.6299	0.6303			0.6292	0.6291	0.6295	0.6295	0.6299
19	0.7480	0.7485			0.7472	0.7470	0.7475	0.7475	0.7480
22	0.8661	0.8666			0.8653	0.8651	0.8656	0.8656	0.8661
24	0.9449	0.9454			0.9441	0.9439	0.9444	0.9444	0.9449
26	1.0236	1.0241			1.0228	1.0226	1.0231	1.0231	1.0236
28	1.1024	1.1029	1.1029	1.1026	1.1016	1.1014	1.1019	1.1019	1.1024
30	1.1811	1.1816	1.1816	1.1813	1.1803	1.1801	1.1806	1.1806	1.1811
32	1.2587	1.2604			1.2588	1.2587	1.2593	1.2593	1.2599
35	1.3780	1.3786	1.3785	1.3782	1.3770	1.3769	1.3775	1.3775	1.3781
37	1,4567	1.4573	1.4572	1.4569	1.4557	1.4556	1.4562	1.4562	1.4568
40	1.5748	1.5754	1.5753	1.5750	1.5738	1.5737	1.5743	1.5743	1.5749
42	1.6535	1.6541	1.6540	1.6537	1.6525	1.6524	1.6530	1.6530	1.6536
47	1.8504	1.8510	1.8509	1.8506	1.8494	1.8493	1.8499	1.8499	1.8505
52	2.0472	2.0479	2.0479	2.0475	2.0460	2.0459	2.0466	2.0466	2.0473
55	2.1654	2.1661			2.1642	2.1641	2.1648	2.1648	2.1655
62	2.4409	2.4416	2.4416	2.4412	2.4397	2.4396	1.4403	2.4403	2.4410
68	2.6772	2.6779			2.6760	2.6759	2.6766	2.6766	2.6773
72	2.8346	2.8353	2.8353	2.8349	2.8334	2.8333	2.8340	2.8340	2.8347
75	2.9528	2.9535	2.9535	2.9531	2.9516	2.9515	2.9522	2.9522	2.9529
80	3.1496	3.1503	3.1503	3.1499	3.1484	3.1483	3.1490	3.1490	3.1497
85	3.3465	3.3474	3.3474	3.3469	3.3451	3.3449	3.3458	3.3458	3.3467
90	3.5433	3.5442	3.5442	3.5437	3.5419	3.5417	3.5426	3.5426	3.5435
95	3.7402	3.7411			3.7388	3.7386	3.7395	3.7395	3.7404
100	3.9370	3.9379	3.9379	3.9374	3.9356	3.9354	3.9363	3.9363	3.9372
110	4.3307	4.3316	4.3316	4.3311	4.3293	4.3291	4.3300	4.3300	4.3309
115	4.5276	4.5285			4.5262	4.5260	4.5269	4.5269	4.5278
120	4.7244	4.7253	4.7253	4.7248	4.7230	4.7228	4.7237	4.7237	4.7246
125	4.9213	4.9233			4.9197	4.9194	4.9204	4.9205	4.9215
130	5.1181	5.1191	5.1191	5.1186	5.1165	5.1162	5.1172	5.1173	5.1183
140	5.5118	5.5128	5.5128	5.5123	5.5102	5.5099	5.5109	5.5110	5.5120
145	5.7087	5.7097			5.7071	5.7068	5.7078	5.7079	5.7089
150	5.9055	5.9065	5.9065	5.9060	5.9639	5.9036	5.9046	5.9047	5.9057

Table 244-1-5 HOUSING BORE LIMITS FOR GRADE 00 AND QUIET BEARINGS - Continued

Bearing Outside Diameter		Housing Bore Limits[5] (inches)							
Diameter		Housing Stationary			Housing Rotating			Special[4]	
Nominal		All[1]	Quiet		Ball	Cylindrical Spherical		Cylindrical Spherical	
MM	Inch	Max	Max	Min	Min	Min	Max	Min	Max
160	6.2992	6.3002	6.3002	6.2997	6.2976	6.2973	6.2983	6.2984	6.2994
170	6.6929	6.6939	6.6938	6.6934	6.6913	6.6910	6.6920	6.6921	6.6931
180	7.0866	7.0876	7.0875	7.0871	7.0850	7.0847	7.0857	7.0858	7.0868
190	7.4803	7.4815	7.4814	7.4809	7.4785	7.4781	7.4793	7.4793	7.4805
200	7.8740	7.8752	7.8751	7.8746	7.8722	7.8718	7.8730	7.8730	7.8742
210	8.2677	8.2689			8.2659	8.2655	8.2667	8.2667	8.2679
215	8.4646	8.4658	8.4657	8.4652	8.4628	8.4624	8.4636	8.4636	8.4648
220	8.6614	8.6626			8.6596	8.6592	8.6604	8.6604	8.6616
225	8.8583	8.8595	8.8594	8.8589	8.8565	8.8561	8.8573	8.8573	8.8585
230	9.0551	9.0563			9.0533	9.0529	9.0541	9.0541	9.0553
240	9.4488	9.4500	9.4499	9.4494	9.4470	9.4466	9.4478	9.4478	9.4490
250	9.8425	9.8437			9.8407	9.8403	9.8415	9.8415	9.8427
260	10.2362	10.2374	10.2373	10.2368	10.2342	10.2339	10.2351	10.2352	10.2364
270	10.6299	10.6311			10.6279	10.6276	10.6288	10.6289	10.6301
280	11.0236	11.0248	11.0247	11.0242	11.0216	11.0213	11.0225	11.0226	11.0238
290	11.4173	11.4185	11.4184	11.4179	11.4153	11.4150	11.4162	11.4163	11.4175
300	11.8110	11.8122			11.8090	11.8087	11.8099	11.8100	11.8112
310	12.2047	12.2059			12.2027	12.2024	12.2036	12.2037	12.2049
320	12.5984	12.5998			12.5962	12.5958	12.5972	12.5972	12.5986
340	13.3858	13.3872			13.3836	13.3832	13.3846	13.3846	13.3860
360	14.1732	14.1746			14.1710	14.1706	14.1720	14.1720	14.1734
370	14.5669	14.5683			14.5647	14.5643	14.5657	14.5657	14.5671
380	14.9606	14.9620			14.9584	14.9580	14.9594	14.9594	14.9608
400	15.7480	15.7494			15.7458	15.7454	15.7468	15.7468	15.7482
420	16.5354	16.5370			16.5329	16.5326	16.5342	16.5342	16.5358
440	17.3228	17.3244			17.3203	17.3200	17.3216	17.3216	17.3232
460	18.1102	18.1118			18.1077	18.1074	18.1090	18.1090	18.1106
480	18.8976	18.8992			18.8951	18.8948	18.8964	18.8964	18.8980
500	19.6850	19.6886			19.6825	19.6822	19.6838	19.6838	19.6854
540	21.2598	21.2615			21.2571	21.2569	21.2586	21.2584	21.2601
580	22.8346	22.8363			22.8319	22.8317	22.8334	22.8332	22.8349

Table 244-1-5 HOUSING BORE LIMITS FOR GRADE 00 AND QUIET BEARINGS - Continued

Bearing Outside Diameter		Housing Bore Limits[5] (inches)							
		Housing Stationary			Housing Rotating			Special[4]	
Nominal		All[1]	Quiet		Ball	Cylindrical Spherical		Cylindrical Spherical	
MM	Inch	Max	Max	Min	Min	Min	Max	Min	Max

NOTES:
1. Does not apply to quiet bearings.
2. Minimum housing bore limit equal to bearing nominal OD.
3. Maximum housing bore limit equal to bearing nominal OD.
4. For use in applications subject to continual vibration and shock with temporary unloading.
5. These tolerances apply to all points along the length of the bearing seat.

Table 244-1-6 SHAFT DIAMETER AND HOUSING BORE LIMITS FOR TAPERED ROLLER BEARINGS

Nominal Bearing Bore (inches)		Diameter Limits (0.0001 inch)			
		Shaft			
		Rotating		Stationary	
Over	**Incl.**	**Max**	**Min**	**Max**	**Min**
0	3	+15	+10	0	-5
3	12	+25	+15	0	-10
12	24	+50	+30	0	-20
Nominal Bearing OD (inches)		**Housing**			
		Stationary		**Rotating**	
Over	**Incl.**	**Max**	**Min**	**Max**	**Min**
0	3	+10	+20	-15	-5
3	12	+10	+20	-20	-10
12	24	+20	+40	-30	-10

5. When clean, remove the bearing. Cover it and allow the excess oil to drain off. Do not wipe. Do not spin. Do not use compressed air. Handle the bearing with lint-free gloves or cloths.

6. Immediately after, place the bearing in a plastic bag or wrap it in aluminum foil. If the bearing is not to be mounted, rebox, properly identify, and store it.

244-1.5.5 USED BEARINGS. Thoroughly consider the justification for cleaning and reusing a bearing. Such procedures are usually feasible only on larger, more expensive bearings or in emergencies. Before disassembly, determine if replacement bearings are available. When reuse of bearings is considered, dismounting procedures demand a high level of care to avoid bearing damage.

244-1.5.5.1 Scrupulously clean used bearings that are being considered for reuse. The following cleaning sequence is recommended. Some of the cleaning materials listed are unsuitable for use at the ship level because they are toxic and are restricted to use in designated areas. Proper stowage, handling, use, and disposal of all consumable materials can be found in **NSTM Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables.** Use of hot oil for all cleaning operations is considered adequate in such cases.

244-1.5.6 Clean and preserve used bearings as follows:

⚠ WARNING

Solvent cleaners can cause serious illness or death if not properly handled. Determine the applicable safety precautions for the particular solvent being used and follow them. These solvents are not permitted aboard submarines.

1. **Soak.** Soaking softens greases, preservative compounds, carbon residues, and foreign matter. Periodic agitation during the soak will increase its efficiency. The soak time depends on the type and amount of contamination and the effectiveness of the soak material. Use a clean, dry container. Any of the following soak materials are recommended:
   a. 2190 TEP oil at 82° ± 5°C (180° ± 10°F) for a minimum of 1 hour.

b. P-D-680, type II, **Dry Cleaning and Degreasing Solvent,**NSN 6850-00-274-5421, at room temperature for several hours

c. O-T-620, 1,1,1 **- Trichloroethane, Technical, Inhibited, (Methyl Chloroform)** NSN 6810-00-664-0388, or MIL-C-81302, type II, **Cleaning Compound, Solvent, Trichlorotrifluoroethane,** NSN 6850-00-681-5688, at room temperature for a maximum of 1 hour.

2. **Rinse.** Immediately after every soak or wash step, rinse the bearing in oil or solvent. This is extremely important when the solvents of subparagraph c are used, since the clean surfaces will have no oil film and will corrode rapidly. Agitate and rotate the bearing to dislodge particles trapped in the retainer pockets. Acceptable rinse materials are as follows:

   a. 2190 TEP oil at 60° ± 5°C (140° ± 10°F) for 5 minutes.

   b. Dry cleaning solvent (P-D-680, type II) at room temperature for 5 minutes.

3. **Ultrasonic Cleaner.** An ultrasonic cleaner will greatly facilitate the removal of difficult residues and trapped deposits between the balls or rollers and cage. Use the ultrasonic cleaner only as a final wash after the bulk of the matter has been removed in steps 1 and 2. Use only cleaning solvents. Proper procedures for using waterbase detergents on bearings have not been established. Operate the ultrasonic cleaner in accordance with existing instructions. Immediately after ultrasonic cleaning, rinse in dry cleaning solvent (P-D-680, type II) at room temperature for 5 minutes.

4. **Preservation.** Repeat the preceding steps as required. When the bearing has been satisfactorily cleaned, inspect it to determine if it is reusable. Rinse and preserve acceptable bearings as previously specified for new bearings.

244-1.6 CARE OF MOUNTED BEARINGS

244-1.6.1 GENERAL. The greatest threats to mounted bearings are brinelling of the races caused by poor handling, false brinelling of the races caused by wearing away of material due to vibratory motion during storage or transport, and corrosion due to a lack of preservative compound on bearing surfaces. All these conditions can be avoided with due care.

244-1.6.2 HANDLING AND STORAGE. Abusive handling and improper storage of assembled machinery can negate all previous precautions taken to prevent premature bearing failure.

244-1.6.2.1 When machinery is to be stored for prolonged periods, select a foundation isolated from other vibration-producing machinery. For grease bearings, hand-coat the bearings to limit corrosion. For oil applications where storage will be for a prolonged period, fill the bearing chamber with a rust preventive oil. To keep bearing surfaces wet, rotate the shaft by hand every several months. If the unit is directly exposed to the weather, rotate the shaft once a month.

244-1.6.2.2 If partial assemblies with mounted bearings (such as rotors) are stored, coat the bearings with a preservative and securely wrap with plastic or foil. Do not use cloth wrapping. When handling heavy assembled machinery, always use mechanical lifting equipment. Fasten suspension lines only to the lifting lugs provided. Any other attaching point may distort the housing or bend the shaft, resulting in bearing misalignment. Never attach a suspension line to the shaft extension.

244-1.7 MAINTENANCE

244-1.7.1 GENERAL. Bearings are an integral part of the assembly, making it impossible to observe their operation. Do not routinely disassemble machinery just to inspect the bearings or lubricant. The following methods have been established to help assess mounted bearing condition.

NOTE

Perform shipboard maintenance in accordance with Maintenance Requirement Cards (MRC) where installed.

244-1.7.2 PREOPERATIONAL INSPECTION. A considerable amount of time can be saved by performing the following preoperational checks:

a. Review the unit's history. For grease-lubricated relubricable bearings, if the unit has been shut down or in storage for over 1 year, remove the end caps to check the grease. If the end caps cannot be removed without major disassembly and, if available records indicate that the bearings have not been lubricated in the past year, lubricate the unit. Greasing procedures applicable to the equipment design can be found in paragraph 244-1.7.7. Also, experience has shown that in units with shafts installed or stowed vertically and using unshielded bearings, the grease may move to a point below the bearing and will not provide lubrication on startup.

b. Rotate the shaft by hand. The shaft shall turn freely without binding. Locate and eliminate the cause of any abnormal resistance to rotation.

c. On units with shaft extensions, check the shaft total indicated runout (TIR) at the extreme end.

d. Check the overall appearance of the unit for indications of bumping or dropping. Severe bearing misalignment can result from abusive handling.

e. Make sure that all hardware is tight.

f. When shafts or housings have been reworked, verify the assembled shaft axial end play, if listed on equipment drawings. This can be done by pushing the shaft from one axial extreme to the other while measuring shaft axial movement with a dial indicator. The maximum force to move the shaft shall not exceed 1-1/2 times the rotating assembly weight. Investigate large excursions from the specified values.

g. Whenever possible, dynamically balance rotating parts in accordance with the applicable specification or technical manual. An in-place balance of the assembled unit may be required.

244-1.7.3 IN-SERVICE INSPECTION. The length of the run-in period for new bearings may vary considerably, but 24 hours is usually sufficient. Major difficulties will almost always appear during this period. Monitor the bearing temperature, noise, and vibration. When the load can be varied, run the unit under minimum load for several hours and then gradually increase to full load at hourly increments. Rolling-element bearings will normally have an extremely long service life if properly designed for the application, correctly installed, and maintained as required. Because of this, the actual time of bearing installation is not usually well known unless accurate records are maintained. Periodic casual inspection of bearing performance is therefore desirable. A daily casual inspection for noise, vibration, and temperature will tend to reduce unexpected failures.

244-1.7.4 TEMPERATURE. All bearings generate heat during operation. Bearing temperature is a function of load, speed, lubricant, and outside heat sources. Properly designed bearing systems operate at steady temperature levels. Such levels should be known from past experience for each machine. Factory test data, if listed on the master drawing, will indicate the bearing temperature rise under the original test conditions. Temperature fluctuations in the safe operating range are to be expected as the grease alternately lumps into the races and channels again, or as the load fluctuates. On the other hand, sharp unexpected temperature increases usually indicate trouble. Regardless of the cause, this symptom is usually self-perpetuating, resulting in rapid failure. Bearing temperature can be routinely checked by placing a hand on the housing. The hand can usually be held in contact with a surface below 55°C (131°F). Where experience indicates that the operating temperature is above this limit, such a temperature is too high to be estimated by touch. Despite the desirability of measuring the actual bearing temperature, do not insert a liquid-in-glass thermometer into the bearing housing, whether against the bearing or in the grease or oil reservoir. Such a thermometer securely fastened with the bulb embedded in a mound of clay or putty on the external housing surface close to the bearing will usually provide satisfactory temperature measurement. Commercially available temperature-sensitive crayons (such as Tempilstiks or Thermomelt) or tape (such as Temp-Plate) can satisfactorily indicate temperature. If the bearing is inaccessible, take measurements on the housing close to the bearing. Self-indicating bimetallic and gas thermometers common to shipboard use require a significant immersion length and will not accurately record surface temperature. Instruments for measuring surface temperature are commercially available and are usually supplied with tip-sensitive pencil probes. These are ideal for accurately measuring remote bearing temperature. Low operating temperatures are desirable, but 110°C (230°F) has been established as the maximum limit for general bearing applications. If the bearing temperature is unexpectedly high in relation to past experience or if the temperature exceeds the maximum design limit, examination is necessary. Bearing overheating may result from many sources. The most common ones are as follows:

a. If the temperature rises immediately after startup in a grease-bearing application, it is probably because the grease has slumped into the races. Stopping the unit and allowing the grease to cool in the channeled state will usually cure this condition.

b. If the temperature rises immediately after startup in an oil lubrication application, stop the unit and immediately check that the oil level is in accordance with the instruction. If the level is satisfactory, the circulating system may be clogged or inoperative.

c. If the temperature rise occurs immediately after the bearing has been lubricated with grease the cause may be an excessive quantity of grease or the wrong type. To avoid this condition, follow the correct lubrication procedure for both quantity and type. If the bearing is overgreased, remove the drain plug and allow the excess to drain. If the grease is the wrong type, disassemble and clean the bearing.

d. Excessive loading of the bearing. This can be caused by excessive bearing preload, excessive shaft or housing interference, or external bearing overload. These are usually caused by mounting or assembly errors.

e. Error in alignment during mounting

f. Tight-fitting seals.

244-1.7.5 NOISE AND VIBRATION. In shipboard applications, noise is structureborne, airborne, and fluidborne. Noise is caused by vibration. All rolling-element bearings generate vibration. In rotating machinery the amplitude of bearing vibration is a function of bearing quality, seat geometry, and fitup. Electronic equipment can measure the structureborne noise of rotating equipment in noise critical applications. Quiet bearings are usually used in noise-critical applications because they generate low levels of vibration. Instruction manuals on the use of such electronic equipment and the analysis of results have been issued to participating ships and should be consulted. In non-noise-critical applications, a rough vibration check can be made by placing a hand on the machine frame. Unusual noises may be heard by holding the ear to one end of a tool, rod, or pipe the other end of which is held to the machine frame as close to the bearing as possible. Only a soft purring sound should be heard. The experienced listener can learn to recognize this sound by practicing on bearings known to be in good condition. If available, a mechanic's stethoscope would be a more reliable tool. Some typical sounds and their causes are as follows:

a. **Squeaking Noise.** Inadequate lubrication or insufficient load (preload)

b. **Metallic Tone.** Insufficient internal bearing clearance caused by excessive shaft or housing interferences, or axial preloading caused by improper adjustment or inadequate lubrication

c. **Smooth, Clear Tone.** Marks in the stationary raceway caused by brinelling. When the sound intensity varies regularly with each revolution, the rotating ring has been brinelled.

d. **Intermittent Noise.** Usually unique to ball bearings and indicates a damaged ball

e. **Crunching Noise.** Presence of dirt. Clean the bearing immediately.

NOTE

The listening method of detecting trouble is comparative. It should not be the basis for tearing down a piece of equipment unless the operator has considerable experience.

244-1.7.6 LUBRICATION. The bearing lubricant is chosen during equipment design, and an equivalent type must be used during maintenance. As a rule, all rolling-element bearings may be lubricated with oil. The use of grease is limited by operating speeds, loads, and temperature. Rolling-element bearing lubrication serves the following primary functions:

a. Prevents metal-to-metal contact between the races and rolling elements that is not true rolling

b. Lubricates the sliding contact that exists between the cage and other bearing parts

c. Lubricates the sliding contact between the rollers and guiding elements in roller bearings

d. Protects the highly finished surfaces of rolling elements and races from corrosion

e. In grease applications, helps seal against the entry of foreign matter

f. In oil applications, provides cooling by dissipating heat.

244-1.7.7 GREASE LUBRICATION. For applications involving moderate speeds and temperatures, the simplicity and reliability of grease lubrication is desirable. Open, single-shield, and single-seal bearings as mounted usually require the periodic addition of grease and are termed relubricable bearings. Double-shield and double-seal bearings are permanently lubricated at the factory and require no further grease. Such bearings are termed prelubricated bearings. The service life of prelubricated bearings is limited to the effective life of the original grease charge. Prelubricated bearings are usually restricted to applications with favorable grease life characteristics. Electrical machines furnished with prelubricated bearings can be recognized by the absence of grease fittings or provision for attaching grease fittings and by the attached warning plate stating **DO NOT LUBRICATE.** Relubricable bearings in new machines are properly packed with grease when they leave the factory. The frequency with which grease must be added depends on the service of the machine and the tightness of the housing seals. Avoid using excessive quantities of grease because it results in a rapid temperature increase to excessive levels. Add grease only when required.

244-1.7.7.1 Grease Addition. Only the grease that is immediately next to and in contact with the bearing takes part in lubrication. The grease in this location may gradually stop lubricating because the oil is depleted, leaving just the thickener. The grease farther removed from the bearing, however, may still be in good condition. It is therefore desirable to add a small amount of grease close to the bearing at specified intervals. The preferred method of adding grease is to open the housing so that the bearing and old grease can be examined and new grease can be placed directly in and next to the bearing. For Navy equipment where extensive disassembly would be required to repack the bearing with grease, the bearings are designed so that fresh grease can be added to the bearing housing by a grease cup, without the need for disassembly. Housing designs vary considerably, making relubrication with a grease cup something of an art. Be careful not to overgrease the bearings. The following procedure is recommended:

1. Select the proper grease cup and clean it thoroughly. Select the correct grease and, using a clean spatula, fill the cup. Screw the cup together, and squeeze out a ribbon of grease until clean grease emerges.
2. Secure the machine. Tag it **OUT OF SERVICE.**Disassemble it as required. Wipe all dirt from the outside of the grease fill-and-vent plugs.
3. Remove the vent plug and make sure that the passage is open by probing it with a clean screw driver, stiff wire, or similar item. Old grease may be forced out the vent. Note the condition of the displaced grease. Dark grease indicates either the onset of oxidation or the presence of dirt. Grease containing metallic particles and dirt indicates trouble. Rub a little grease between the fingers. If water is present, it will form droplets. Particles will be felt easily. When contaminants are present, corrective action is necessary.
4. Remove the pipe plug from the grease supply passage. Observe the condition of the grease in the pipe. If acceptable, proceed. If unacceptable, remove the grease pipe, if so designed, clean it, pack it full of the correct grease, and reinstall it. If the pipe is empty, remove it, clean it, fill it with the correct grease, and reinstall it. If the grease in the supply passage is unacceptable and the pipe is not removable, remove the bearing end cap or end bell and hand-pack the bearing.
5. Mount the grease cup on the equipment. Fill the grease cup.
6. Screw down on the grease cup as far as it will go. If grease is drawn into the cup as the cap is unscrewed, the preferred action is as follows:
   a. Screw the cap back into the cup as far as it will go to force the grease back into the lubrication supply passage.
   b. Remove the cup from the equipment.
   c. If relubrication is complete, install the supply passage pipe plug and operate the equipment as recommended.
   d. If relubrication is not complete, remove the cap from the cup and reinstall the cup on the equipment.
   e. Load the cup with grease and screw down on the cap as far as it will go, as previously recommended.
   f Repeat these steps as required until relubrication is complete. An alternate procedure to the above is to drill a small hole in the cap after the cup is removed from the equipment. The hole diameter shouldn’t be larger than 1/16th of an inch. The cap must be removed from the cup prior to drilling. The cap must be thoroughly cleaned after drilling to remove all metal chips. Any burrs around the drilled hole must be removed prior to cleaning. The operator must hold a finger over the hole to prevent grease from escaping while screwing in the cap.

7. Remove the grease cup and install the supply passage pipe plug. Start the machine and allow it to run for 30 minutes. Replace the vent pipe plug.

NOTE

Grease may or may not flow out the vent, depending on the housing design. If a grease gun is to be used, follow the previously mentioned steps. Before adding grease determine the amount of grease per pump of the gun and the grease capacity of the bearing housing. Do not add more grease than needed to fill half of the housing.

NOTE

Never lubricate electrical machinery with a grease gun. If grease gun fittings are found on electrical machinery, remove them and install a suitable grease cup fitting and pipe plug.

244-1.7.7.2 Grease Replacement. Replace all old grease in the bearing housings when the machinery is disassembled for any reason. Remove those bearing caps or covers that permit observation of bearing and lubricant. Depending on the conditions found, one of the following actions may be necessary:

a. If the grease in the bearing is still good, replace only the grease in the housing.
   1. Wrap the bearing in clean, lint-free material.
   2. Scrape the old grease from all accessible portions of the housing. Be careful not to introduce dirt into the housing or the bearing. Do not wipe.
   3. Flush out the bearing cap or cover it with clean, warm 2190 TEP oil. Apply a light coat of grease to the unpainted bearing housing surfaces.

NOTE

Do not flush with oil if the oil could leak into the windings of electrical machinery. It may be impractical to flush out the complete housing without removing the bearing.

   4. Drain well.
   5. In horizontal applications with an open bearing, pack the housing on both sides of the bearing 1/2 full of grease.
   6. In horizontal applications with a single-seal or single-shield bearing, pack the housing opposite the seal or shield 1/2 full.
   7. In vertical applications with an open bearing, or a single-seal or single-shield on top, pack the housing below the bearing 3/4 full.
   8. In vertical applications with a single-seal or single-shield on the bottom of the bearing, the amount of grease above the bearing is critical. Limit the housing pack above the bearing to an amount that will lie

on the stationary bearing ring (1/3 to 1/2 full). Do not overpack or allow grease to slump into bearing. The grease will bleed into the bearing during normal operation.

9. In all cases lightly coat the bearing with grease.
10. Pack the entire length of the grease inlet passage and inlet pipe with clean grease.
11. Reassemble the bearing.

b. If the grease bearing is sticky or rancid, contains dirt or foreign matter, or is generally deteriorated, wash out the bearing in accordance with the procedures in paragraph 244-1.5.5. If the bearing shows excessive wear or if any parts are damaged, replace the bearing. Otherwise, pack the bearing itself with clean grease per paragraph 244-1.8.5.9. Prepare the bearing housing and pack the grease in the housing in accordance with the procedure in paragraph 244-1.7.7.2.a. Observe proper replacement procedures.

244-1.7.7.3 Preferred Greases. Preferred Navy bearing greases for shipboard auxiliary machinery are as follows:

a. Bearings operating below 110°C (230°F) in non-noise-critical applications use DOD-G-24508, **Grease, High Performance, Multipurpose,** available in 1-pound cans, NSN 9150-00-149-1593.

b. Bearings operating above 110°C (230°F) in non-noise-critical applications, except electric motor bearings, use MIL-L-15719, **Lubricating Grease (High-Temperature, Electric Motor, Ball and Roller Bearings),** available in 8-ounce tubes, NSN 9150-00-257-5358.

c. Quiet bearings for noise-critical applications use DOD-G-24508, grease available in 1-pound cans, NSN 9150-00-149-1593.

d. Where specifically approved for the application, use MIL-G-81322, **Grease, Aircraft, General Purpose, Wide Temperature Range,** or DOD-G-24508 available in the following:
   1. MIL-G-81322, 8-ounce tube, NSN 9150-00-181-7724.
   2. DOD-G-24508, 8-ounce tube, NSN 9150-00-149-1592.

e. Roller bearings in surface ship control surface systems use MIL-G-24139, **Grease, Multipurpose, Water Resistant,** available in 5-pound cans, NSN 9150-00-180-6382.

NOTE

Other size containers may be available under other NSN's. If a specified grease is obsolete, consult **NSTM Chapter 262, Lubricating Oils, Greases, Hydraulic Fluids, and Lubricating Systems**, for approved substitute.

244-1.7.8 OIL LUBRICATION. Oil lubrication is desirable where other components (such as gears) are oil lubricated or for high-temperature or high-speed applications. Bearing housings with self-contained oil bath lubrication or with an oil sump that is filled to a given level usually have an oil gage or sight window. Add oil whenever the oil level drops below the lower limit. The interval between complete oil changes depends on operating speed, temperature, and contamination. When not specified, change oil semiannually.

244-1.7.8.1 Oil Replacement. Drain oil while it is warm into a clean container. Compare a small sample with new, unused oil. If cloudy, water is undoubtedly present. Allow a darker and thicker sample to stand to check for sediment. If the oil contains metallic particles, determine the source and correct the problem. Place a magnet against the side of a glass containing the drained oil and let it sit for several hours. Then check to see if metallic particles have collected near the magnet. If so, such particles most likely came from wear. Investigate and eliminate the source.

244-1.7.8.2 Quiet Bearing Lubrication. Quiet bearing lubricating oil should be 2190 TEP, which is available in the following quantities:

a. 2190 TEP, 5-gallon pail, NSN 9150-00-235-9061

b. 2190 TEP, 55-gallon drum, NSN 9150-00-235-9062.

NOTE

Other size containers may be available under other NSN's.

1.8 BEARING REPLACEMENT

244-1.8.1 PRELIMINARY INSPECTION. When equipment using rolling-element bearings requires repair, conduct an in-place inspection. The nature of the casualty can frequently be determined, and this may eliminate unnecessary disassembly. Check for the following:

a. Freedom of rotation. If binding occurs, check close running clearances for noncontact. In coupled units remove the coupling and rotate each unit independently.

b. Excessive heating of the bearings. Eliminate other heat sources.

c. Excessive bearing noise. Eliminate other noise sources.

d. Loose or broken bolts or parts. Check the foundation.

e. Distorted bearing supports, cracked or bent bearing caps, and loose balance rings, if used.

f. Loose or inaccurate coupling alignment, if used.

g. Coastdown time. Compare with previous experience. Short times indicate high torque. Listen to the unit during coastdown. It may pass through resonances that may pinpoint a faulty component.

244-1.8.2 WORK AREA AND TOOLS. The average shop fails to realize the necessity for the highest degree of cleanliness to prevent bearing contamination. An indication of the conditions required of the bearing manufacturer to ensure the cleanliness of packaged bearings is as follows:

a. The air entering the processing space shall be filtered and air conditioned.

b. The floor, walls, and ceiling shall be dust-free.

c. Entry to the area shall be restricted by means of double doors.

d. The air in the room shall contain no more than 100 particles, 5 microns (0.0002 inch) or larger, per cubic foot of air.

e. All personnel shall wear lint-free coats, head and shoe covers, and lint-free gloves.

f. Nothing extraneous to the operation (food, drink, cigarettes) shall be brought into the area.

244-1.8.2.1 Cleanliness. Positive cleanliness control shall be exercised. Although establishing surgically clean white room facilities may be unfeasible, the following conditions should be adhered to:

a. In any work area make cleanliness the rule, orderliness a habit.

b. Handle rolling-element bearings in a clean, dry location.

c. Avoid areas in which turning, grinding, sandblasting, or blowing is carried on.

d. The work area shall be away from any machines that create dust-laden air or disturbing vibrations.

e. A clean workbench with a smooth metal top should be available - dirt and small metal chips cling easily to wooden bench tops.

f. When it is impossible to move the assembled equipment to a shop, remove the partial assembly that requires bearing work to a suitable location.

g. If even this is impossible, sweep out and vacuum the assembly area in the machinery space before beginning reassembly.

h. Ready all components and tools so that assembly can proceed without delay.

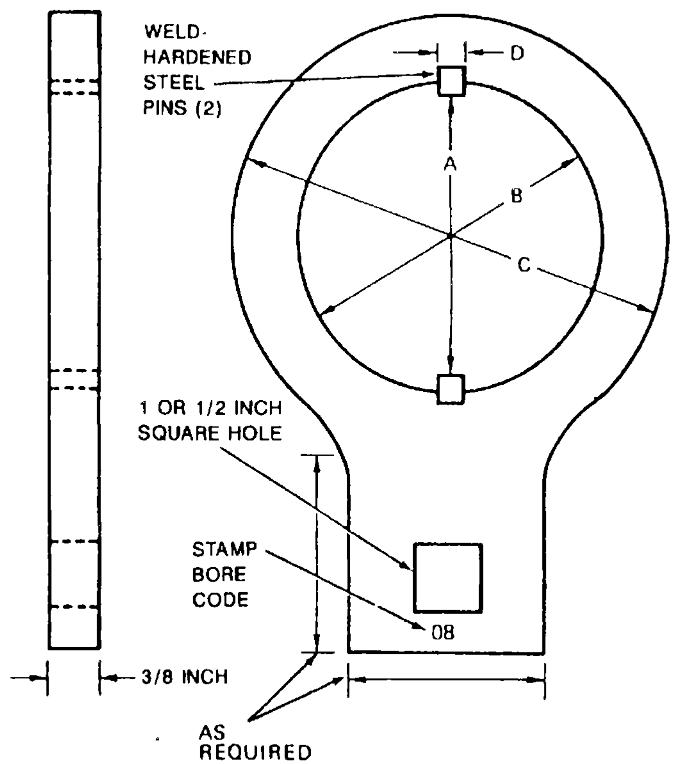
i. Redirect the airflow from the ventilation ducts and shut down unneeded equipment that will circulate dirt and dust.

244-1.8.2.2 Tools. The tools that will be needed are largely determined by the magnitude of the job and should be assembled before beginning work. Measuring instruments shall be stabilized at the same temperature as the parts requiring measurement. The following basic tools and equipment are recommended for bearing replacement work:

a. **Arbor Press.** This should be of sufficient size to accommodate the assemblies with which you are working. It should be kept clean and in good repair. The face of the ram shall be smooth and perfectly square with its axis. The press should operate smoothly and with accurate control.

b. **Mounting Tubes.** These are short lengths of steel tubing of various diameters for use with different sizes of bearings. The inside diameters of the tubes should be slightly larger than the bore of the bearing inner ring. Outside diameters should be slightly smaller than the OD of the bearing outer ring. Faces should be absolutely square and parallel, and the length should be such as to clear any shaft used.

c. **Hand Tools.** Hammers and drifts should not be of soft, flaky material such as brass, bronze, or aluminum. A weighted-head hammer with composition or leather ends and a soft, cold-rolled steel drift are preferred. Bearing locknut spanner wrenches are standard for smaller sizes. An efficient locknut spanner (Figure 244-1-3) can be manufactured in any shop.



DIMENSIONS (INCHES)

BORE CODE	A (MIN)	B (MIN)	C (NOM)	D (MAX)
08	2-3/32	2-5/16	3-5/16	3/16
09	2-3/8	2-19/32	3-5/8	3/16
10	2-17/32	2-3/4	3-3/4	3/16
11	2-3/4	3-1/32	4-1/16	3/16
12	2-15/16	3-7/32	4-1/4	3/16
13	3-5/32	3-7/16	4-1/2	3/16
14	3-13/32	3-11/16	4-3/4	3/16
15	3-21/32	3-15/16	5	5/16
16	3-15/16	4-7/32	5-3/8	5/16
17	4-1/8	4-15/32	5-3/4	5/16
18	4-3/8	4-23/32	6	5/16
19	4-21/32	5	6-1/4	5/16
20	4-29/32	5-1/4	6-1/2	5/16
21	5-3/32	5-1/2	7	7/16
22	5-3/8	5-25/32	7-1/2	7/16

MATL: HARDENED 4340 OR EQUAL

APPLICATION METHOD

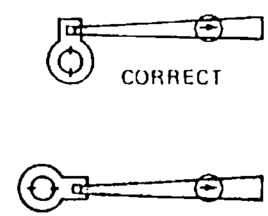


Figure 244-1-3 Locknut Spanner Wrench . . . .

d. **Bearing Pullers.** Pullers should conform to GGG-P-781, **Puller, Mechanical Puller Attachment, Mechanical, and Puller Set, Mechanical.** Every ship has such pullers.

e. **Torque Wrenches.** Use torque wrenches corresponding to GGG-W-686, Wrench, Torque, to properly torque bolts on end bells, end caps, and bearing locknuts.

f. **Convection Oven.** Bearings still in their original intimate wrap are placed on a shelf in an oven thermostatically controlled to a nominal 95° ± 5°C (203° ± 10°F). Depending on bearing size, a soak period of 1/2 to 1 hour will usually suffice. When several bearings are heated simultaneously, they should not be stacked, but placed side by side. Many shops have manufactured ovens using light bulbs mounted in a box lined with foil. In such apparatus, temperature should be controlled by a thermostat rather than by the less reliable method of controlling lamp size and the size of the enclosure. Do not use a convection oven when both inner and outer rings are to be fitted at the same time, since reducing interference on one ring will only increase it on the other.

g. **Bore Heater.** A light bulb or electric heating element is inserted in the bearing bore. An advantage of this method is that the inner ring is heated while the outer ring remains relatively cool. This permits easy handling during mounting. In this method heating is controlled by ensuring that the heating element is centered in the bearing bore. Ring temperature should not exceed 95°C (203°F). Cover the bearing to avoid contamination.

h. **Induction Heater.** The induction heater is basically a transformer in which the bearing ring acts as a short-circuited secondary winding. A high current is induced in the bearing ring, resulting in an extremely rapid heating rate. This heater is not approved for ring expansion of quiet bearings. When using for other bearings, use a contact pyrometer or other reliable method to limit ring temperature to 95°C (203°F). The bearing shall never be left unattended in this heater. Disconnect the heater power cord when installing or removing the bearing. Cover the bearing to avoid contamination and demagnetize it before mounting.

i. **Oil Bath.** The hot oil bath method consists of heating bearings in oil at a temperature below 95°C (203°F). Do not use this with quiet bearings.

j. **Wiping and Handling Materials.** Lint-free, clean cloths for covering partial assemblies and for wiping grease and dirt from shafts, housings, and hands should be on hand in ample quantities. Do not use waste, burlap, or cheesecloth. Use clean, insulated gloves when handling bearings. Wear clean clothes when mounting bearings.

k. **Grease.** Keep limited stocks of grease at hand. Small containers are preferred as a measure to avoid contamination. Apply grease with a clean metallic or plastic spatula.

l. **Measuring Instruments.** For installing quiet bearings, dial-indicating comparative bore and snap gage readings in units of 1/10,000 (0.0001) inch are preferred. Such gages measure the difference between the measured object and a standard of known dimensions. Standards are provided for each shaft and housing size corresponding to a particular bearing size. (Repair ships and yards should have these instruments. They are desirable but not always practical for shipboard.) All ships should have carefully calibrated inside and outside micrometers reading to 0.0001 inch, a dial indicator reading to 0.0001 inch, and master precision gage blocks for checking.

244-1.8.3 DISASSEMBLY AND BEARING REMOVAL. Care in removing a bearing is as important as the care in installing a new bearing. Do not destroy any evidence of why a bearing failed, as this information may lead to the solution of the trouble. In an emergency, and if a replacement is unavailable, it may be necessary to reinstall the bearing (paragraph 244-1.5.5). If the machine is dismantled for reasons other than bearing replacement, bearings should not usually be removed. In such instances, the bearing shall be tightly wrapped in a lint-free covering while other work is performed.

244-1.8.3.1 General. Consider the complexity of the job and the experience of the personnel with the fundamentals of bearing handling. Obtain drawings and study the bearing scheme carefully. Read all available repair instructions thoroughly and completely before taking any action. Discuss the entire repair procedure so that each person knows what to do.

244-1.8.3.1.1 Use proper tools, and use them for their intended purpose. Chiseling, prying, and needless hammering are definitely discouraged. Before disassembly, matchmark all adjacent parts including end bells, stator feet, cartridge covers, end caps, coupling halves, and so forth so that they are remounted in their exact original position. When removing parts over the shaft, be careful not to damage the shaft surface or threading. As small parts are removed, place them in a tote pan. Tag large parts for identification.

244-1.8.3.1.2 Dismount bearings by one of the following methods. Pressure for removal (and installation) of a bearing shall be applied directly to the interference-fitted ring (Figure 244-1-4). In most applications, the inner ring is tight on the shaft. In a few cases the outer ring is tight in the housing. In a very limited number of applications both rings will be tight. The technical manual or applicable ship or equipment drawing should provide the fitup limits. If it is impossible to apply the force directly to the interference-fitted ring, the bearing will undoubtedly be unfit for further service.

CAUTION

Never use a naked flame to heat a shaft, bearing, or housing. This can significantly distort the components.

244-1.8.3.2 Arbor Press Method. If possible, place the bearings to be removed and the shaft or housing on which they are mounted into an arbor press. This is one of the best methods of removing bearings; use it whenever possible. When working with a shaft assembly, place the bearing inner rings against a pair of flat blocks of the same thickness. Take care to keep the shaft straight to prevent damage from cocking. Use a firm, steady pressure and force the shaft out (Figure 244-1-5a). When working with a housing, support the housing against a pair of flat blocks of equal thickness. Using a sleeve, push against the outer ring, or both rings, and force the bearing out (Figure 244-1-5b).

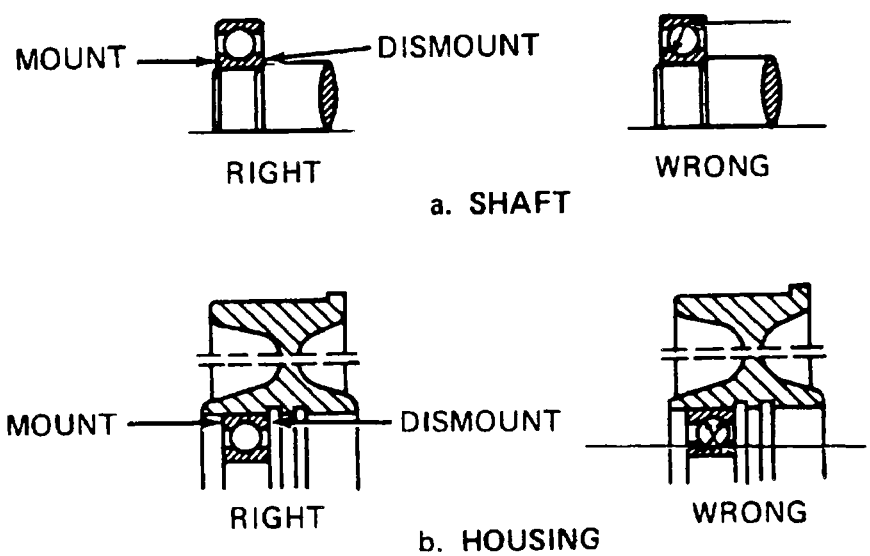


Figure 244-1-4 Application of Mounting and Dismounting Forces to Tightly Fitted Bearing Rings

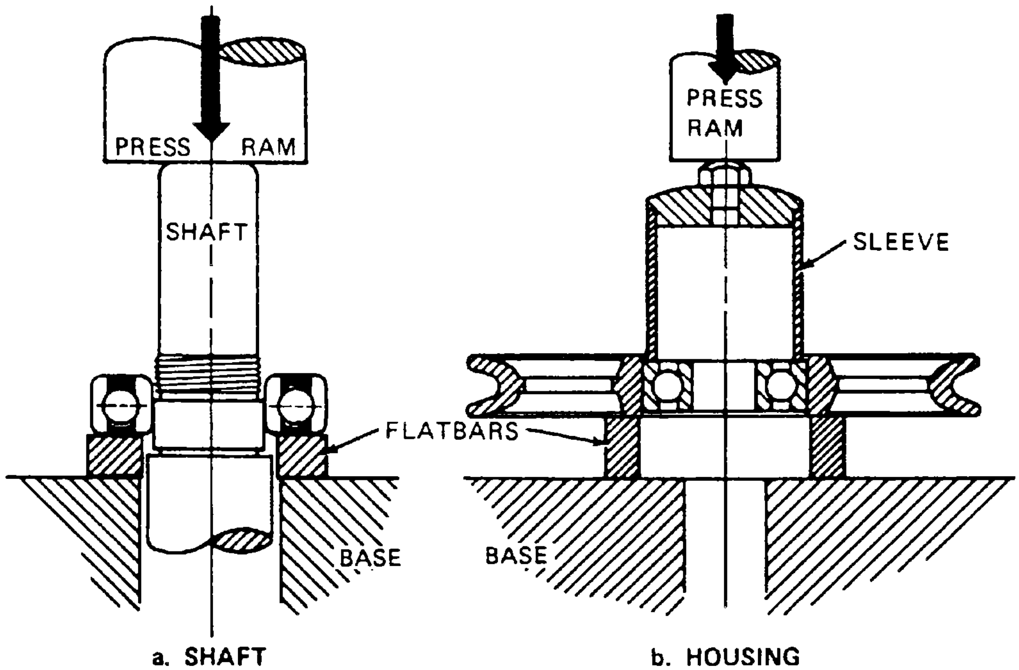


Figure 244-1-5 Arbor Press Method of Removing Bearings

244-1.8.3.3 Puller Method. If an arbor press is unavailable, use pullers that conform to GGG-P-781. The puller attachment (type XII in the specification), which can be inserted behind the bearing inner ring, should be used in conjunction with puller types I or VII. Puller jaws (type I) should be set so that they will pull straight and not slip. An uneven pressure in pulling may cock the bearing, so exert an even pressure with a straight pull (Figure 244-1-6). Always use shaft center protectors of type XIII, class 3 or class 4, conforming to GGG-P-781. When enough space is unavailable for installing the type XII attachment behind the bearing, it may be possible to remove the bearing by pulling on the inner cap or cartridge. This should be done by manufacturing a split spacer that, when fitted between the bearing inner ring and the housing cap or cartridge, will prevent loading of the bearing outer ring (Figure 244-1-7).

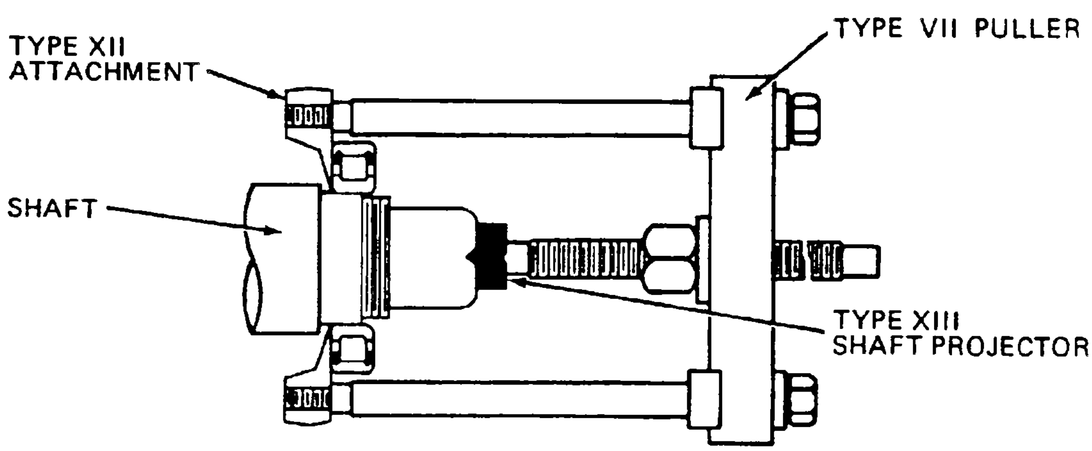


Figure 244-1-6 Bearing Puller Removal Using Split Puller Attachment and Shaft Protector

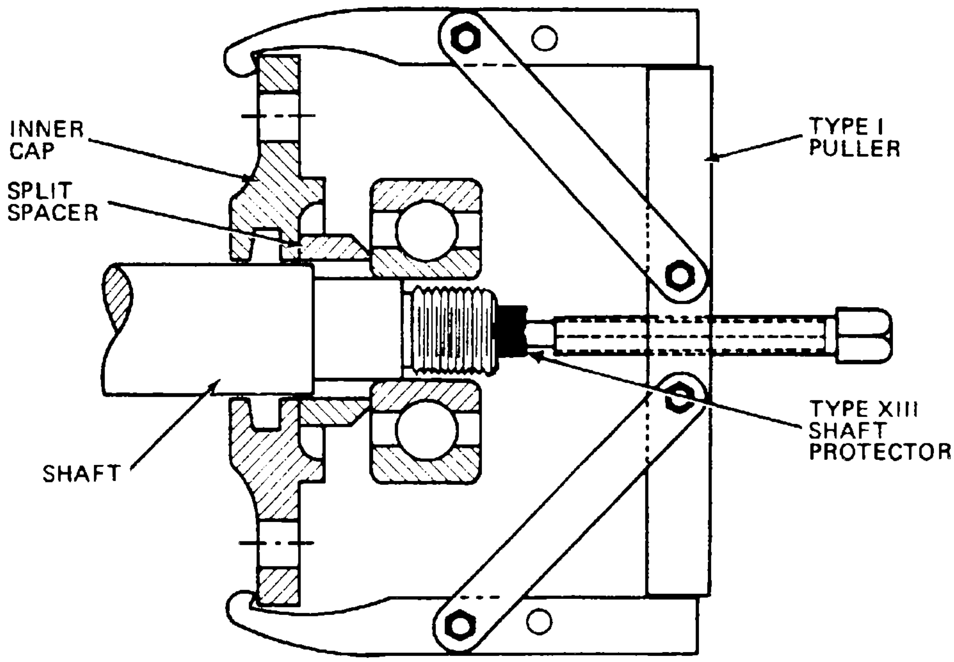


Figure 244-1-7 Split Spacer Allows Use of Cover to Remove Inner Ring

244-1.8.3.4 Seized Bearing. Remove a seized bearing as follows:

1. Protect the rest of the assembly from debris that will be generated, using plastic drapes, rags, canvas, and so on.
2. Split the free ring with a small hand grinder at two places and remove it.
3. Saw through the cage and remove it.
4. Split the seized ring about 3/4 through with the grinder, taking care to avoid shaft or housing damage. Crack the ring with a cold chisel. Remove the ring.
5. Correct any damage done to the shaft or housing.

244-1.8.4 COMPONENT INSPECTION AND REPAIR. If the shaft was damaged during bearing removal, restore it before measuring or reworking the surfaces. Inspect and repair the components as follows:

1. Inspect the end bells, cartridges, or other bearing-carrying parts for splits and cracks. If any are found, repair or replace the piece.
2. Examine the shaft and housing bearing seats for damage, wear, or other deterioration. If there is no evidence of such deterioration or wear and if the seats are not suspect, the bearing seats need not be measured or reworked before installing new bearings during shipboard bearing replacements. Bearing seats shall be inspected during all other bearing replacements, even if there is no evidence of wear or deterioration. The original dimensions are usually adequate and should not be changed merely to conform to some other limits.
3. If there is evidence of seat damage or wear, inspect the bearing seats for conformance to the dimensions and tolerance limits of Table 244-1-2. Because bearing tolerances require measuring accuracies of 0.0001 inch, use a dial-indicating, comparative snap gage for measuring shaft diameters and a dial-indicating bore gage for measuring housing diameters. Standard hand-held micrometers are inadequate for inspecting bearings. If the seat roundness 1/2 diameter tolerance limit is greater than 0.0004 inch, a dial indicator with 0.0001 graduations may be used to inspect seat roundness. As measurements are being made, frequently check the gage back to the gage block, and correct any variations. Use the following procedure for snap gage measurements:

a. Obtain the basic bearing number (for example, 318) stamped on the bearing or from the equipment drawing.

CAUTION

Wear insulated gloves while handling gage blocks to avoid heat transfer and fingerprint corrosion.

b. Select the appropriate, mandatory dimensions from Table 244-1-2 (for example, a quiet bearing with a rotating shaft) and assemble the gage blocks (3.5437 to 3.5434).

c. Place the shaft, gage blocks, and snap gage in a clean area free of drafts and temperature changes.

d. Position the snap gage over the gage block and against the lower anvil so a movement of approximately 1/2 the total movement on the indicator pointer is produced (Figure 244-1-8). Lock the anvil in this position.

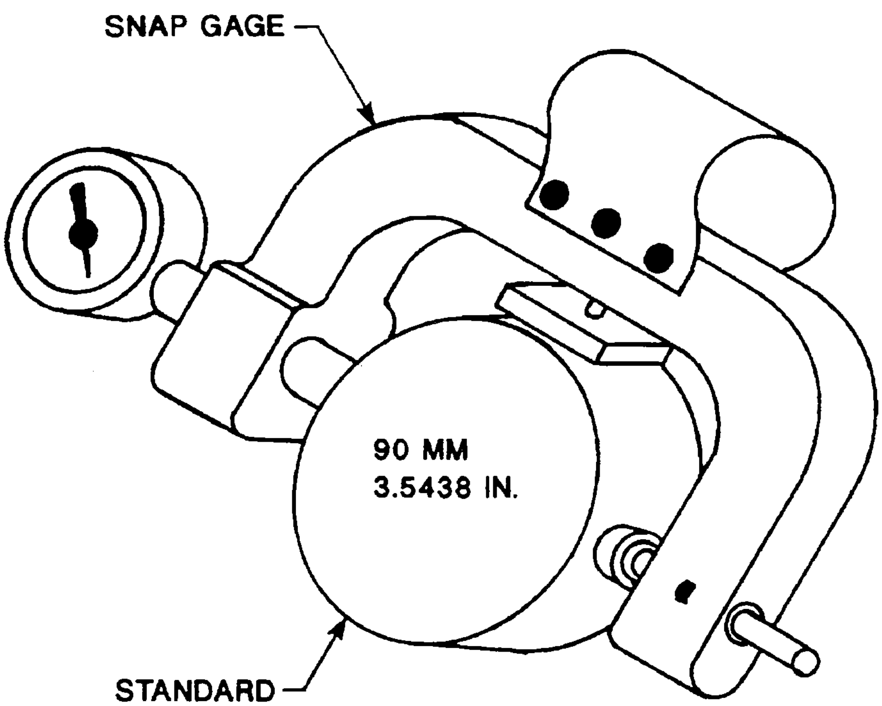


Figure 244-1-8 Setting Dial-Indicating Snap Gage to Gage Block

e Turn the dial face so that the indicator reads zero. The gage is now set to the exact size of the block.

f. Allow the snap gage and gage block to sit on or near the work piece for 15 minutes. If the indicator has moved, reset it to zero. Continue this procedure until the indicator reading stabilizes at zero.

g. Measure the shaft diameter as shown in Figure 244-1-9. Take six measurements of seats less than 1-inch wide and nine measurements of seats over 1-inch wide and record the findings as shown in Figure 244-1-10. Recheck the gage with the master block after measuring to make sure that the setting has not changed.

NOTE

Hold the snap gage lightly by the grip and guide it past the high point several times while measuring.

4. Use the following procedure for bore gage measurements:
   a. Obtain the basic bearing number (for example, 318) stamped on the bearing or from the equipment drawing.

CAUTION

Wear insulated gloves while handling gage blocks to avoid heat transfer and fingerprint corrosion.

   b. Select the appropriate, mandatory dimensions from Table 244-1-4 and Table 244-1-5 (for example, a quiet bearing with a stationary housing) and assemble gage blocks or setting ring (7.4809 to 7.4814).
   c. Place the housing, bore gage, gage block, or setting ring and accessories in a clean area free of drafts and temperature changes.

CAUTION

Hold the bore gage lightly by the grip only. Never exert any pressure on the sensing contact.

   d. Install an extension adapter of the required size to the bore gage. Adjust the extension so that a rocking motion of the gage, between the gage block end calipers or setting ring, moves the indicator pointer approximately 1/2 the total movement on the dial (Figure 244-1-11). Snug up the locknut, but do not tighten.
   e. Rock the gage slowly and find the minimum reading. Set the dial face to zero, and check to be sure the setting is accurate.
   f. Allow the bore gage to sit on the gage block or setting ring for 15 minutes. If the indicator has moved, reset it to zero. Continue this procedure until the indicator reading stabilizes at zero.
   g. Measure and record the housing diameters at nine locations as shown in Figure 244-1-12 and Figure 244-1-13.

NOTE

Rock the bore gage back and forth within the housing and observe where the indicator stops its swing and reverses its motion. This point is the minimum reading that represents the actual diameter of the housing.

   h. Recheck the gage with the gage block after measuring to be sure that the setting has not changed.

5. If components are damaged or worn, measure the shaft shoulders as shown in Figure 244-1-14 for runout to be sure that the face of the shoulder is perpendicular to the axis of the shaft. Shoulders should be square, as specified in Table 244-1-2. If there is no undercut on the shaft (Figure 244-1-14), check the manufacturer's drawing and modify the shaft accordingly.

6. Repair undersized shaft seats using the methods presented in Table 244-1-7. Reduce oversized seats by machining. Perform final machining by grinding. Inspect the seats after final machining.

7. Stone all burrs and sharp edges.

8. Check bearing locknuts, lockwashers, and preload springs. If springs were subjected to high temperatures, they may have lost their stiffness. Nuts and lockwashers should be free of burrs and their faces should be square. Self-locking nuts that still function may be reused. Abutting faces of spacers, slingers, and sleeves shall be square and parallel and shall retain a good finish in accordance with Table 244-1-2.

9. Clean all components thoroughly, using approved methods and solvents or detergents as dictated by safety

regulations. Once cleaned, store parts in a clean, dust-free area until needed for assembly.

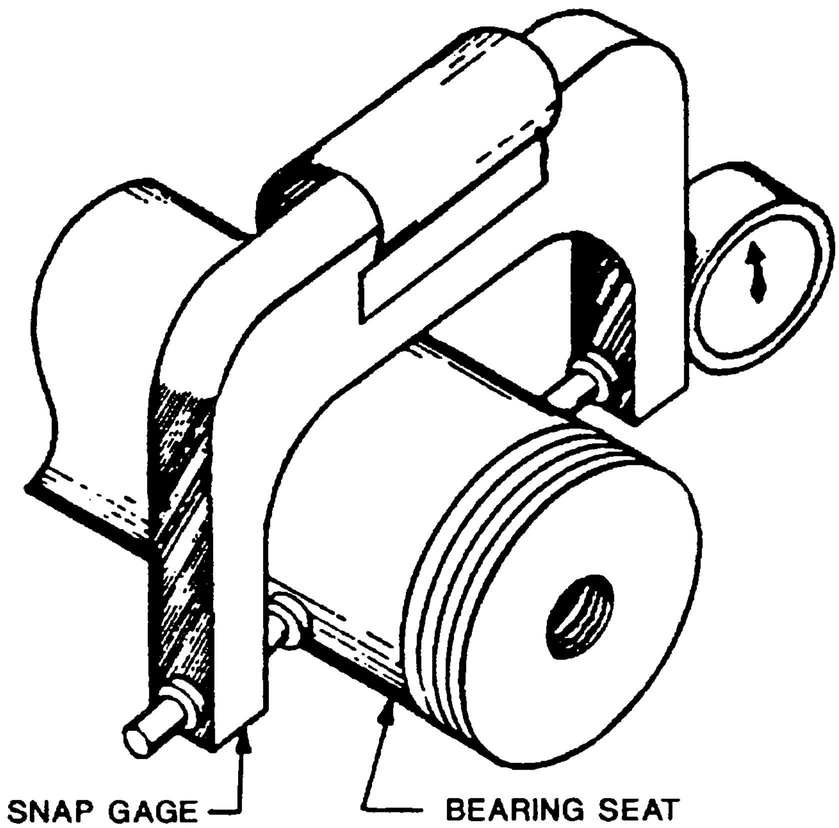
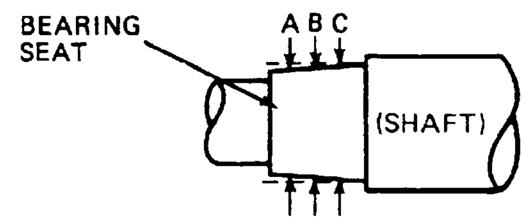


Figure 244-1-9 Measuring Bearing Seat with Snap Gage



DRIVE END

	A	B	C
1			
2			
3			

OUTER END

	A	B	C
1			
2			
3			

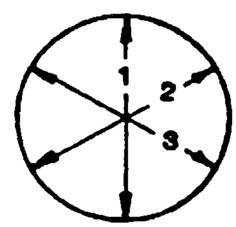


Figure 244-1-10 Shaft Diameter Measurement Recording

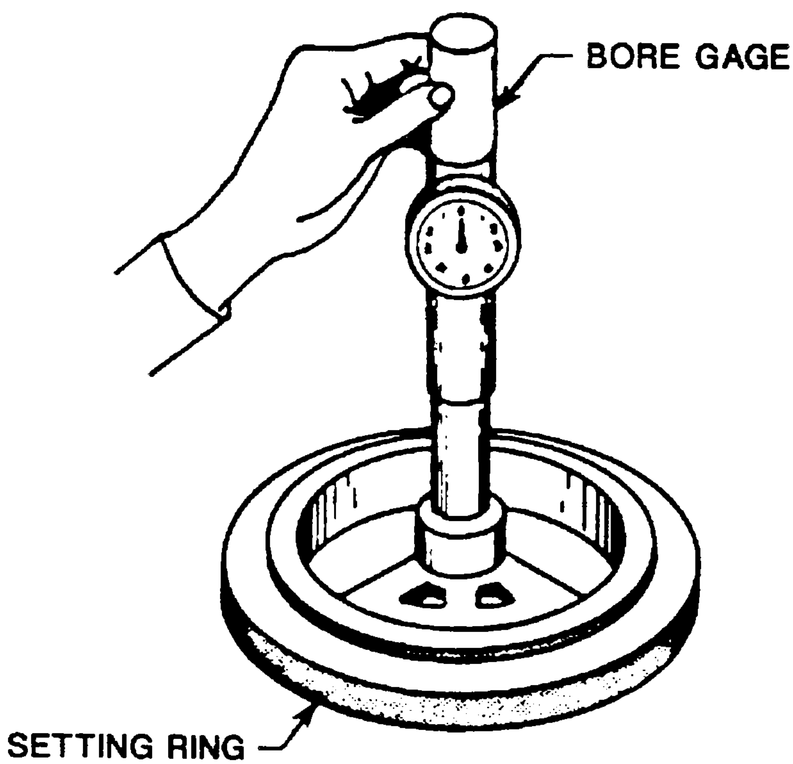


Figure 244-1-11 Setting Dial-Indicating Bore Gage to Setting Ring

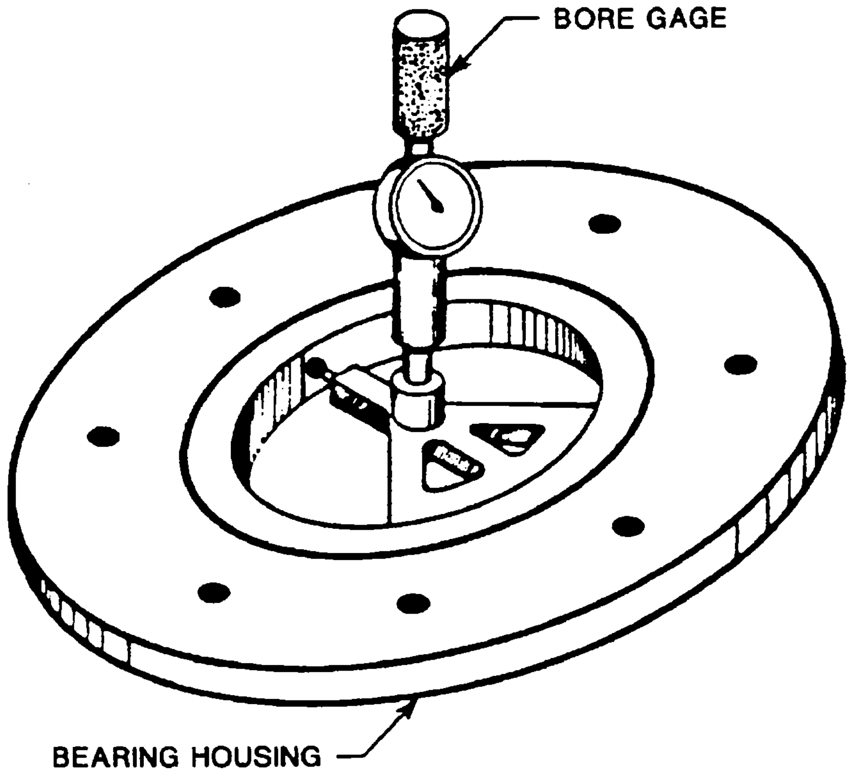


Figure 244-1-12 Measuring Bearing Housing Bore with Bore Gage

DRIVE END

	A	B	C
1			
2			
3			

OUTER END

	A	B	C
1			
2			
3			

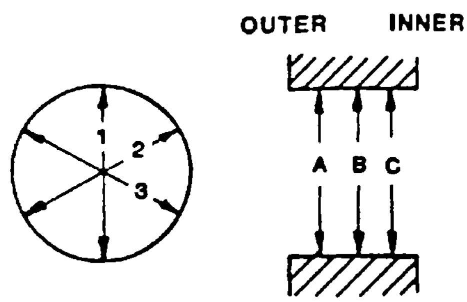


Figure 244-1-13 Housing Diameter Measurement Recording

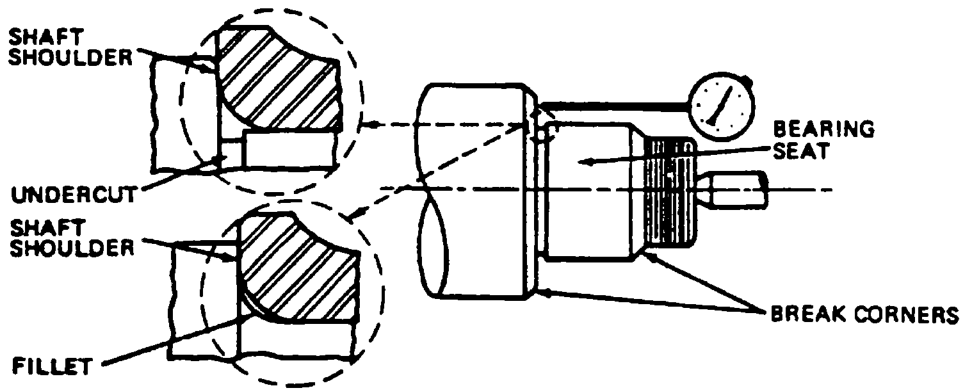


Figure 244-1-14 Measuring Shaft Shoulder Runout

Table 244-1-7 REPAIR METHODS FOR UNDERSIZED BEARING SHAFT SEATS

Repair Method	Application	Reference
Electroplating (chromium)	0.0015 to 0.025 inch thick	DOD-STD-2182, **Engineering Chromium Plating (Electrodeposited) for Repair of Shafting (Metric)**
Brush Electroplating	Various thicknesses. Good for pitted or scored areas. Portable equipment	MIL-STD-2197, **Brush Electroplating on Marine Machinery**
Sleeving	Thickness limited by strength requirements of shafting or housing.	Interference of 0.001 inch per inch diameter minimum (0.001 inch minimum). Stress-relieve before installing. Pin in two places.

244-1.8.5 BEARING INSTALLATION AND ASSEMBLY. Nearly all rolling-element bearing applications require an interference fit on at least one of the bearing rings. Consequently, all mounting methods are based on obtaining the necessary interference without undue effort and with no risk of damage to the bearing. The first and most important rule when mounting and dismounting bearings is that the mounting pressure shall never be applied in such a way that it is transmitted through the rolling elements. Apply the mounting force directly against the interference-fitted ring (Figure 244-1-4). Bearings shall remain packaged until they are required for installation and shall not be cleaned routinely. All unnecessary handling of bearings is definitely discouraged. Observe the conditions described in paragraph 244-1.8.2 to ensure cleanliness and to avoid bearing contamination. The same personnel who disassembled the machinery should also assemble it.

244-1.8.5.1 General. Ring expansion will simplify the mounting of interference-fitted bearing rings. Expand the rings by one of the methods described in paragraphs 244-1.8.2.2 f through 244-1.8.2.2i. All such methods require care, as bearing damage invisible to the eye can result. The convection oven method is preferred in most cases and should always be used for installing quiet bearings. The other methods listed are less desirable and should be used only by a skilled mechanic who has the expertise to avoid bearing damage. All methods except the convection oven require removal of the bearing intimate wrap. With the wrap removed, take care during ring expansion to avoid contamination. When the bearing outer ring is mounted with an interference fit in the housing, the housing, depending on size, can also be expanded by these methods. Do not freeze the bearing or shaft because corrosion may result from condensation.

CAUTION

Never use a naked flame to heat a shaft, bearing, or housing. This can significantly distort the components.

244-1.8.5.1.1 Obtain drawings and study the bearing scheme carefully. Read all available repair instructions thoroughly and completely before taking any action. Discuss the entire assembly procedure so that each person knows what to do. Use extreme care in assembling all parts. Be careful not to damage mating surfaces or shaft threading. Avoid undue force. Mount bearings by one of the following methods. The entire shaft or housing, including keyways, threads, splines, grooves, and so on, shall be thoroughly clean, since foreign matter or dirt between the inner ring and shoulder can cause misalignment (Figure 244-1-15). Bearings will not seat firmly against the shaft shoulder unless the shoulder is clean. Apply a thin coat of clean oil to the bearing seats before assembly. Before mounting bearings on the shaft or in the housing, ensure the correct bearing orientation to avoid unnecessary disassembly. Draw a line through the bearing and compare sides. If the bearing is exactly the same on both sides, either side can be mounted first. When the sides are different, the bearing must be mounted only one way. If you mount a bearing backwards, you will find out later because the machine cannot be assembled or because it fails rapidly. A seal or shield that is on the wrong side may interfere with bearing lubrication or may permit contaminants to enter the bearing. Special instructions for mounting duplex bearings are in paragraph 244-1.8.5.7.

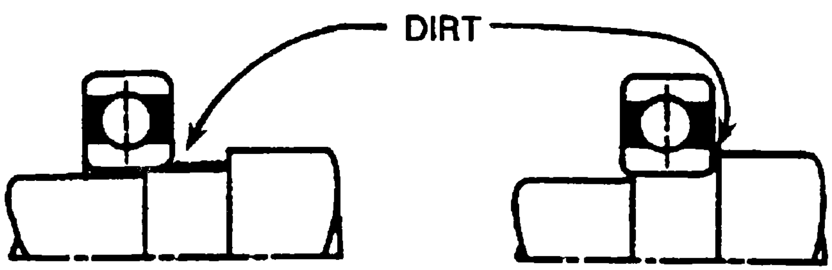


Figure 244-1-15 Effect of Dirt in Mounting Bearings

244-1.8.5.2 Bearing Locknuts. Bearing locknuts ensure that the bearing mounts hold the bearings correctly. A conventional locknut and lockwasher is shown in Figure 244-1-16. Self-locking locknuts (Figure 244-1-17), sometimes referred to as prevailing torque retaining nuts, are essentially the same size and material as the conventional locknuts. They are equipped with a nylon compression collar, however, that has a temperature limit of 300°F. The collar eliminates the need for a lockwasher. Self-locking locknuts permit convenient assembly and disassembly. The resilient collar follows the metal threads in engagement during assembly. This develops compression of the collar, with the metal threads of the shaft eliminating the space between the shaft threads and the collar. This compression develops tension between the mating parts, providing better locking and more protection against loosening, especially from vibration.

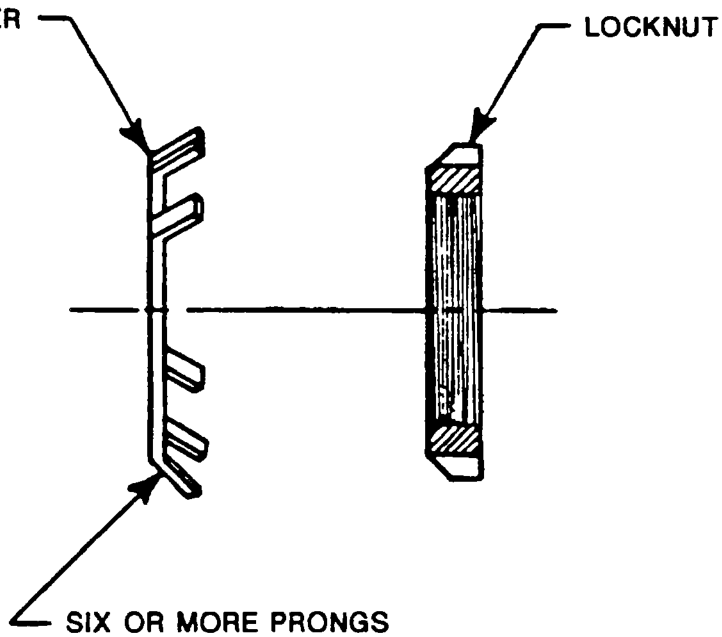


Figure 244-1-16 Conventional Locknut and Lockwasher

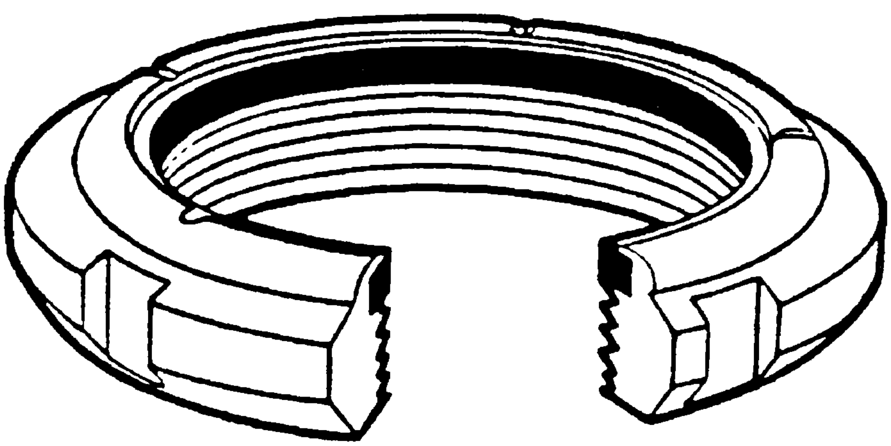


Figure 244-1-17 Self-Locking Locknut

244-1.8.5.2.1 Assemble the unit in accordance with the equipment technical manual. All parts should go together easily without undue force. When outboard parts are tightly fitted, apply steady, even pressures and avoid hammering. Ensure correct location of mating parts by aligning matchmarks. Tighten all bolts holding end bells and end cabs by diagonal sequencing. Finally, tighten with a torque wrench to the specified values or, as a minimum, to the appropriate values of Table 244-1-8.

244-1.8.5.3 Heat Source Method. For shaft interference-fitted rings, the preferred method of mounting is to use a heat source to expand the inner ring (paragraph 244-1.8.5.1). Wear lint-free insulated gloves or use clean cloths when handling hot bearings. A 100°F difference between the parts to be fitted should be enough for the bearing to slide all the way to the shoulder. Any difficulty may indicate the shaft is oversized. Install the locknut while the bearing is hot, and torque to the value specified in Table 244-1-9. Cover the assembly while left to cool to protect it from atmospheric dirt. Loosen the locknut and retorque after the assembly cools.

244-1.8.5.4 Arbor Press Method. If a heat source is unavailable, the next best method is to use an arbor press and a piece of tubing. Remove any burrs, sharp corners, and so on from the shaft or housing, and carefully center the bearing at the beginning of the seat - the corner radius of the bearing will help. Place the tube on the appropriate ring face, and apply pressure with the arbor press ram (Figure 244-1-18a and Figure 244-1-18c). With uniform pressure the bearing should go on smoothly all the way. If it sticks or requires extra force at any point, stop the pressure. Look for cocking burrs on the seat or a tapered seat.

244-1.8.5.5 Parallel Block Method. For shaft interference-fitted rings, another way of using the arbor press is to use parallel blocks under the bearing inner ring and press the shaft into the bearing (Figure 244-1-18b).

244-1.8.5.6 Emergency Method. In extreme emergency only, when none of the above apparatus is available, small bearings can be mounted by holding a sleeve against the interference-fitted ring and hammering alternately at opposite points on the sleeve. Use light blows, and work around the sleeve to avoid cocking (Figure 244-1-19).

244-1.8.5.7 Special Procedures for Duplex Bearings. Duplex bearings consist of two angular-contact ball bearings mounted so that they can control the rigidity and precision of the shaft location. They are usually mounted either DB or DF (Figure 244-1-20). As the figures show, the distinguishing feature of each duplex mounting is the relative position of the thick and thin faces of each bearing outer ring. The thin face is referred to as the counterbored face, or simply, the face. The thick face is referred to as the back face, or simply, the back. Some angular-contact bearings are manufactured with a counterbored inner ring face. This is insignificant, however, in achieving the correct mounting and should be disregarded. In the DB mount, the back faces of the outer rings are abutted. In the DF mount, the counterbored faces of the outer rings are abutted. Duplex pairs are either flush ground or modified for preload or end play. All single angular-contact bearings that are flush ground can be duplexed. Where preload or end play is specified, however, only single bearings from a single manufacturer, with the same contact angle and with faces ground for the same modified condition, should be duplexed. To avoid complications in selecting single bearings for duplexing, use only bearings furnished as duplex pairs. For precision pairs such as quiet bearings, both bores and outside diameters are selected to match closely on tolerance. Also, the high point of radial runout of each ring is marked on one face of both the inner and the outer rings of each bearing. Depending on the manufacturer, the radial runout mark could be a burnished spot, a circle, or an arrow. During installation these marks must be lined up at the same angular position so that the high points of runout of both bearings coincide (Figure 244-1-21). These bearings must be procured under the proper stock number for the specified application because a preloaded bearing will not operate satisfactorily in an application where a bearing with a loose internal setup is required, and vice versa. An early failure would result in either case.

Table 244-1-8 RECOMMENDED TORQUE (IN FOOT-POUNDS) FOR BOLTS, NUTS, AND STUDS ON END CAPS AND END BELLS

Bolt, Nut, Stud Size (Inch)	**Hexagon Head Bolt Grade 1 and 2**  **No Marking Carbon Steel Corrosion-Resistant Steel**	**Hexagon Head Bolt Grade 5**  **Marking Carbon Steel Alloy Steel**	**Hexagon Head Bolt Grade 8**  **Marking Carbon Alloy Steel**
1/4	2-4	6-8	9-12
5/16	4-8	13-17	18-25
3/8	6-12	23-30	35-45
7/16	10-20	35-50	55-70
1/2	15-30	55-75	80-110
9/16	23-45	80-110	110-150
5/8	30-60	110-150	170-220

Table 244-1-8 RECOMMENDED TORQUE (IN FOOT-POUNDS) FOR BOLTS, NUTS, AND STUDS ON END CAPS AND END BELLS - Continued

Bolt, Nut, Stud Size (Inch)	Hexagon Head Bolt Grade 1 and 2  No Marking Carbon Steel Corrosion-Resistant Steel	Hexagon Head Bolt Grade 5  Marking Carbon Steel Alloy Steel	Hexagon Head Bolt Grade 8  Marking Carbon Alloy Steel
3/4	50-100	200-260	280-380
7/8	80-160	300-400	460-600
1	123-245	440-580	680-900
1-1/8	195-390	600-800	960-1280
1-1/4	273-545	840-1120	1360-1820
1-3/8	365-730	1100-1460	1780-2380
1-1/2	437-875	1460-1940	2360-3160

NOTES:
1. Applicable to UNC, NC, UNF, and NF threads, class 2 and 3 fit.
2. Stud grade marking identical to that for hexagon-head bolts. Symbols appear on nut end of stud.
3. Nut grade marking is applied to the top face of the nut. Grades 1 and 2, no marking; grade 5, three raised dashes; grade 8, six raised dashes.
4. Applicable to plated and nonplated fasteners-no special lubrication.
5. Multiply by 12 to convert to inch-pounds.

Table 244-1-9 TORQUE VALUES FOR BEARING LOCKNUTS (DRY THREADS)

Bearing Bore Code	Torque Value (ft-lb)
00	10-20
01	10-20
02	10-20
03	10-20
04	12-35
05	23-50
06	32-60
07	39-70
08	50-80
09	64-90
10	67-100
11	82-125
12	99-150
13	131-175
14	152-200
15	173-250

Table 244-1-9 TORQUE VALUES FOR BEARING LOCKNUTS (DRY THREADS) - Continued

Bearing Bore Code	Torque Value (ft-lb)
16	197-275
17	222-325
18	248-375
19	277-425
20	345-475
21	380-550
22	380-550
24	380-550
26	380-550
32	380-550

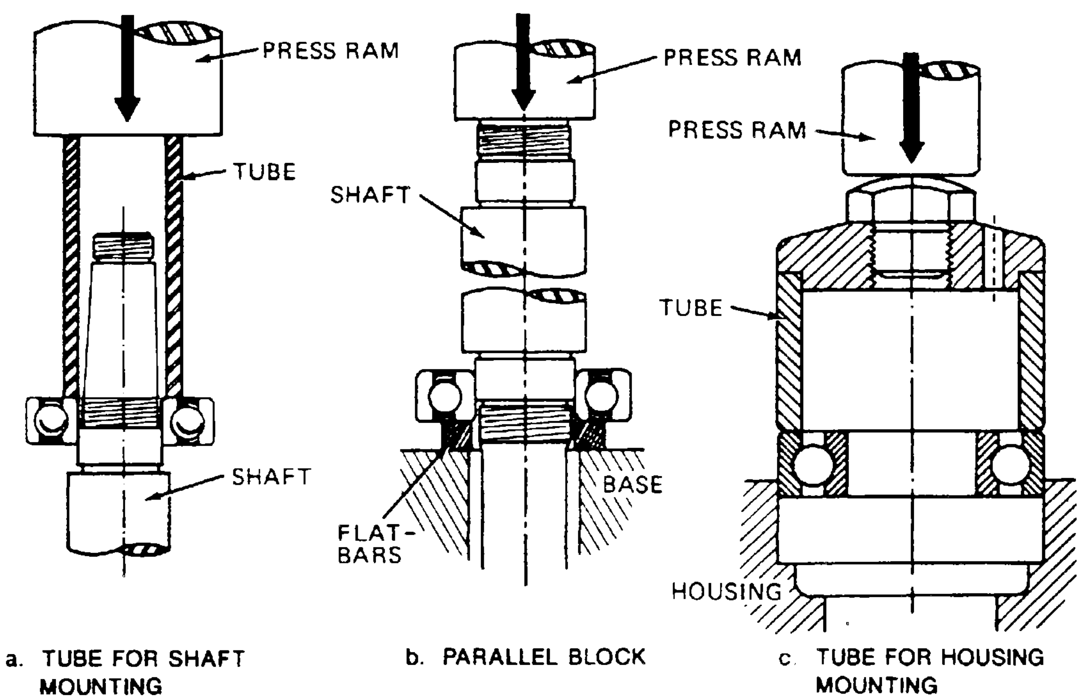


Figure 244-1-18 Pressing Bearings on Shaft with an Arbor Press

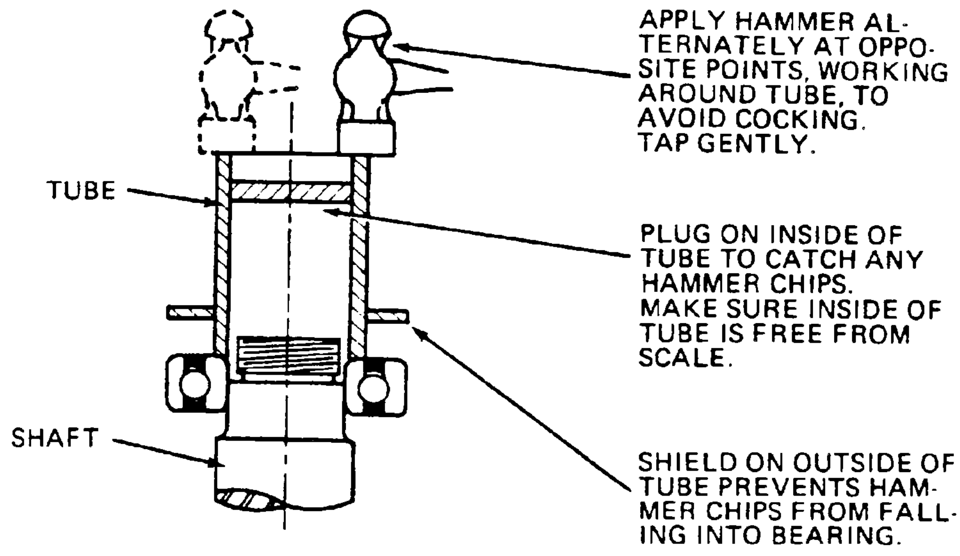


Figure 244-1-19 Hammer Mounting - Use in Emergencies Only

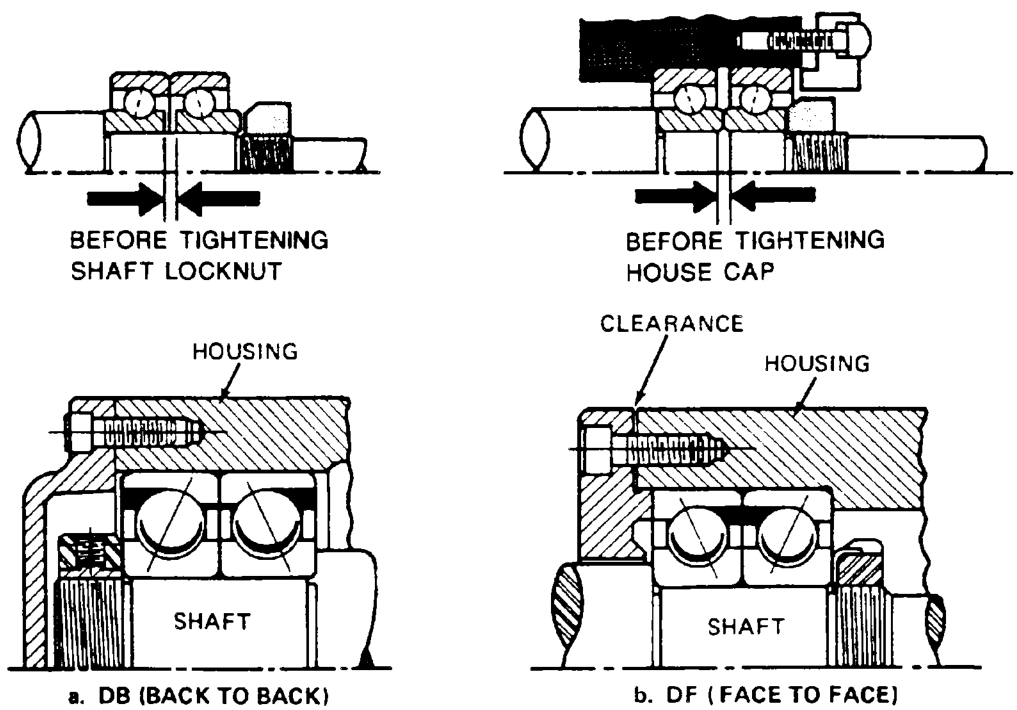


Figure 244-1-20 Duplex Bearing Arrangements Showing Relation of the Outer Ring Faces

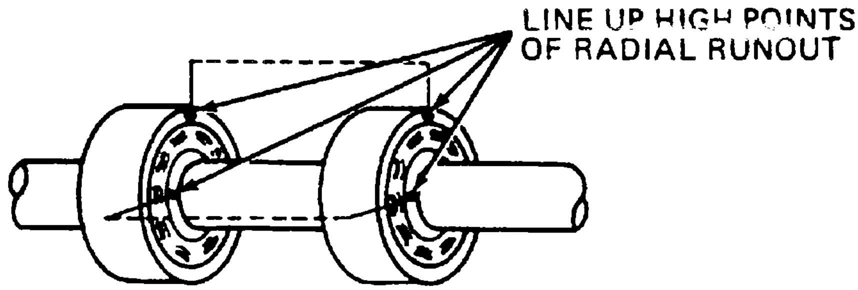


Figure 244-1-21 Bearing Ring Radial Runout Alignment of Precision Bearing Pairs

244-1.8.5.7.1 Assuming that the bearings are heated as indicated in paragraph 244-1.8.5.3, duplex bearings shall be installed one at a time. After orienting the inner bearing to achieve the correct duplex mount, press it firmly into contact with the shaft shoulder, or in a few cases, a backing sleeve or oil impeller. The bearing should be held against the shaft shoulder by the locknut and a sleeve. The sleeve should have parallel faces and be at least as wide as the outer bearing. (Disassemble the old bearing, increase the bore diameter, and use as the spacer.) See Figure 244-1-22. Do not remove the holding device until the entire assembly is at room temperature. Cover the bearing while it cools.

244-1.8.5.7.2 Install the outer bearing in a similar manner. Before installing the outer bearing, orient it to achieve the correct duplex mounting. If so marked, align the points of maximum radial runout so that these marks are align in the same angular position as those on the inner bearing. Bearing rigidity with the DB mount is achieved by the clamping action of the bearing locknut through the inner rings. It is therefore desirable to rotate the bearing outer rings by hand while tightening the locknut. This allows the rolling elements to seat and avoids brinelling the races. In addition, do not loosen the locknut once it is installed. Install any sleeve or hub of an adjacent part that is clamped between or in conjunction with the bearings before tightening the locknut. With the DF mount, the bearing rigidity is achieved by the clamping action of the cap and housing shoulders through the bearing outer rings. In this case, therefore, rotate the shaft by hand during final assembly while tightening the housing end cap bolts in a diagonal sequence to allow the rolling elements to seat and to avoid brinelling the races. After final tightening of the bolts with a torque wrench, enough clearance must exist between the end cap and the housing to ensure actual clamping of the rings (Figure 244-1-20b).

244-1.8.5.7.3 If heat is not used for installing duplex bearings, use an arbor press. Be certain the bearings seat firmly against the shaft shoulder and each other. With the DB mount, press the second bearing on far enough so that the locknut threads can be fully engaged, and then use the locknut to force the bearings together and fully clamp them.

244-1.8.5.8 Bearing Locknut Torques. Unless otherwise specified, torque all bearing locknuts to the appropriate value specified in Table 244-1-9.

244-1.8.5.9 Grease Pack.

a. At installation, pack the bearing with grease. Quiet bearings are supplied with the correct amount and type of operational lubricant. With all other grades of bearings, double-shield, double-seal, and single-seal bearings are shipped with the correct amount and type of operational lubricant. Single-shield and open bearings, however, are shipped with a preservative slush. Only open and single-shield bearings, therefore, excluding quiet bearings of these types, will require grease to be packed into the bearing at installation. Pack grease in a bearing from one side until the grease just begins to come past the balls on the opposite side. Distribute this grease uniformly within the bearing air space. Apply a light coat of grease to any remaining ungreased surfaces of the bearing.

b. With all relubricable bearings, fill the bearing housing cavity 20 to 50 percent full. The lower limit applies to vertical applications, the higher limit to horizontal applications (paragraph 244-1.7.7.2). Bearing operational greases for shipboard machinery should conform to those indicated (paragraph 244-1.7.7.3), depending on service application. The grease should be applied with a clean metallic or plastic spatula. Apply a light coat of grease to all unpainted bearing housing surfaces. With prelubricated bearings (double-sealed or double-shielded), do not add grease to the bearing housing cavity.

c. If the grease inlet passage and inlet pipe have not had old grease cleaned out, clean it out. Then pack the entire length of the passage and pipe with new grease to prevent corrosion.

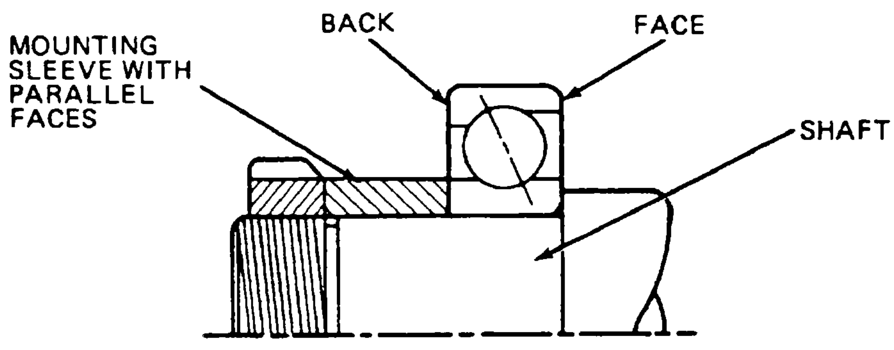


Figure 244-1-22 Mounting of Duplex Bearing (DB Mount Shown)

244-1.8.5.10 Preload Springs. Preload springs are used to reduce ball skidding, thereby reducing noise and increasing bearing life. It is important that such springs be installed correctly during assembly. Various types of springs are used for this purpose. In most applications one spring or a series of springs is clamped between the bearing outer race and the inner or outer bearing cover. Check the drawing to determine the correct orientation.

244-1.8.5.11 Axial Runout. Where quiet bearings are used, the maximum axial runout should not exceed the values listed in Table 244-1-10. Bearing axial runout is the sum of the runout of the bearing outer ring face with reference to the shaft and the inner ring face with reference to the housing. This measurement is made during the final stages of assembly on units where the design allows making the measurements (Figure 244-1-23 - add measurements B and C). Values obtained for measurement A on Figure 244-1-23 indicate shaft radial runout. Large values of radial runout indicate bent shafting that may cause excessive radial vibration and should therefore be minimized.

244-1.8.5.11.1 When assembling two or more machinery components such as pumps, compressors, blowers, or motors, it is essential that some degree of alignment be maintained between respective shafting. The most common method of specifying alignment of close-coupled and rigid-coupled units is to list face and rim runout requirements. The face reading indicates angular misalignment between two flanges. The rim reading measures axial misalignment between the shafts (Figure 244-1-24). Acceptance limits should be as specified on the drawing or in the technical manual. If face runouts are unlisted, use the appropriate value from Table 244-1-2 applicable to housings. Rim runouts should not exceed 0.005 inch and are normally less, as specified.

244-1.8.5.12 Oil Lubrication. In oil-lubricated bearing applications be sure to add the lubricant to the correct level before operating the machinery (244-1.7.8).

Table 244-1-10 RECOMMENDED MAXIMUM AXIAL RUNOUT FOR BEARING, SHAFT, AND HOUSING ASSEMBLIES USING QUIET BEARINGS

Bearing Bore Code 200 and 300 Series	**Bearing Bore (inch) (mm)**		**Maximum Recommended Axial Runout of Assembly (inch)**
00 to 03	0.3937 to 0.6693	10 to 17	0.0004
04 to 10	0.7874 to 1.9685	20 to 50	0.0005
11 to 17	2.1654 to 3.3465	55 to 85	0.0010
18 to 26	3.5433 to 5.1181	90 to 130	0.0015

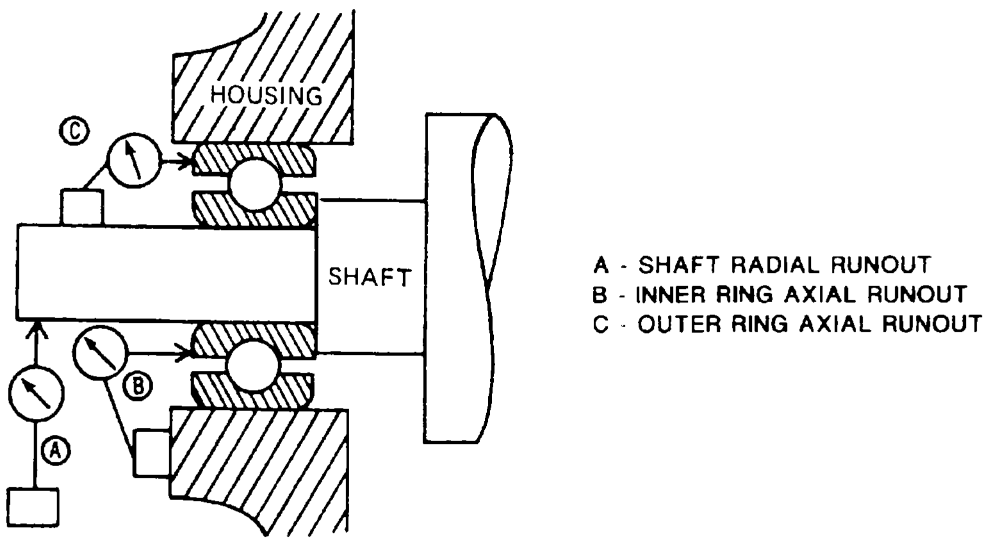


Figure 244-1-23 Measurement Location for Determining Bearing Axial Runout and Shaft Radial Runout

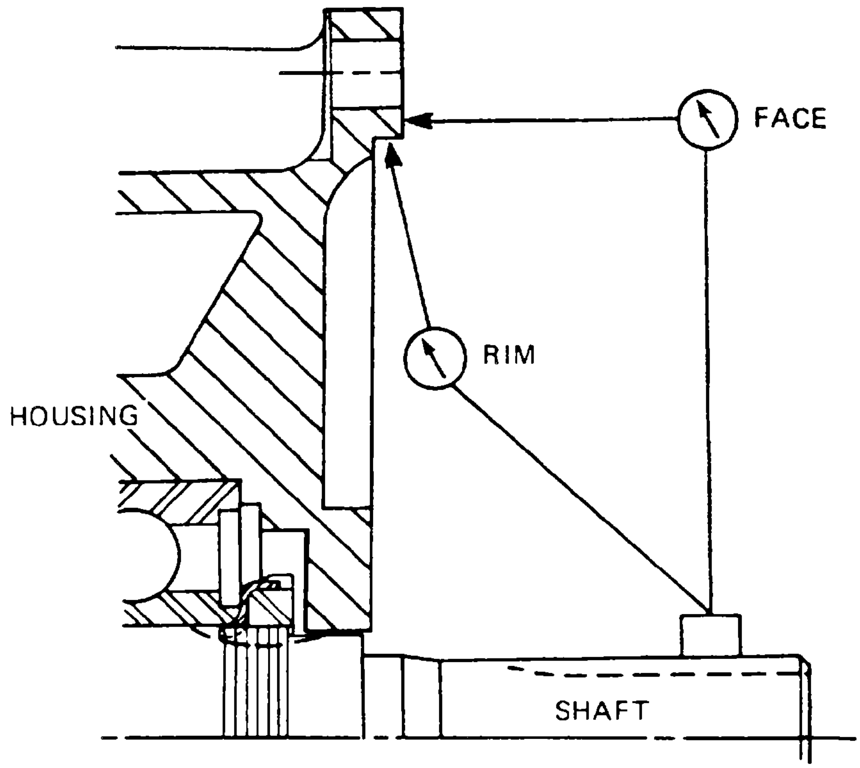


Figure 244-1-24 Measurement Location for Determining Face and Rim Runouts

244-1.8.6 POSTREPAIR INSPECTION. To ensure correct operation after bearings have been installed, check rotating machinery for torque, noise, and temperature when possible while it is still in the shop (refer to paragraph 244-1.7 for detailed inspection methods).

244-1.8.6.1 Torque. Any indication of high torque, binding, or drag means trouble. The completely assembled machine should turn freely without binding. High torque can be caused by excessive axial preload, pressure from an improperly located cover plate, or misalignment of the shaft or housing.

244-1.8.6.2 Noise. Bearings should operate at low noise levels. Any unusual operating noise after installation shall be carefully analyzed before the bearings are considered to be the cause.

244-1.8.6.3 Temperature. Noise and excessive torque will usually be accompanied by a rise in temperature. A noticeable rise also may be caused by excess grease.

244-1.8.6.4 Record Keeping. Maintain documentation on as-released measurements and shop test performance until the component performs satisfactorily aboard ship. Such a record can be of great value if the application exhibits operating trouble after installation.

244-1.8.6.5 Preinstallation Tests. Follow the inspection procedures described in paragraph 244-1.7.2.

244-1.9 SAFETY PRECAUTIONS

44-1.9.1 Observe the following precautions when working with rolling-element bearings:

a. Unless absolutely necessary, never use a piece of machinery if the bearings are known to be in poor condition.

b. Since good bearing performance depends on proper lubrication, never start a piece of machinery until all bearings are known to be properly supplied with lubricant, both in quality and in quantity.

c. Determine the normal running temperature of each bearing under all conditions of load and speed, and investigate immediately any changes.

d. The rapid heating of a bearing is a danger sign. A bearing temperature uncomfortably hot to the touch is not necessarily running overheated. If the bearing has taken an hour or more to reach that temperature, it is probably safe. If that same temperature is reached in a few minutes, however, expect serious trouble.

e. Watch the performance of newly installed bearings carefully when first starting a piece of machinery until it is known that they have reached and are operating at a safe running temperature.

f. If possible, give newly installed bearings a run-in period applying no load.

g. Do not use waste cloths to clean bearings or journals. Use only lint-free cloths.

h. When renewing rolling-element bearings be sure to use the type and grade designated on the machinery drawings and as specified by allowance parts list and the technical manual.

i. Never try to repair damaged rolling-element bearings by replacing balls or rollers.

j. Do not remove a rolling-element bearing from its original container and wrapping until every preparation has been made to install it.

k. When installing rolling-element bearings, be sure that the inner race is seated tightly against the shaft shoulder.

l. Avoid excessive lubricant in rolling-element bearings. Very little lubricant is required. Excessive lubricant fills the spaces between elements. This impedes free movement and causes early failure.

m. Be particularly careful to seal housings of rolling contact bearings against the entry of foreign matter.

SECTION 2

LINESHAFT BEARINGS

244-2.1 GENERAL

244-2.1.1 INTRODUCTION. Main propulsion lineshaft bearings are inside a ship's hull between the aftermost propulsion flange and the stern tube seal. They provide radial support for the main propulsion lineshaft. Information in this section applies to main propulsion lineshaft bearings installed in ships and, if relevant, to those installed in boats.

244-2.1.2 DESIGN. This section discusses sliding-surface-type ring-oiled and disk-oiled lineshaft bearings. Disk-oiled babbitted bearings are self-aligning (with a few exceptions) and are lubricated by a disk clamped to the shaft. This design is used on newer ships. Ring-oiled babbitted bearings are usually self-aligning and are lubricated by oil rings that are rotated by the lineshaft. Older ships usually use ring-oiled bearings. Some bearings on noncombatant ships are of the straight-cylindrical type.

244-2.2 DRAWINGS AND TECHNICAL MANUALS

244-2.2.1 STANDARD DRAWING. Lineshaft bearings differ in design detail among ship classes. All detail designs have evolved from the requirements of NAVSHIPS dwg 810-1385953 (the lineshaft bearing standard drawing) and of MIL-B-18558, Bearing, Propulsion Lineshaft, Oil Disk Lubricated.

244-2.2.2 TECHNICAL MANUALS. Review specific ship drawings before and during maintenance that requires removal of covers. On many ships, equipment technical manuals are available and should be used, in addition to this NSTM chapter, for guidance in maintenance and repair.

244-2.3 SAFETY PRECAUTIONS

244-2.3.1 All safety precautions used in connection with sliding-surface bearings shall be in accordance with NAVMAT P-5100, **Safety Precautions for Shore Activities.**

244-2.3.2 Additional safety precautions to be observed when working with sliding-surface bearings are as follows:

a. Take precautions to avoid contact with rotating shafts; these shafts are extremely hazardous.

b. When maintenance procedures require that a shaft be kept stationary, secure and tag out equipment that could rotate the shaft. Personnel responsible for driving equipment and for ship operation shall be informed when work will commence and when it will be completed. Engage shaft locks.

c. Take precautions to avoid igniting lubricating oil, a combustible.

d. Since bearing parts are heavy and difficult to handle, take adequate precautions when bearing shells are rolled out.

e. Wear eye protection, aprons, gloves, acid-resistant safety footwear, and other protective clothing when caustic chemicals and molten metal are used for bearing babbitting procedures.

f. Provide adequate ventilation when fume-producing procedures are followed (for example, acid and flux baths).

244-2.4 LINESHAFT BEARING DESIGN

244-2.4.1 GENERAL. The bearing is a self-aligning bearing shell in a housing constructed for easy removal or replacement of essential components. The housing consists of a steel pedestal and cap.

244-2.4.2 LUBRICATION. Lineshaft bearings commonly have a self-contained lubrication system and are either ring or disk oiled. These bearings have either a thin, precision insert-type babbitted bearing liner or a thick-walled babbitted shell mounted on the self-aligning housing.

244-2.4.2.1 Ring-Oiled. A typical ring-oiled lineshaft bearing is shown in Figure 244-2-1. This bearing generally has two or three rings with a top and bottom babbitted (or babbitted insert) shell mounted in a self-aligning seat that is usually spherical.

244-2.4.2.2 Disk-Oiled. The disk-oiled bearing operates similarly to a ring-oiled bearing. The disk carries oil from the pedestal oil sump. Oil removed from the disk by a scraper, located at the top of the bearing, runs into a pocket at the top of the upper bearing shell, from where it enters the bearing through drilled holes.

244-2.4.2.2.1 Laboratory tests have shown that a disk delivers more oil at all speeds than a ring, especially at turning gear speeds. Disk-oiled bearings also tend to be more reliable than ring bearings because rings sometimes break or hang up. Since the bore of the disk is smaller than the shaft outside diameter (OD), the disk pinches the shaft when the split joints are bolted together.

244-2.4.2.2.2 The scraper is usually a high-quality bronze and is loaded against the disk by its own weight or by a spring. In most designs a pin or bolt restrained by a slot in a guide in the housing prevents the scraper from rotating. A Disk-oiled bearing is shown in Figure 244-2-2.

244-2.4.2.3 Oil Delivery Rate Comparison. A comparison of oil delivery rates for a typical ring and disk of the same size is shown in Figure 244-2-3.

244-2.4.3 MAJOR COMPONENTS. The following major components of the lineshaft bearing are shown in Figure 244-2-1 and Figure 244-2-2.

244-2.4.3.1 Bearing Pedestal (Part 1). The bearing pedestal is the bottom portion of the bearing housing that positions and aligns the bearing shell. The pedestal supports the entire bearing assembly and the shaft and is bolted to the bearing foundation.

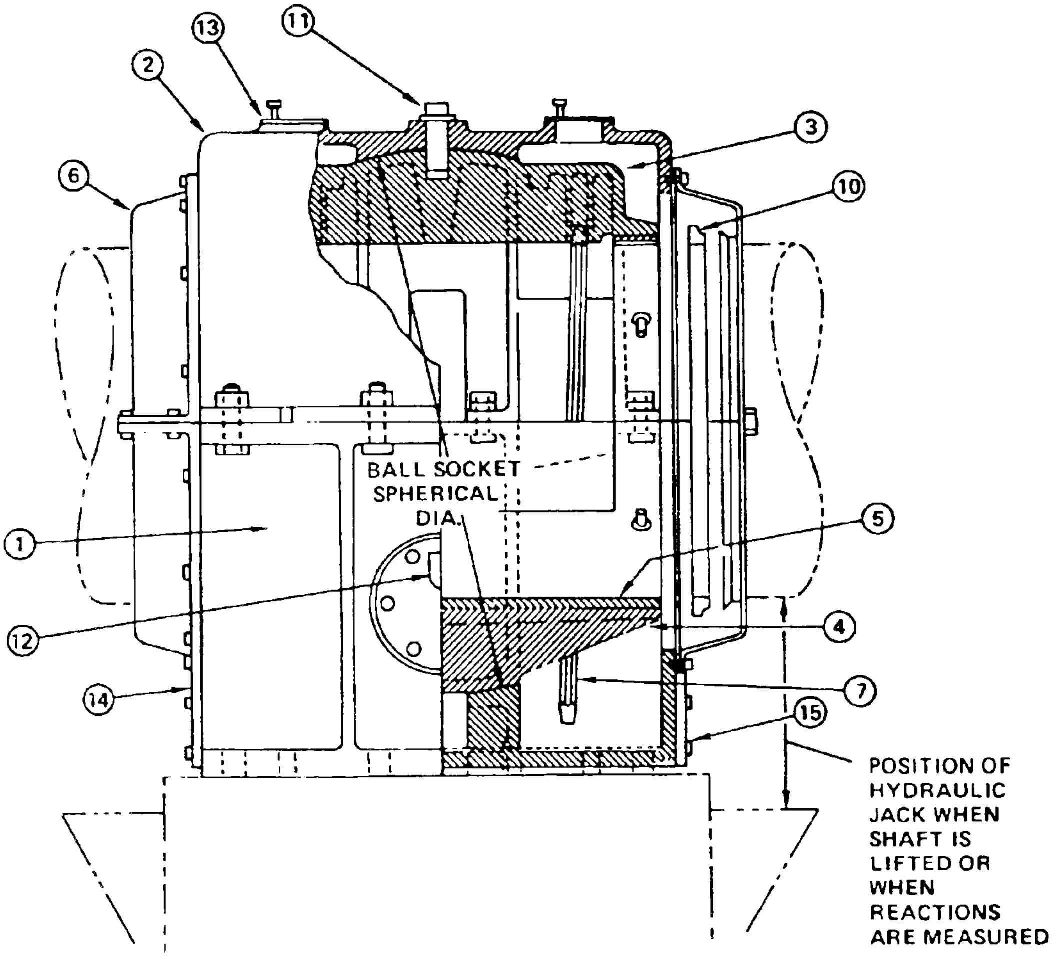
244-2.4.3.2 Bearing Cap (Part 2). The bearing cap is a detachable top bearing housing part. Its primary functions are to secure bearing elements in the bearing housing and to support vertical shock and vibratory loads. It is bolted to the bearing pedestal.

244-2.4.3.3 Bearing Housing (Parts 1 and 2). The bearing housing is the assembly of the bearing pedestal, cap, and end covers (or seals).

244-2.4.3.4 Bearing Shell (Parts 3 and 4). The bearing shell is the self-aligning detachable bearing part, consisting of a top and a bottom segment with an inside diameter (ID) that is cylindrically machined to receive a precision insert or, in the case of a thick-walled shell, is cylindrically machined to be babbitted. Babbitt thick-walled bearing shells in accordance with DOD-STD-2188, Babbitting of Bearing Shells (Metric), and check the babbitt bond in accordance with DOD-STD-2183, Bond Testing, Babbitt-Lined Bearings.

244-2.4.3.5 Bearing Insert (Part 5). A bearing insert is a cylindrical split bearing made to precise tolerances and finishes that uses thin babbitt instead of thick babbitt. Babbitt the inserts in accordance with DOD-STD-2188, and check that the babbitt bond is in accordance with DOD-STD-2183. Do not rebabbitt bearing inserts.

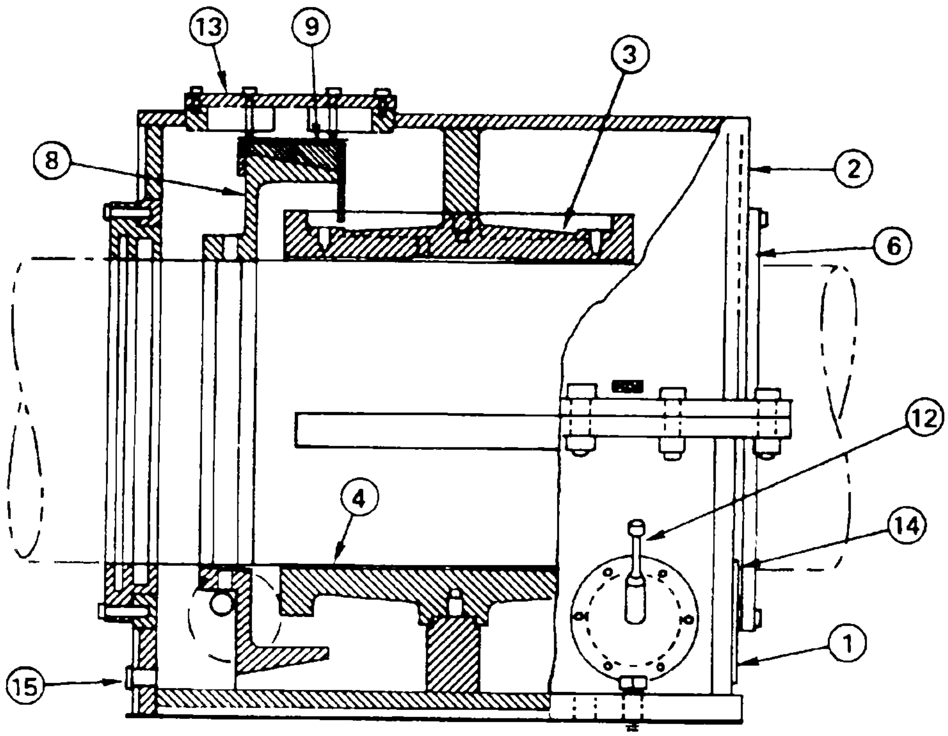
244-2.4.3.6 Oil Ring (Part 7). An oil ring is a fabricated metal ring (roughly triangular in cross section) that has an ID of approximately 1-1/3 times the shaft journal diameter. The oil ring is hung on a horizontal shaft journal to rotate with the shaft. The lower segment of the ring is immersed in and drawn through an oil-filled sump. Oil adhering to grooves machined in the inner diameter of the ring will be carried to the top of the shaft to lubricate the bearing.



PART NO.	NOMENCLATURE
1	BEARING PEDESTAL
2	BEARING CAP
3	UPPER BEARING SHELL
4	LOWER BEARING SHELL
5	BEARING INSERT
6	OIL RETAINING END COVER
7	OIL RING
*8	OIL DISK
*9	OIL SCRAPER
10	OIL SLINGER RING
11	PIVOT PIN
12	OIL GAGE
13	SIGHTHOLE
14	HANDHOLE
15	PIPE PLUG

* SHOWN ON DISK-OILED BEARING

Figure 244-2-1 Ring-Oiled Bearing



PART NO.	NOMENCLATURE
1	BEARING PEDESTAL
2	BEARING CAP
3	UPPER BEARING SHELL
4	LOWER BEARING SHELL
* 5	BEARING INSERT
6	OIL RETAINING END COVER
* 7	OIL RING
8	OIL DISK
9	OIL SCRAPER
*10	OIL SLINGER RING
*11	PIVOT PIN
12	OIL GAGE
13	SIGHTHOLE
14	HANDHOLE
15	PIPE PLUG

* SHOWN ON RING-OILED BEARING

Figure 244-2-2 Disk-Oiled Bearing

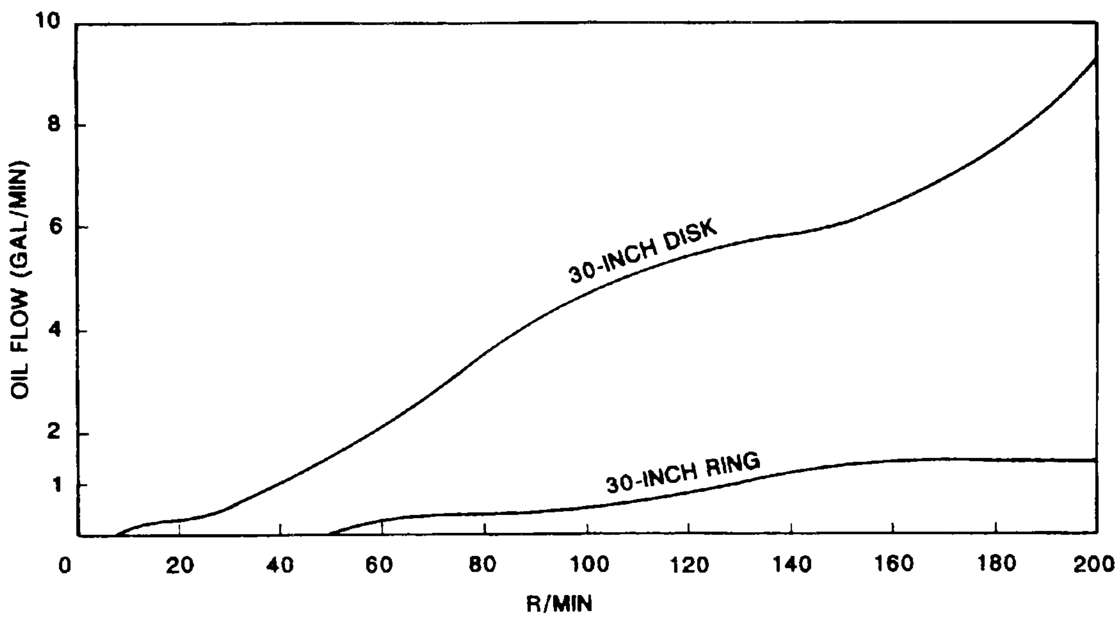


Figure 244-2-3 Ring and Disk Oil Delivery Rates

244-2.4.3.7 Oil Disk (Part 8). An oil disk is an annulus of thin metal clamped on a shaft journal so that its lowest segment is immersed in an oil-filled sump. As the shaft rotates, the attached oil disk carries oil above the journal, where the adhering oil is scraped off the disk and diverted to the bearing.

244-2.4.3.8 Oil Slinger Ring (Part 10). An oil slinger ring is a split ring attached to and rotating with the shaft. The slinger deflects oil that travels down the shaft and keeps it in the housing. Oil is slung from the shaft by centrifugal force.

244-2.4.3.9 Pivot Pin (Part 11). A pivot pin is a loose dowel in the bearing cap and upper bearing shell. It prevents the bearing shell from rotating. This pin also covers the depth micrometer hole used for measuring bearing clearance.

244-2.4.3.10 Oil Gage (Part 12). The oil gage is usually a bayonet rod with marks to indicate oil level. In some installations it may be a sight fitting.

244-2.4.3.11 Sighthole (Part 13). A sighthole, or inspection port, is a hole in the bearing cap that is located above the oil ring or disk. It usually has a cover to prevent bearing contamination. The metal sighthole cover plates are being replaced on some ships by permanently installed Lucite (plastic) covers. The advantage of this modification is that the covers do not have to be opened to observe oil ring and disk operation. This minimizes contamination and allows the oil ring and disk operation to be inspected more frequently and at higher shaft speeds.

244-2.4.3.12 Handholes (Part 14). Handholes (always provided with covers) are located in the bearing pedestal. They are used for oil sump cleanout and inspection.

244-2.4.3.13 Bearing Sump Temperature Monitors. Thermometers are installed to measure lineshaft bearing sump oil temperature. They are immersed during all operating conditions. Only bimetallic thermometers are used. Mercury thermometers are prohibited. A resistance temperature element (RTE) may be installed instead of a thermometer to measure sump oil temperatures.

CAUTION

RTE leads are delicate and require cautious handling. To avoid damage to leads and connectors, take particular care to disconnect the leads at the connectors when the bearings are rolled out.

244-2.4.3.14 Bearing Babbitt Temperature Monitors. Many bearings have RTE's embedded in the babbitt on the bearing shells to monitor the babbitt temperature. It is normal for RTE's embedded in the bearing babbitt to indicate temperatures higher than the oil sump temperature. They will also respond more quickly to changes in the bearing condition than will oil sump temperature monitors. If used, RTE's are located approximately 20° from the bottom, in the direction of the line of center for ahead rotation. One RTE is located at each bearing end at a distance from the end equal to about 20 percent of the bearing length. RTE's are embedded in the babbitt 1/8 inch below the bearing surface. If only one RTE is used, it is located in the bearing center.

244-2.4.4 SELF-ALIGNING MOUNTS. The three kinds of mounts normally used in sliding-surface bearings are shown in Figure 244-2-4.

244-2.4.4.1 Diaphragm Mount. A diaphragm mount, in which a journal bearing is supported on a rib in the housing, is shown in Figure 244-2-4a. In this type of mount, rib thickness is controlled so that the rib will deflect as a diaphragm does, allowing the bearing to align to the shaft.

244-2.4.4.2 Knuckle Mount. The mount often called a knuckle mount is shown in Figure 244-2-4b. Two ribs are machined on the OD of the bearing shell, with a narrow spherical surface between. The spherical surface mates with a corresponding surface in the housing, allowing the bearing to rock and align itself.

244-2.4.4.3 Spherical Mount. The spherical mount, in which a sphere is machined on the outside diameter of the shell to allow the bearing to align under load, is shown in Figure 244-2-4c.

244-2.4.5 MISALIGNMENT. If misaligned, journal bearings generate an appreciable righting moment. A sample pressure profile is shown in Figure 244-2-5.

244-2.5 OPERATING PROCEDURES AND PROBLEMS

244-2.5.1 OPERATING CRITERIA. A properly installed and lubricated lineshaft bearing has only two primary operating criteria: lube oil temperature shall not exceed 82°C (180°F), and babbitt temperature shall not exceed 121°C (250°F).

244-2.5.2 LUBRICATING OIL. Lubricant used in lineshaft bearings is usually the same oil used for other propulsion machinery. Currently, all steam, gas turbine, and electric-engine powered ships as well as some diesel-engine powered ships (i.e. LPD 4 Class and LSD 41/49 Class) use MIL-PRF-17331 , Lubricating Oil, Steam Turbine and Gear, Moderate Service, 2190 TEP. However, other diesel-engine powered ships (i.e. LPD 17 Class and MCM 1 Class) use either 2190 TEP or engine oil in their line shaft bearings.Most lineshaft bearings have a fully self-contained oil system.

244-2.5.2.1 Some ships have a piping system to discharge and renew bearing oil.

Instructions regarding such systems can be found in **NSTM Chapter 262, Lubricating Oils, Greases, Specialty Lubricants, and Lubrication Systems**.

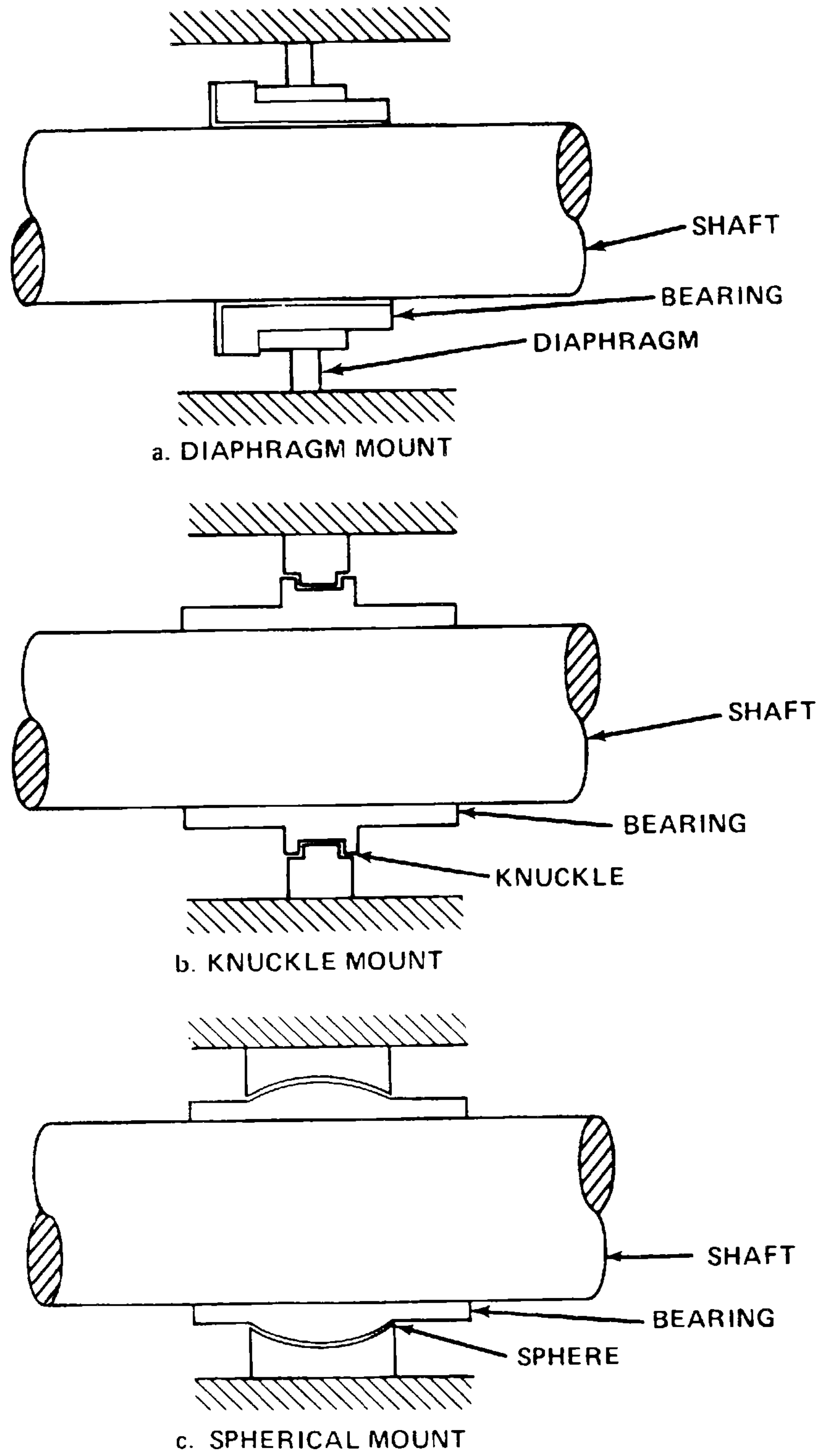


Figure 244-2-4 Bearing Mounts

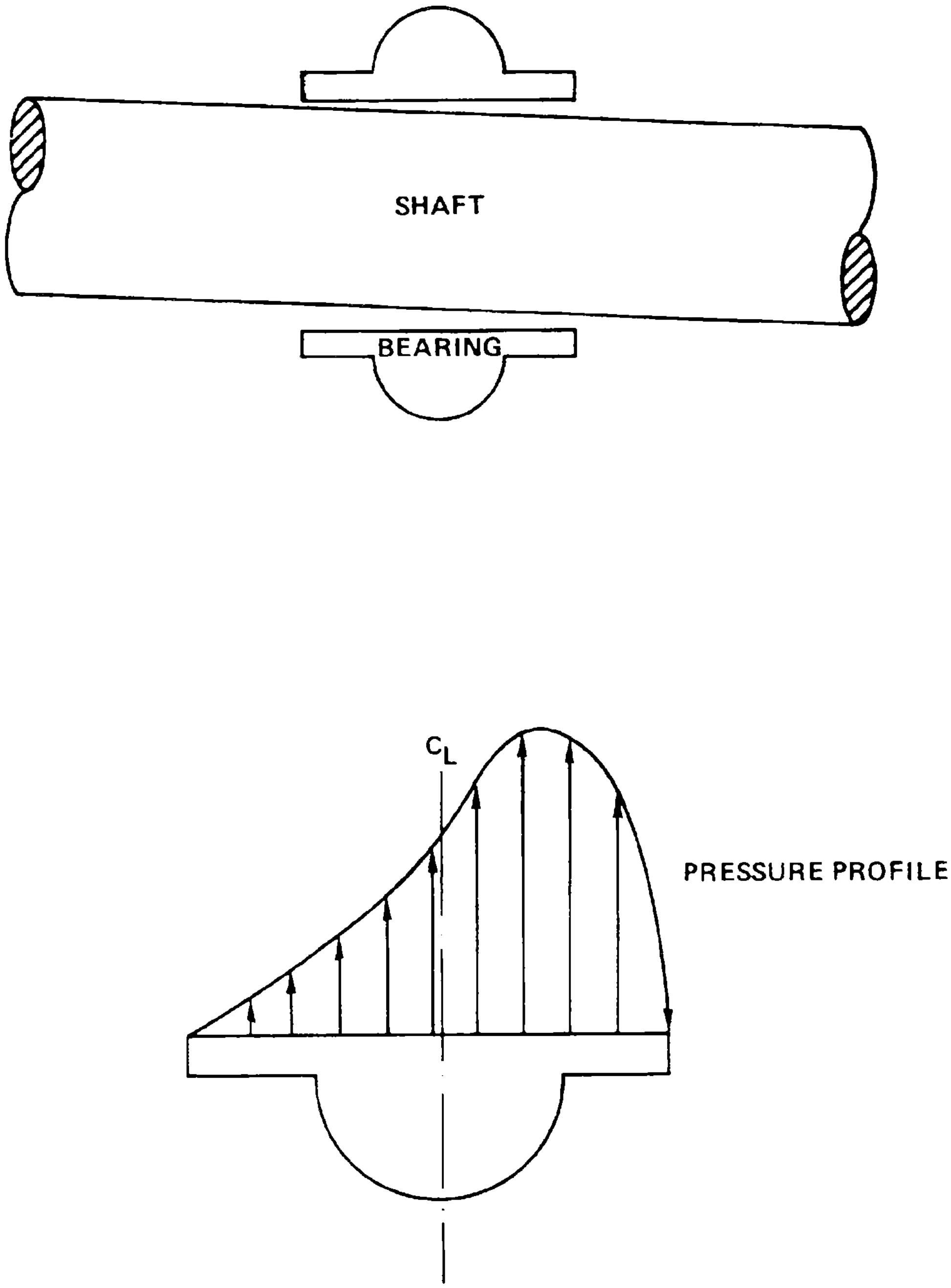


Figure 244-2-5 Misaligned Bearing

244-2.5.2.2 Bearing lubricant shall be clean and contaminant-free to prevent bearing damage. Replace lubricating oil that contains water or sediment. (see paragraph 244-2.6.5).

NOTE

For LPD 17 Class and MCM 1 Class, if the sump was previously filled with 2190 TEP (MIL-PRF-17331) lubricating oil but is now being filled with engine oil, ensure a minimum of 90-95% of the 2190 TEP has been removed prior to filling with engine oil.

NOTE

For LPD 17 Class and MCM 1 Class, if the sump was previously filled with engine oil but is now being filled with 2190 TEP (MIL-PRF-17331), ensure that as much as possible (95-100%) of the engine oil has been removed prior to filling with 2190 TEP.

WARNING

Mixing of 2190 TEP (MIL-PRF-17331) and engine lubricating oils is strictly prohibited. A very small amount of engine oil can be detrimental to the foaming and demulsibility characteristics of 2190 TEP.

244-2.5.2.3 For LPD 17 Class and MCM 1 Class, if the sump oil was changed from 2190 TEP (MIL-PRF-17331) to engine oil, following 7 days of underway operation, take an oil sample and perform a transparency and visible sediment test in accordance with Naval Ships' Technical Manual (NSTM) Chapter 262 (Figure 262-5-2). If results are satisfactory, continued operation of the line shaft bearing is permitted. Otherwise, drain, clean, and refill the sump with clean engine oil and re-perform test following an additional 7 days of underway operation.

244-2.5.2.4 For LPD 17 Class and MCM 1 Class, if the sump oil was changed from engine oil to 2190 TEP (MIL-PRF-17331), after filling the sump, take an oil sample and submit to Naval Surface Warfare Center (NSWC) Philadelphia Code 615 for calcium content analysis. If results are satisfactory, continued operation of the line shaft bearing is permitted. If the sample indicates 10 PPM of calcium or greater, the sump shall be drained, cleaned, refilled with clean 2190 TEP, and another sample taken and analyzed for calcium content. Repeat this process until a satisfactory sample is achieved. Otherwise, if the sample indicates less than 10 PPM of calcium, the 2190 TEP is acceptable for use.

244-2.5.3 BEARING SECURITY. To avoid malicious tampering, spaces that contain lineshaft bearings should be watched or locked. Unlocked spaces not under continuous watch shall be checked at intervals by a roving patrol.

CAUTION

An increase in bearing or oil temperature to an above-normal level unaccompanied by a similar change in the ambient or foundation temperature may indicate bearing distress. Watch such a bearing carefully, check the oil level, and take an oil sample.

244-2.5.4 BEARING TEMPERATURES. Normal lineshaft bearing oil sump temperatures will usually be about 28°C (50°F) above the ambient temperature if the supporting structure is not heated by an outside source. The temperature indicated by RTE's embedded in the bearing will be higher than the sump oil temperature.

The maximum permissible temperature when an RTE is inserted in the bearing babbitt is 121°C (250°F). If RTE's are connected to scanning instruments, set alarms to 11.1°C (20°F); 16.6°C (30°F) for submarines, above the maximum normal temperature (as measured on trials), but not exceeding a maximum setting of 121° C (250°F). The sump oil temperature measured by thermometer or immersed RTE shall not exceed 82°C (180°F).

244-2.5.4.1 Overheated Bearings. Lineshaft bearings are designated hot or uncontrolled hot according to the following criteria.

244-2.5.4.1.1 Lineshaft bearings fitted with direct-reading lube oil temperature thermometers:

a. **Hot**
   1. Sump oil temperature is higher than the normal operating temperature (considering the level of loading and shaft speed) but less than 82°C (180°F).
   2. Normal operating temperatures can be maintained only by use of artificial cooling or by slowing the shaft.

b. **Uncontrolled Hot**
   1. Bearing sump oil temperature exceeds 82°C (180°F).
   2. Smoke emits from bearing.
   3. Unusual noise emits from bearing.
   4. Remote bearing high-temperature alarm sounds.

244-2.5.4.1.2 Lineshaft bearings fitted with RTE's:

a. **Hot**
   1. Bearing temperature is above normal operating temperature (as measured on sea trials) but does not exceed 121°C (250°F).
   2. Normal temperatures can be maintained only by use of artificial cooling.

b. **Uncontrolled Hot**
   1. Bearing temperature equals or exceeds normal maximum bearing temperature (as measured on sea trials) by 11.1°C (20°F); 16.6°C (30°F) for submarines.
   2. The temperature is 121°C (250°F) or greater.

244-2.5.4.2 Hot Bearings. In the event of a hot bearing, proceed as follows:

1. Notify Main Engine Control.
2. Obtain permission to slow the shaft until temperatures are below maximum normal.

CAUTION

Do not exceed the normal lube oil cooldown rate of the applicable ship's operating instructions. Rapid cooling may cause condensation inside the bearing case.

CAUTION

For emergency cooldown do not run water over the bearing case. Water leaking through the end covers and sight covers could contaminate the bearing oil.

3. Use a blower to air-cool the bearing. In an emergency, apply rags wetted with water to cool the bearing.

4. Check oil level.

5. Take an oil sample.

NOTE

Babbitt in the oil indicates a wipe. Open and inspect the bearing as soon as possible (paragraph244-2.6.13).

6. Use the information in Table 244-2-2 to determine the cause of and remedy for the hot bearing.

244-2.5.4.3 Uncontrolled Hot Bearings. In the event of an uncontrolled hot or wiped bearing, proceed as follows:

1. Notify Main Engine Control.

2. Obtain permission to stop and lock the shaft.

NOTE

The decision to continue operating the shaft or to lock it and, subsequently, whether to repair or replace the bearing depends on the degree of damage.

CAUTION

Do not exceed the normal lube oil cooldown rate of the applicable ship's operating instructions. Rapid cooling may cause condensation inside the bearing case.

CAUTION

Do not run water over the bearing case to cool it down. Water leaking through the end covers and sight covers could contaminate the bearing oil.

Table 244-2-2 LINESHAFT BEARING DIAGNOSIS

Symptom	Probable Cause	Suggested Remedy
Hot bearing	Faulty lubrication	Fill sump to high mark; check for leaks
	Low oil level	Renew oil.
	Water in oil	Repair or replace.
	Stuck or defective oil rings	Repair or replace.
	Damaged disk	Correct or replace.
	Incorrectly installed disk	Repair or replace.
	Damaged oil scraper	Correct.
	Incorrectly installed scraper	Repair or correct.
	Loose or incorrectly installed scraper pin	Check clearance;
	Insufficient clearance	repair or replace.
	Dirt	Renew oil; inspect bearing.
	Journal damage	Repair.
	Defective instrumentation	Replace or calibrate.
	Thermometer	Shift to spare RTE; calibrate; check
	Resistance temperature element (RTE)	wire and connectors.
	Overload	Feeler check. Jack-check for bearing
	Misalignment	load.
	Partial or nonuniform bearing contact	Free shell seat.
	Excessive clearance	Replace or rebabbitt bearing.
	Incorrect installation	Install correctly.
	Bearing installed end to end	Calibrate.
	Incorrectly marked dipstick	Repair or replace. At parting line,
	Pinched or warped bearing	increase clearance.
	Pivot pin binding	Repair; align cap and shell.
Wipe	Similar to causes of hot bearing	Partial wipe - repair if possible;
Babbitt or	Light: Circumferential	heavy wipe - replace.
Journal Damage	grooving, pitting, embedded dirt, discolored	None. If damage is very light, repair.
	Heavy: Same as above.	Replace or repair.
	Babbitt: Cracks, separation	Replace or rebabbitt.
	Journal: Flats	Repair.
Excessive vibration	Loose foundation fasteners	Tighten.
	Operation at resonant frequency	Normal. No action required.
	Torsional critical	Change speed.
	Bulkhead packing	Replace; reposition.
	Damaged propeller	Inspect; repair; replace.
	Driving machinery	Inspect; repair.
	Bent shaft	Inspect; repair.
Wear	Slight	Small amount of wear is normal.
	Oil contamination	See Faulty Lubrication.
	Bearing damage	See Faulty Lubrication.
	Incorrect installation	See Incorrect Installation.
	Overload	See Overload.
	Starts and stops; turning	Normal. Caused by lack of film.

3. Use blower to air-cool the bearing or apply rags wetted with water to the bearing case so that it can be examined.

4. Examine the bearing and sump to determine the extent of the wipe.

5. Use the information in Table 244-2-2 to determine the cause of and remedy for uncontrolled hot or wiped bearing.

NOTE

As an interim action, scrape or replace bearing shell.

244-2.5.5 VIBRATION AND NOISE. Vibration and noise during low-speed operation may be caused by uneven shaft rotation resulting from intermittent gripping of the shaft by the stern tube bearing or strut bearing. This condition usually improves as the stern tube bearings wear in. If it becomes severe or persists at higher speeds, it may be due to adjacent bearing weardown. Realignment or replacement of the stern tube and strut bearings may be necessary.

244-2.5.5.1 Bulkhead gland packing rubbing against one side of the shaft may bow and overheat the shaft and stuffing box. This possibility is greatest after a compartment air test. The magnitude of vibration will increase with time as additional shaft bowing increases the effect of the rubbing.

244-2.5.5.2 Correction requires cooling the shaft either with air blowers or by shutting down the shaft. Before resuming shaft rotation, repack and center the bulkhead gland, as required.

244-2.5.6 SEAWATER IMMERSION. Instructions for cleaning and restoring lineshaft bearings that have been immersed in seawater because of flooding are included in **NSTM Chapter 079, Volume 3, Damage Control, Engineering Casualty Control.**

244-2.5.7 PROTECTION FROM CONTAMINANTS. During overhaul and whenever the ship is in an industrial area for extended periods, protect lineshaft bearings from dust, dirt, and abrasives. Covers shall be tight, and bearing ends shall be covered with plastic that is sealed and secured by tape to the bearing and shaft. Use plastic at least 4 mils thick to minimize the possibility of damage to the protective cover.

244-2.5.8 CASUALTY CONDITIONS. If a casualty has occurred or seems likely to occur, Main Engine Control shall be notified and kept informed of developments.

244-2.6 MAINTENANCE

244-2.6.1 SCHEDULED MAINTENANCE. The maintenance schedule shall meet the minimum requirements for normal peacetime conditions. Maintenance operations may be scheduled at more frequent intervals because of accelerated operations or severe local conditions. The recommended maintenance schedule for oil-lubricated lineshaft bearings is provided in Table 244-2-3. Record all maintenance activity in the bearing log (Figure 244-2-6). Properly performed preventive maintenance will help avoid casualties and will reveal potentially hazardous conditions. Compare inspection information with information from previous inspections kept in the bearing log. Useful information for comparison would be operating temperatures, oil levels, clearances, and damage to driving machinery and lineshafting equipment and components.

NOTE

If installed, the Planned Maintenance System (PMS) Maintenance Requirement Cards (MRC) supersede all the scheduled maintenance requirements in Table 244-2-3.

244-2.6.2 PROCEDURES. Whenever a bearing is opened for inspection, the following associated maintenance procedures shall be performed, although not necessarily in the sequence given:

Table 244-2-3 SCHEDULED MAINTENANCE

Period	Maintenance Action
Hourly, under way	Check bearing operating condition. Check bearing temperature. Check drain plug for tightness.
Each watch, under way	Inspect oil rings through inspection ports for rotation. Be sure joints are smooth and screws are flush with surface.
In accordance with MRC A2-B3WH-N MRC Code 2000 R-1	Sample and inspect lube oil.
24 Months	Measure lineshaft bearing wear with a depth gage. If a depth gage hole does not exist, bi-annual measurement is not required.
When directed by lube oil sampling and inspection.	Clean sump and renew oil in lineshaft bearing.
Annually	Inspect foundation fasteners for ocndition and tightness.
When bearing damage is suspected as indicated by abnormal oil samples, noise, or operating temperature.	If a depth gage hole exists, measure lineshaft bearing wear with a depth gage. If a depth gage hole does not exist, insert feelers (wire type) from the bearing ends.

NOTE

Items are general. Some will not apply to a specific lineshaft bearing.

CAUTION

All internal fasteners should be self-locking. If a self-locking feature is ineffective, install new fasteners or nylon inserts.

a. Fastener inspection

b. Bearing-to-journal alignment check

c. Inspection for correct bearing shell installation

d. Bearing babbitt and contact inspection

e. Bearing seating surface inspection

f. Oil dipstick calibration

g. Oil ring (or disk and scraper) inspection

h. Oil ring guide inspection

i. Shaft journal inspection

j. Gasket inspection

k. Pivot pin inspection

l. Bearing clearance (leads)

m. Sump cleanliness.

BEARING LOG

USS ___________________
BEARING _______________

BEARING DESIGN DATA

INSTALLED BEARING CLEARANCE (from ship log or bearing housing)	IC*	
BEARING REPLACEMENT CLEARANCE (from PMS, technical manual, or NSTM table 244-2-5)	RC*	
DEPTH CONSTANT (from ship log or bearing housing)	DC*	

MEASUREMENT RECORD DATA

DATE	DEPTH MICROMETER READING, MR	WEAR, W=(MR-DC)	BEARING CLEARANCE BC=(IC+W)	IF BC > RC, REPLACE OR REBABBITT BEARING
COMMENTS:				

DATE	DEPTH MICROMETER READING, MR	WEAR, W=(MR-DC)	BEARING CLEARANCE BC=(IC+W)	IF BC > RC, REPLACE OR REBABBITT BEARING
COMMENTS:				

DATE	DEPTH MICROMETER READING, MR	WEAR, W=(MR-DC)	BEARING CLEARANCE BC=(IC+W)	IF BC > RC, REPLACE OR REBABBITT BEARING
COMMENTS:				

* These parameters must be re-established (measured and recorded) each time the bearing is disturbed for inspection, rebabbitted, or replaced. Likewise, a label plate identifying these parameters along with the date they were measured, shall be manufactured and attached to each bearing.

Figure 244-2-6 Bearing Log

244-2.6.3 LUBRICATING OIL. The oil used to lubricate lineshaft bearings is usually the same oil used for propulsion machinery.

244-2.6.4 LUBRICANT CONTAMINATION. Lubricant can be contaminated with either water or solids. Both will affect bearing performance.

244-2.6.4.1 Water Contamination. Water condensed when a bearing cools is retained in the bearing oil sump. This maybe fresh water or salt water, depending on the moisture in the air. Water impairs the oil film between the journal and the bearings and causes rusting. These rusted areas cause additional oil contamination. Water may also promote the formation of tin oxide on the babbitt surface.

244-2.6.4.2 Solid Contamination. Dirt, dust, and abrasive material in the air enter the bearing and accumulate in the oil. The types of contaminants and the rate of accumulation depend on ship location and local conditions. The shipyard industrial environment, hull blasting, and boiler rebricking have a high potential for producing contaminants that can damage lineshaft bearings.

244-2.6.5 LUBRICATING OIL INSPECTION. Sampling and inspecting lube oil for water and solids is scheduled and required by the Planned Maintenance System (PMS). Lube oil sampling is in accordance with Maintenance Requirement Card (MRC) A2-B3WH-N MRC Code 2000 R-1. Inspect lube oil sample for water and sediment in accordance with the qualitative visual assessment procedure in **NSTM Chapter 262,** paragraph 262-5.1.3.2. The sample is satisfactory if it passes the visual inspection. Oil that does not meet the visual inspection criterion shall be submitted to the bottom sediment and water (BS & W) test specified in **NSTM Chapter 262,** paragraph 262-5.1.3.3. If the oil exceeds the contamination limits as specified in **NSTM Chapter 262,** paragraph 262-5.1.3.3, drain the oil, clean the sump (paragraph 244-2.6.6), and renew the oil charge.

244-2.6.6 CLEANING OIL SUMPS. The bearing oil sump shall be clean and free of foreign material before the oil charge is renewed. Clean the sump as follows:

1. Wipe sump clean with lint-free rags. Pay particular attention to corners and the area above the oil level.
2. If flushing is required, use clean bearing oil. Do not use flushing oil for the oil charge.

NOTE

Do not use abrasives or material that can shed for cleaning the oil sump. If solids cannot be removed with lint-free rags, use scrapers.

3. Always inspect the oil sump for cleanliness and removal of tools and other foreign material before putting inspection covers and cover gaskets into place.

244-2.6.7 DIPSTICKS. Most lineshaft bearings use dipsticks to indicate sump oil volume. The dipstick full level indication is calibrated at the factory by the bearing manufacturer. No further dipstick calibration is required. Occasionally, dipsticks can be a source of trouble when a lineshaft bearing dipstick calibrated for use in the forward end of the bearing housing is inadvertently installed in the aft end. In this case, under some conditions of pitch and roll, any significant shaft rake can reduce the oil charge, resulting in an oil level that is below the oil ring or disk.

244-2.6.7.1 Oil dipsticks are sometimes inadvertently interchanged among bearings. Such dipsticks will provide false readings.

244-2.6.7.2 The dipstick on newer bearings is inserted into the housing internal sump through a boss cast into a housing cleanout hole cover on the shaft alley walking side of the bearing (Figure 244-2-2).

244-2.6.7.3 On some housings, however, the dipstick is inserted into a tube or pipe tapped and threaded into the housing side or end. This arrangement is hazardous. The tube may rotate because of vibration or because someone leaned a foot on it. The oil will then drain from the housing, resulting in failure. For such dipstick installations the tube shall be securely braced against rotation by means of a steel strap welded to the housing.

Table 244-2-4 BEARING OIL CONTAMINANT MAXIMUMS

Contaminant	2190 TEP	MIL-L-9000
Neutralization No.	Greater than 0.5	Not applicable
Total Base No.	Not applicable	2.0
Sediment and Water	See **NSTM Chapter 262**	0.2 percent bottom sediment and water

244-2.6.8 LUBE OIL DRAIN PLUG. Most lineshaft bearings have a pipe plug that serves as a drain plug in the lower forward or aft face of the pedestal. The plugs have occasionally vibrated loose and allowed the oil to drain onto the deck, causing a bearing failure. This can be prevented if the plugs are screwed in tightly and checked when the bearing temperature is checked.

CAUTION

If bearing clearance is less than the previous reading, resolve the discrepancy. This condition could indicate a wiped bearing.

244-2.6.9 BEARING CLEARANCE. Operating clearance of new, reused, or replacement bearings shall be within the design clearances listed in Table 244-2-5. When the bearing clearance equals the bearing replacement clearance listed in the bearing technical manual or in Table 244-2-5, the lineshaft bearings shall be disassembled and inspected (paragraph 244-2.6.13) to determine the necessary corrective action. Bearing clearance is measured directly using lead wire or feeler gages (paragraphs 244-2.6.9.2 and 244-2.6.9.3), and indirectly by using the depth micrometer method (paragraph 244-2.6.9.1). If the depth micrometer reading is inconsistent with previous readings or the ship bearing log, or if the depth constant is suspect, the bearing clearance shall be measured by feeler gage to confirm or establish a new depth constant. The bearing housing shall not be disassembled only to take bearing clearances. Lead wire shall be used to measure bearing clearances when the bearing is disassembled for other purposes and during bearing overhaul.

244-2.6.9.1 Depth Micrometer Reading Depth micrometer readings indicate bearing wear.

244-2.6.9.1.1 Many bearing housings have a boss machined on top to provide a flat surface for a depth micrometer. A hole is drilled in this flat, and a plug is installed in the hole to protect the flat and prevent bearing contamination. Keep the flat clear and free of nicks so that depth micrometer readings are accurate.

244-2.6.9.1.2 A depth constant, the installed bearing clearance and the date on which the depth constant was taken shall be scribed on or near the flat. The depth constant is the stamped depth micrometer reading taken of a bearing shell with a bearing clearance to be used for future bearing wear assessment. The depth constant is established for newly installed or rebabbitted bearings and should have a clearance within those specified in Table 244-2-5. A new clearance shall be established by taking lead wire clearance reading whenever a new or rebabbitted bearing shell is installed or whenever a bearing housing is disassembled (paragraph 244-2.6.9.2). Whenever the bearing is already assembled, use the following procedure to verify or establish a new depth constant:

Table 244-2-5 LINEHSAFT BEARING CLEARANCES

	Design Clearance		
Journal Diameter (inches)	Newly Installed or Rebabbitted Bearing Minimum Acceptable Clearance (inch)	Newly Installed or Rebabbitted Bearing Maximum Acceptable Clearance (inch)	Bearing Replacement Clearance (inch)
5	0.008	0.012	0.019
6	0.010	0.014	0.022
7	0.011	0.015	0.025
8	0.012	0.016	0.028
9	0.013	0.017	0.030
10	0.015	0.021	0.033
11	0.016	0.022	0.036
12	0.017	0.023	0.038
13	0.018	0.024	0.040
14	0.020	0.026	0.042
15	0.021	0.029	0.044
16	0.022	0.030	0.046
17	0.023	0.031	0.047
18	0.024	0.032	0.049
19	0.025	0.033	0.051
20	0.027	0.036	0.052
21	0.028	0.038	0.054
22	0.029	0.039	0.055
23	0.030	0.040	0.056
24	0.031	0.042	0.058
25	0.032	0.043	0.059
26	0.033	0.044	0.060
27	0.034	0.045	0.061
28	0.035	0.046	0.062
29	0.036	0.048	0.063
30	0.037	0.050	0.064
NOTE: If a journal diameter does not match exactly to the diameter from the above table, use the next higher dimension.			

1. Secure the bearing lube oil system.

2. Measure the bearing clearance using feeler gages and the procedure in paragraph 244-2.6.9.3. Inspect the end of the bearing shell to ensure that the bearing shows no evidence of extruded babbitt.

3. If the reading obtained in step 2 is greater than the replacement clearance in accordance with the technical manual or Table 244-2-5, then replace or rebabbitt the bearing.

4. Obtain a new bearing depth micrometer reading (see paragraph 244-2.6.9.1.3). This depth micrometer reading will be used for future bearing wear assessment.

5. Scribe the new bearing depth constant, bearing clearance and measure date on or near the depth micrometer boss. In addition, enter them in the bearing log.

244-2.6.9.1.3 All bearing depth micrometer readings shall be recorded in the ship's bearing log (Figure 244-2-6). Use the following procedure to take depth micrometer readings:

NOTE

Bearing clearance readings will be affected by the CPP system temperature. The clearances must be taken with the CPP system temperature equal to the system temperature when the baseline clearance was established.

1. Secure the lube oil system.
2. Insert the depth micrometer into the hole with its flange flat on the boss surface (Figure 244-2-7). Be sure the boss is clean and free of nicks. If the boss does not exist or would provide inaccurate readings, see paragraph 244-2.6.9.1.4.
3. Screw the micrometer shaft down until it contacts the top of the shaft.
4. Take a micrometer reading.
5. Repeat step 3 and step 4 twice, and average the three micrometer readings.
6. Subtract the micrometer reading from the bearing depth constant. This is the bearing wear.
7. Record the average micrometer reading and bearing wear in the bearing log (Figure 244-2-6).

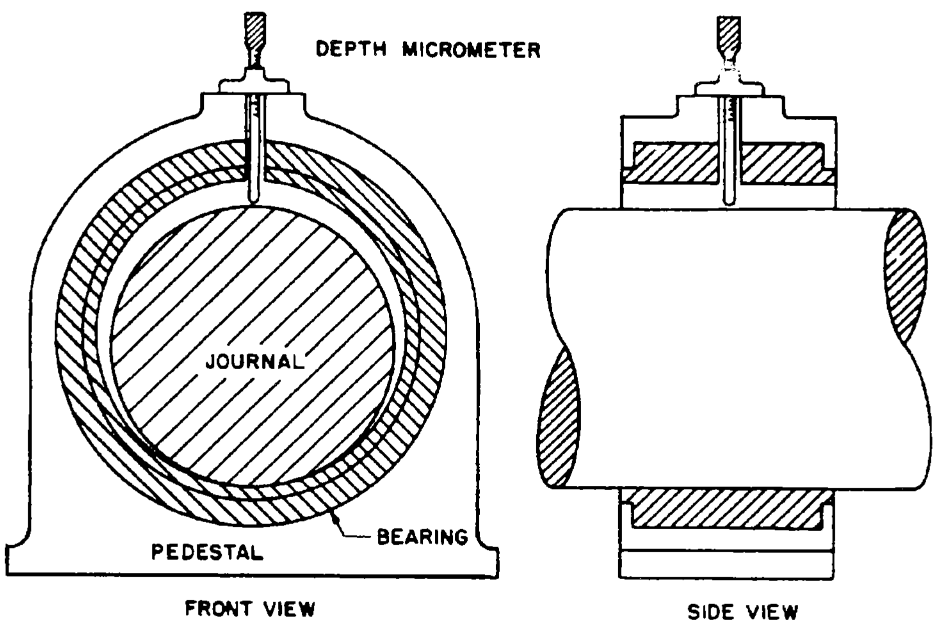
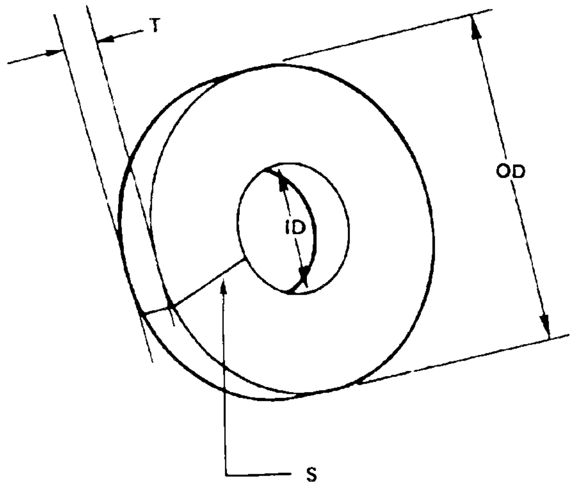


Figure 244-2-7 Depth Micrometer Clearance Reading

244-2.6.9.1.4 Some bearings have no boss for the micrometer hole. If a boss does not exist or if a reading would be changed by conditions such as accumulated paint, rust, ridges, or upper shell hole size, manufacture a washer that will fit in the space protected by the pivot pin collar (Figure 244-2-8).



OD - SLIGHTLY LESS THAN PIVOT PIN COLLAR DIAMETER
S - SCRIBE LINE. FOR USE ALINE WITH SCRIBE LINE ON CAP.
ID - SLIGHTLY LARGER DIAMETER THAN THAT OF DEPTH MICROMETER ROD
T - THICKNESS APPROX. 1/4 INCH

Figure 244-2-8 Depth Micrometer Washer

NOTE

Rod diameter should be approximately shell-hole size. If the upper bearing shell hole is considerably greater in diameter than the depth micrometer rod, it may be necessary to use an insert rod to be sure that the readings are at the bearing center. The depth micrometer rod must bear on the insert when a reading is taken. The insert should have parallel ends.

CAUTION

If bearing clearance is less than the previous reading, resolve the discrepancy. This condition could indicate a wiped bearing.

244-2.6.9.2 Bearing Clearance by Taking Leads. Lead wire shall be used to measure bearing clearance whenever a bearing is disassembled for other purposes and during every overhaul.

NOTE

Plastigage may be substituted for lead wire.

244-2.6.9.2.1 Lead Wire Size. Use lead wire that is only slightly greater in diameter (0.005 to 0.010 inch) than the existing clearance. Excessively thick lead wire may dent the babbitt and deflect the shell, which would result in a false reading. Before disassembling the bearing, measure the bearing clearance by inserting wire feelers from the bearing ends. Select the proper lead on the basis of this feeler measurement. Available lead wire diameters are shown in Table 244-2-6. Use the following procedure for measuring the bearing clearance by lead wire:

Table 244-2-6 LEAD WIRE DIAMETERS

National Stock Number	Diameter (inch)
9525-277-6036	0.010
9525-277-6037	0.015
9525-277-6038	0.020
9525-277-6039	0.025
9525-277-6040	0.028
9525-277-6041	0.032
9525-277-6043	0.040
9525-277-6045	0.049
9525-277-6047	0.065
9525-277-6050	0.134

1. Remove the upper bearing shell.
2. Place four wires of soft, unalloyed lead circumferentially on the journal. Do not use hard fuse wire or solder wire of any kind. Position the leads to contact the babbitt strips in the upper bearing shell (Figure 244-2-9).
3. Reinstall the bearing shell, taking extreme care to prevent damaging the oil rings and the oil ring guides.
4. Tighten shell fasteners in accordance with Table 244-2-7.
5. Remove upper bearing shell.
6. Remove leads from the journal. Attach each lead to a piece of paper with the leads spaced the same distance apart and arranged in the same order as they were on the journal.

244-2.6.9.2.2 Lead Wire Examination. Examine the wire to see if it is squeezed out evenly along its entire length, indicating uniform clearance. If the leads are squeezed thin in some places and thick in others, the clearance is irregular.

Table 244-2-7 BEARING SHELL PARTING-LINE BOLT TORQUES

Bolt Size (inches)	Torque Dry (lb-ft)
5/16	11
3/8	19
1/2	45
5/8	93
3/4	150
7/8	202
1	300
1-1/8	474
1-1/4	659
1-3/8	884
1-1/2	1057
1-5/8	1448

Table 244-2-7 BEARING SHELL PARTING-LINE BOLT TORQUES - Continued

Bolt Size (inches)	**Torque Dry (lb-ft)**
1-3/4	1884
1-7/8	2336
2	2721
2-1/4	3117
2-1/2	4380
2-3/4	7319
3	9455

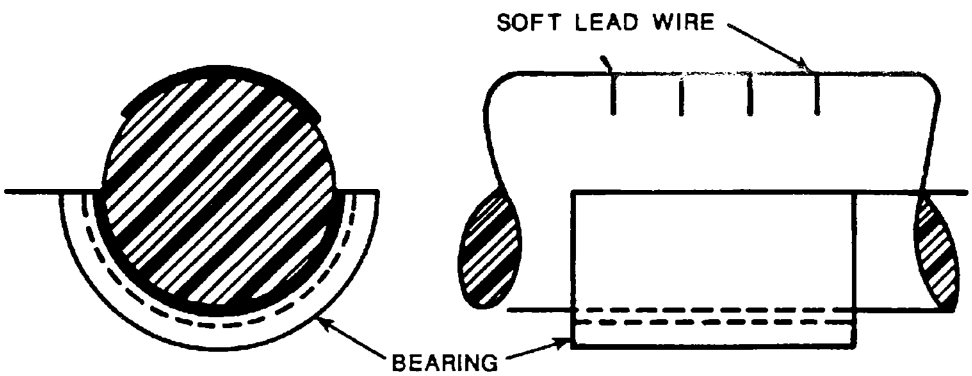


Figure 244-2-9 Placing Lead Wires for Reading Bearing Clearance

244-2.6.9.2.3 Carefully measure the thickness of each lead with a micrometer at several places along the length of the wire in order to know the clearance at all points. Leads that vary in thickness indicate an uneven bearing surface. Such bearings should be refitted to give a uniform clearance.

244-2.6.9.3 Bearing Clearance by Feeler Gage. Wire feeler gages are preferred for measuring bearing clearances. Flat feeler gages are an acceptable substitute. Make a set of wire feeler gages from stiff steel or braze wire (Figure 244-2-10). Wire diameters (Brown and Sharpe wire gage) shall range from slightly less than bearing design clearance value to about maximum clearance value. Measure wire; tag and mark as shown in Figure 244-2-10. Retain wire set for future use. Use the following procedure to measure bearing clearance with a feeler gage:

CAUTION

Do not loosen or move disk of disk-oiled bearing.

1. Remove or push back bearing end covers. Loosen oil slinger (where installed) and push back about 6 inches.
2. Take readings at forward and aft ends of bearing (except where disk interference does not permit).
3. Be sure that all parts are clean and that no dirt or tools are left in the bearing.

4. If using wire gages, select a wire that is 0.002 to 0.008 inch less in diameter than the bearing clearance. Insert wire about 1-1/2 inches at the top (12 o'clock), at the end of the bearing. Hold the wire against the upper shell babbitt. Insert a feeler blade between the wire and the journal. The clearance is the sum of the wire diameter and the thickest feeler blade(s) inserted.

5. If using a flat feeler gage, insert the thickest gage that will fit snugly between the shaft and the upper shell babbitt at the top (12 o'clock) position.

6. Replace parts moved or removed.

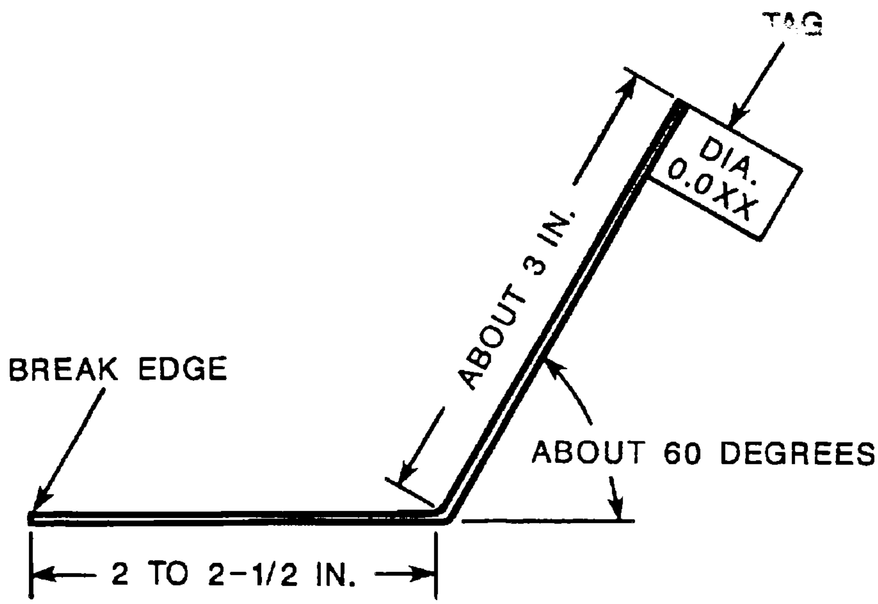


Figure 244-2-10 Wire Feeler Gage Set

244-2.6.10 MISASSEMBLY DAMAGE. Bearing damage ranging from immediate wipe to hot operation may occur because of incorrect assembly, as follows:

a. Turning the bearing shell end to end or mismating top or bottom shells with halves from other bearings. Matchmark parts to ensure correct reassembly. A marking pen is recommended; other means such as a scribe or prick punch, however, are acceptable.

b. Installing fitted bolts in incorrect positions.

c. Forcing incorrect bolts to match holes.

244-2.6.11 ROLLING OUT A BEARING SHELL. Rolling a bearing out of its housing can be a difficult task. Because bearing parts are heavy and hard to handle, the job can also be hazardous unless adequate safety precautions are taken.

WARNING

Take care to keep hands clear of housing and bearing parting lines at all times.

CAUTION

Take care not to damage the spherical and babbitt surfaces.

244-2.6.11.1 After the cap parting-line bolts have been removed, install jack bolts. Rotate the jack bolts to break the flange joint. Drilled lifting plates or eyebolt holes are provided on some housings. Install eyebolts in the holes provided for this purpose. If holes are not provided, install eyebolts in the four corner parting-line bolt holes.

244-2.6.11.2 Install an overhead chain fall of adequate capacity. Lift the upper half of the housing, walk it along the shaft, and lower it on wooden blocks placed on the deck. The upper bearing half, or shell, is usually provided with lifting eyebolt holes on the top centerline.

244-2.6.11.3 After removing the parting-line bolts, install the eyebolts in the upper shell. Use the chain fall and strap(s) to remove the upper shell. If necessary, provide lines to steady the load. Before the lower half of the bearing shell can be rolled out, the shaft weight must be taken off the bearing shell by a hydraulic jack or other suitable shaft lifting device. Lift the shaft until it clears the ends of the bearing on the lower centerline by 0.005 to 0.008 inch. If the shaft is not raised enough, the shell will not roll at all. If it is raised too much, it may create interference when the shell is rolled around to the top of the shaft.

244-2.6.11.4 After the shaft weight has been taken off the bearing shell, roll the bearing around on top of the shaft.

NOTE

Take care when rolling the shell around. Force the shell to roll by hammering on one parting line edge of the bearing with a piece of wood or soft brass, by using a bar as a lever between the back of the shell and the housing, or by using chain falls through eyebolts in the parting-line bolt holes.

244-2.6.11.5 To control shell rotation, place a block of wood over the housing parting line on the opposite side of the bearing from where the rolling force is being applied. Once the shell starts to roll around the journal, the oil film between babbitt and journal and bearing seating offers little resistance to motion. The shell may spin around the journal unless restrained by the wooden block.

244-2.6.12 BEARING CONTACT PATTERNS. Wear patterns in lineshaft bearings reveal information about bearing operation and alignment.

244-2.6.12.1 In a normal wear pattern the polished area in the babbitt surface of the bottom half of the bearing shell extends uniformly over the bearing length and is in the bottom dead center 20° to 60° of the total arc. This is sometimes called the contact area. The normal contact pattern in the lower bearing shell is shown in Figure 244-2-11. The upper shell should show no contact.

244-2.6.12.2 Polished areas located randomly throughout the bearing lower half indicate high spots. In an older bearing these areas have usually worn in with time.

244-2.6.12.3 A polished area in the lower center of the bearing, not extending to the ends, indicates that the center is high. Sometimes the opposite results, and polished areas are at the ends and not the center. If the contact pattern is skewed, as shown in Figure 244-2-11 (the polished area is in one quadrant at one end and in the opposite quadrant at the other end), or is in the top half at the ends, the bearing is misaligned and must be realigned.

244-2.6.12.4 The athwartship misalignment shown in Figure 244-2-11 occurs when the lineshaft center is offset athwartships with respect to the bearing center.

244-2.6.12.5 No contact indicates an unloaded bearing that requires vertical repositioning.

244-2.6.12.6 Contact patterns provide guidance in determining the cause and correction of such conditions as bearing overheating, wiping, and misalignment. Contact patterns are generated when the shaft rotates on the jacking gear or during starts and stops when there is little or no oil film between the shaft and the bearing surface, so they do not necessarily provide an accurate picture of normal bearing operating conditions. As an oil film develops it tends to move uniformly, distributing the load over the bearing surface. For this reason, polished contact patterns produce a distorted view of load distribution.

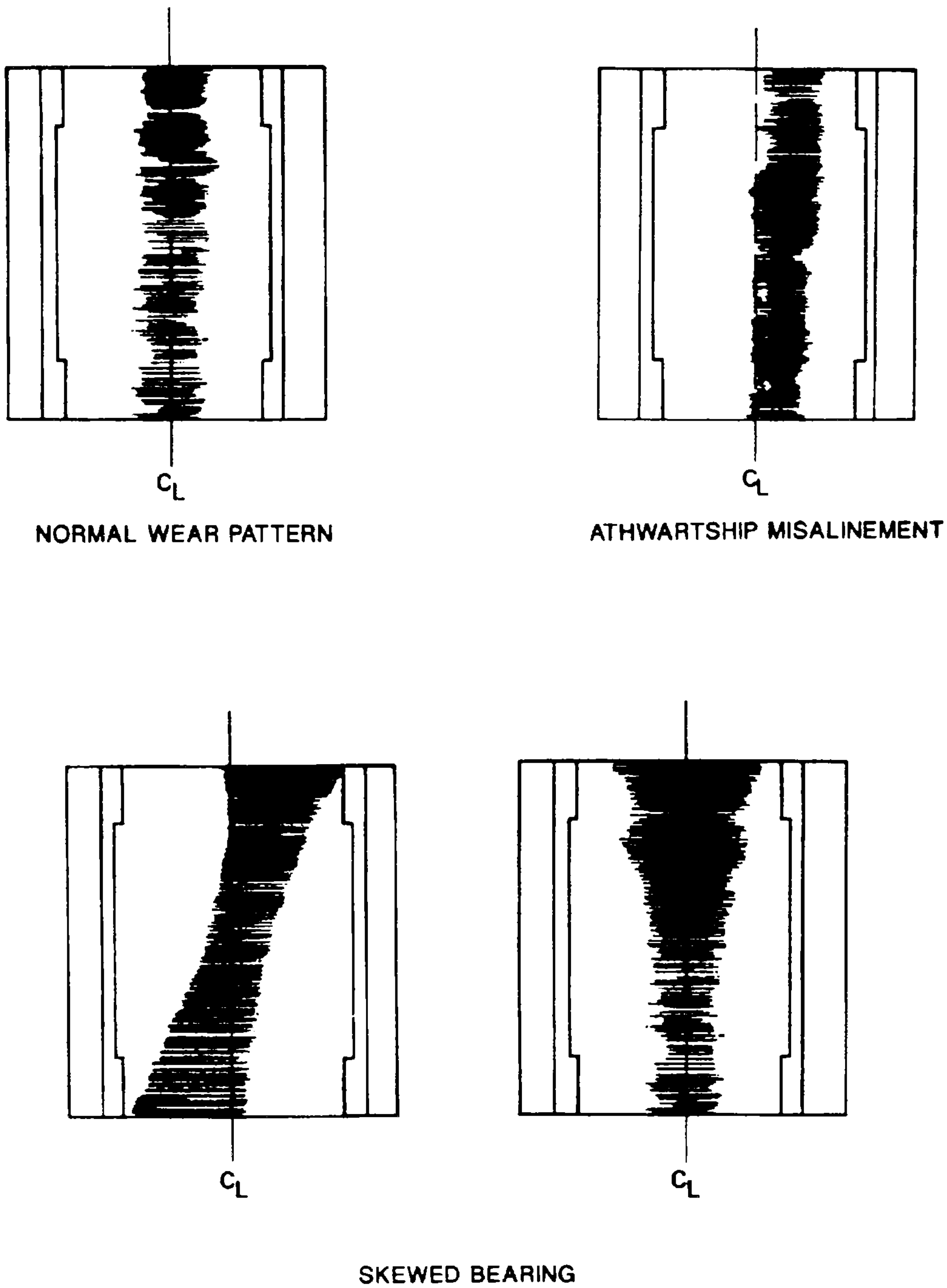


Figure 244-2-11 Lower Shell Contact Patterns

244-2.6.12.7 Do not use contact patterns, therefore, as a basis for rejecting a bearing unless there is also other evidence of distress (for example, actual smearing of the babbitt or overheating). If such other evidence exists, scrape the smeared or heavy contact areas to blend them with the adjacent surface

244-2.6.13 BEARING BABBITT INSPECTION. Inspect the condition and contact of the lower half bearing shell. Bearing babbitt contact is indicated by the polished portion of the bearing shell.

244-2.6.13.1 Slight circumferential grooving and localized wipes indicated by shiny spots are acceptable, but babbitt buildup requires removal.

244-2.6.13.2 Unacceptable conditions are wiping, heavy or extensive circumferential grooving, pitting, cracks, active embedded dirt, loose babbitt, and discoloration ranging from gray to black, which indicates corrosion or oxidation. Repair or replace the bearing shell if these conditions exist. Repair thick-walled bearing shells by rebabbitting them in accordance with DOD-STD-2188, and check the babbitt bond in accordance with DOD-STD-2183. Do not rebabbitt bearing inserts.

NOTE

Light hand pressure may reveal loose babbitt.

244-2.6.14 LINESHAFT BEARING ALIGNMENT. There are three types of bearing alignment to consider during a bearing maintenance check.

CAUTION

Never use plastic chocks for bearing alignment because about 95 percent of the heat from a lineshaft bearing needs to dissipate through the chocks to the foundation. Plastic chocks, which have low thermal conductivity, make the bearing run much hotter.

244-2.6.14.1 Vertical Alignment. The first type is vertical alignment, or the elevation of the bearing with respect to the shaft. In extreme cases, improper vertical bearing alignment can cause the bearing to overload and wipe. This alignment is usually measured with a hydraulic jack or by measuring shaft gap and sag to determine the bearing or reaction. The procedure for vertical alignment can be found in **NSTM Chapter 243, Propulsion Shafting.**

244-2.6.14.2 Athwartship Alignment. The second type of bearing alignment is athwartships. This alignment is best measured by inserting a feeler between the shaft and the bearing, both port and starboard and forward and aft. Comparing these readings indicates athwartships misalignment. The readings taken on opposite sides of the journal shall be no less than 25 percent of the diametral clearance. This misalignment is corrected by repositioning the bearing, as required, to port or starboard.

244-2.6.14.3 Skewed Alignment. The third type of bearing alignment concerns whether the bearing is skewed with respect to the shaft centerline. Skewing may be caused by a failure of the self-aligning mount (spherical or knuckle) as a result of corrosion, galling, or too tight a fit. Horizontal skewing may be evidenced by polished contact areas at the ends of the bearing on opposite sides. This condition may also be indicated if feeler readings taken on the same side of the journal differ by more than 10 percent. This misalignment is corrected in the horizontal plane by taking the load off the bearing using a hydraulic jack and adjusting the side clearances manually. Vertical skewing may be indicated if the polished contact area is wider on one end of the bearing. In the vertical plane this condition will usually correct itself if the load is relieved several times by the hydraulic jack.

244-2.6.15 BEARING PINCH OR WARP. Bearing pinch is an out-of-round condition indicated by a closing up of clearance at the bearing parting. Nonuniform measurements at the bearing parting indicate a warp. Bearings may be pinched and warped as a result of incorrect babbitting or a mismatched upper and lower shell. Pinched or warped bearings shall be corrected or replaced. Some pinched bearings can be salvaged by reboring or scraping.

244-2.6.16 RING-OILED BEARING ALIGNMENT INSPECTION. To conduct this inspection, use the following procedure:

1. Slide the end covers back or remove them.

2. Loosen the oil slinger rings and slide them back about 6 inches.

3. Check the journal position by inserting a 0.002-inch feeler, 2 inches deep minimum, between the journal and the bearing. With a marking pen, mark the feeler positions on the end of the shell (Figure 244-2-12).

NOTE

Satisfactory condition is indicated by approximately the same feeler position between the journal and the bearing, both port and starboard and fore and aft, with no gap between the journal and the bearing bottom. Position a feeler between the bearing and the journal at a 45° (or greater) angle from the parting line. All other findings indicate incorrect position.

4. Check for clearance and pinch at the parting line by taking feeler readings from both ends, above and below the parting line.

NOTE

Values should agree within 0.003 inch.

5. Provide lube oil to the main gear (if installed) and rotate the main shaft 1/4 turn with the turning gear.

6. Repeat step Table 244-2-5

NOTE

Feeler positions should be at or near the positions of step 1. If not, roll the shaft 3/4 turn and repeat step 1 Large feeler position changes after rolling 1/4 turn may indicate shaft runout. Arrange to check for a bent shaft.

244-2.6.17 RING-OILED BEARING SHAFT INSTALLATION. Check ring-oiled bearings to determine that the bearing shell is installed with the forward end forward. First, measure the distance from the top center of the forward oil ring to the forward face of the shell. Then measure from the top center of the aft oil ring to the aft face of the shell. The shorter dimension is forward because of shaft rake.

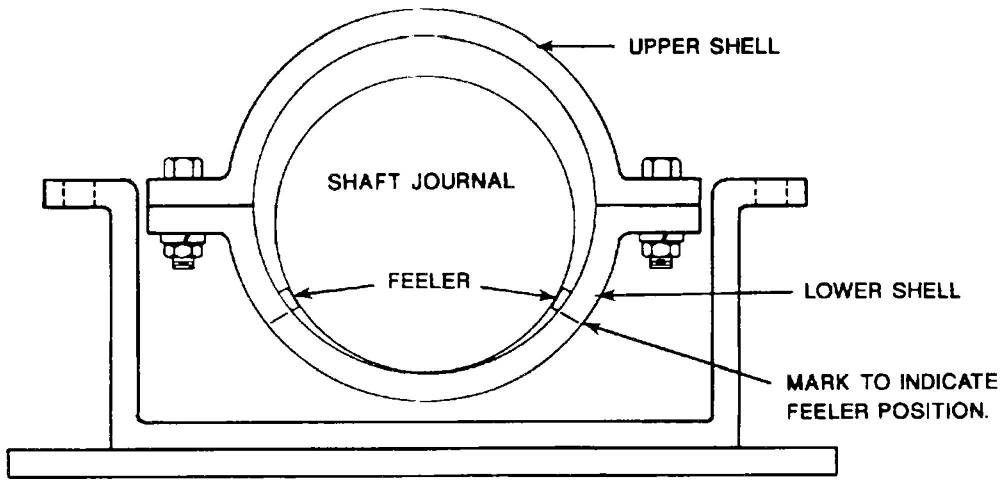


Figure 244-2-12 Ring-Oiled Bearing Feeler Positions

244-2.6.18 DISK-OILED BEARING ALIGNMENT INSPECTION. This inspection is similar to that for the ring-oiled bearings except that the disk is not moved axially along the shaft. Because the disk is not usually moved, there is no access for the feeler check at one end as there is for ring-oiled bearings. To conduct this inspection, use the following procedure:

1. Remove the upper bearing shell.
2. Insert feelers vertically between the shell and the shaft, both fore and aft, port and starboard (Figure 244-2-13).
3. Check the accessible end of the bearing for pinch at the parting line.

NOTE

Values shall agree within 0.003 inch.

NOTE

For some bearings the axial location of the disk and the oil slinger with respect to the bearing end is critical. Check these dimensions. If they are incorrect, move the disk and the oil slinger axially to the design distance specified on the drawings.

244-2.6.19 BEARING SHELL INSTALLATION INSPECTION. Examine the shell partings of bearings to make sure that the spherical or knuckle surfaces match and are flush with the housing parting at each side. Position the upper shell (when marked) so that the forward end directional arrow corresponds with the correct position.

NOTE

If the spherical surfaces do not match, the top and bottom halves of the shell have been mismatched or mismated. Correct this condition by properly matching the halves or by installing mating top and bottom halves. Mismatch usually results when the top half has been installed backward, relative to the bottom half. Mismating results when the top half of one shell has been installed on the bottom half of another.

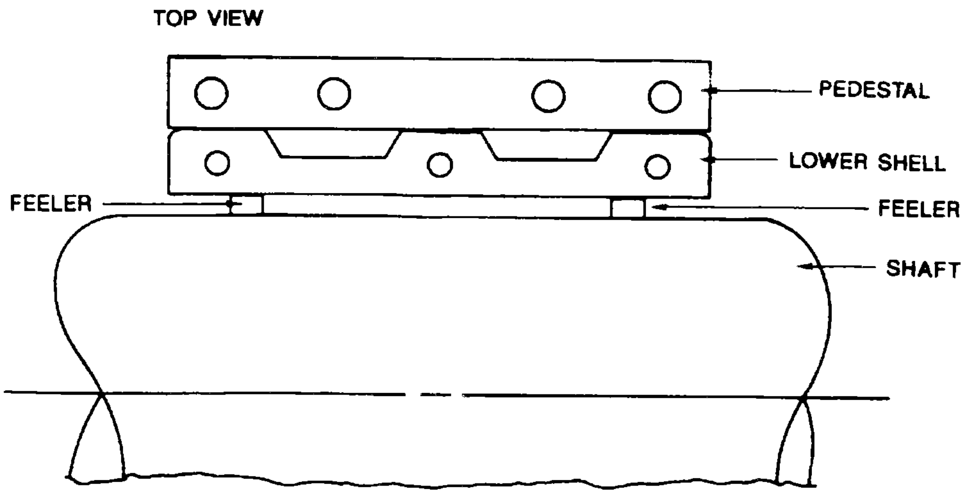


Figure 244-2-13 Disk-Oiled Bearing Feeler Positions

244-2.6.20 BEARING SHELL SELF-ALIGNING SEATING SURFACE INSPECTION. With some exceptions, lineshaft bearing shell backs are spherical and have a self-aligning feature. Proper maintenance of sphere and knuckle mounts will maximize the self-aligning capability. When the sphere and knuckle mounts are properly maintained, appreciable aligning capability results.

244-2.6.20.1 Inspect spherical or knuckle surfaces for corrosion, galling, burrs, and high spots that may impair movement. If binding is suspected, determine the ball-to-socket clearance.

244-2.6.20.2 Check shell sphere-housing clearance by bending the proper wire gage (see clearances, Table 244-2-8) with a right-angle bend and inserting wire through the pivot pin recess. The ball of a spherical design will not blue into the socket lower half except at one point, so do not use a bluing test to check contact.

Table 244-2-8 SHELL SPHERE TO HOUSING CLEARANCE

Journal Diameter (inches)	Sphere Clearance	
	Minimum (inch)	Maximum (inch)
6-13	0.004	0.008
14-20	0.006	0.012
21-30	0.008	0.016
31-36	0.010	0.020

244-2.6.21 · SHAFT BEARING JOURNAL INSPECTION. Shaft journals are machined to be round and smooth. Deviation from this original configuration will impair bearing operation. The journal surface should be bright and shiny. Circumferential grooving caused by dirt and abrasive material reduces the area in contact with the bearing, impairs the oil film, and damages or removes the babbitt. Slight circumferential grooving is acceptable. When grooving is considerable, journal repair is required. A deep blue or blackened surface may indicate corrosion, deposits, or excessive temperature. Burrs are usually caused by solids in the oil or mechanical interferences. Babbitt deposits are due to local or general wiping of the bearing babbitt. Unacceptable conditions are considerable or heavy circumferential grooving; blackened surface; rough, pitted, or burred surface; and babbitt deposits.

NOTE

Flat spots are caused by excessive use of stones, scrapers, and abrasives. Do not handwork journals. When required, handwork should be done only by experienced personnel.

244-2.6.22 SCRAPING. Hold scraping to a minimum. Never scrape bearings to alter the basic surface geometry or to change the effective bearing clearance. Bearings are manufactured to precise tolerances and, in general, should require no scraping or fitting during installation. Bearings usually show a polished area of babbitt over the bottom central 10 to 60°of arc. This does not mean that the shaft does or should contact the bearing over this arc at any one time. What does happen is that, at low shaft speeds, the oil film between the journal and bearing is thin, proportional to speed. Because the oil film is thin, the shaft tends to polish off babbitt asperities (irregularities) at the bottom dead center and for as much as 30° in the direction of journal rotation.

244-2.6.22.1 Scraping a bearing to obtain a uniform blued contact is undesirable. It destroys the bearing arc by producing a bearing surface with the same curvature radius as the journal. When the journal and bearing have the same curvature radius, the clearance over the arc is zero, preventing the oil film from forming and causing the bearing to have no load capacity. Scraping to blend a generous clearance at the wings or parting line into the bottom 60° contact area is also undesirable because it shortens the active bearing arc, raises the running temperature of the bearing, and reduces the minimum oil film thickness.

244-2.6.22.2 Since the attitude angle of the bearing (that is, the location of the point of minimum film thickness) usually exceeds 30° at full power, in an area relieved by scraping, the shaft is forced to run at its worst operating point. Such operation is undesirable.

244-2.6.22.3 Use scraping to:

a. Blend or smooth the edges of all oil grooves as required to produce a smooth junction, but only over narrow areas, such as at a chamfer.

b. Remove high spots anywhere on the bearing surface, but only to reduce them to match the surrounding surface profile.

244-2.6.23 OIL RING INSPECTION. Whenever bearings are opened, inspect the oil rings to be sure that they turn freely and are satisfactory for further service. Correct any adverse conditions before reinstalling the oil rings. An oil ring can sustain bore wear or side wear. The causes of these conditions are discussed in the following paragraphs.

244-2.6.23.1 Oil rings may have one or more grooves on the inside diameter. Testing has indicated that a ring with four 1/8x1/8-inch circumferential grooves delivers the most oil to the bearing. Grooves shall be a minimum of 1/32 inch deep. When groove depth is reduced to 1/32 inch, remachine the grooves or replace the ring.

NOTE

If the oil ring is excessively worn or cannot be turned it may deliver insufficient oil, causing the bearing to overheat.

244-2.6.23.2 Progressive wear of the oil ring against the bearing or guides may cause the heads of the joint retaining screws or rivets to wear off. This allows the retaining screws or rivets to back out and hang up on the guide, stopping the ring from rotating. When this happens, the bearing inevitably fails because of oil starvation.

244-2.6.23.3 The ring may also stop rotating if it rubs the guide until a groove is worn, and then the ring hangs up in the guide.

244-2.6.23.4 Other conditions that can stop the ring from rotating are loose ring joints, warped or bent rings, and projections from the side of a ring (burrs, nicks, and dents) that cause high areas.

244-2.6.24 OIL RING GUIDES. The oil ring guides are grooves cast into or secured in the upper bearing shell or housing. Each guide positions an oil ring. Wear between the side wall of the guide and the oil ring can occur, possibly causing the oil ring to hang up. Inspect guides for any condition that could stop or slow oil ring rotation, such as burrs, dents, grooves, and rough areas. Guide fingers should not contact the journal.

244-2.6.25 DISK AND SCRAPER INSPECTION. Whenever bearings are opened, inspect the oil disk and scraper to be sure they are satisfactory for further service.

244-2.6.25.1 A gap at the disk split, joints that are not smooth and concentric, or loose fasteners may cause surface irregularities that will cut into the scraper as the shaft rotates. This will eventually cause the bearing to fail when the scraper ceases to function.

244-2.6.25.2 An incorrect initial position, excessive wear, or looseness of the antirotation pin securing the scraper can increase the space between the scraper and the disk. This will reduce or stop oil flow to the bearing.

WARNING

Asbestos is a hazardous material and shall not be used. Always wear gloves when removing asbestos gaskets.

244-2.6.26 SEALING JOINTS.

244-2.6.26.1 Gaskets. Gaskets are used for an oiltight cover fit. They are never used between the bearing pedestal and the cap flange. Rubber gaskets can usually be reused. Inspect the gaskets for cuts, tears, and distortion that may impair sealing capability. Paper gaskets may be used to replace rubber gaskets that are unsuitable for further service. Paper gaskets are usually 1/32 inch thick, symbol 2290. When installing paper gaskets, seal both sides of the gasket with a light coat of sealing compound in accordance with MIL-S-45180, **Sealing Compound,**

Gasket, Hydrocarbon Fluid and Water Resistant, type 3. Replace paper and asbestos gaskets with paper gaskets. Be sure the gasket seating surface is clean. Take care to avoid damaging the surface when scraping oil sealant.

244-2.6.26.2 Metal-to-Metal Joints. Assembly of metal-to-metal joint shall be as follows:

a. Clean, scrape, and stone the joint to remove any raised metal from mating surfaces.

b. Verify correct assembly of bearings and components so that joint will not be held open. Verify correct pinch fit of bearing (if applicable).

c. Do a joint contact blue check if bearing or other components were changed or if the joint is known to be damaged or leaking. Blue check the joint and hand work mating surfaces as necessary to achieve a continuous band of contact inside the hole pattern.

d. Apply a thin coat of non-hardening Permatex or equivalent sealant on the joint, stopping 1/4 inch from the edges. Excess sealant will seep into and contaminate the lube oil system.

e. Reinstall component or cover, and tighten fasteners in a crosswise incremental torque.

244-2.6.26.2.1 As an alternate method, perform the following steps:

NOTE

This method will produce a more leak-resistant joint, but extreme caution must be exercised in applying sealant to prevent excess sealant from seeping into and contaminating the lube oil system,

a. Clean, scrape, and stone the joint to remove any raised metal from mating surfaces.

b. Verify correct assembly of bearings and components so that joint will not be held open. Verify correct pinch fit of bearing (if applicable).

c. Do a joint contact blue check if bearing or other components were changed or if the joint is known to be damaged or leaking. Blue check the joint and hand work mating surfaces as necessary to achieve a minimum of 70-percent contact inside the bolt pattern. Areas of non-contact should be generally distributed evenly and not concentrated in one area thereby leaving a potential leak path.

d. Apply a thin coat of an oil-resistant silicone sealant such as Permatex Ultrablue 77B or equivalent on the joint, with an approximately 1/2 inch wide inner barrier of non-hardening Permatex or equivalent sealant if flange width permits, stopping 1/4 inch from the inside edge.

NOTE

The silicone compound Permatex Ultrablue 77B has been shown to be effective and to allow disassembly. However, other silicones, even in the same Military Specification or NSN, must be tested before use.

e. Reinstall component or cover, and tighten fasteners in a crosswise incremental torque.

244-2.6.27 OIL SLINGERS. Oil slingers, secured to the shaft near the end covers, deflect lube oil that has traveled down the shaft. The oil slingers, in halves to facilitate assembly, are secured by bolts at the flange. Bolts of most designs are prevented from backing out by upsetting (staking) bolt holes or by the use of self-locking screws.

244-2.6.28 COTTER PINS. Do not use cotter pins. Replace castellated nuts and cotter pins with self-locking nuts in accordance with MIL-N-25027, Nut, Self-Locking, 250°F, 450°F, 800°F.

244-2.6.29 PIVOT PIN. The pivot pin (antirotation dowel) prevents the bearing from rotating in the housing. It fits loosely to permit the bearing shell to move in its seat to align with the journal.

244-2.6.29.1 Inspect the antirotation pivot pin and the hole in the upper bearing shell for distortion and damage. Replace pivot pins that are bent, distorted, out of round, or otherwise unsuitable for further service. Remachine damaged pivot pinholes. The pin must slide freely in the hole. Pivot pin dimensions for a standard Navy lineshaft bearing are listed in Table 244-2-9. These dimensions are also typical of other lineshaft bearings.

Table 244-2-9 PIVOT PIN DIMENSIONS

Journal Diameter (inches)	**Pin Diameter (inches)**	**Pin Length (inches)**
6-13	7/8	2-1/2
14-19	1	2-1/2
20-28	1-1/4	2-3/4
29-36	1-1/2	3

244-2.6.29.2 Make sure that the pivot pin can be installed without force. The pin will be damaged if the bearing is forcibly assembled with the cover hole and upper bearing shell misaligned. The hole surface can also be damaged during such assembly. If the dowel cannot be installed without force, check for a mismatch between dowel pin holes in the cap and the bearing. Correct port and starboard mismatch by removing the cap and, after the shaft is lifted, rotating the shell to remove the load. Fore-and-aft mismatch indicates that the limit of bearing self-alignment has been reached and bearing-to-shaft realignment is required.

244-2.6.30 END SEALS. End seals prevent oil from leaking along the journal and also prevent oil contamination from the environment. Lineshaft bearing end seal oil leakage rate shall not exceed 1 drop per minute.

244-2.6.30.1 Double-Lip End Seals. Many Disk-oiled lineshaft bearings have double-lip end seals. These seals have two significant advantages: they allow the bearing to operate in a flooded compartment, and they prevent airborne dirt from entering the oil sump. Double-lip end seals, however, have had a history of oil leakage. The inner lip seal faces the bearing to prevent oil leakage and the outer lip seal faces the machinery space to prevent water from entering the bearing oil. The problem with this design is that the lip seals are held in contact with the shaft by garter springs, resulting in wear and grooving of the shaft. If grooving of the shaft oil seal journal is encountered, installation of an oil seal spacer (dutchman) is acceptable as a permanent repair. The intention of this alteration is to reposition the lip seals to a smooth shafting surface. A Departure From Specification (DFS) request must be submitted for approval on a per-case basis.

244-2.6.30.2 Hybrid End Seal. A newly designed hybrid end seal uses a labyrinth seal to contain the bearing oil and a single lip seal to prevent water contamination of the oil (Figure 244-2-14). The labyrinth seal has two teeth with sufficient drainage holes to prevent oil from contacting the rubber lip seal and leaking. The labyrinth seal limits the flow of oil from the bearing housing because of its small clearance with the shaft. The side clearance between the labyrinth seal and the shaft should be within 0.004 inch and the bottom clearance 0.004 to 0.009 inches smaller than the top clearance. The lip seal faces the machinery space and seals around the shaft if space flooding occurs. Water pressure forces the seal's concave section to compress against the shaft. The lip seal prevents water intrusion only and has a negligible effect on preventing oil leakage. The labyrinth seal can be manufactured locally from readily available wrought or plate aluminum. The existing double-lip seal housings can be modified and reused with this seal. Permatex 2 can be used on the outer diameter of the lip seal and the lip seal joint instead of the 1/8-inch-diameter O-ring located between the labyrinth and the outer lip seal.

244-2.6.30.3 Large Clearance End Closure. Most older design ring-oiled bearings do not have positive-contact end seals. They have wide clearance end bells with an oil slinger bolted to the shaft inside the housing at each end and a large clearance baffle plate to prevent oil leakage. These seals are being retrofit with lip seals to prevent water contamination of the bearing housing if space flooding occurs.

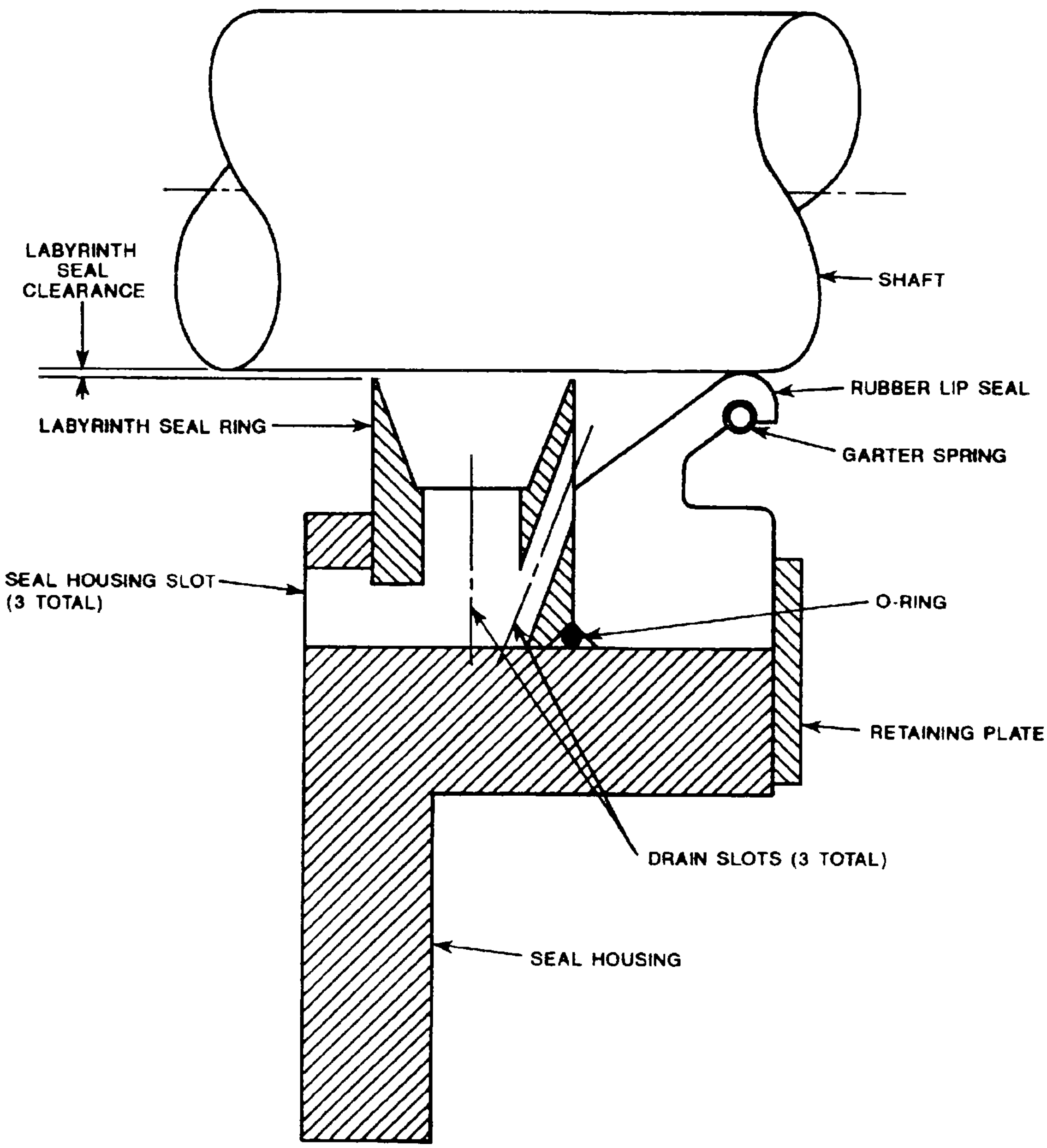


Figure 244-2-14 Hybrid End Seal

244-2.6.30.4 Felt Oil Seals. Felt oil seals are used occasionally. They are assembled in a groove in the bearing casing or end cover, are stationary, and contact the shaft. Oil traveling along the shaft is removed by the felt. The seals should not be hard or contain abrasive material. Do not use color to indicate the condition of the felt.

244-2.6.30.5 Cast-In Metal Oil Seals. Soft metal, such as babbitt, may be cast into grooves in the end covers or casing. The seal is a close fit with the shaft and reduces the flow of oil and oil mist from the bearing. Inspect cast-in metal end seals for wear, clearance, and loosening. Replace loose seals. Repair or replace worn seals as appropriate.

244-2.6.30.6 Metal Ring Seal. A metal seal ring, in halves that are secured together, may be installed in a retainer groove in the end cover. This type of oil seal is not secured to the casing or shaft and is free to rotate.

This seal is sometimes called a floating ring seal. The seal is a close fit with the shaft and the forward and aft end of the holder. Floating seals usually wear very slowly. Make sure the seals are free to rotate. Remove dirt from the grooves and drain holes.

244-2.6.30.7 Wipers. Wipers may be of felt or other material. They bear against the shaft and remove oil that travels along the shaft. They are kept in contact with the shaft by gravity or by light spring pressure. Make sure the wiper contacts the shaft and is positioned to remove oil. The wiper shall be free in the holder or cartridge so that it can follow shaft movement. Inspect the felt for resiliency and for abrasive dirt. Replace felts that contain abrasives.

244-2.6.31 FASTENERS. Ship vibration occasionally causes the foundation or parting-line bolts and nuts to work loose. They can also be missing, broken, or excessively corroded.

244-2.6.31.1 Detect loose bolts by sounding with a hammer. For bolts 5/8 inch and smaller, it may be easier to determine tightness by torquing. Unsatisfactory fastener conditions, other than looseness, can be detected by visual inspection.

244-2.6.31.2 Replace missing and excessively damaged fasteners. Fastener material and fit shall be in accordance with drawing requirements.

244-2.6.31.3 When fasteners are installed or tightened, torque the parting-line bolts in accordance with Table 244-2-7 and torque the foundation bolts in accordance with Table 244-2-10.

244-2.7 DISPOSAL OF SAMPLES AND USED OIL

244-2.7.1 OIL SAMPLE. If oil drawn for a sample has no contaminants, return oil to the bearing sump.

Table 244-2-10 FOUNDATION BOLT TORQUE TABLE

Fastener Diameter (inches)	**Torque Dry (lb-ft)**
5/8	150
3/4	250
7/8	378
1	583
1-1/8	782
1-1/4	1097
1-3/8	1460
1-1/2	1748
1-3/4	3118
1-7/8	4191
2	4604
2-1/4	6407
2-1/2	7144
2-3/4	12092
3	15776
NOTE: Use SAE grade 3 (100,000 lb/in^2 tensile strength, minimum) bolts or better.	

244-2.7.2 USED OIL. Symbol 2190 TEP oil containing water and solids shall be reused after it has been cleaned in a settling tank and then centrifuged. Do not mix lineshaft bearing oil and oil charge for the main lube oil system. Store used 2190 TEP oil in a contaminated oil tank if it cannot be processed in accordance with this procedure. Store used MIL-L-9000 oil in a contaminated oil tank.

SECTION 3

MAIN PROPULSION THRUST BEARINGS

244-3.1 GENERAL

244-3.1.1 INTRODUCTION. Main propulsion thrust bearings transmit the axial thrust generated by the propeller to the ship's hull. They also maintain the required position of the propulsion shaft and main reduction gear.

244-3.1.2 ROLLING-ELEMENT THRUST BEARING. Many smaller ships use rolling-element thrust bearings for the main propulsion thrust bearing. Rolling-element thrust bearings can be classified as angular-contact ball bearings, cylindrical roller bearings, spherical roller bearings, or tapered roller bearings. Rolling-element bearings have definite load-and speed-dependent life limits: when they reach these limits they must be replaced. They are therefore not widely used in high-load applications; hydrodynamic thrust bearings are used instead. For further information on rolling-element thrust bearings, refer to Section 1 of this NSTM chapter.

244-3.2 HYDRODYNAMIC THRUST BEARINGS

244-3.2.1 GENERAL DESCRIPTION. Most main propulsion thrust bearings are pivoted-shoe, self-equalizing, hydrodynamic bearings. These bearings support the load between the thrust collar and the bearing surface through an oil film. The bearing load-carrying properties depend on the fluid film shape and relative velocity of the sliding surfaces. Above about 20 rpm, main propulsion thrust bearings operate as full-film hydrodynamic thrust bearings. Bearings operating with full-film lubrication have essentially an unlimited life. Most bearing wear occurs at low shaft speeds, when the bearing operates with boundary lubrication. Operating at low shaft speeds for long periods of time is therefore undesirable.

244-3.2.2 PIVOTED-SHOE, SELF-EQUALIZING THRUST BEARING. The pivoted-shoe, self-equalizing thrust bearing has individual pads or shoes. Each of these shoes is free to tilt on its pivot support to promote the formation of the oil film wedge (Figure 244-3-1). A system of leveling plates compensates for differences in the load distribution between shoes. Each pivoting thrust shoe consists of a babbitt surface, steel backing or body, and hardened-steel support disk. During operation the babbitted face of the shoe rides on a film of lubricating oil against the main shaft thrust collar. The hardened-steel support disk allows the thrust shoe pad to tilt and promote the formation of the oil film wedge. The thickness of the oil film is inversely proportional to the load carried by a thrust bearing. Equalizing the oil film thickness, therefore, equalizes the load. The load transmitted by the oil film to any one thrust shoe causes that shoe to press against its upper leveling plate. The upper leveling plate is supported on each side by two lower leveling plates. The intermeshing action of the leveling plates distributes load among the pivot shoes evenly and, therefore, eliminates excessive thrust on any one shoe. The leveling plates can accommodate a permanent misalignment between the thrust collar and the housing of up to 20 minutes of arc. It cannot accommodate total collar runouts greater than 0.001 inch, however, without adversely affecting the oil wedge.

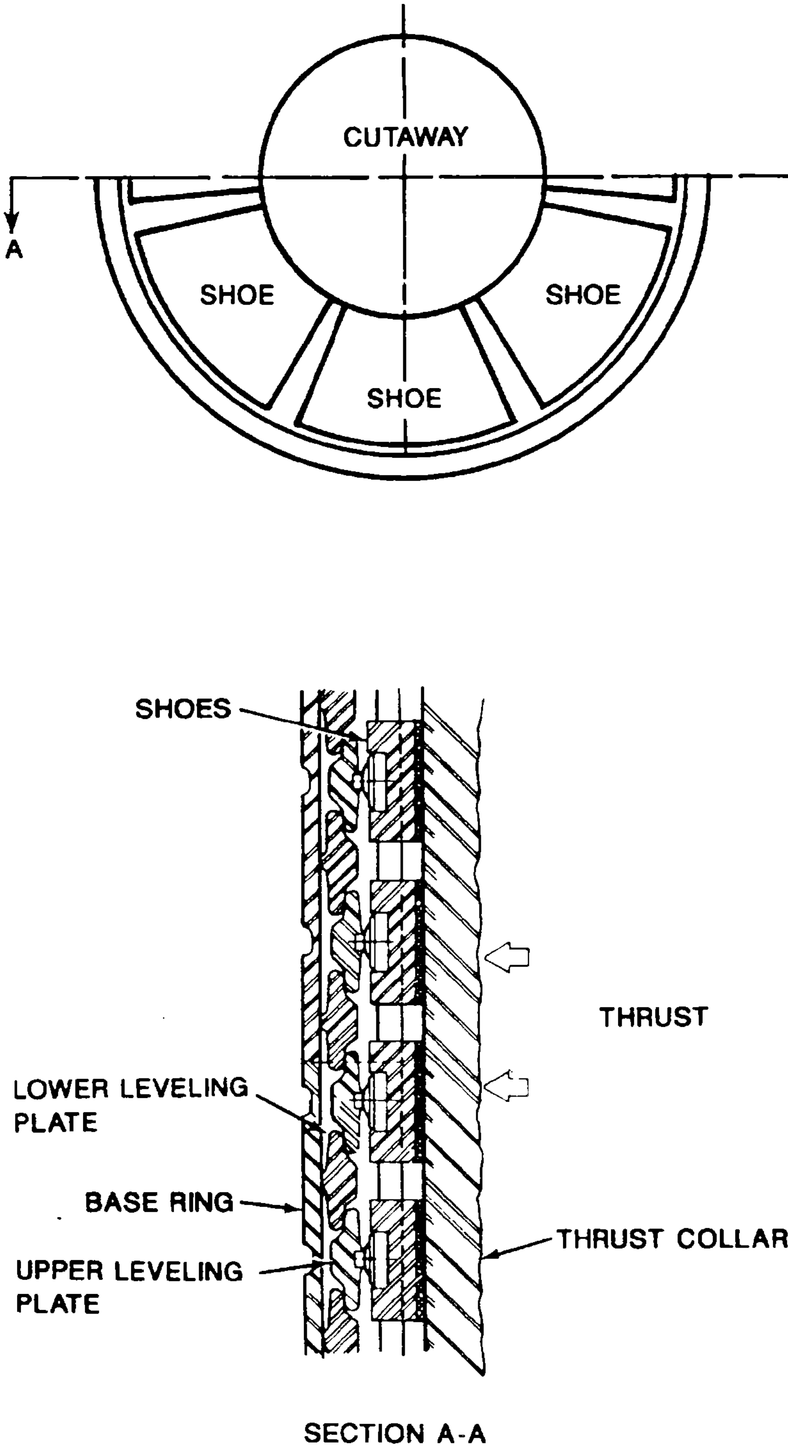
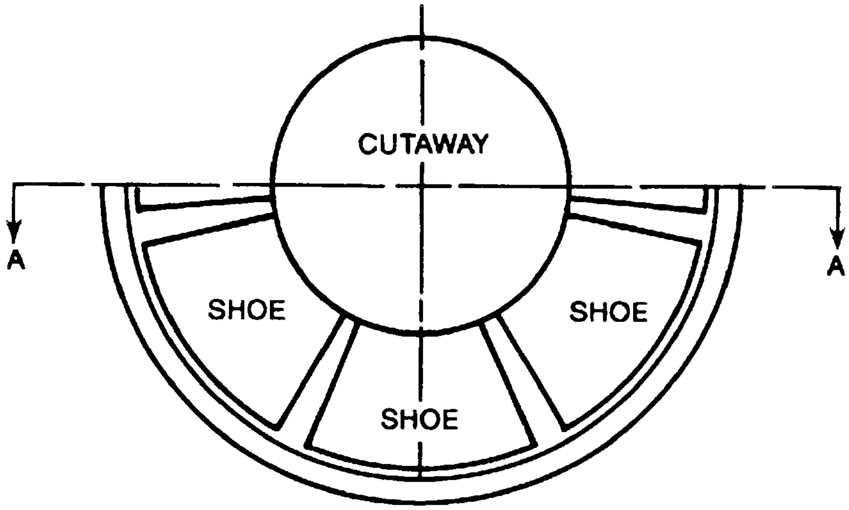


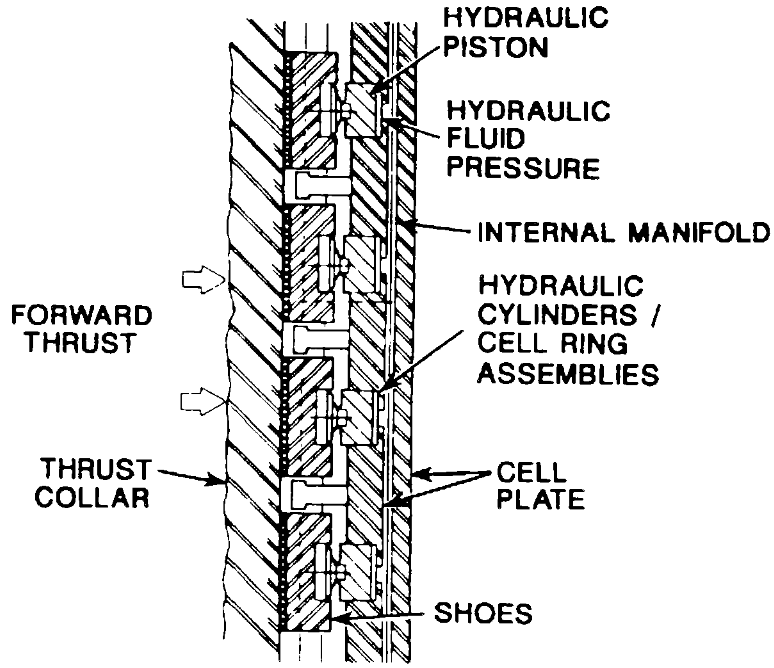
Figure 244-3-1 Pivoted-Shoe, Self-Equalizing Thrust Bearing

244-3.2.3 SELF-EQUALIZING THRUST BEARING WITH VIBRATION REDUCER. On some self-equalizing thrust bearings the forward thrust element is modified to incorporate a vibration reducer (VR) (Figure 244-3-2. In this arrangement the forward leveling plates and base ring are replaced with hydraulically pressurized piston-cylinder assemblies. The load is equalized because the pressure of the hydraulic fluid behind each piston is equalized through common connections in an internal manifold and external piping system. This configuration is used almost exclusively in submarines.

244-3.3 THRUST BEARING ASSEMBLY

244-3.3.1 THRUST SHOES. Main propulsion thrust bearings on surface ships and submarines usually have six or eight thrust shoes. A six-shoe, self-equalizing bearing with one shoe removed and inverted to expose the support disk and leveling plates is shown in Figure 244-3-3. Thrust bearings often use interchangeable bearing components for the ahead and astern thrust elements. In some applications the astern side may have a reduced number of or smaller shoes to reduce bearing power loss. The thrust shoes are typically made of steel and covered with a tin-based babbitt on the bearing surface. Two shoes are usually fitted with a resistance temperature element (RTE) embedded in the babbitt to monitor the bearing temperature. One RTE is active and the other is a spare.





SECTION AA

Figure 244-3-2 Self-Equalizing Thrust Bearing with Vibration Reducer

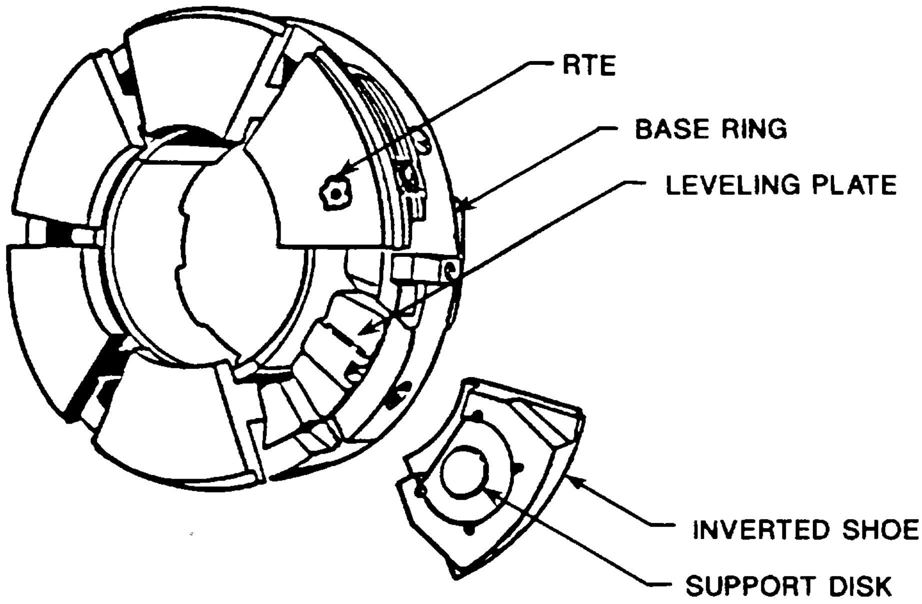


Figure 244-3-3 Six-Shoe, Self-Equalizing Thrust Bearing

244-3.3.2 LEVELING PLATES. The self-aligning feature of the leveling plates equalizes the thrust load among the shoes. The internal mechanical arrangement of the thrust shoes and leveling plates is shown in Figure 244-3-4. The leveling plate position is maintained either by radial dowels or by bolts and the base ring. The upper leveling plates contact the shoes and transmit the load to the lower leveling plates. The plates are made of forged steel for added strength.

244-3.3.3 BASE RING. The base ring, or retainer ring, is made of steel. It locates the leveling plates and shoes, and transmits the load from the lower leveling plates to the housing and filler plates. The base ring is split and held together with screws and dowels. A holding key keeps it stationary in the housing. A typical base ring assembly is shown in Figure 244-3-5.

244-3.3.4 SHIMS. Shims, sometimes called filler plates, are located and transmit the thrust load between the base rings and the housing. The thickness of the shims can be adjusted to obtain suitable axial end play in the thrust bearing assembly. End play is necessary to minimize excessive fluid power losses in the unloaded thrust bearing. Limiting the axial end play is necessary to minimize the inertia loadings under reverse thrust transients and to maintain the thrust collar position.

244-3.3.5 HOUSING. The housing transfers the bearing load reactions to the ship structure. It has a horizontally split upper half (and in some cases a vertically split upper half) to permit access to the thrust bearing (and journal bearing when present). The housing also contains the lubricating oil. Lifting eyebolts are installed on the upper half housing to permit ease of handling. The housing usually has a sight flow indicator or bubbler assembly to allow visual examination of the lubricating oil flow. On adjacent and remote mount thrust bearings, the lower-half housing has drilled feet for anchor bolts and locating dowels. On integrally mounted thrust bearings the lower-half housing is part of the main reduction gear housing. The lower-half housing also contains the lubricating oil drain flange connections. A typical remote mount thrust bearing housing is shown in Figure 244-3-6. See paragraph 244-2.6.26 for applicable housing sealing procedures.

244-3.3.6 SIGHT FLOW INDICATOR and BUBBLER ASSEMBLY. Sight flow indicators or bubbler assemblies are located on top of the housing. They monitor the discharge oil flow through the main thrust and journal bearings. The indicator, or bubbler, consists of a body fitted with glass observation ports (Figure 244-3-7). Oil in the indicator or bubbler indicates that oil is circulating through the bearings.

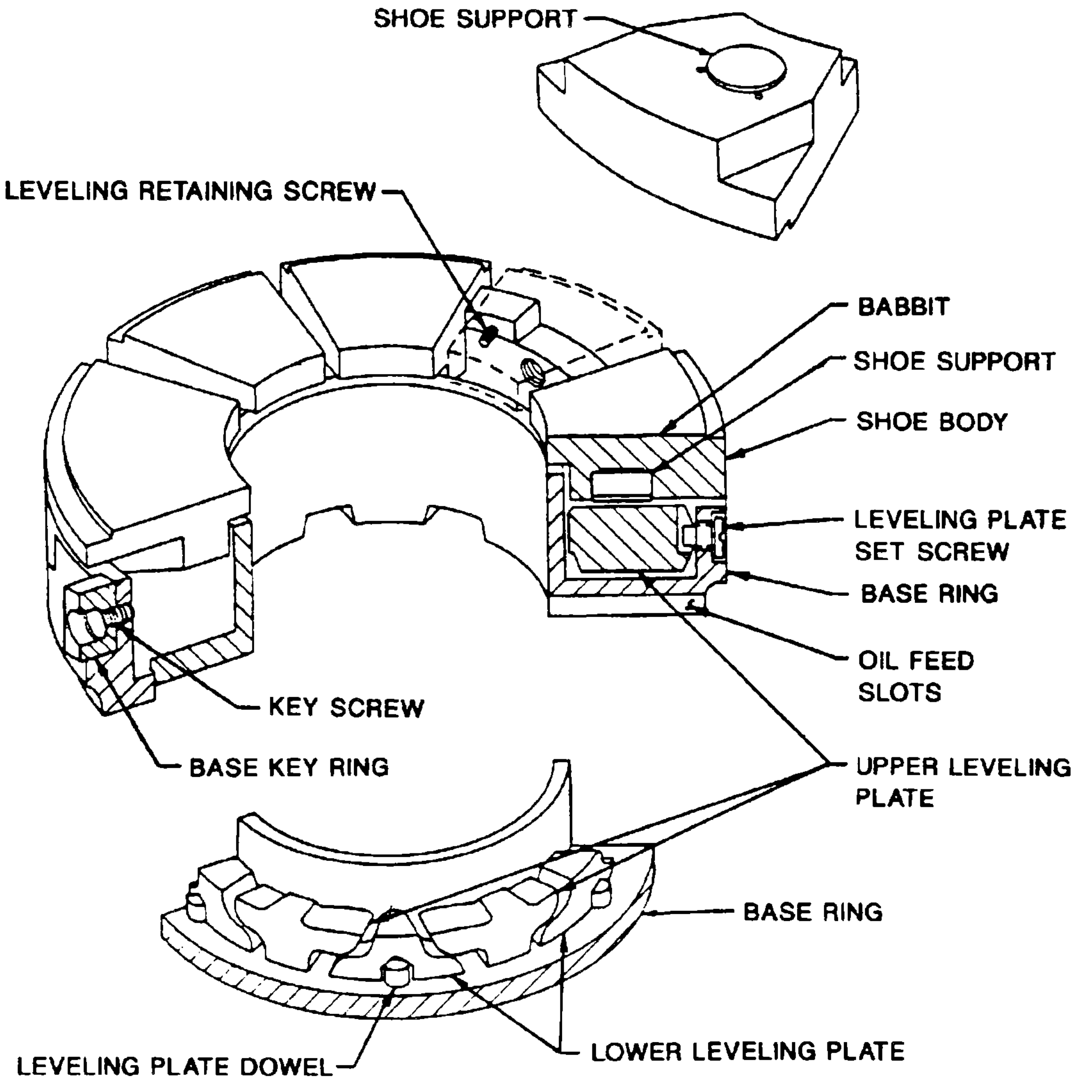


Figure 244-3-4 Leveling Plate Arrangement

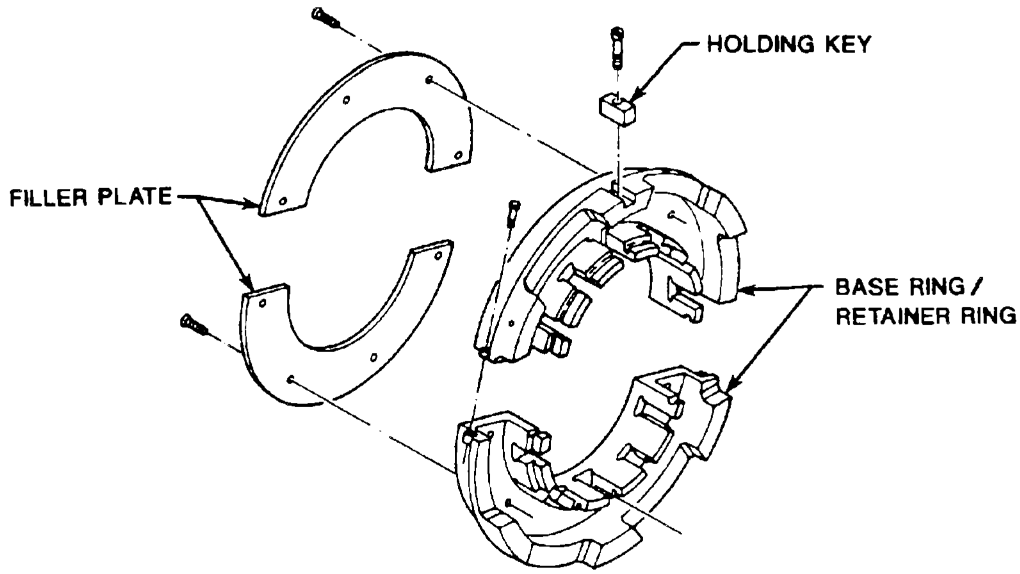


Figure 244-3-5 Typical Base Ring Assembly

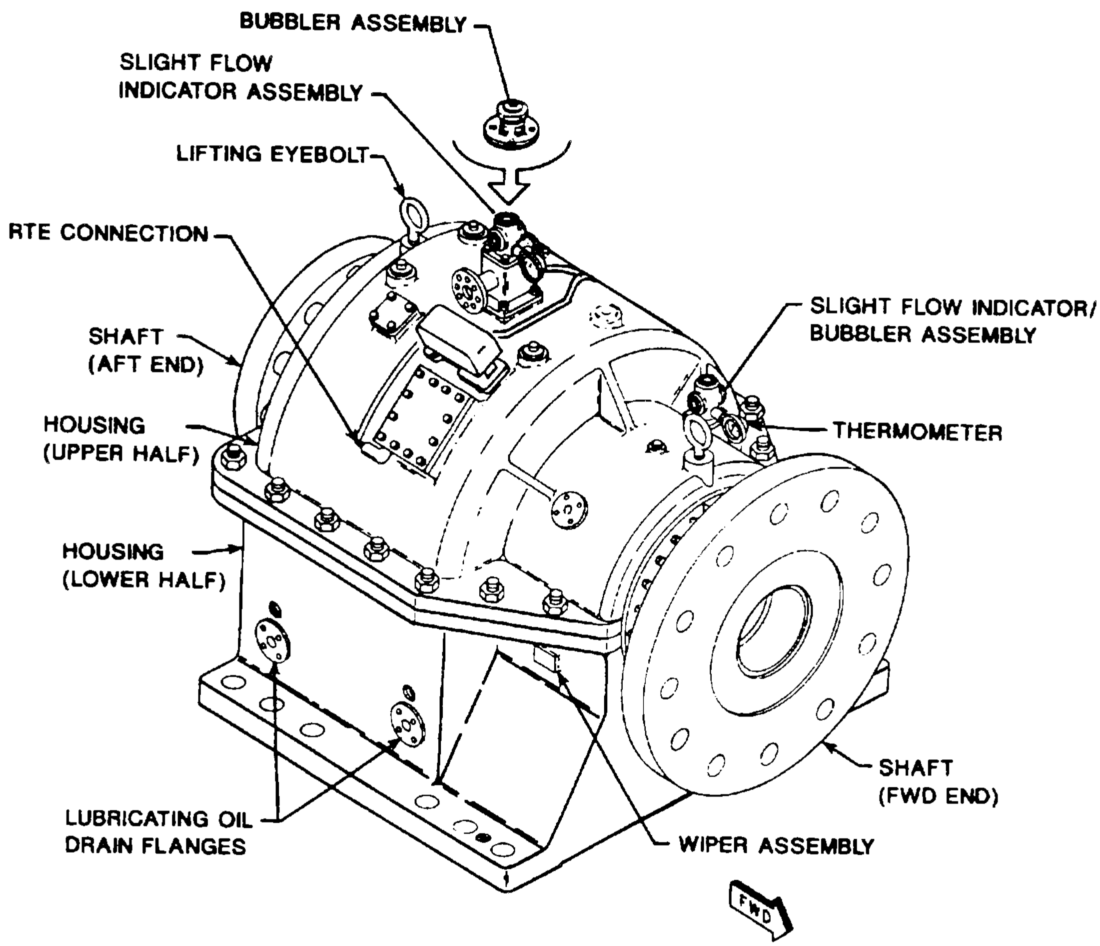


Figure 244-3-6 Typical Remote Mount Thrust Bearing Housing

244-3.3.7 END SEAL ASSEMBLY. End seal assemblies seal the main thrust bearing against lubricating oil leaking past the shaft at the housing ends and against oil contamination from water external to the housing. Lubricating oil in the housing is deflected off the shaft by an oil deflector or slinger and collected in the lower housing oil sump and lube oil return lines. Wiper assemblies are sometimes used instead of deflectors to remove oil that travels along the shaft. The wiper surface is usually made of felt. The shaft seal is located between the deflector or wiper and the housing endwall. It seals oil that has not been deflected or wiped from the shaft. The shaft seal arrangement may be close-clearance rings with labyrinth seals, carbon ring seals with garter springs, or rubber lip seals with garter springs. Typical end seal assembly arrangements are shown in Figure 244-3-8.

244-3.3.8 JOURNAL BEARING. The journal bearing in the main propulsion thrust bearing assembly acts as a pressure-lubricated lineshaft bearing to support the weight of the thrust shaft. This type of bearing is also found on remotely mounted surface ship thrust bearings. The journal bearing has spherically mounted, babbitt-lined bearing shells. The bearing shells are composed of top and bottom halves held together by dowels and capscrews and prevented from rotating by an antirotation dowel in the top half. Various arrangements of oil grooving are used to distribute the oil to the bearing surface and to promote the formation of an oil wedge between the shaft and the bearing. A typical journal bearing is shown in Figure 244-3-9.

244-3.3.9 THRUST SHAFT. The thrust shaft is the segment of the main propulsion shafting that passes through the main thrust bearing housing. There are shaft flange connections on both sides of the shaft after it passes through the housing. The thrust collar is integral with the thrust shaft. A typical thrust shaft is shown in Figure 244-3-10.

244-3.4 SURFACE SHIP MAIN PROPULSION THRUST BEARING

244-3.4.1 General. Surface ship main propulsion systems usually have the self-equalizing thrust bearing arrangement. Main shaft propulsion thrust loads are transmitted through the main thrust bearing to the housing and thus the ship structure.

244-3.4.2 INTEGRAL MOUNT THRUST BEARING. Surface ship thrust bearings are usually integral with the main reduction gear (MRG) housing. The thrust collar is integral with the bull gear shaft. The thrust bearing housing top half is separate from the MRG housing so that it can be repaired without removing the MRG housing top half. The thrust load is transmitted directly from the thrust bearing, through the MRG housing, to the ship structure. This type of thrust arrangement is shown in Figure 244-3-11. For more information on MRG's, refer to **NSTM Chapter 241, Propulsion Reduction Gears, Couplings, Clutches, and Associated Components.**

244-3.4.3 ADJACENT MOUNT THRUST BEARING. Some surface ships have main reduction gears that are mounted on vibration isolation mounts. These ships may have thrust bearings mounted aft and adjacent to the main reduction gear housing. The thrust collar is still integral with the bull gear shaft, but the thrust bearing has a separate housing bolted directly to the ship's structure. There may be a flexible housing connection between the thrust bearing and the main reduction gear to collect oil. This type of thrust bearing arrangement is shown in Figure 244-3-12.

244-3.4.4 REMOTE MOUNT THRUST BEARING. Some surface ships may have thrust bearings remotely mounted aft of the main reduction gear. These thrust bearings also have a journal bearing in the housing that acts as a pressure-lubricated lineshaft bearing to support the weight of the separate thrust shaft (Figure 244-3-13).

244-3.4.5 CV CLASS AUXILIARY THRUST BEARING

244-3.4.5.1 General. Auxiliary thrust bearings are installed on the two outboard shafts of the CV class propulsion systems to be used in the event of a casualty. Under normal operating conditions, the thrust shoes in the auxiliary bearings are clear of the thrust collar and carry no load. In a casualty situation, the shaft between the main and the auxiliary thrust bearing is uncoupled, and the astern thrust or drag of the locked or trailing propeller is then transmitted to the hull through the auxiliary thrust bearing. The auxiliary thrust bearing is designed to carry much smaller loads than the main propulsion thrust bearings.

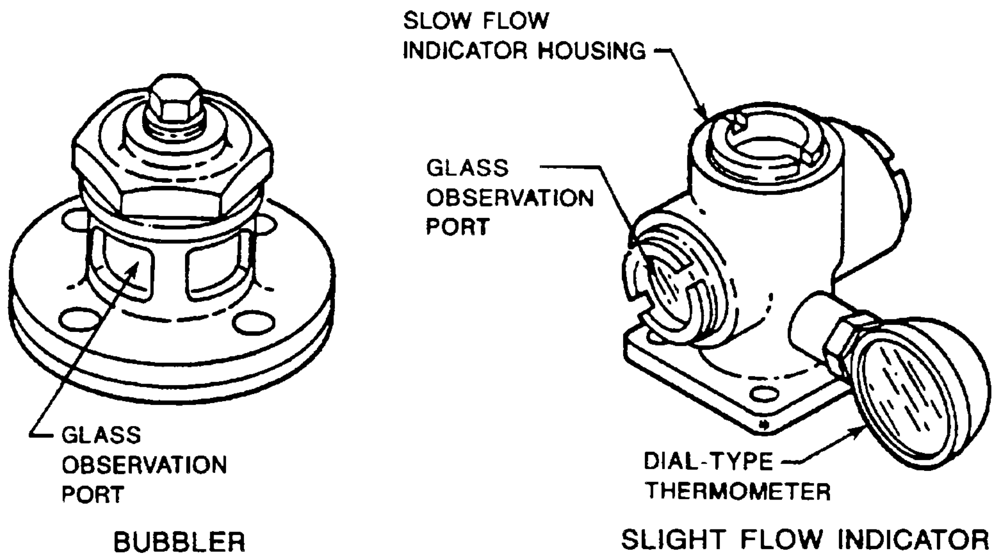


Figure 244-3-7 Sight Flow Indicator and Bubbler Assembly

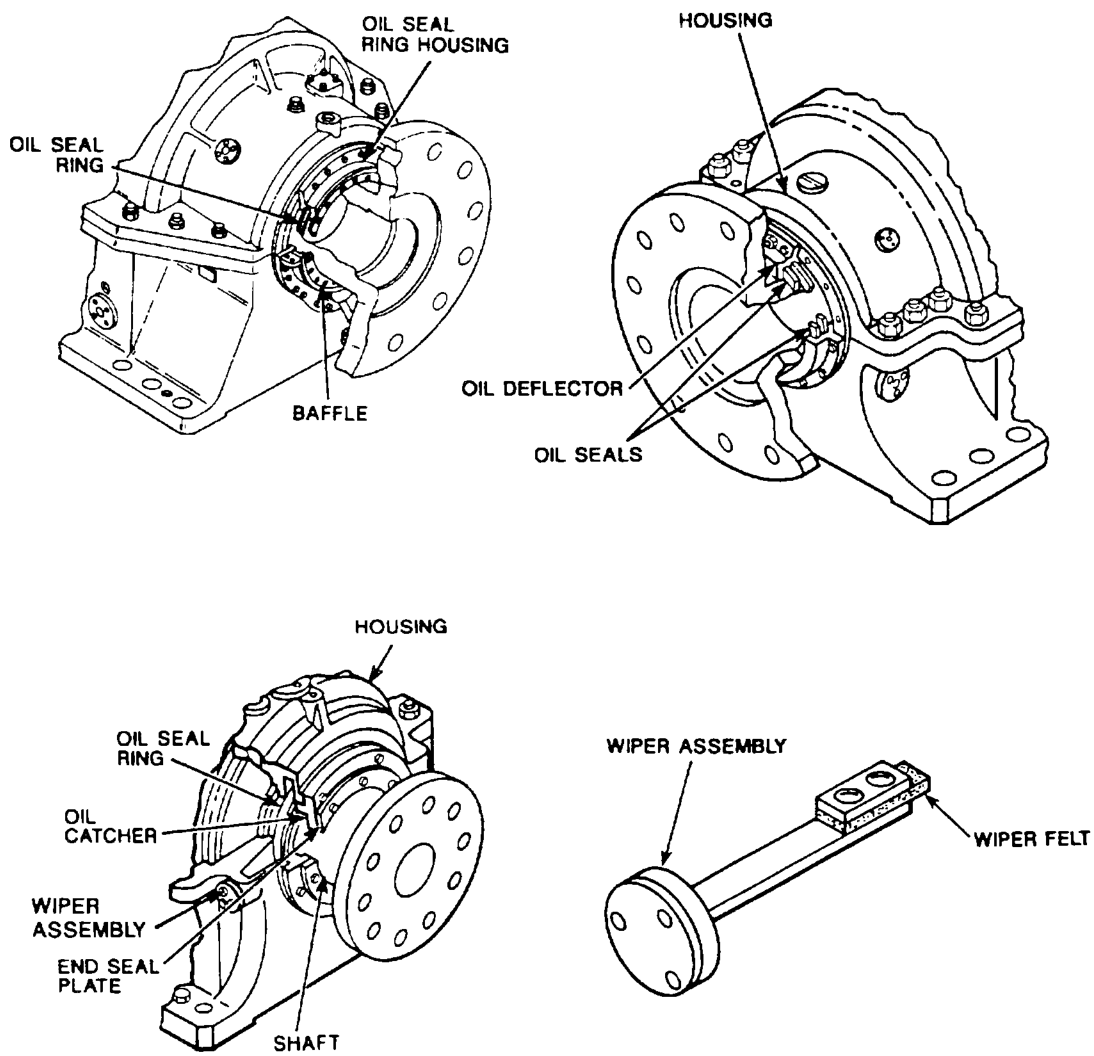


Figure 244-3-8 End Seal Assembly Arrangements

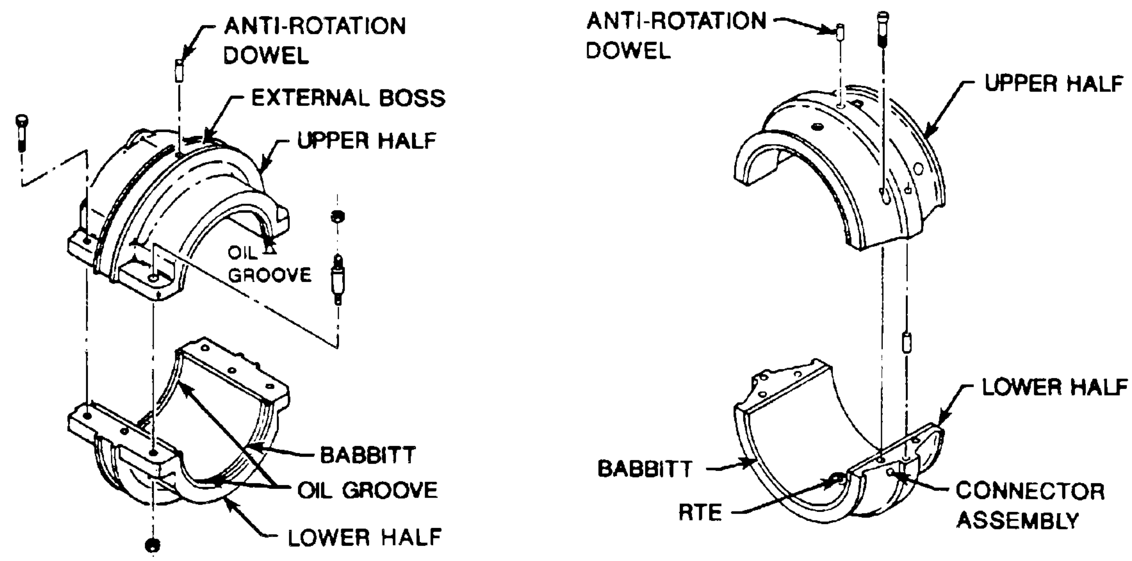


Figure 244-3-9 Typical Journal Bearing

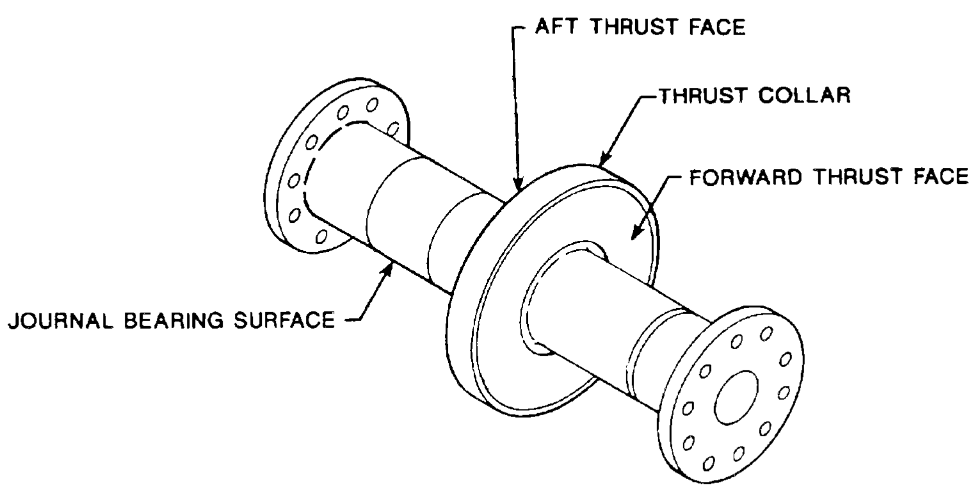


Figure 244-3-10 Typical Thrust Shaft

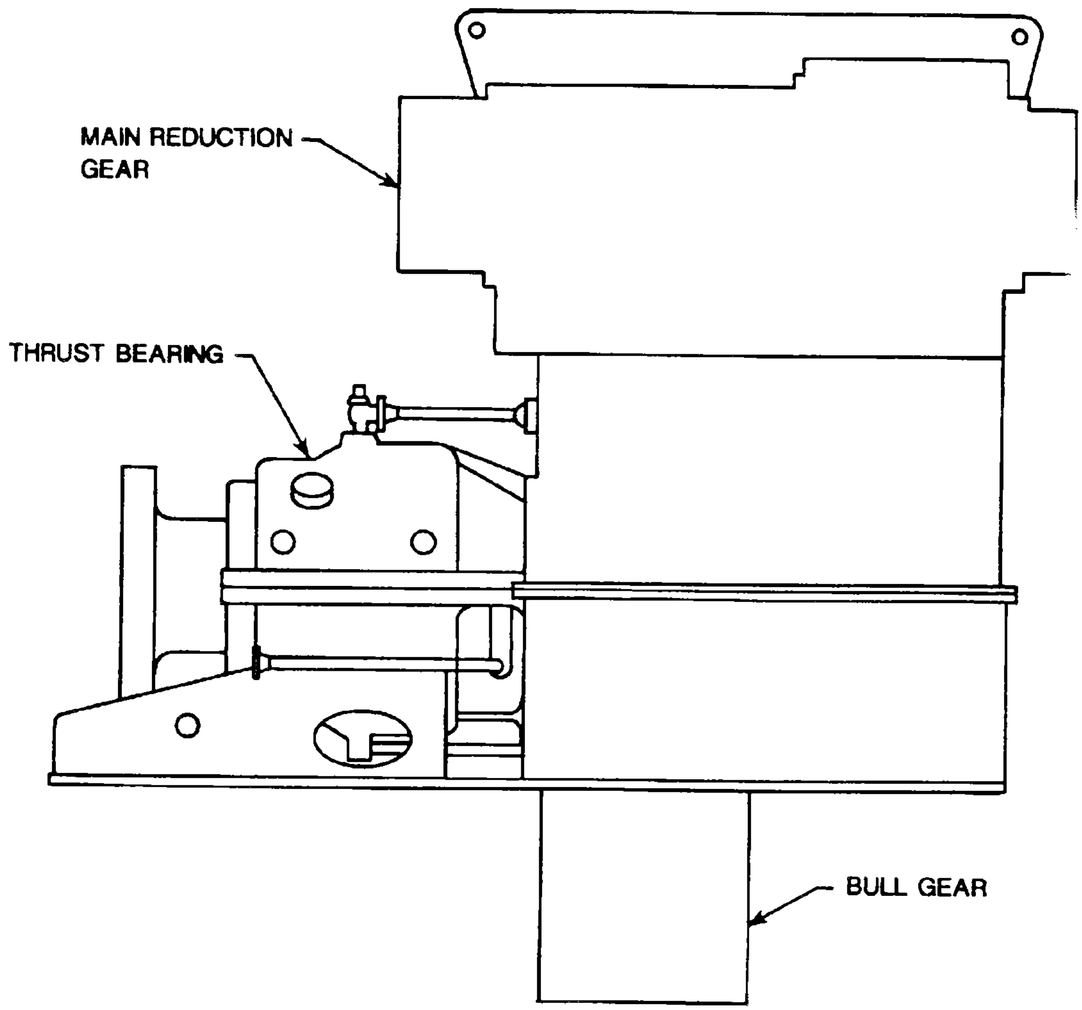


Figure 244-3-11 Surface Ship Integral Mount Thrust Bearing Arrangement

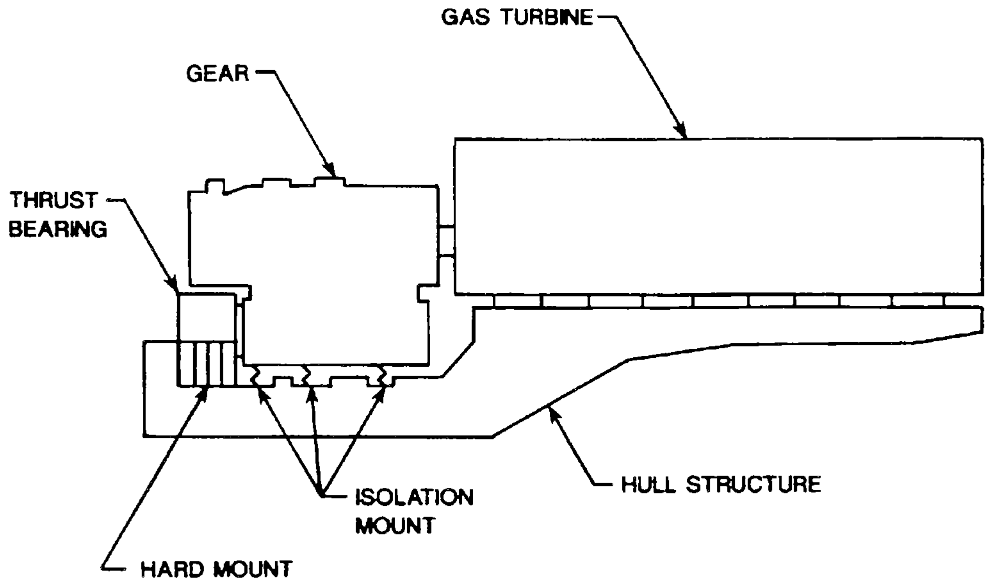


Figure 244-3-12 Surface Ship Adjacent Mount Thrust Bearing Arrangement

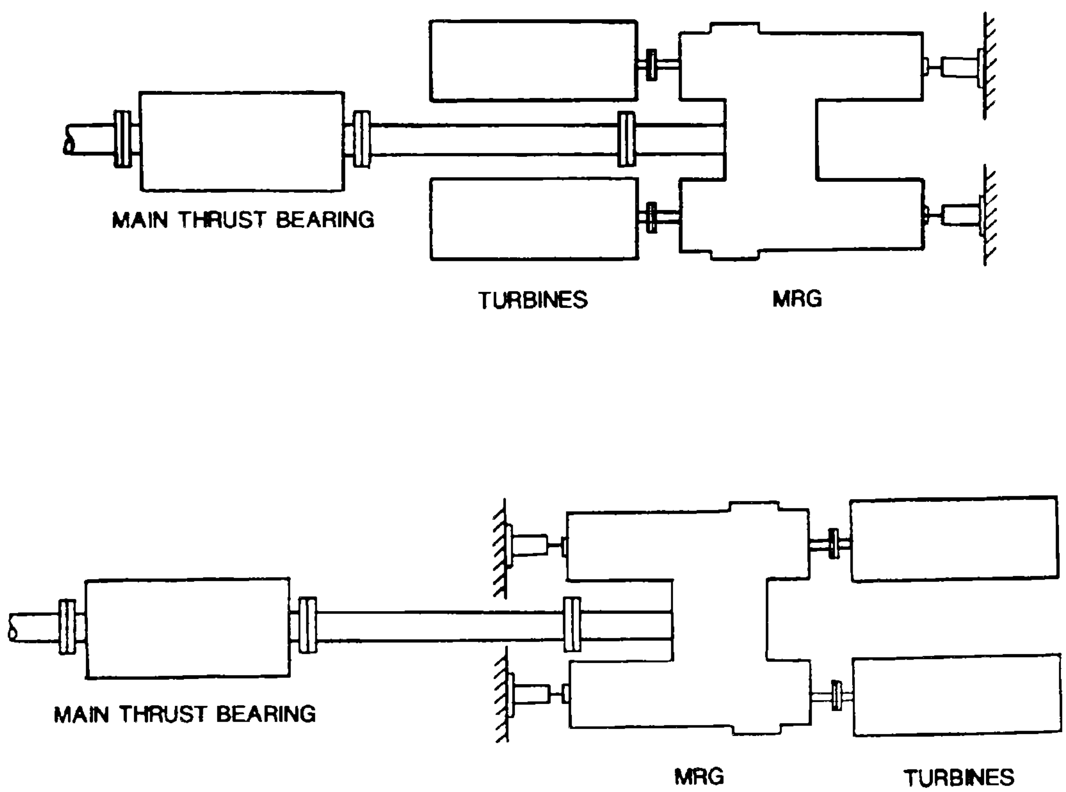


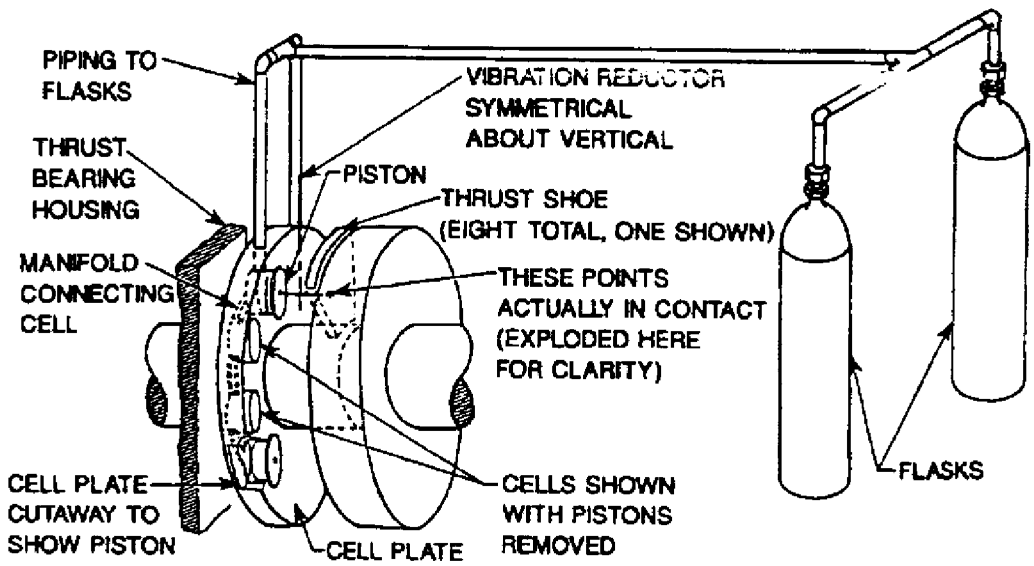
Figure 244-3-13 Surface Ship Remote Mount Thrust Bearing Arrangement

244-3.4.5.2 Auxiliary Thrust Bearing Assembly. A typical auxiliary thrust bearing has three self-equalizing thrust shoes that carry the astern-directed load generated by the forward motion of the ship acting on the disconnected shaft and one thrust shoe to carry ahead loadings generated by the aft motion of the ship acting on the disconnected shaft. The three astern shoes are carried in a half base ring in the lower housing containing the leveling plates. The position of the astern unit toward or away from the collar by means of a worm-and-ring gear. The ahead side of the collar has only one thrust shoe, which acts as a bumper to limit the forward travel of the shaft. The single shoe is held loosely in a steel cage that is threaded into the lower housing. The single shoe can also be moved forward or aft by means of a work-and-ring gear.

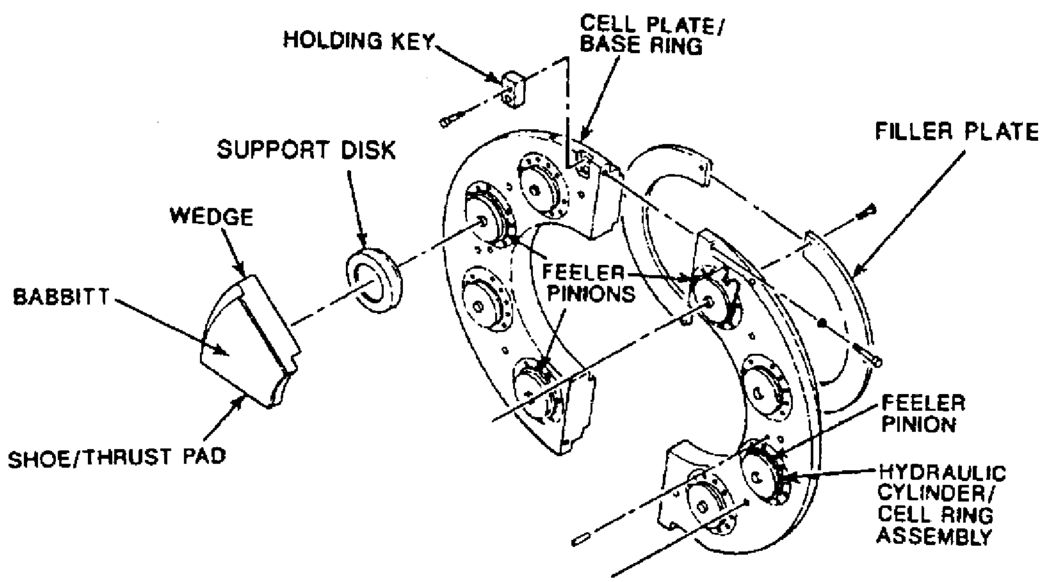
244-3.5 SUBMARINE MAIN PROPULSION THRUST BEARINGS

244-3.5.1 GENERAL. Submarine thrust bearing assemblies use a self-equalizing thrust bearing for aft thrust loads and a vibration reducer thrust bearing for forward thrust loads. These are sometimes referred to as the astern and ahead elements of the thrust bearing. Submarine thrust bearing assemblies also have a journal bearing in the housing that acts as a lineshaft bearing.

244-3.5.2 VIBRATION REDUCER THRUST BEARING. The vibration reducer (VR) assembly absorbs and dampens the transmission of longitudinal propeller vibratory loading to the hull. A typical VR is shown in Figure 244-3-14. The VR assembly supports main shaft propulsion loadings through hydraulically pressurized pistons. Vibratory thrust loadings are absorbed in the compressible hydraulic fluid of the piping and flask system. The load is equal on each thrust shoe because the pressure of the hydraulic fluid supporting each piston is equalized through common connections in an internal manifold and an external piping system. The thrust loadings change on the main shaft with shaft propulsive and depth pressure loadings. These changes in load move the main shaft against the hydraulically loaded pistons. A control system adjusts the piston hydraulic pressure to maintain the position of the shaft within the design limits of its working travel. The major components in the VR thrust bearing assembly are described in paragraphs 244-3.5.2.1 through 244-3.5.2.3.



A. Typical Vibration Reducer System.



B. Typical Vibration Reducer Internal Components.

Figure 244-3-14 Typical Vibration Reducer Assembly

244-3.5.2.1 Cell Plate Assembly. The cell plate, which Waukesha Bearings sometimes calls a base ring, is a split-configuration ring held together with screws and dowels. Each half of the cell plate has a semicircular annulus to act as a manifold between the piston assemblies.

244-3.5.2.2 Piston Assembly. Two types of VR pistons are used on submarines. The older design is the quad-ring piston assembly; the newer design is the rubber-bonded piston (RBP) assembly (Figure 244-3-15). The older design is being replaced by the RBP by means of ship alteration design (SHIPALT) because quad-ring pistons have had galling and stiffness problems. Any quad-ring pistons on SSN 594 through SSN 688 classes that are removed for inspection or maintenance and found to be galled shall be replaced by RBP's. This does not apply to TRIDENT pistons; RBP's are unavailable for that ship.

244-3.5.2.3 Feeler Mechanism Assembly. The primary function of the feeler mechanism assembly is to monitor thrust collar movement fore and aft of the centered position. Shaft movement causes a retainer pushrod in the feeler mechanism to actuate a dial indicator. Both the direction and the amount of motion of the shaft are indicated through the dial indicator. Periodic inspection and recalibration of the assembly is required to ensure accuracy of the readings. There are two types of feeler mechanism assembly.

244-3.5.2.3.1 One type of assembly, provided by Kingsbury, has a secondary function that detects if pistons are hard up. This assembly has a feeleion, gear, rings, and ring lever handle (Figure 244-3-16). It works by moving the feeler ring lever handle up or down. The motion of the handle causes the feeler pinion to rotate the feeler gear a few degrees, which in turn rotates the piston feeler rings. If the handle moves easily, the pistons are assumed to be floating because of hydraulic pressure in the VR system. If the handle fails to move easily, the pistons are most likely hard up and will not rotate because of a lack of hydraulic pressure. Sometimes, however, a leaking or galled piston can produce the same effect. If the handle will not move, check the dial indicator to verify that the pistons are hard up. Also check the lube and hydraulic oil levels to determine if oil is being transferred from one system to the other. If indications support a leaking or galled piston, replace the piston.

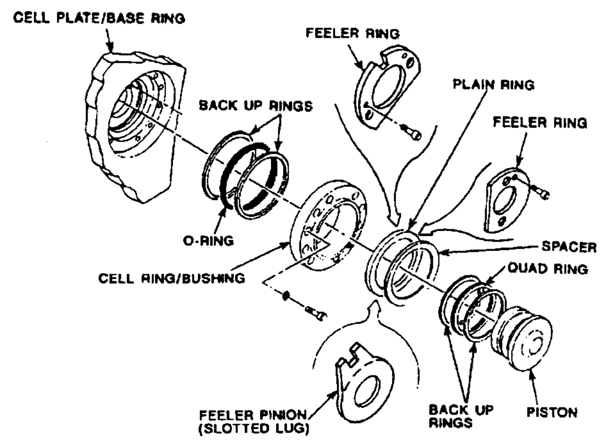
244-3.5.2.3.2 The other type of feeler mechanism assembly, provided by Waukesha Bearings, has no secondary function. A separate microswitch and probe insert assembly detects the piston hard-up condition. This type of feeler mechanism assembly, with microswitch and probe insert assembly, is shown in 244-3.5.3. When the hydraulic pressure in the VR system is sufficient to support the pistons, the microswitch activates an indicating light on the thrust bearing housing. The microswitch signal is separate from the shaft position indicating signal discussed in paragraph 244-3.5.3, and the possibility of a galled or leaking piston applies here.

244-3.5.2.3.3 Provisions have not been made for including the feeler mechanism when converting a thrust bearing from the quad-ring design to the RBP design. An electric control system can reliably determine piston location and detect a hard-up condition, so the feeler mechanism is not required.

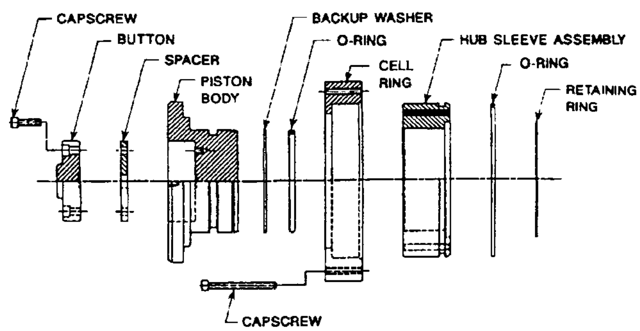
NOTE

Unless a thrust bearing has an electric control system it cannot be converted from the quad-ring design to the RBP design.

244-3.5.3 VIBRATION REDUCER CONTROL SYSTEMS. A control system in the VR maintains the position of the main shaft within acceptable limits. Two systems are used for controlling the position of the main shaft: pneumatic and electric. Most pneumatic systems have been replaced with the more desirable electric system. In each system, the position of the shaft is monitored through the control and indicator assembly feeler arm that follows the axial movement of the thrust collar. The feeler arm motion is converted into a microswitch position-indicating signal or dial indicator reading that permits a hydraulic control valve to operate either automatically or manually.



PISTON AND CELL RING ASSEMBLY



RUBBER-BONDED PISTON

Figure 244-3-15 Piston Assembly

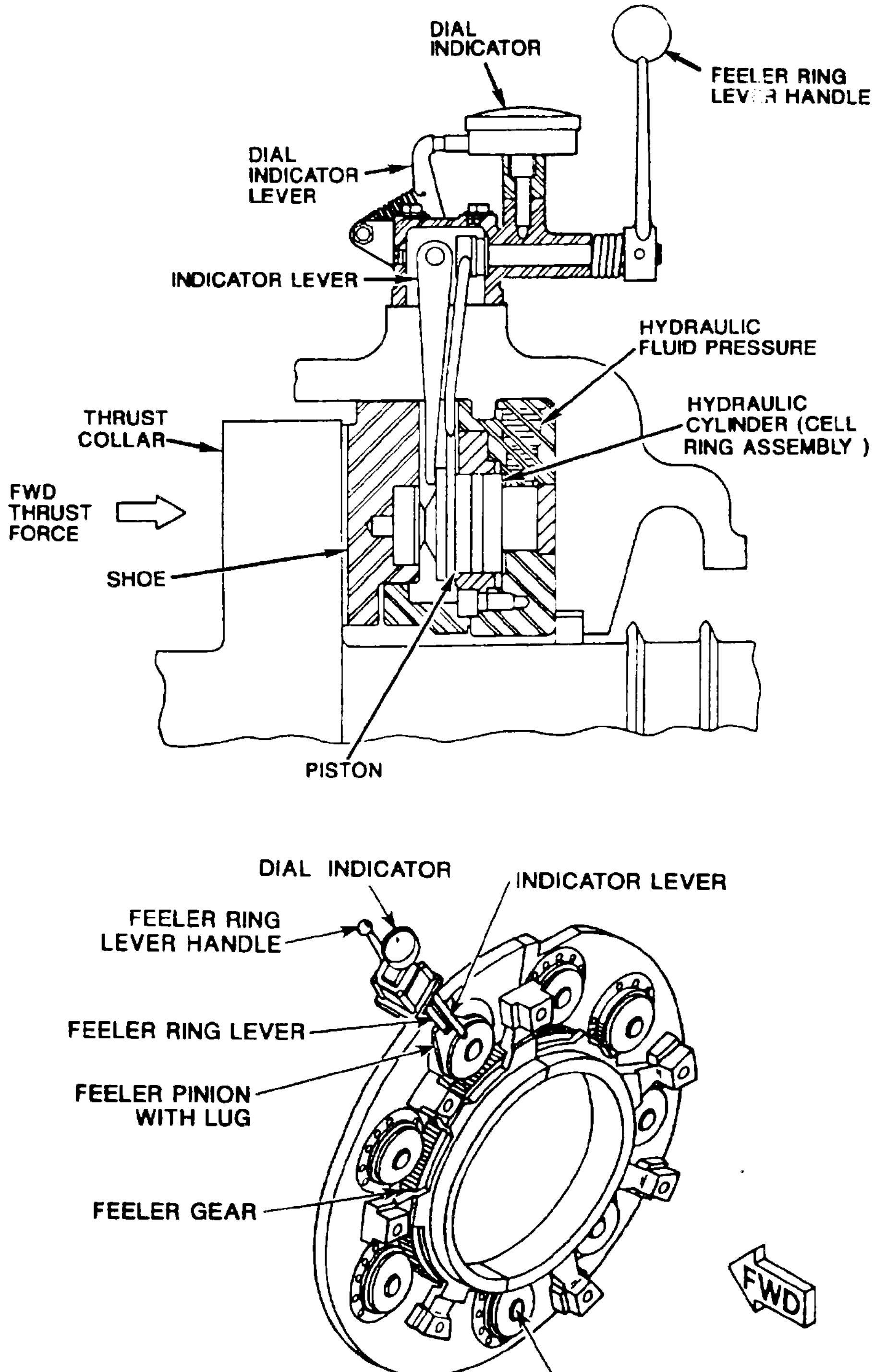


Figure 244-3-16 Feeler Mechanism Assembly (Kingsbury)

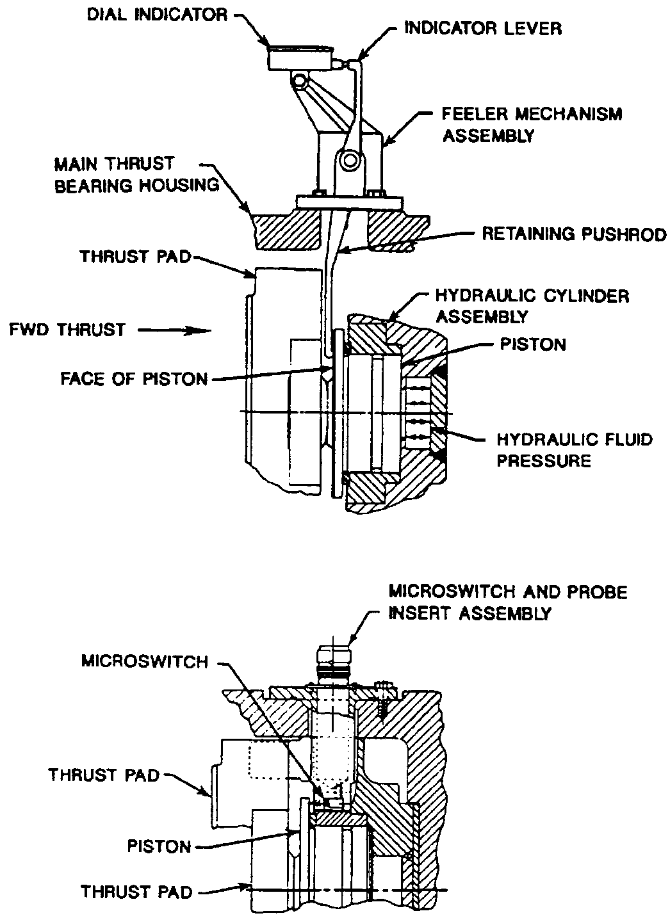


Figure 244-3-17 Feeler Mechanism Assembly with Microswitch and Probe Insert Assembly (Waukesha Bearings)

244-3.5.3.1 Indicating Panel. The position signal is also displayed on the shaft position indicating panel in the maneuvering room. The panel consists of five indicating lights that show thrust collar position. A green light indicates that the thrust collar is positioned properly in the neutral band. Two yellow lights indicate that the thrust collar has moved forward or aft of the neutral zone into the warning zone. The automatic control system should adjust the hydraulic pressure in the VR system to shift the thrust collar back into the neutral zone. Two red lights indicate that the thrust collar has moved forward or aft of the warning zone into the critical zone. This situation indicates that the VR may go hard up. If the automatic control system does not correct this condition, manually operate the control system to shift the thrust bearing back into the neutral zone. If the VR remains hard up, the propulsion system must operate within the limits of the speed-versus-depth-limitation guidelines for hard-up operation. These guidelines can be found in the appropriate technical or ship system manual.

244-3.5.3.2 Pneumatic Control System. The pneumatic control system converts forward or aft movement of the main shaft into an air pressure signal. Movement of the main shaft thrust collar displaces the feeler arm that operates a pneumatic control valve. The displacement signals to the pneumatic control valve change the output air pressure. This change regulates the hydraulic pressure to the thrust shoe pistons.

244-3.5.3.3 Electric Control System. The electric control system converts movement of the main shaft into an electrical signal. The electrical signal adjusts the hydraulic pressure in the thrust shoe pistons to control the position of the main shaft.

244-3.5.3.4 Manual Override Operation. The manual override of the control system requires manual adjustment of the supply and return valves to the thrust bearing hydraulic pistons according to visual observations of the thrust collar position dial indicator. Forward movement of the thrust collar requires increased hydraulic pressure in the VR. Pressure is increased by opening the supply valve from the hydraulic supply system. When the thrust collar is hydraulically forced back to center, shut the supply valve. Aft movement of the thrust collar requires decreased hydraulic pressure in the VR. Hydraulic fluid is vented from the VR by opening the return valve to the hydraulic system. When the thrust collar moves forward to center, shut the return valve. Refer to the ship specific Engineering Operational Sequencing System (EOSS), Ship's Information Book (SIB), Training Aid Book (TAB), or thrust bearing instruction plate for detailed information on emergency control system operation.

244-3.5.4 VIBRATION REDUCER CONTROL SYSTEM CALIBRATION. Calibrate whenever the thrust bearing or VR is overhauled or whenever there is reason to believe the calibration has been disturbed and is inaccurate. When calibrating the system, as a minimum, perform the following:

1. Use dial indicators to determine the total thrust bearing end clearance. (End clearance is defined as maximum travel aft subtracted from maximum travel forward.)
2. Determine the neutral shaft position by dividing the end clearance and adding 10 mils aft of zero.
3. Establish the control system dead band by measuring the appropriate distance forward and aft of the neutral position (found in the technical manual). The dial indicator and indicating system can then be set in accordance with the ship's technical manual.

244-3.6 LUBRICATION SYSTEMS

244-3.6.1 TYPES OF LUBRICATION SYSTEMS. The main shaft thrust bearing receives pressurized lubricating oil through an external lubricating system. Thrust bearings that are integral with the main machinery receive pressurized lubricating oil from the external propulsion lube oil system. Thrust bearings that are installed in a separate housing on surface ships may use the external propulsion lube oil system, or they may have a self-contained, pressurized lubrication system internal to the housing. In a few cases where bearings are located remotely from the engines and reduction gears, a separate external lube oil system may be provided.

244-3.6.2 THRUST BEARING LUBRICATION SYSTEM. An external lubrication system delivers lube oil under positive pressure from a source external to the bearing housing by a pump and associated piping. Oil temperature is controlled by heaters and coolers in the lube oil system. Remotely mounted and submarine thrust bearings receive oil through three inlets: one for the ahead thrust bearing, one for the astern thrust bearing, and one for the journal bearing. Integral and adjacently mounted thrust bearings receive oil from the main reduction gear supply. Oil enters the annular space around the outside of each base ring at the back end of the bearing. From there, the oil flows radially inward, through machined channels or drilled holes in the back of the base ring or cell ring, to the shaft. It then flows axially between the shaft and inner diameter of the base ring or cell ring until it reaches the thrust collar. The thrust collar forces the oil outward centrifugally between the thrust shoes and the collar to form the hydrodynamic oil film that supports the thrust load. Oil flow from the trailing and circumferential edges of the shoes is thrown outward into an annular space between the rim of the collar and the housing. There it is discharged through a passage in the upper housing cover. It passes through a sight flow indicator or bubbler assembly and out through a discharge line in the top of the housing. A typical submarine or remotely mounted thrust bearing lubrication diagram is shown in Figure 244-3-2.

244-3.6.3 LUBE SYSTEM OIL. The standard oil used in main propulsion thrust bearings is MIL-L17331, Lubricating Oil, Steam Turbine and Gear, Moderate Service, Military Symbol 2190 TEP. The following are the normal, specified operating conditions:

LUBE OIL TEMPERATURE SPECIFICATIONS, °F:	
Normal Inlet	120
Maximum Inlet	130
Minimum Inlet	90
Maximum Outlet	180
LUBE OIL PRESSURE SPECIFICATIONS, psig:	
Nominal	22
Minimum	5
Maximum	36
VR TEMPERATURE SPECIFICATIONS, °F:	
Nominal	110 to 130
Minimum	60
Maximum	160

244-3.7 OPERATION

CAUTION

The temperature of the babbitt should not exceed 250°F, and the temperature of the lubricating oil should not exceed 180°F.

244-3.7.1 MAIN PROPULSION THRUST BEARING OPERATION. Periodically check the following on the main shaft thrust bearings:

a. Temperature of the bearing babbitt by RTE

b. Temperature of the lube oil by supply and discharge dial thermometers

c. Supply pressure of lube oil

d. Flow of oil through sight flow indicators

e. Thrust collar position (submarine installations).

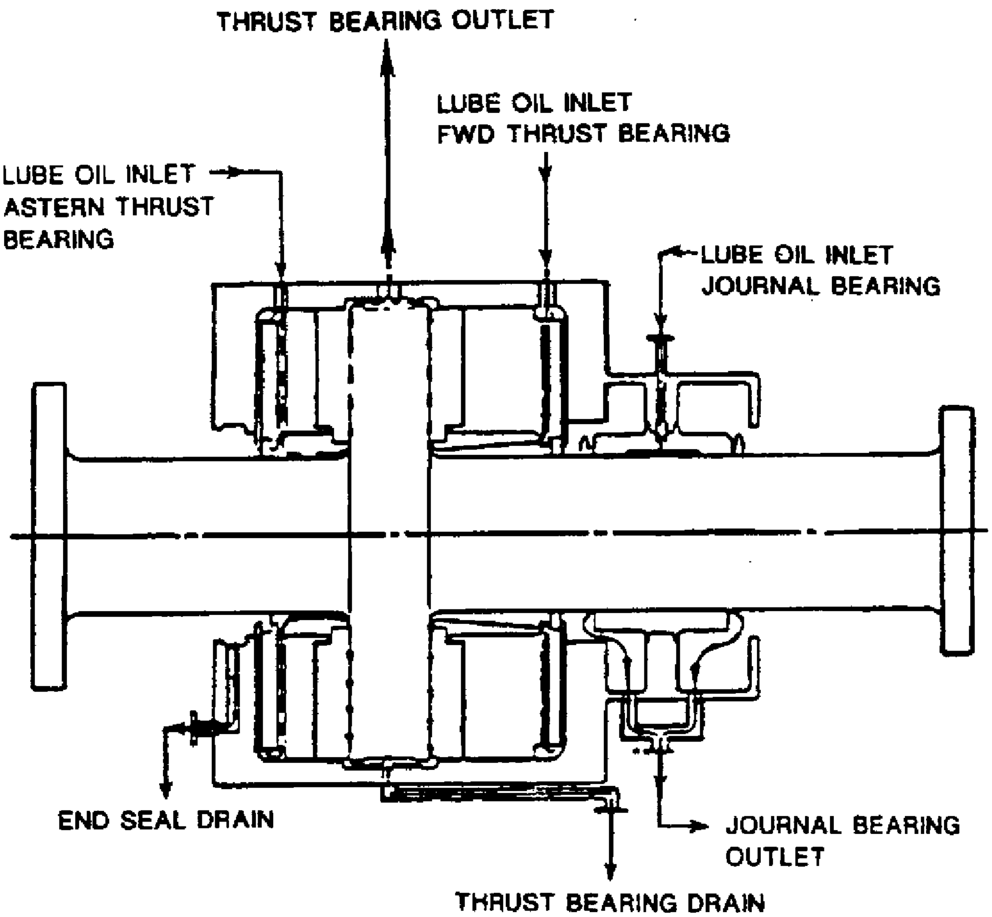


Figure 244-3-18 Typical Submarine Thrust Bearing Lubrication Diagram

244-3.7.2 PREOPERATIONAL CHECKS. Perform the following preoperational checks on the main thrust bearing and associated components:

a. Sample lube oil for metal particles, dirt, and water

b. Visually inspect the piping and valves for leakage and loose or broken fittings.

c. Check the feeler mechanism for free movement to ensure that the VR is pressurized.

d. Be sure that the VR manifold is filled with hydraulic fluid.

e. Be sure that all system hydraulic tanks, accumulators, and flasks are properly filled with hydraulic fluid.

f. Be sure that the VR piping and flask system valves are set to their proper operating positions. Refer to the ship specific EOSS, SIB, TAB, or thrust bearing instruction plate.

g. For thrust bearings that are integral with the main machinery and are supplied directly from the propulsion lube oil system, follow procedures for main engine startup. Check the oil flow through a sight glass or bubbler at the outlet. Check and record the lube oil pressure and temperature.

h. For self-contained systems, check oil quality and level. Lubricant shall be clean and contaminant-free to prevent any damage. Replace oil that contains water, sand, or grit. Raise the oil level to the high (full) mark. Be fore getting under way, when shafts are spun during liftoff, check oil rings on the journal bearing for rotation. Check disk and scraper for correct position and operation.

244-3.7.3 BEARING TEMPERATURES. Temperature is the sole criterion by which the operator can judge the condition of individual bearings during operation. Watch standers should therefore monitor and log temperatures periodically to detect any tendency for the bearing to overheat and to take appropriate corrective action. Bearing temperatures increase with increases in speed and load.

244-3.7.3.1 High Bearing Temperature. High bearing temperatures and limits are discussed in detail in the following paragraphs. If a bearing temperature increases above the normal running temperature, check the system oil pressure and temperature out of the cooler to be sure that they are in the normal operating range. If these measures do not reveal the problem, slow or stop the shaft and investigate further.

244-3.7.3.2 Normal Operation. There is a normal temperature range over which the bearing operates. Proper bearing operation is ensured when temperatures at a given speed are within a few degrees of those obtained when bearings were known to have been in good condition. Establish for reference, therefore, a series of recorded temperatures at standard speeds. The temperature of oil supplied to the bearing ranges between 120°F and 130°F. Compare oil temperatures on the basis of equal inlet temperatures.

244-3.7.3.3 Thrust Variation. Thrust bearing temperatures can be expected to vary by more than a few degrees at given speeds if a variable thrust force is imposed (such as that introduced by a high-speed flexible coupling in a geared propulsion system).

244-3.7.3.4 Temperature Measurement. Bearing temperatures can be measured by two different systems with differing temperature limits. One system measures the bearing drain oil temperature with a thermometer or an RTE; the other measures the babbitt temperature with an RTE. The drain oil temperature limit is 180°F. Limiting temperatures for babbitt-imbedded RTE's have been established as 250°F for both journal and thrust bearings.

244-3.7.3.5 Resistance Temperature Element System. The RTE system provides a central electrical readout of machinery temperatures. This system permits use of an alarm usually set to sound when the temperature is 20°F (11.1°C), 30°F (16.6°C) for submarines, higher than that obtained during initial ship trials.

244-3.7.3.5.1 Practices to follow when setting temperature monitoring system alarms are listed in Table 244-3-1. Deviations from these maximum settings shall be approved by the Naval Sea Systems Command (NAVSEA) on an individual ship basis.

244-3.7.3.5.2 Make the initial settings before initially operating the bearing. Make the final settings before the Inspection Survey (INSURV) trial or final postoverhaul trial if an INSURV trial is not run. Base these settings on the highest values observed from the ship sea trials or shipbuilder test form data taken during all previous trials.

244-3.7.3.5.3 Use the setpoints provided in Table 244-3-1 if specific setpoint instructions are not contained in the **Steam and Electric Plant Manual,** if applicable, or in the component technical manual. The alarm settings shown in Table 244-3-1are to be made with oil discharging from the Lube oil cooler outlet between 126°F and 130°F with temperature as close as possible to 130°F and normal clearances in the installed bearing. If the bearing or rotating element is replaced, check and reset the bearing temperature alarm settings on the affected bearing(s) in accordance with the methods discussed in Table 244-3-1.

Table 244-3-1 MAXIMUM ALARM TEMPERATURE SETTINGS

Thermocouple and RTE Sensing Location	Initial Alarm Setting	Final Alarm Setting
Journal bearing babbitt, °F	250	Set each bearing alarm 20°F (11.1°C), 30°F (16.6°C) for submarines, higher than that obtained during initial ship trials or at 250°F, whichever is lower.
Thrust bearing babbitt, °F	250	Set each shoe alarm 20°F (11.1°C), 30°F (16.6°C) for submarines, higher than the maximum running temperature of that shoe observed during trials or at 250°F, whichever is lower.
Bearing oil drain line, °F	180	180
Sight flow fitting, °F	180	180

244-3.7.3.5.4 Ships equipped with RTE systems have a drain-oil thermometer in each bearing to permit an independent check of bearing condition. The two measurements will not agree. Compare each measurement either with its applicable limit in Table 244-3-1 or, preferably, with previous temperatures noted at the particular speed.

244-3.7.3.5.5 The RTE system inherently responds to temperature changes more quickly than a thermometer and will give earlier warning of any bearing overheating. Any bearing temperature measured by RTE or thermometer that continues to rise after the ship speed and oil inlet temperature have stabilized should be considered abnormal (despite being within specified limits) and should be investigated. Reducing shaft speed will most quickly reduce heat input into the bearing and is the action that will most likely prevent a bearing wipe or limit consequent bearing damage.

244-3.8 MAINTENANCE

CAUTION

Carefully examine all replacement parts using detail drawings as acceptance or rejection criteria. Replacement parts not conforming to drawings could cause premature bearing failure.

244-3.8.1 SHIPBOARD MAINTENANCE. Shipboard maintenance is those adjustments and repairs that can be performed without lifting the upper housing. It includes repair or adjustment of external wiring, piping, and fittings; and replacing the end oil seals on either end of the housing. Replace fittings that require repair or adjustment. Repair the replaced fittings, if possible, and return them to stock.

244-3.8.2 SCHEDULED MAINTENANCE. The maintenance schedule shall meet the minimum requirements for normal peacetime conditions. Maintenance may be conducted at more frequent intervals when required by accelerated operations or severe local conditions. The recommended maintenance schedule for main propulsion thrust bearings is shown in Table 244-3-2.

NOTE

If installed, the Planned Maintenance System (PMS) Maintenance Requirement Cards (MRC) supersede the recommended maintenance schedule (Table 244-3-2).

244-3.8.3 MAINTENANCE STANDARDS. Inspect thrust pads for replacement when the shaft axial movement exceeds the installation dimension by the wear allowance. Replace the thrust pads when the pad height measurement indicates that the wear allowance has been exceeded. Examine the thrust pads when the RTE readout indicates that 250°F has been exceeded.

Table 244-3-2 SCHEDULED MAINTENANCE

Frequency	Title of Work Item	Maintenance
Weekly	RTE Lead Wires	Examine connections for looseness, breaks, dirt, and oil. Conduct ground and continuity tests.
Weekly	Hydraulic System	Examine connections, piping, and fittings for looseness, breaks, or dirt.
Weekly	Lubricating System	Same maintenance actions as for hydraulic system.
In accordance with applicable MRC	Thrust Bearing and Journal Bearing	Measure bearing wear.
At Disassembly	Oil Seals	Replace end seals.

244-3.8.4 TROUBLESHOOTING. Malfunctions in the bearing will be indicated by abnormal readings on the RTE's and thermometer, abnormal flow in the sight flow indicator, vibration, or noise.

244-3.8.4.1 The most common problem in thrust bearings with VR's is shaft hunting, both forward and aft. Shaft hunting may be caused by misaligned control valve setpoints, misaligned fill and drain valve setpoints, or sticking control valves. Correct shaft hunting by realigning control valve setpoints, realigning fill and drain valve setpoints, or loosening or replacing control valve packing. A severely misaligned control system may push the shaft hard aft and actually lock the thrust collar between the ahead and astern thrust shoes like a disk brake. A locked thrust collar can easily be detected by the inability to rotate the thrust shaft, by an RTE reading in the high astern bearing, and by the shaft position indicated on the dial indicator. If this condition occurs, manually override the control system immediately and realign it.

244-3.8.4.2 Wiping failures sometimes occur on main thrust bearings, but such failures are rare. Wiping failures can be detected early by rapid increases in shoe RTE readings or lube oil discharge temperatures. Another good indication that the bearing has wiped is babbitt in the lube oil strainers.

244-3.8.4.3 Refer to Table 244-3-3 for a troubleshooting guide.

Table 244-3-3 MAIN THRUST BEARING TROUBLESHOOTING GUIDE

Malfunction	Probable Cause	Corrective Action
Hot Bearing	Insufficient oil flow	Check pump output pressure and sightflows. Check for pump malfunction, plugged orifices, or clogged lines or strainer. Clean and correct as required.
	Overloaded journal bearing	Check for change in shaft alignment caused by wear of stern tube or lineshaft shaft bearings. Align shaft or replace bearings as required.
	Wiped bearing	Check bearing clearances and compare with previous readings. Check for babbitt in strainer. Repair or replace bearing surfaces as required.
	Dirty oil	Determine source of contamination. Purify lubricating oil source by draining lubricating oil and cleaning sump.
	Faulty RTE	Connect spare RTE. Check circuit continuity for shorts or grounding. Repair or replace as required.
	High inlet oil temperature	Check inlet oil temperature. Correct as required.
Vibration or Noise	Bent shaft	Check shaft runout. Straighten or replace shaft.
	Seal rub	Check seal. Replace as required.
	Wiped bearing	Check bearing clearances and compare with previous readings. Check for babbitt in strainer. Repair or replace bearing surfaces as required.
	Loose foundation or top-casing bolts	Tighten bolts to required torque.
	Inactive VR	Check pressure of hydraulic system. Check for faulty control and indicator assembly or faulty solenoid control valves. Repair or replace as required.
Shaft Hard Up	Faulty or inactive VR	Check pressure of hydraulic system. Check for faulty control and indicator assembly or faulty solenoid control valves. Repair or replace as required.
Shaft Hunting	Faulty VR	Check for hydraulic system leaks or faulty control and indicator assembly. Repair or replace as required.
Shaft Seal Oil Leaking	Damaged end seal ring or gasket	Check seal. Replace as required.
High or Low Lube Oil	Malfunctioning lube oil heater	Refer to applicable technical manual.
	Malfunctioning lube oil cooler	Refer to applicable technical manual.

SECTION 4

MAIN PROPULSION STERN TUBE AND STRUT BEARINGS

244-4.1 INTRODUCTION

244-4.1.1 The stern tube and strut bearings support the waterborne propulsion shafting of a ship aft of the main shaft seal (Figure 244-4-1). The stern tube bearing is aft of the propeller shaft hull penetration in the stern tube. Surface ships may have one or two stern tube bearings; submarines have only one. The strut bearings are in struts that are structural members extending from the hull to support the waterborne shafting (Figure 244-4-1). Some surface ships have one or two strut bearings commonly called the main and intermediate strut bearings. Because submarines have no struts, the bearing outside the pressure hull immediately forward of the propeller is called the propeller bearing. The stern tube and strut bearings use seawater for lubrication and cooling.

244-4.2 BEARING DESIGN

244-4.2.1 STERN TUBE AND STRUT BEARINGS. These bearings are designed to the standard drawing for water-lubricated stern tube and strut bearings, NAVSHIPS dwg 803-1385664. It contains all required dimensions. The military specification for water-lubricated stern tube and strut bearings is MIL-B-17901, **Water-lubricated Bonded Synthetic Rubber Bearing Components.**

244-4.2.1.1 Stern tube and strut bearing assemblies are classified by material and configuration as follows:

Class I - Stave bearing, metallic backed stave

Class II - Cylindrical bearing with cylindrical metallic backing and internally molded rubber stave forms

Class III - Stave bearing, nonmetallic backed stave

Class IV - Cylindrical bearing with cylindrical nonmetallic backing and internally molded rubber stave forms

244-4.2.1.2 Class I and III stern tube and strut bearings are used with shaft diameters of 6 inches or greater. They have split bronze shells with dovetail grooves that run lengthwise along the inside of the bearing shell. Metallic-backed or non-metallic-backed synthetic rubber strips, called staves, are located in the grooves and provide the bearing wear surface.

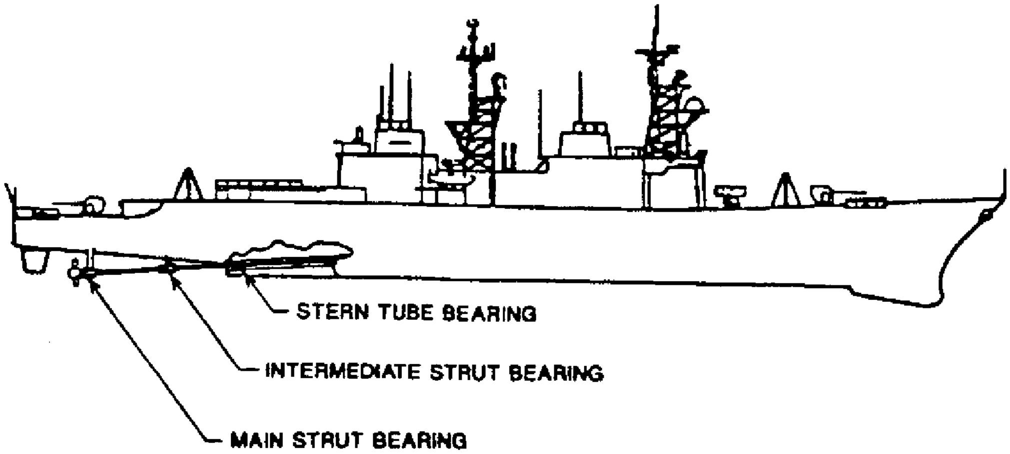


Figure 244-4-1 Stern Tube and Strut Bearing Locations

244-4.2.1.3 Class II and IV stern tube and strut bearings are used with shaft diameters under 6 inches. They have a fully molded rubber bearing wear surface bonded to split bronze or nonmetallic shells. Lengthwise water grooves are molded in the rubber surface. Class II and IV bearings are interchangeable. Class IV bearings are preferred, however, because they are lightweight and the shell material is corrosion resistant.

244-4.2.1.4 Each class of bearing is illustrated in Figure 244-4-2. The bearing shell for classes I and III is illustrated in Figure 244-4-3.

244-4.2.2 STAVES.

244-4.2.2.1 Staves are long, metallic-backed (class I) or non-metallic-backed (class III) rubber strips (Figure 244-4-2) that slide into the bearing shell (Figure 244-4-3) and are held with retaining rings. Class II and IV bearings have the same stave form, but the rubber strips are connected together and bonded to the housing (Figure 244-4-2). Rubber-stave-type bearings are designed for a maximum projected area loading of 40 lb_f per in^2 . Under this loading the rubber will typically deflect 0.020 to 0.040 inch. The projected area loading of the bearing is defined as:

$$\text{Projected Area Loading} = \frac{\text{Total Load } (lb_f)}{\text{Bearing Length (in) x Shaft Dia. (in)}}$$

Class I and III bearing staves are interchangeable. Class III bearing staves are preferred, however, because they are lightweight and the backing material is corrosion resistant. The backing on class I and III bearing staves is shaped so that the staves slide into dovetailed slots in the bearing shell.

244-4.2.2.2 The Navy supply system has a stock of 1/16″ and 1/8″ oversize-thickness staves of common sizes and length. Oversize-thickness staves are oversize only in the backing material thickness dimension. The thickness of the rubber is the same for both respective standard-size and oversize bearing staves. The width of the backing material is also the same as for standard-size staves. Oversize-thickness staves will therefore fit in the bushing slots from which standard-size staves have been removed. Do not use shims in back of standard-thickness staves.

244.4.2.2.3 If refurbishment of waterborne bearing sleeves would reduce the sleeve outside diameter no more than 0.310″ from the original design size, non-standard thickness staves can also be ordered directly from the manufacturer. In this particular application, determine the appropriate stave thickness necessary to achieve the design bearing clearance in accordance with the standard drawing for water-lubricated stern tube and strut bearings, NAVSHIPS dwg 803-1385664.

244-4.2.3 BEARING GROOVES. The grooves between the staves serve two purposes: they provide a channel to bring water into the bearing and provide a path for flushing grit and frictional heat away from the bearing. Rubber bearings can easily handle particle-filled water (lubricant). Bearing pressure forces the grit particles into the rubber surface. In this condition the particles cause minimum damage to the rubber and shaft. They are eventually flushed out by water flowing through the bearing grooves.

244-4.2.4 BEARING CLEARANCE.

244-4.2.4.1 Top Clearance. Bearing top clearance is measured and recorded following each bearing renewal, typically during drydock availabilities. As the rubber stave material of the bearing wears down during the life of the bearing, the clearance between the top of the shaft and the bearing staves at the 12 o'clock location increases. The shaft sleeve material also gradually wears down, further increasing the bearing clearance. When the top clearance exceeds the maximum operating clearance specified in paragraph 244-4.2.5, renew the bearings. When renewing bearing staves, if standard-sized staves provide clearances that are greater than the maximum operating clearances, oversized staves are available that can be used to achieve the desired clearances. (Refer to Sections 244-4.2.2.2 and 244-4.2.2.3 for additional oversized stave information.) . If the shaft sleeve is excessively worn, pitted, or otherwise marred, the sleeve may have to be refurbished or the shaft resleeved.

CAUTION

Do not bore out, sand, machine, or grind the staves to achieve the required clearance for renewed bearings. This could compromise the bearing surface of the staves.

244-4.2.4.2 Shaft-to-Stave Retainer (STSR) Clearance. In an attempt to monitor wear of waterborne bearing staves between extended docking cycles, FTSCLANT/FTSCPAC has developed an alternative process which estimates the remaining service life of the bearing staves by measuring the shaft-to-stave retainer (STSR) clearance. STSR clearance is the clearance between the stave retainer ring and the bottom of the shaft, as measured at the 6 o'clock location. Chapter 18 of the Underwater Ship Husbandry Manual, NAVSEA S600-AA-PRO-180, also provides additional guidance regarding the location and procedures utilized for measuring STSR clearances. Upon receiving approval, many of the surface ship classes have installed 5 inch diameter access holes at the 6 o'clock position in the fairwaters adjacent to the waterborne bearings. As the rubber stave material wears down during the life of the bearing, the STSR clearance will decrease. The magnitude of decrease in STSR clearance can likewise be converted to an increase in top clearance by the same amount, thus aiding in determination of the remaining life expectancy of the bearing staves before requiring renewal. Additionally, these access holes allow evaluation of the stave end profiles, which is critical in identifying any existing damage (i.e. evidence of delamination, debonding, extrusion, and/or obstructed cooling water passages). The bearing stave end profile is a direct reflection of the operation and lubrication characteristics of the waterborne bearing assembly. FTSCLANT/FTSCPAC, NSWCCD-SSES, or NAVSEA must evaluate any abnormal wear or damage evident by altered stave end profiles. The stave end profiles are best evaluated via videotape, recorded by divers.

244-4.2.4.3 If fairwater access holes are installed, a reference STSR clearance shall be established each time a waterborne bearing is removed, renewed (i.e. staves replaced) and/or its retainer ring disturbed. This dimension shall be recorded in the docking report during docking availabilities as well as provided to FTSCLANT/FTSCPAC. If, between docking cycles, the STSR clearances are measured and a reference dimension has not been previously established, videotape of the stave end profiles must accompany the clearance readings and be forwarded to FTSCLANT/FTSCPAC for review. STSR clearance measurements are to be scheduled annually, or sooner if shaft-to-fairwater clearance indicates contact or imminent contact, during a routine diving inspection.

244-4.2.5 CLEARANCE TABLES. Minimum and maximum design clearances and clearances for renewing stave bearings are shown in Table 244-4-1; partial-arc bearings are shown in Table 244-4-2. These clearances are general guidelines. Ship specific drawings or procedures may specify different requirements and should take precedence.

244-4.2.6 BEARING MATERIAL

244-4.2.6.1 Stave Facing Material. The facing material of the bearing stave is a synthetic rubber compound bonded to the stave backing. The NAVSEA approved rubber thickness is 5/16″. The allowable thickness tolerance for the rubber facing is ±1/32″ in accordance with NAVSHIPS dwg 803-1385664. The tensile strength, elongation, hardness, and surface-finish properties of this compound are specified in MIL-B-17901.

244-4.2.6.2 Metal Parts. Metal parts for class I bearing assemblies are made of naval brass, as specified in FED Spec QQ-B-637, **Brass, Naval: Rod, Wire, Shapes, Forgings, and Flat Products With Finished Edges (Bar, Flat Wire, and Strip)** or FED Spec QQ-B-639, **Brass, Naval: Flat Products (Plate, Bar, Sheet, and Strip).** Metal parts of class II bearings are made of casting or tubing. Specifications for the casting are in MIL-B-17901, and specifications for the tubing are in QQ-B-637 or QQ-B-639.

244-4.2.6.3 Nonmetallic Parts. The nonmetallic backing material for class III bearing staves and class IV bearing shells shall meet the requirements in MIL-B-17901.

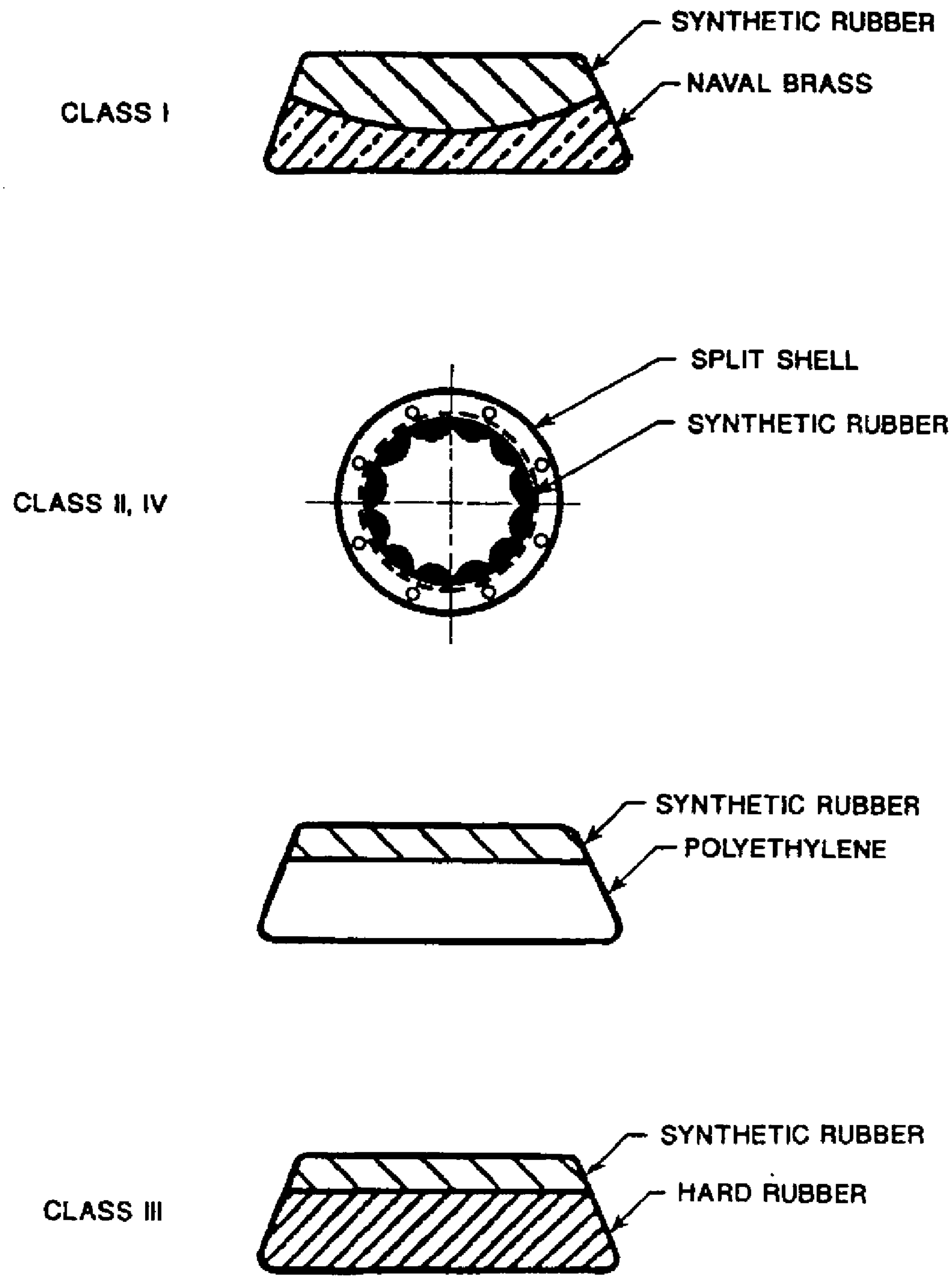


Figure 244-4-2 Classes of Stern Tube and Strut Bearings

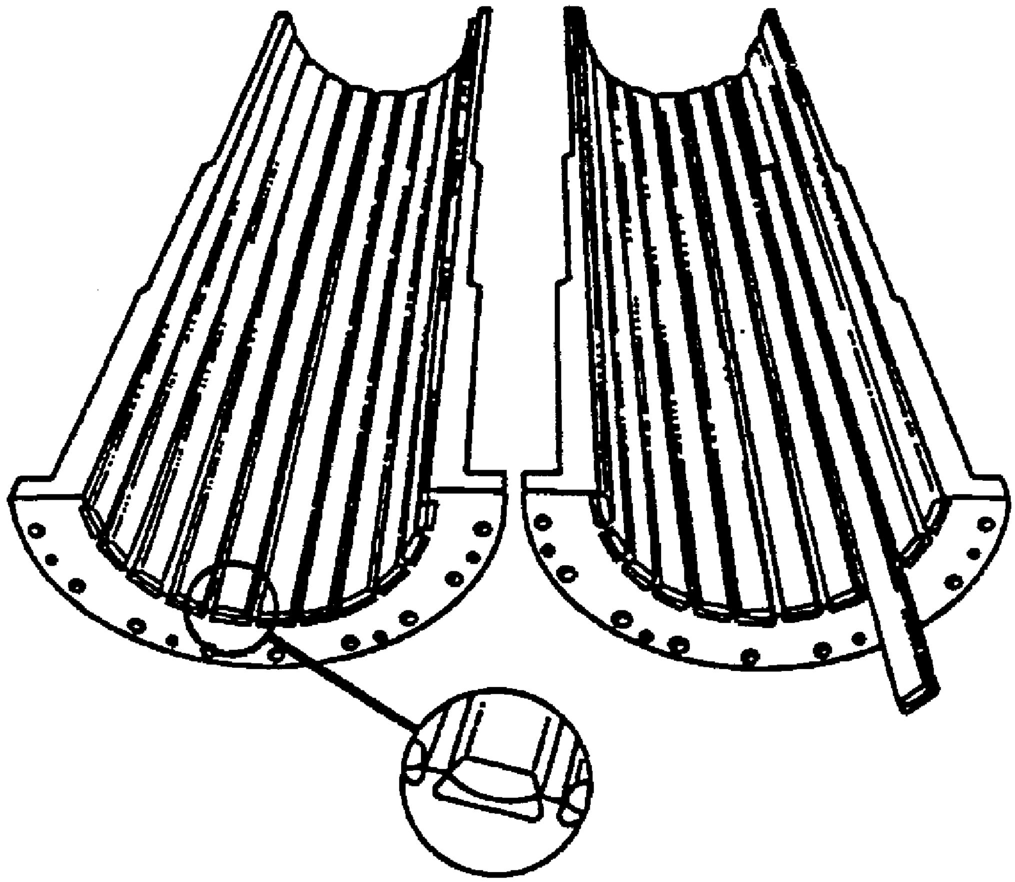


Figure 244-4-3 Bearing Shell for Class I and III Staves

244-4.2.7 SUBMARINE BEARINGS

244-4.2.7.1 Submarine Stern Tube Bearings. The forward stern tube bearing of some submarine classes is unloaded and used as a snubber to prevent main shaft seal contact under shock loading.

244-4.2.7.2 Submarine Self-Aligning Propeller Bearings. The propeller bearing is supported by a self-aligning mount (Figure 244-4-4). The mount has a rubber sleeve mounted between the bearing shell and the outer mount. This arrangement allows the propeller bearing to move and tilt to accommodate relative shaft-to-hull movement during hull-distorting maneuvers.

244-4.2.7.3 Partial-Arc Bearing. A new stern tube and propeller bearing design called the partial-arc bearing (PAB) was developed for the SSN 21 class submarine. This design provides improved low-speed, quiet operation (Figure 244-4-5). Unlike traditional stave-type bearings, in which staves form many small bearing pads, the PAB has a single large bearing pad in each of its halves. Using a single large bearing pad reduces the tendency of the bearing to stick-slip by promoting the formation of the hydrodynamic lubricant film at lower shaft speeds as compared with the traditional stave-type bearing. The PAB design also uses a new polymer material called Thordon SXL for the bearing face inserts. This material provides better mixed-film lubrication properties to further reduce the tendency of stick-slip. The bearing face inserts are bonded to backing shells, which are mounted in the bearing shell. The bearing inserts are held in the bearing shell by anti-rotation keys on the horizontal centerline and retainer rings at the bearing ends. The propeller bearing shell is made of copper-nickel alloy and is not horizontally split as in traditional bearing shells. This requires that the shaft be removed to inspect and service the bearing surface. The stern tube bearing shell is made of Inconel and is split to facilitate bearing renewal. A new self-aligning mount (SAM) developed for the propeller PAB provides low tilt stiffness. This allows the bearing to align itself better to changing shaft slopes while providing high torsional stiffness to reduce the SAM's influence on stick-slip behavior. Cooling and lubrication for the bearing is supplied by piping that feeds seawater to a circumferential groove at the bearing midlength. The seawater is distributed along the length of the bearing by horizontal centerline reliefs in the Thordon inserts. The seawater is fed to the active bearing surface from the relief area to form the hydrodynamic film between the shaft and bearing surface.

Table 244-4-1 STAVE BEARING CLEARANCES

Outside Diameter Shaft Sleeve (inches)	Minimum Operating Diametral Clearance of Renewed Bearings (inch)	Maximum Operating Diametral Clearance of Renewed Bearings (inch)	Total Operating Diametral Clearance at Which to Renew Bearings (inch)
6-3/4 to 6-7/8	0.027	0.142	0.142
7 to 7-7/8	0.030	0.154	0.154
8 to 8-7/8	0.032	0.157	0.165
9 to 9-7/8	0.035	0.160	0.177
10 to 10-7/8	0.037	0.162	0.187
11 to 11-7/8	0.040	0.165	0.197
12 to 12-7/8	0.042	0.167	0.207
13 to 13-7/8	0.045	0.170	0.217
14 to 14-7/8	0.047	0.172	0.226
15 to 15-7/8	0.050	0.175	0.235
16 to 16-7/8	0.052	0.177	0.243
17 to 17-7/8	0.055	0.180	0.252
18 to 18-7/8	0.057	0.182	0.259
19 to 19-7/8	0.060	0.185	0.267
20 to 20-7/8	0.062	0.187	0.274
21 to 21-7/8	0.065	0.190	0.281
22 to 22-7/8	0.067	0.192	0.286
23 to 23-7/8	0.070	0.195	0.292
24 to 24-7/8	0.072	0.197	0.295
25 to 25-7/8	0.075	0.200	0.299
26 to 26-7/8	0.077	0.202	0.301
27 to 27-7/8	0.080	0.205	0.304
28 to 28-7/8	0.082	0.207	0.307
29 to 29-7/8	0.085	0.210	0.310
30 to 30-7/8	0.088	0.213	0.313
31 to 31-7/8	0.090	0.215	0.315
32 to 32-7/8	0.092	0.217	0.317
33 to 33-7/8	0.095	0.220	0.320
34 to 34-7/8	0.098	0.223	0.323
35 to 36	0.098	0.223	0.327

Table 244-4-2 PARTIAL-ARC BEARING CLEARANCES

Outside Diameter Shaft Sleeve (inches)		Minimum Operating Diametral Clearance of Renewed Bearings* (inches)	Maximum Operating Diametral Clearance of Renewed Bearings* (inches)	Maximum Operating Diametral Clearance at Which to Renew Bearings (inches)	Maximum Wear (inches)
From	**To**				
6 3/4	6 7/8	0.024	0.028	0.070	0.046
7	7 7/8	0.025	0.029	0.073	0.048
8	8 7/8	0.029	0.034	0.083	0.054
9	9 7/8	0.032	0.038	0.094	0.061
10	10 7/8	0.036	0.042	0.104	0.068
11	11 7/8	0.040	0.046	0.114	0.075
12	12 7/8	0.043	0.050	0.125	0.082
13	13 7/8	0.047	0.055	0.135	0.088
14	14 7/8	0.050	0.059	0.146	0.095
15	15 7/8	0.054	0.063	0.156	0.102
16	16 7/8	0.058	0.067	0.166	0.109
17	17 7/8	0.061	0.071	0.177	0.116
18	18 7/8	0.065	0.076	0.187	0.122
19	19 7/8	0.068	0.080	0.198	0.129
20	20 7/8	0.072	0.084	0.208	0.136
21	21 7/8	0.076	0.088	0.218	0.143
22	22 7/8	0.079	0.092	0.229	0.150
23	23 7/8	0.083	0.097	0.239	0.156
24	24 7/8	0.086	0.101	0.250	0.163
25	25 7/8	0.090	0.105	0.260	0.170
26	26 7/8	0.094	0.109	0.264	0.170
27	27 7/8	0.097	0.113	0.267	0.170
28	28 7/8	0.101	0.118	0.271	0.170
29	29 7/8	0.104	0.122	0.274	0.170
30	30 7/8	0.108	0.126	0.278	0.170
31	31 7/8	0.112	0.130	0.282	0.170
32	32 7/8	0.115	0.134	0.285	0.170
33	33 7/8	0.119	0.139	0.289	0.170
34	34 7/8	0.122	0.143	0.292	0.170
35	36	0.126	0.147	0.296	0.170
*** Fully loaded bearing, no water swell.**					

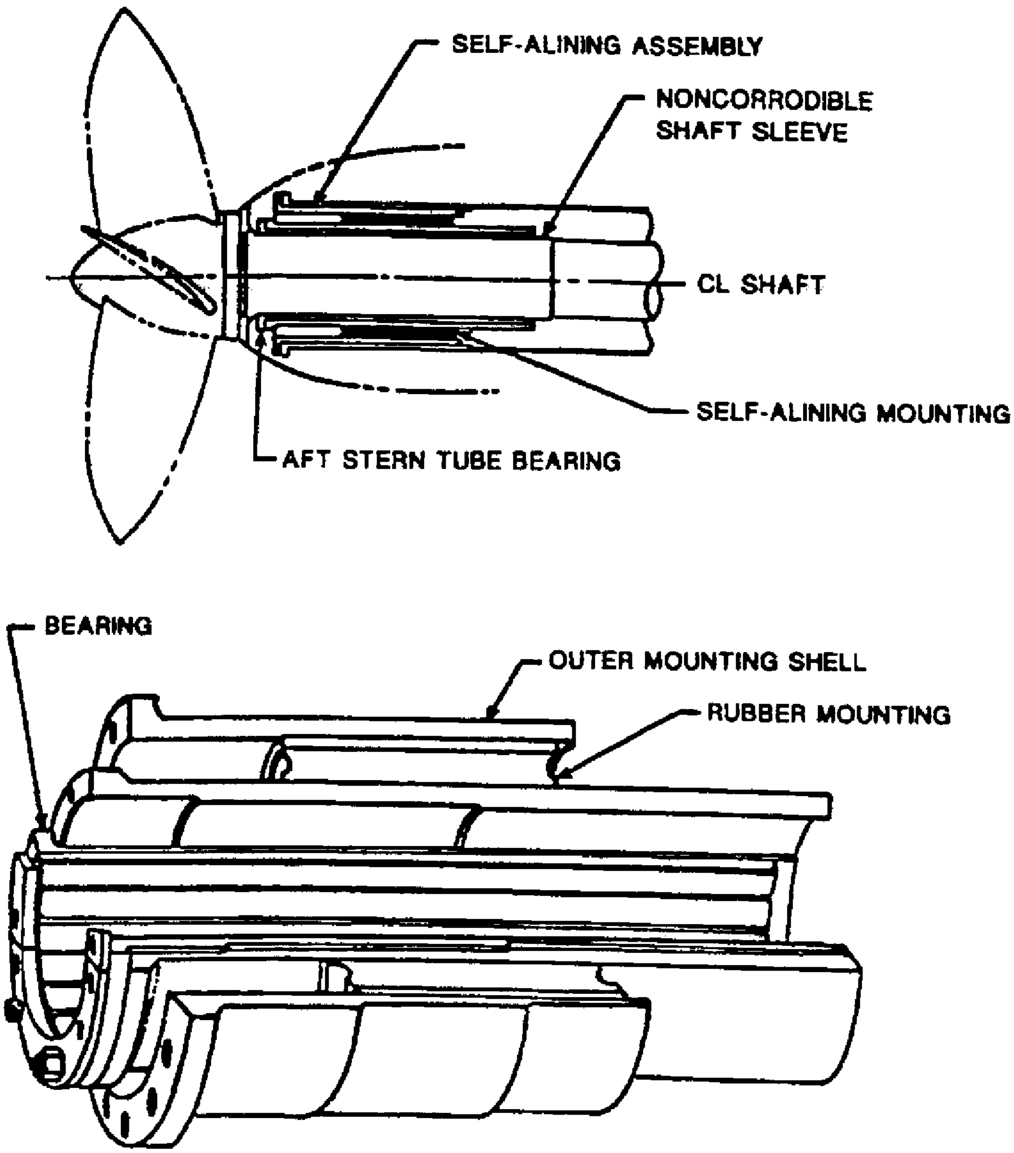


Figure 244-4-4 Self-aligning Mount

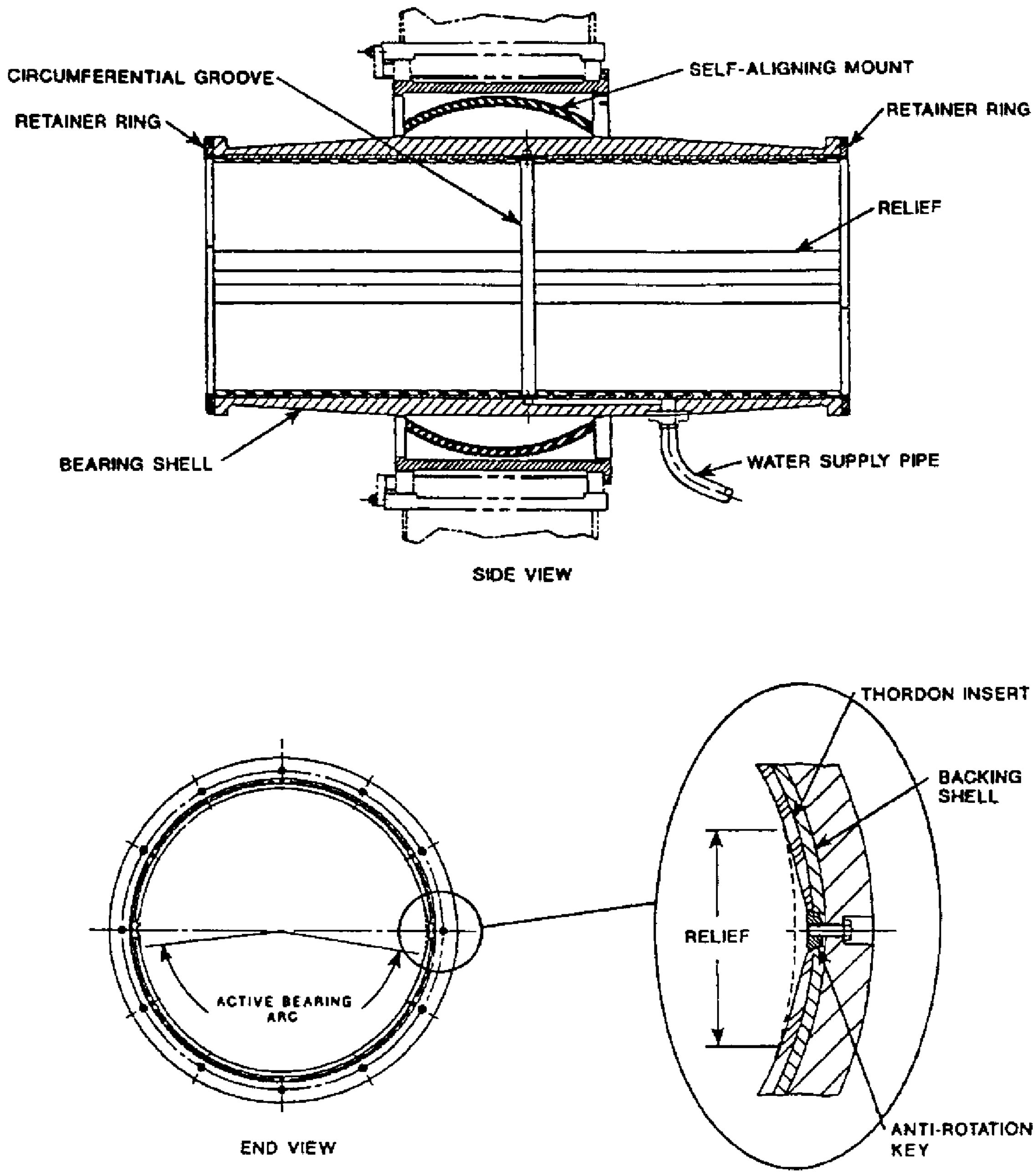


Figure 244-4-5 Partial-Arc Propeller Bearing

244-4.3 LUBRICATION

244-4.3.1 LUBRICATION THEORY

244-4.3.1.1 Hydrodynamic Lubrication. A film of seawater separates the propulsion shafting and bearing surfaces of stern tube and strut bearings at normal shaft operating speeds. Seawater is drawn into the bearing-shaft interface by the rotation of the shaft. As the shaft speed is increased, more seawater is drawn into the shaft-bearing interface until the seawater wedge develops enough pressure to entirely separate the shaft and bearing surfaces by a film of seawater. Full separation of the shaft and bearing surfaces by the lubricant film is called hydrodynamic lubrication, shown in the right portion of the curve in Figure 244-4-6. The hydrodynamic pressure profile for stave-type and partial-arc bearings is shown in Figure 244-4-7. Hydrodynamic lubrication allows small particles to pass through the bearing lubricant film without damaging the bearing or shaft surfaces and has an extremely low coefficient of friction.

244-4.3.1.2 Mixed-Film Lubrication. As the shaft speed is decreased below that needed to produce a full lubricant film, the bearing begins operating with mixed-film lubrication, shown in the middle portion of the curve in Figure 244-4-7. In mixed-film lubrication the shaft and bearing surfaces begin to come into contact. As the shaft speed is further reduced, friction increases rapidly as the film is further reduced. Thus more of the shaft and bearing surface microscopic high spots come into contact with one another. Operating in the mixed-film lubrication region can result in bearing instability such as stick-slip. Mixed-film lubrication continues as long as the lubricant film continues to support some of the bearing load.

244-4.3.1.3 Boundary Lubrication. As the shaft speed is further reduced, shaft speed breaks down the lubricant film completely and the shaft and bearings surfaces come into full contact. This type of lubrication is called boundary lubrication and is shown in the left portion of the curve in Figure 244-4-6. In boundary lubrication, friction and wear are at their highest and are determined primarily by the material and molecular film properties of the interacting shaft and bearing surfaces.

244-4.3.1.4 Bearing Break-In. Water-lubricated stern tube and strut bearings have been shown to perform better after a break-in period (Figure 244-4-8). During break-in, shaft and bearing surface high spots are polished as the bearing is operated with mixed-film lubrication. As the surfaces are polished, the number of microscopic points of contact is reduced and the bearing load is spread over a greater surface area. Bearing break-in increases the lubricant film thickness and decreases the amount of bearing friction.

244-4.3.2 PROVISIONS FOR LUBRICATION.

244-4.3.2.1 General. Two methods can be used to ensure an adequate water supply to water-lubricated bearings: pressure lubrication and natural lubrication. Most strut and propeller bearings are open to the sea on both ends. Seawater therefore flows naturally into the forward end of the bearing and out of the aft end. An exception to this is SSBN 726 and SSN 21 class submarines, which have seawater pumped into the propeller bearing. In stern tube bearings, seawater is pumped into the forward end and discharged from the aft end. Water flows through the bearing to lubricate, flush, and cool it. Water flow to pressure-lubricated bearings should be 2 gallons per minute for each foot of bearing length. For surface ships this is provided by a typical pressure of 10 to 25 psi through the flushing connection at the forward end of the stern tube. The supply pressure for submarines is automatically maintained slightly above submergence depth pressure.

244-4.3.2.2 Drydock Lubrication. When required to rotate propulsion shafting in drydock, stern tube and strut bearings shall be lubricated with water from a fire hose or other suitable water source during the entire rotation evolution. The stern tube seal cooling water piping system should also be aligned to assist with lubrication of the stern tube bearing(s).

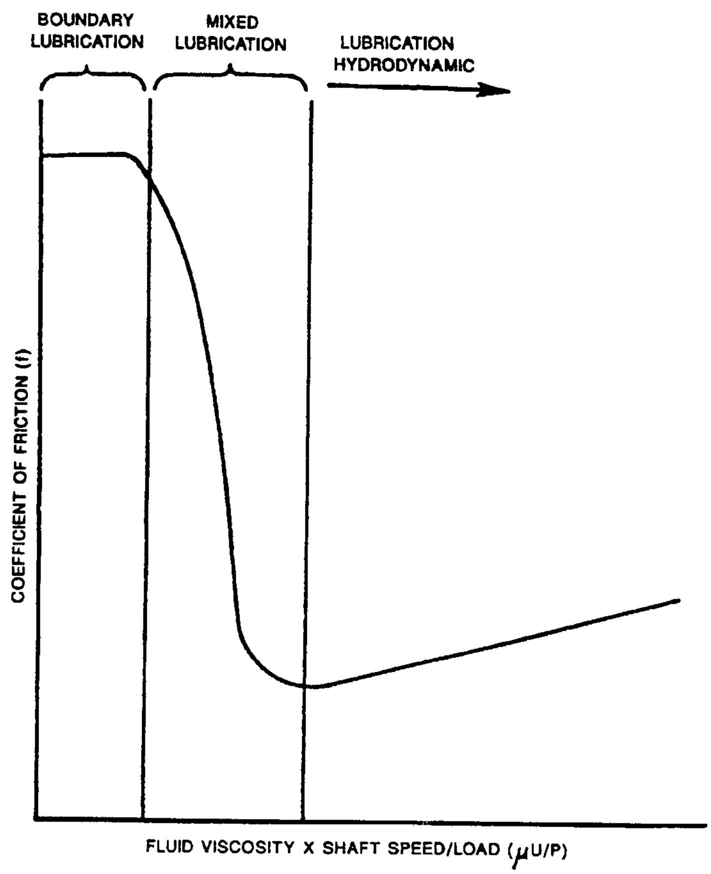


Figure 244-4-6 Three Regions of Lubrication: Boundary, Mixed, and Hydrodynamic (Log-Log Plot)

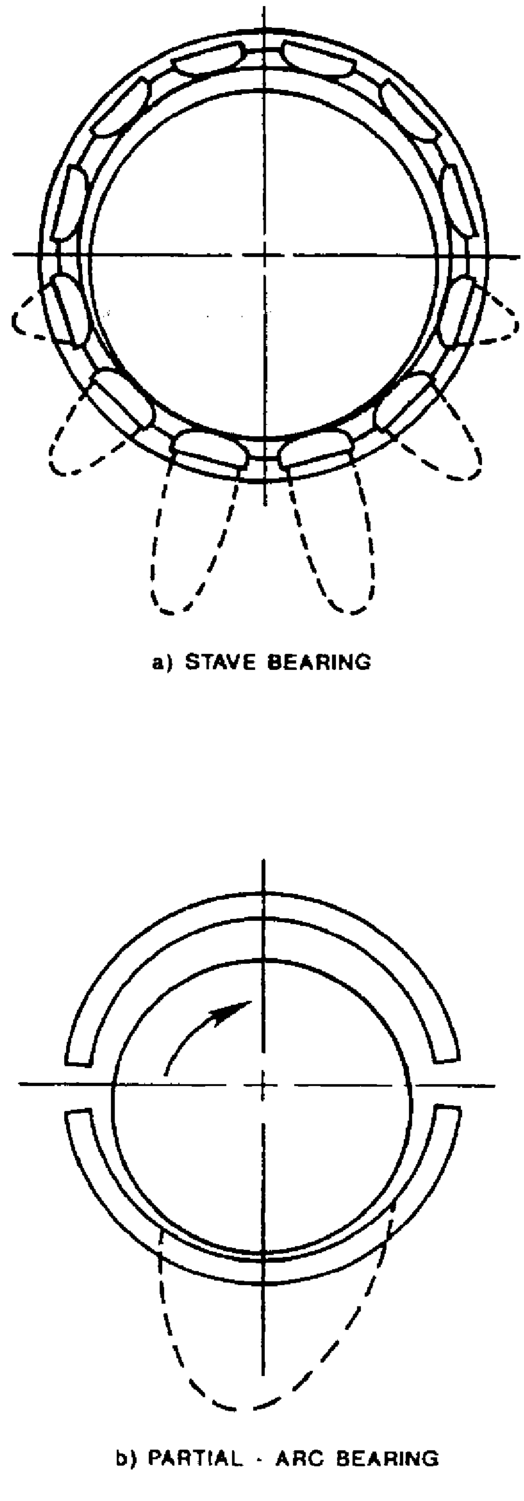


Figure 244-4-7 Stave-Type and Partial-Arc Bearing Pressure Profile

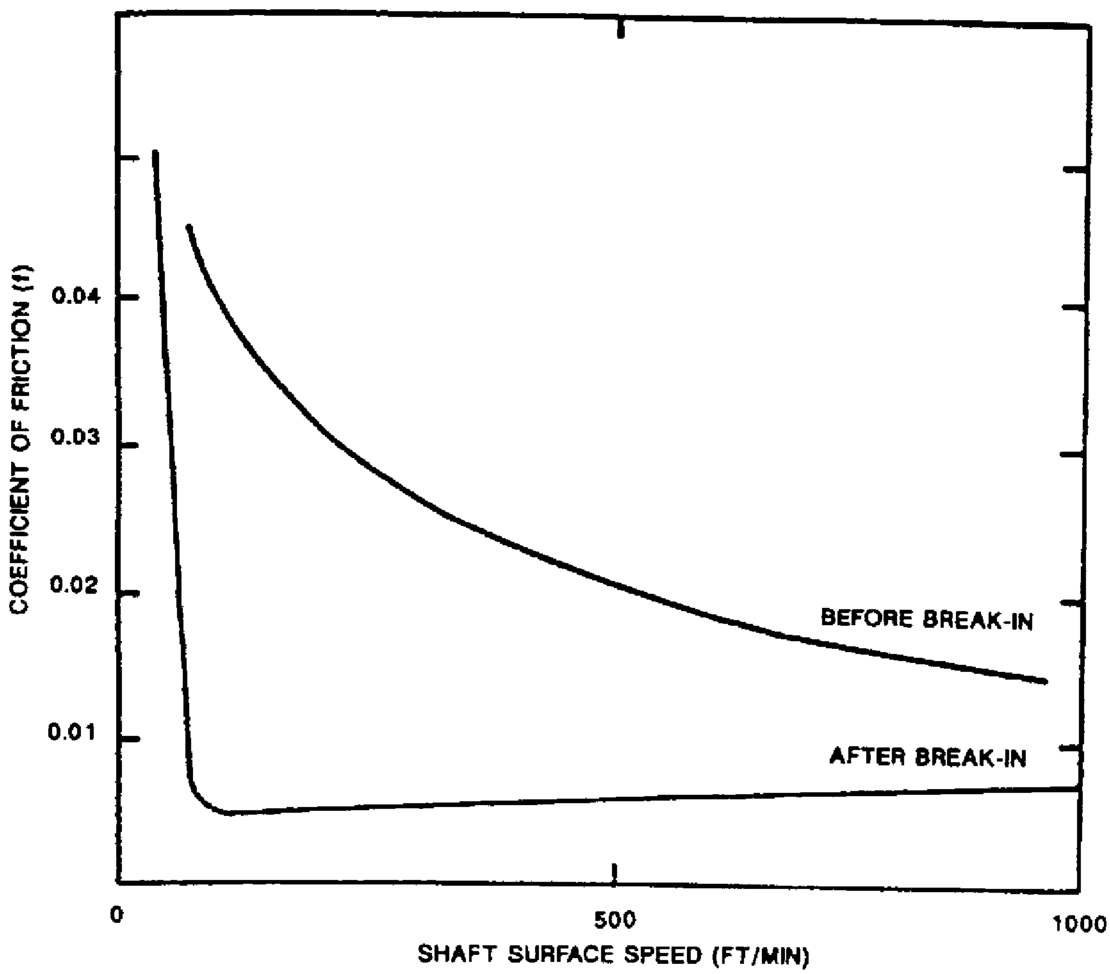


Figure 244-4-8 Typical Dynamic Friction Coefficient for Water-Lubricated Stave Bearings Before and After Break-in

244-4.4 OPERATIONAL PROBLEMS AND PROCEDURES

244-4.4.1 GENERAL. Carefully monitor the performance of newly installed bearings, particularly during startup or when unusual noises are detected. At low shaft speed rubber stave bearings tend to experience a phenomenon known as stick-slip. The shaft and rubber stick and slip in a cyclic fashion. This happens because the hydrodynamic water film has not yet fully developed to lift the shaft off the rubber stave properly. Stick-slip can be identified by chattering or squealing. Increase shaft speed to avoid this situation. Loose staves may contribute to stick-slip problems. Tightening the staves by local peening of the lands between the dovetailed slots is permitted.

244-4.4.2 HIGH TEMPERATURE. Water-lubricated bearings should run silently when in full operation. Noise can signify working frictional forces and the subsequent generation of heat. Do not subject rubber staves to temperatures of 180°F (83°C) or above for prolonged periods, because rubber deteriorates rapidly at high temperatures. When rubber overheats it may break away in chunks from the stave backing. The chunks of rubber that break away are too large to be flushed from the grooves. They may then lodge in the bearing grooves and restrict water lubrication of the bearing, causing more overheating. They may also rotate around the bearing and tear more rubber away from the staves. This continues until the bearing is totally destroyed.

244-4.4.2.1 The water-lubricated bearings incorporate design features to generate a water wedge during the lubrication cycle.

CAUTION

Do not alter the bearing surface of the staves by boring out, sanding, machining, or grinding the stave rubber surface. These procedures do not produce consistent bearing surfaces, which may lead to premature bearing failure.

244-4.4.2.2 Class III staves, being nonmetallic backed, have a higher coefficient of thermal expansion than class I metallic-backed staves. This may cause the staves to loosen in the dovetailed slots at the low temperatures that may be experienced in cold water operation.

244-4.4.3 CORROSION. Corrosion is the chemical process of surface deterioration that distorts a working part and impairs performance. In a bearing, corrosion may occur on the shell, the stave rubber-to-brass interface, the brass backing, or the shaft sleeve. During corrosion of the brass-to-rubber interface of class I staves, zinc leaches out of the brass. This process is known as dezincification (Figure 244-4-9). The synthetic rubber of the stave bearings resists corrosion and will not itself contribute to any shaft corrosion. Corrosion of the brass backing on class I bearing staves will loosen the staves in the dovetail slots. As the shaft becomes rougher, it acts abrasively on the bearing. This grinding may reduce the shaft diameter at the bearing, distorting the shaft and affecting bearing performance. Sacrificial zinc anodes are bolted to the bearing case to prevent corrosion of the bearing shell. The zinc corrodes instead of the bearing shell.

244-4.4.4 SLEEVE MATERIAL. Proper selection and preparation of the sleeve material can reduce shaft and sleeve corrosion. Select hard, close-grained materials that are free of pits, porosity, sand inclusions, and other defects. The surface should have a smooth, polished finish. A corrosion-free shaft lets the stave bearings work with maximum efficiency. Additional information on shaft sleeves can be obtained in **NSTM Chapter 243, Propulsion Shafting.**

244-4.5 MAINTENANCE

244-4.5.1 When properly installed, water-lubricated bearings require no maintenance other than monitoring of the bearing clearances. Bearing and journal surfaces are completely separated by water, and therefore the bearings experience minimal wear. Replace the bearing staves (and dress the journals, if necessary) whenever a top clearance exceeds that specified in Table 244-4-1. This top clearance can be measured directly or estimated from the corresponding shaft-to-stave retainer (STSR) clearance reading. Additionally, if during routine diving inspections the stave end profiles reveal an inconsistency in either shape or material condition, specifically regarding evidence of abnormal wear, damage, blockage of the bearing water channels, or extrusion from the bearing ends, a boroscope inspection of the bearing should be accomplished and forwarded to FTSCLANT/FTSCPAC, NSWCCD-SSES, or NAVSEA for evaluation.

244-4.6 INSPECTION

244-4.6.1 GENERAL. Examine stave bearings and take clearance measurements whenever the ship goes into drydock. Insert a feeler gage into the bearing to measure clearances between the shaft sleeve and the stave. Insert the feeler gage 4 to 6 inches into the bearing on both the forward and the aft ends, if possible without disassembling the ship seals. When checking clearances, remove the retaining ring and check the stave ends for unbonding. While waterborne, measure the shaft-to-stave retainer (STSR) clearances during routine diving inspections. Also inspect the stave end profiles for evidence of abnormal wear, damage, blockage of the bearing water channels, and extrusion from the bearing ends. Further waterborne inspection of the bearings using a boroscope is to be performed as required if suspect conditions exist.

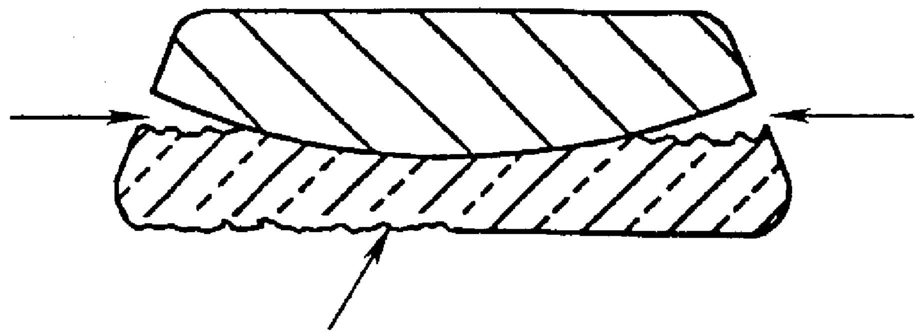


Figure 244-4-9 Dezincification of Class I Bearing Stave

244-4.6.1.1 Check unloaded stern tube bearings for unbonding only. These bearings should not wear and are used only to protect the shaft seal during shock loads. Renewing the aft propeller bearing should provide adequate clearance in the unloaded stern tube bearing. Measure the clearance of unloaded stern tube bearings only at the following times:

a. During overhaul

b. When evidence is found of shaft contact

c. When a shaft noise has been detected and reported.

244-4.6.2 REPORTING. Complete a ship docking report (NAVSHIPS form 9997/4, Figure 244-4-10) on entering and just before leaving drydock. Record the stave bearing clearances as well as the shaft-to-stave retainer (STSR) clearances on NAVSHIPS form 9997/4. In addition to the required docking report distribution, forward a copy to NAVSEA Philadelphia (NSWCCD-SSES Code 9323), 1569 Constitution Avenue, Philadelphia, PA 19112-1403. Retain these records for the life of the ship.

244-4.6.3 STAVE WEAR. Shaft contact patches on staves can indicate problems in the bearing. A normal wear pattern and wear caused by shaft misalignment are shown in Figure 244-4-11 and Figure 244-4-12, respectively. If wear patterns indicate shaft misalignment, refer to **NSTM Chapter 243** for the procedure to check shaft alignment. A stave with chunks of rubber missing is shown in Figure 244-4-13. This is caused by heat building up and the rubber chunking out.

244-4.6.4 WEAR RATE. Typical wear rates for bonded, synthetic rubber bearings are approximately 0.010 to 0.020 inch per year for submarines and 0.020 to 0.030 inch per year for surface ships. Ships with controllable-pitch propellers may experience higher wear rates if excessive operation is conducted with the propeller turning at 0 pitch (idling). This operating condition should be minimized as much as practical due to insufficient water flow through the naturally lubricated stave bearings, resulting in increased bearing wear.

244-4.7 REPLACEMENT CRITERIA

244-4.7.1 Stern tube and strut bearings should be replaced at routine dockings whenever the rate of wear indicates that the allowable top clearances will be exceeded before the next scheduled docking. If applicable, the top clearance can be estimated from the corresponding shaft-to-stave retainer (STSR) clearance reading. Two formulas for determining projected top clearances at the next scheduled drydocking are given in Figure 244-4-14. If the projected top clearance exceeds that listed in Table 244-4-1, renew the bearing at the present docking. At interim dockings the main shaft seal need not be removed to measure the clearance of the inboard stern tube bearing unless the history of the bearing, excessive wear of the other bearings on the same shaft, or abnormal operating conditions since the clearances were last measured make the condition of these bearings doubtful.

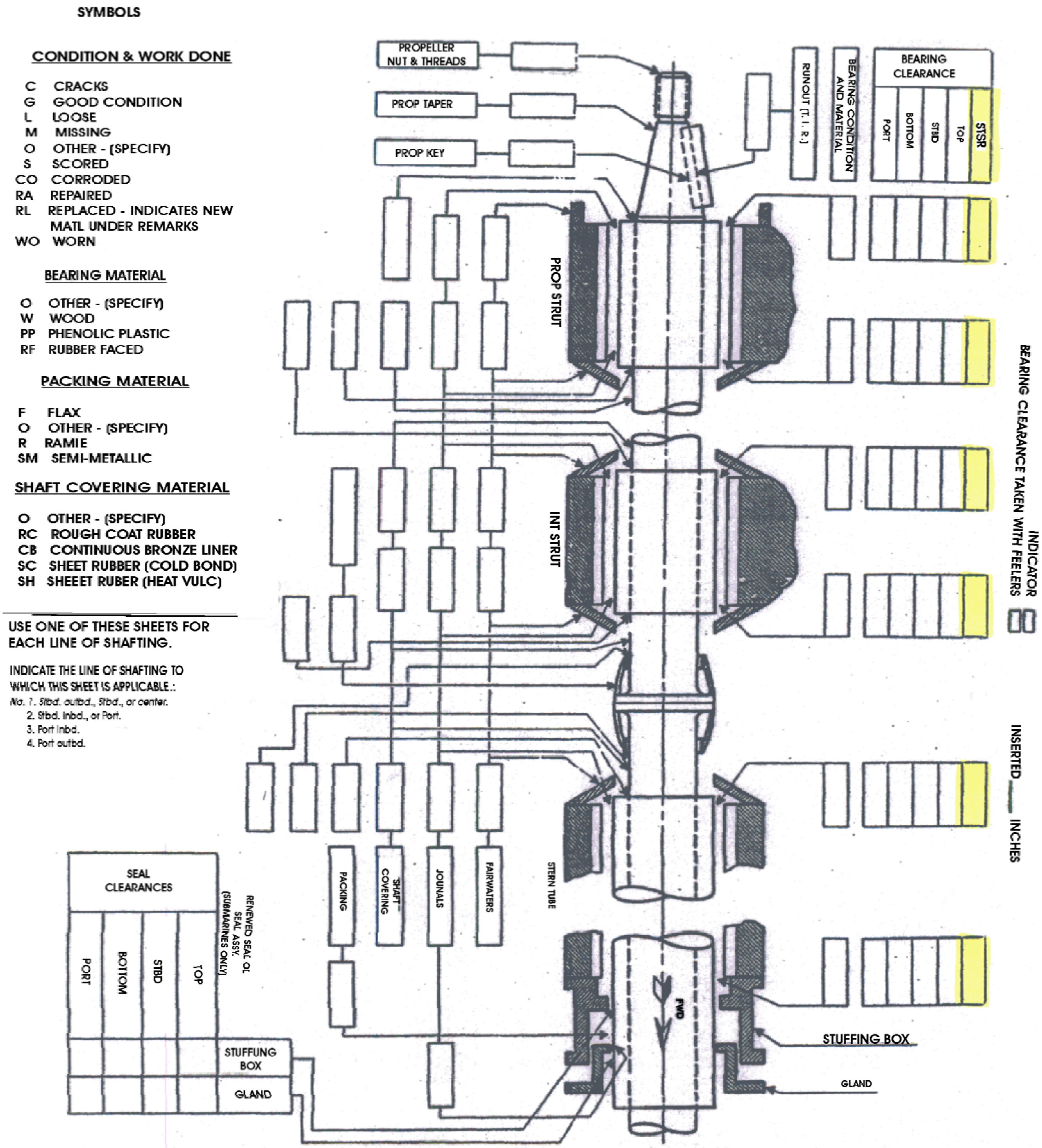


Figure 244-4-10 NAVSHIPS Form 9997/4

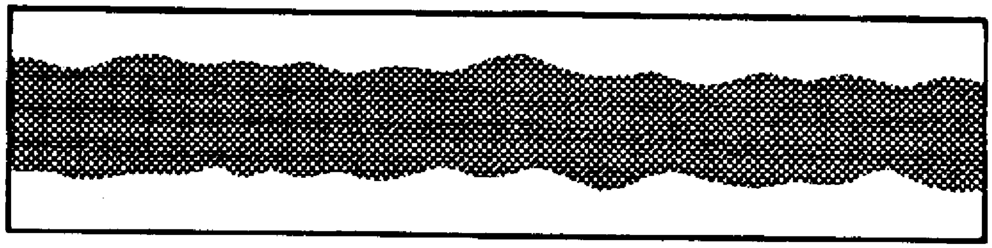


Figure 244-4-11 Normal Wear Pattern

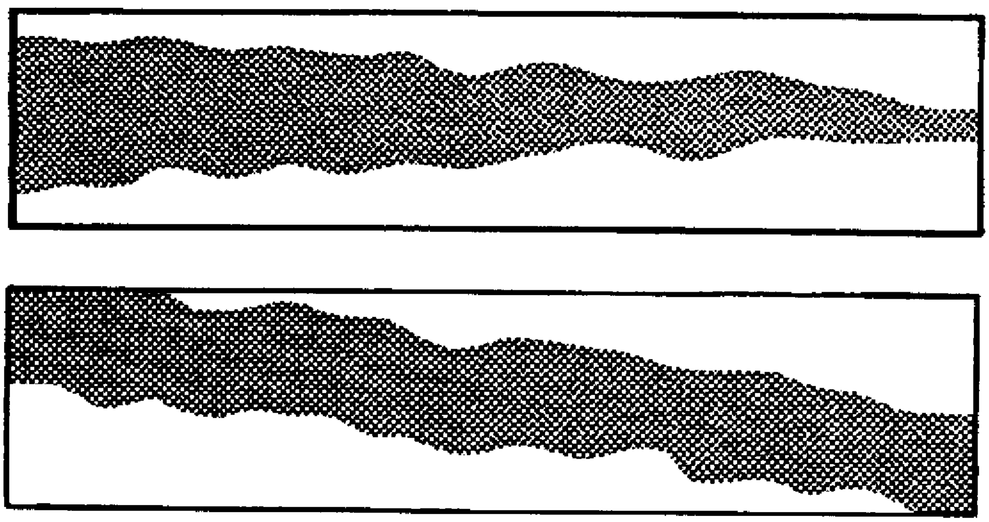


Figure 244-4-12 Shaft Misalignment Wear Pattern

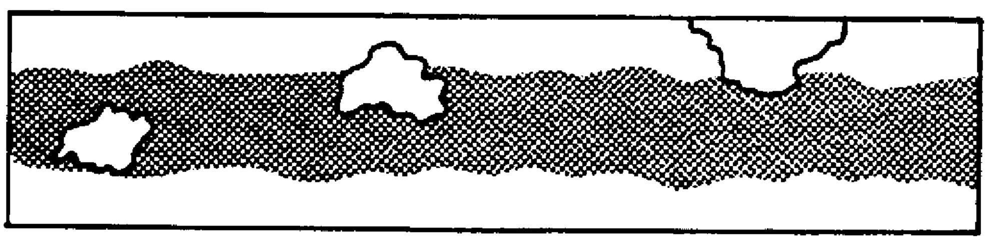


Figure 244-4-13 Chunking Out of Stave Bearing

FORMULA 1

$$\text{ANNUAL MAXIMUM TOP CLEARANCE CHANGE RATE} = \frac{\left(\text{PRESENT MAXIMUM TOP CLEARANCE}\right) - \left(\text{LAST MAXIMUM TOP CLEARANCE}\right)}{\left(\text{YEARS SINCE LAST RECORDED CLEARANCE}\right)}$$

FORMULA 2

$$\text{MAXIMUM PROJECTED TOP CLEARANCE} = \left(\text{ESTIMATED YEARS TO NEXT DOCKING PERIOD}\right)\left(\text{ANNUAL MAXIMUM TOP CLEARANCE CHANGE RATE}\right) + \left(\text{PRESENT MAXIMUM TOP CLEARANCE}\right)$$

Figure 244-4-14 Projected Top Clearance Formulas

244-4.8 BEARING RENEWAL

244-4.8.1 GENERAL. It is easier to remove the bearings with the shaft already removed. When removing the shaft, be sure to lift it off the rubber bearing surface before sliding it out. Sliding the shaft across the bearing will scratch the bearing surface and adversely affect bearing performance. If the bearing must be removed with the shaft in place, first remove the upper half of the bearing shell or bushing by sliding it out along the shaft. The shaft may now be lifted to remove the pressure on the bottom bearing shell. Remove the lower half of the bearing.

NOTE

A soapy water solution can be used to protect the bearing staves and to reduce sliding friction from incidental shaft to bearing contact during bearing removal. The use of tallow is strictly prohibited.

244-4.8.2 STAVE REMOVAL. With the bushings removed from the ship, disassemble the retaining rings and push the staves out of the dovetailed slots. They may have to be driven out with a hand-held, air-driven impact hammer. Because the coefficient of thermal expansion of class III staves is greater than that of brass, cooling the staves with ice will aid in stave removal. As a last resort, the staves may have to be cut lengthwise and removed in sections. Take care to avoid damaging the dovetailed slots.

244-4.8.3 NUCLEAR AIRCRAFT CARRIERS. For CVN-65 and CVN-68 Class, the following stave configuration shall be used on all water-lubricated bearings during renewal:

a. Use 1/16-inch oversize staves (1/16-inch oversize backing material with standard thickness rubber) conforming to NAVSEA Dwg. 803-1385664 for the bottom eight (8) staves.

b. Utilize staves possessing a reduced backing thickness (1/16-inch undersize backing material) for the top eight (8) staves, while maintaining standard rubber thickness.

NOTE

An order for custom-sized staves will need to be placed with the stave vendor accordingly.

c. Use standard size staves (standard backing material thickness with standard thickness rubber) conforming to NAVSEA Dwg. 803-1385664 for the twelve (12) side staves.

244-4.9 INSTALLING STAVES

244-4.9.1 GENERAL. If class III staves will not fit into the slot, immerse them in ice water for 30 minutes or otherwise expose them to cold temperatures. This will permit the staves to be installed by hand. Do not cool class III staves to below 0°F. Do not use dry ice to cool staves. Once the stave has been slid into the slot and the stave and bearing shell are at the same temperature, the installer can tap lightly on the stave face with a rubber mallet to determine from the sound if the stave is tight in the slot. When tapping indicates loose spots in the slot, lightly peen the brass land area between the staves at that location. This should tighten the staves. Keep peening to a minimum.

CAUTION

Do not directly hammer the stave ends during installation, as this will cause cracking and separation at the stave ends. Use a wooden block to buffer the stave from the hammer.

244-4.9.2 PRECAUTIONS

244-4.9.2.1 Fitting Staves. When installing staves in the dovetailed slots, if the side clearance is greater than 0.011 inch (when the strips are flush with the bottom of the groove and hard against one side), no method of securing the bearing strips is acceptable. Install a new bearing shell. After the bearing strips have been secured, they must fit snugly (without play). Place a curved template equivalent to the outside diameter of the shaft sleeve across three consecutive staves. The clearance between the template and the staves shall not exceed 0.018 inch (0.010 inch for SSN 688 class). If exceeded, replace the staves or bearing shell. The clearance between the end of the bearing stave and the retaining ring shall not exceed 0.032 inch. The bearing stave shall not extend beyond the end of the bearing shell.

244-4.9.2.2 Stave Surface Finish. The surface finish of the rubber staves is very important for proper operation of the bearing. Do not sand or grind the rubber stave bearing surface to obtain proper clearance. Use oversized staves, resleeve the shaft, or turn down the shaft sleeve to obtain proper clearance.

244-4.9.2.3 Installation. When installing the shaft, be sure to lift it off the rubber bearing surface before sliding it in. Sliding the shaft across the bearing will scratch the bearing surface and adversely affect bearing performance. Reinstall the retaining rings, and secure the bolts with lockwire. Remove the remains of the sacrificial zinc anodes, and install new anodes. Secure these bolts with lockwire.

NOTE

A soapy water solution can be used to protect the bearing staves and to reduce sliding friction from incidental shaft to bearing contact during bearing installation. The use of tallow is strictly prohibited.

244-4.10 PRESERVATION

244-4.10.1 PRESERVATION COMPOUND. Voids between the bearing shells and stern tubes and shaft struts shall be filled with corrosion preventive compound in accordance with **NSTM Chapter 631 (V2), Preservation of Ships in Service - Surface Preparation and Painting.** Tallow shall not be used in bearing voids and shall be removed if discovered upon bearing disassembly.

244-4.10.2 DRAIN AND FILL HOLES. Threaded plugs for drain-and-fill holes in stern tubes and shaft struts shall be opened immediately after dry-dock when danger of freezing exists to drain trapped water which may cause rupture due to freezing. corrosion preventive compound · These plugs are manufactured from a bronze material and are typically damaged and/or destroyed upon removal. Thus, replacement plugs may be manufactured using Delrin or equivalent material.

244-4.10.3 STORAGE. To ensure long service life, protect the rubber surfaces of the bearings from light, compression set, age hardening, and excessive heat or cold during storage. Compression set occurs when rubber sustains a prolonged, concentrated load. Properly supporting equipment during storage so that the shaft does not rest on the rubber bearing faces prevents this type of distortion. The maximum storage life for bearing staves, prior to installation, is 3 years, as required by MIL-HDBK-695D. Staves which exceed this shelf-life must be discarded and are not to be installed under any circumstance.

244-4.10.4 WATERBORNE BUILDING. Further guidance on preservation during the waterborne building period can be found in **NSTM Chapter 050, Readiness and Care of Inactive Ships.**

SECTION 5

RUDDER STOCK BEARINGS AND SEALS

244-5.1 DESIGN

244-5.1.1 GENERAL. Rudder stock bearings are an integral part of a ship's steering system. The bearings support and transmit the rudder stock radial and thrust loads to the ship's hull. The upper carrier bearing supports the thrust load due to the weight of the rudder stock and the radial loads due to the hydrodynamic forces from the rudder. The lower radial bearing only supports radial loads due to the hydrodynamic forces from the rudder. Both bearings must also withstand any shock forces due to the weight of the rudder and stock. Three general arrangements of rudder stock bearings are in use.

244-5.1.2 HYBRID ARRANGEMENT. Rudder stock bearings may be arranged as shown in Figure 244-5-1. This is called a hybrid arrangement because it uses a roller bearing for the upper carrier bearing and a sliding-surface bearing for the lower radial bearing.·Some older ship classes are configured with this hybrid rudder arrangement. The AOE-6, LSD-41/49, and LPD-17 are the most recent ship classes to possess this type of rudder system. However, the LPD-17 ship class has horn rudders with a third pintle bearing at the lower end of the horn. The CVN-68 class is also configured with a similar three-bearing horn rudder design, but all three bearings are of the sliding-surface type.

244-5.1.2.1 Upper Carrier Bearing. The upper carrier bearing is a self-aligning roller bearing to accommodate both radial and thrust loads. It is made in accordance with FED Spec FF-B-185, **Bearings, Roller, Cylindrical and Self-Aligning,** and conforms to NAVSEA dwg 803-5001104. It is lubricated with grease (MIL-G-24139, **Grease, Multipurpose, Water Resistant, or Termalene II)** and sealed with packing glands.

244-5.1.2.2 Lower Radial Bearing. The lower radial bearing is a sliding-surface bearing. Sliding-surface bearings are designed in accordance with NAVSEA dwg 803-5001104. These bearings consist of a bushing made from either gun-metal f FED Spec QQ-C-390, **Copper Alloy: Castings (Including Cast Bar),** or centrifugally cast copper-nickel alloy, ASTM B369, Standard Specification for Copper-Nickel Alloy Castings, Alloy No. C96400, which retain laminated-phenolic staves conforming to MIL-P-18324, **Plastic Material, Laminated Phenolic, For Bearings (Water or Grease Lubrication).** The use of Thordon SXL solid sleeve bearing material is also permitted in lieu of laminated-phenolic staves when bearing pressures and material deflection allow. The rudder stock is sleeved to protect it from wear. Bearings may be lubricated with grease (MIL-G-24139 or Termalene II) or a combination of grease and water. In bearing applications which utilize Thordon SXL solid bearing sleeve material, lubrication is not required. Packing glands seal the top of the bearing and exclude sand from the bottom of the bearing.

244-5.1.3 OLD ROLLER BEARING ARRANGEMENT. The old rudder bearing arrangement that used double-spherical roller bearings for both the upper carrier bearing and the lower radial bearing is shown in Figure 244-5-2.

244-5.1.3.1 Upper Carrier Bearing. The upper carrier bearing is a self-aligning, double-spherical roller bearing that accommodates both radial and thrust loads. It is made in accordance with FED Spec FF-B-185 and conforms to NAVSEA dwg 803-5001104. It is lubricated by either oil or grease, depending on ship class. This bearing is sealed with split rubber lip seals that are glued or stapled together and retained by a garter spring.

244-5.1.3.2 Lower Radial Bearing. The lower radial bearing is a self-aligning, double-spherical roller bearing made in accordance with FED Spec FF-B-185 and conforming to NAVSEA dwg 803-5001104. It is lubricated with oil supplied at a pressure slightly greater than sea pressure to prevent bearing seawater contamination. The lube oil system has a head tank to maintain this pressure and a settling tank to separate water and other contaminants from the lube oil. This bearing is mounted as low in the ship as possible to reduce weight, which requires the lower bearing seal to function also as the hull seal. This seal was originally designed as a rubber lip seal, but numerous seal failures required a redesign. When the seal failed it would cause bearing failure by oil starvation and oil contamination of the environment. This seal is not accessible from inside the ship.

244-5.1.3.3 Mechanical Face-Type Seal. The lower radial bearing oil seal design has been changed to a mechanical face-type seal (Figure 244-5-3). Mechanical face-type seals work better than the old rubber lip seal design because they can accommodate larger radial deflections due to wear and load. The neoprene (rubber) body of the mechanical face-type seal is split for assembly. It is wrapped and vulcanized to seal the splitline. The clamp ring clamps the body to the rudder stock. At installation the body is slightly compressed, and because it is an elastomer, it provides the force necessary to seal the face. The face is made of a nonmetallic material, and it seals against the seat, which is made of Ni-Resist (ASTM A 439, type D-2, **Standard Specification for Austenitic Ductile Iron Castings).** The seat is attached to the rudder trunk or hull.

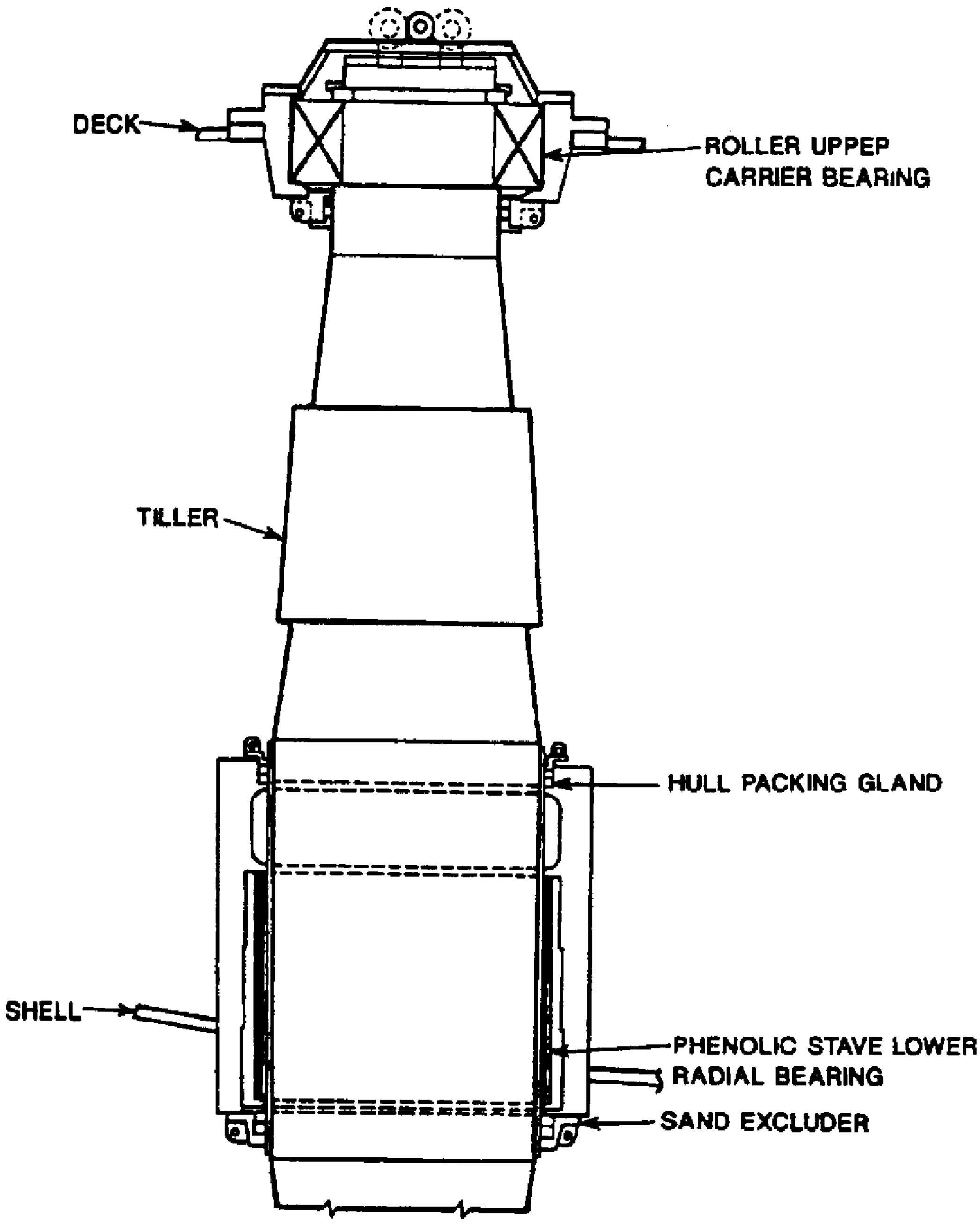


Figure 244-5-1 Hybrid Arrangement of Rudder Stock Bearings

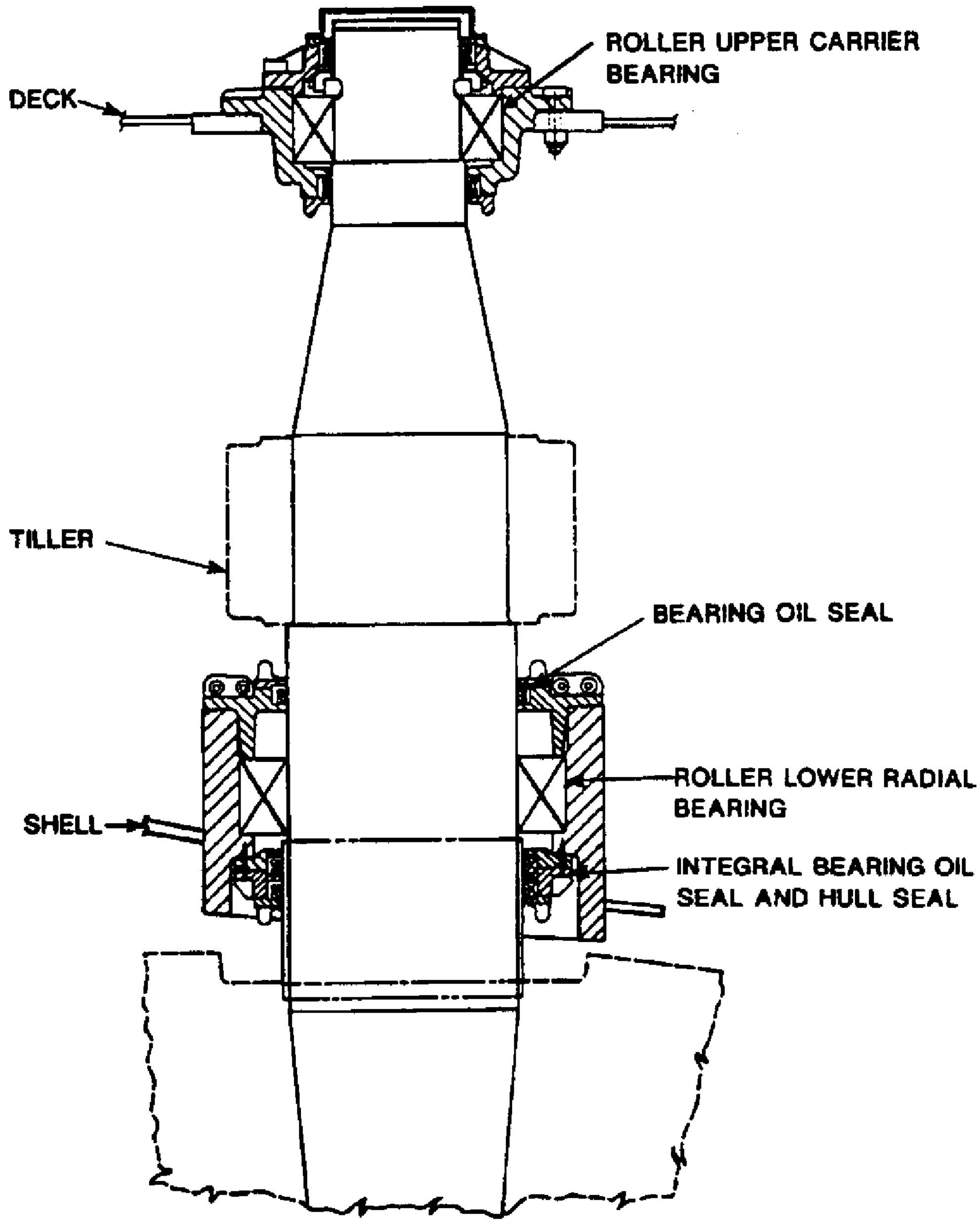


Figure 244-5-2 Old Roller Bearing Arrangement of Rudder Stock Bearings

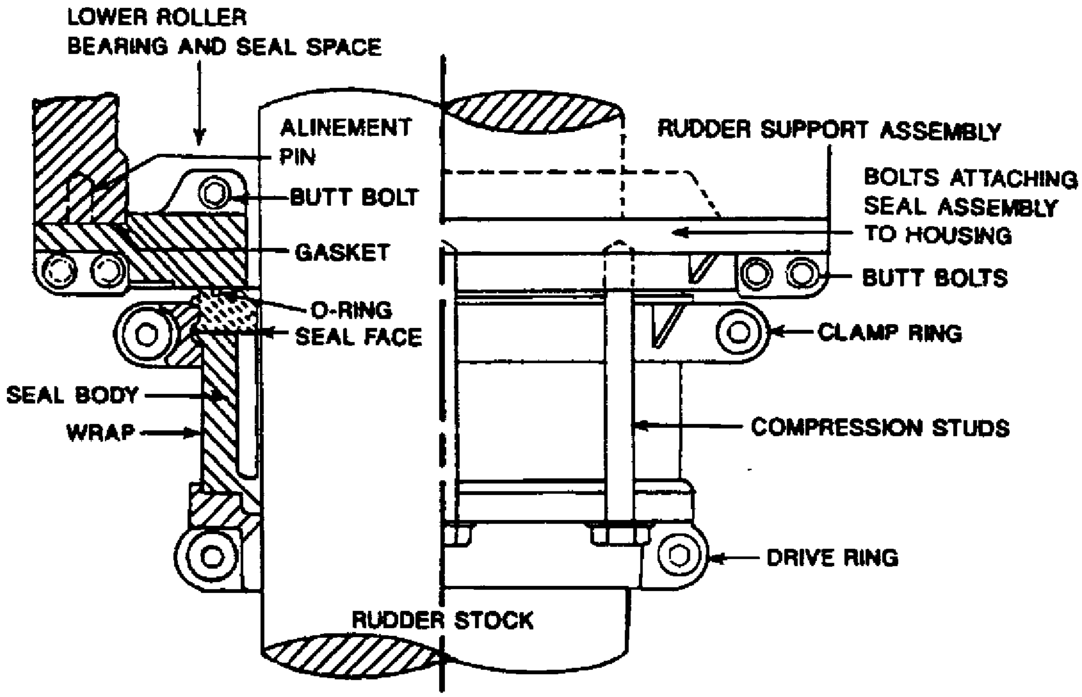


Figure 244-5-3 Mechanical Face-Type Seal for Rudder Stock Bearings

244-5.1.4 NEW ROLLER BEARING ARRANGEMENT. The new rudder bearing arrangement using roller bearings for both the upper carrier bearing and the lower radial bearing is shown in Figure 244-5-4.

244-5.1.4.1 Upper Carrier Bearing. This bearing is the same as the old upper carrier bearing (paragraph 244-5.1.3.1).

244-5.1.4.2 Lower Radial Bearing. This bearing is functionally similar to the lower radial bearing in the old roller bearing arrangement (paragraph 244-5.1.3.2), but it has a different sealing arrangement. It has a separate lip seal for the bearing and mechanical face-type seal for the hull, with a leakoff connection between the two seals. The allowable seawater leakage rates for the hull seal are 1 pint per day static and 1 gallon per day dynamic.

244-5.1.4.3 Mechanical Face-Type Seal. This mechanical face-type seal is the same as that described in paragraph 244-5.1.3.3.

244-5.1.5 LUBRICATION. Excessive steering engine resistance can be caused by lack of lubrication in the bearings.

244-5.1.5.1 Grease Lubrication. The bearing rings and the areas between the rollers, rings, and separators (cages) of grease-lubricated bearings should be completely packed with the required grease. The housings should then be completely filled, since this will help preserve them and seal them against moisture. Completely filling the housing will neither adversely affect the bearing temperature nor impede bearing operation, since rudder movement is relatively slow. If, at the time of routine inspection, the grease has become oxidized or discolored, remove that portion of the grease and replace it with fresh grease. Replacement grease should always conform to MIL-G-24139 or Termalene II.

244-5.1.5.2 Oil Lubrication. The operation of oil-lubricated bearings depends on the condition of the lubricating oil. Oil used in rudder stock bearings is usually the same oil used for other propulsion machinery. Steam and gas turbine powered ships use MIL-L-17331, **Lubricating Oil, Steam Turbine and Gear, Moderate Service, 2190 TEP.** Diesel engine powered ships use MIL-L-9000, **Lubricating Oil, Shipboard Internal Combustion Engine, High Output Diesel, NATO Code 0-278.** Check the oil level and the condition of the oil frequently. Where practical, check the level daily and sample the oil weekly. Sample the oil to determine its neutralization number and to check for water, foreign matter, or metallic particles in the system. Solid materials can be found by allowing the oil sample to settle. (Refer to **NSTM Chapter 262, Lubricating Oils, Greases, Specialty Lubricants, and Lubrication Systems.)** Change lube oil only when samples indicate an excessive neutralization number or when samples show evidence of contamination. For bearings mounted below the waterline, carefully maintain the oil level and seals so that seawater does not enter the bearing housing and deteriorate the system.

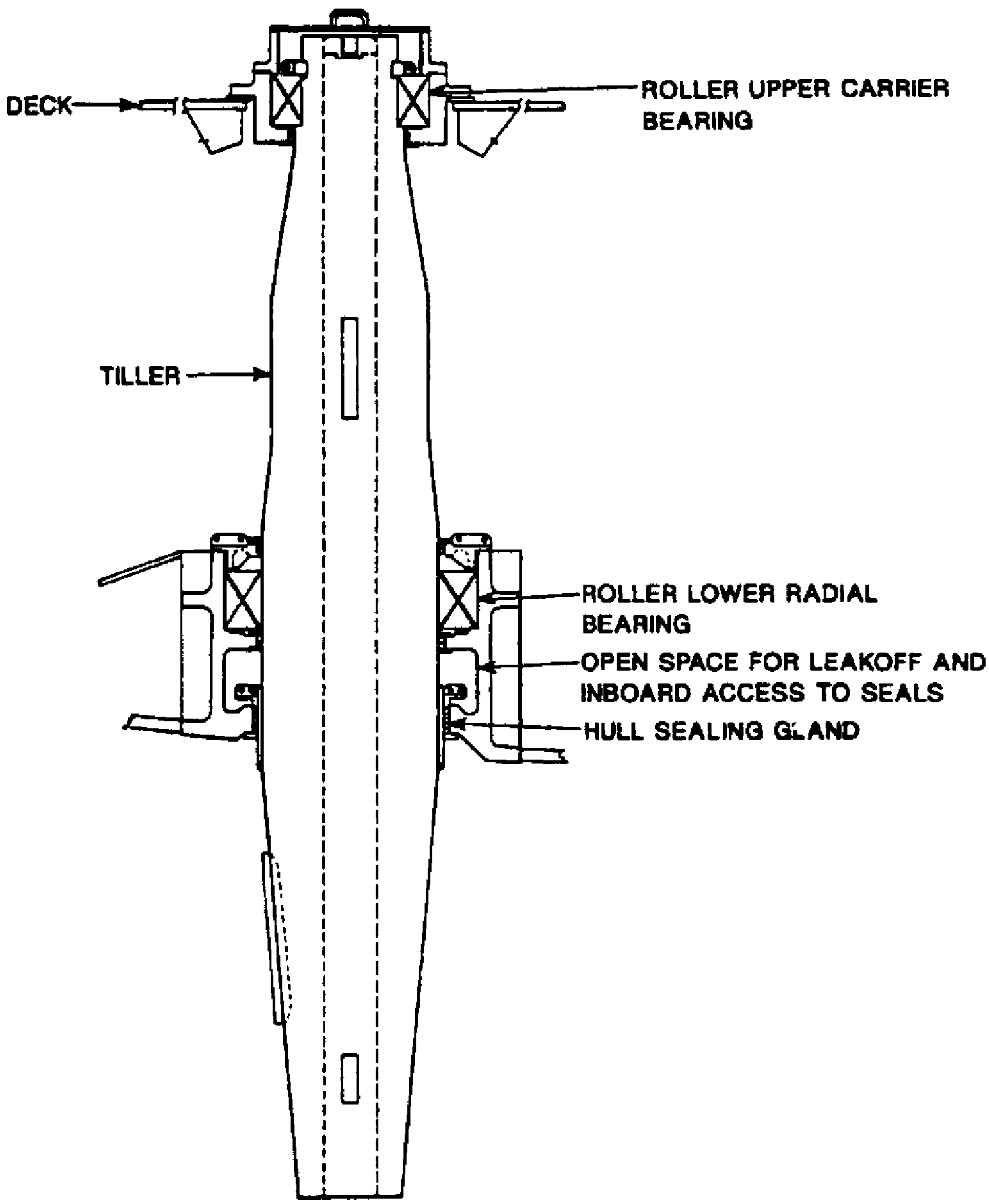


Figure 244-5-4 New Roller Bearing Arrangement of Rudder Stock Bearings

244-5.1.6 BEARING CLEARANCE. Sliding-surface-type bearings must have clearance between the rudder stock journal and the bearing to allow the lubricant to circulate and to permit a film to form between the rudder stock journal and the bearing. The bearing must be fitted so that its radius of curvature is greater than that of the journal. This difference allows a certain amount of play between the journal and the bearing.

244-5.1.6.1 Bearing clearance must be uniform throughout the entire length of the bearing. If the clearance is not uniform, only part of the bearing surface will take the load. The friction on this limited surface will cause the bearing to run warmer than normal, which might cause a failure. With large bearings a slightly larger clearance is usually allowed at the sides of a bearing to prevent the journal from being nipped if a bearing runs warm and to ease the handling of the bearing on and off the journal during fitting. The slightly larger clearance at the bearing ends permits a better distribution of lubricant for cooling.

244-5.1.6.2 In assembling a bearing, the splitline faces of the shells must be butted up metal to metal, but allow enough space for lubricant clearance between the journal and the bearing metal. The desired result is to reduce this clearance to a minimum while ensuring sufficient flow of lubricant to prevent overheating.

244-5.1.6.3 The amount of clearance depends on:

a. Bearing size

b. Accuracy of the shaft alignment

c. Lubrication system (gravity or forced)

d. Desired operating temperature

e. Lubricant viscosity.

244-5.1.6.4 Bearing clearances are given in Figure 244-5-1. Unless otherwise specified, use them as a general guide. If given, use the clearances on NAVSEA dwg 803-5001104.

244-5.2 BEARING OPERATION

244-5.2.1 The characteristic low-speed rotation but high-bearing loading in rudder bearings makes heat generation of slight consequence. Wear or material deformation, however, shall be checked periodically.

244-5.3 MAINTENANCE

244-5.3.1 Removing the rudder stock or lifting the bearing to inspect the rolling-contact bearings is unnecessary. Check the surface finish of the rollers and adjacent bearing rings by drawing a stylus across the exposed surfaces. If spalling or pitting is detected, remove the stock for a more detailed inspection of the bearings. The stock should be removed only if there is evidence that the exposed rolling-contact surface has spalled or is pitted. Maintenance inspections recommended for rolling-contact rudder bearings are listed in Figure 244-5-2.

244-5.4 CLEARANCE MEASUREMENT

244-5.4.1 GENERAL. In measuring the clearance of bearings, take readings by means of a dial gage with the stock jacked hard over to the opposite side of the bearing. Take readings with the rudder stock jacked forward, aft, to port, and to starboard. If the dial gage readings at a given bearing indicate an excessive amount of bearing wear, replace that particular bearing.

Table 244-5-1 CLEARANCES FOR SLIDING-SURFACE-TYPE RUDDER STOCK BEARINGS

A	B	C
Outside Diameter of Stock or Pintle Including Sleeve (Journal Diameter) (Inches)	**Minimum Operating Diametric Clearance (inch)**	**Maximum Allowable Diametric Clearance Above Which Bearings Shall Be Renewed (inch)**
1	0.005	0.05
2	0.005	0.05
3	0.006	0.06
4	0.006	0.06
5	0.007	0.06
6	0.008	0.06
7	0.009	0.06
8	0.010	0.07
9	0.011	0.07
10	0.012	0.07
11	0.013	0.07
12	0.014	0.07
13	0.015	0.08
14	0.016	0.08
15	0.017	0.08
16	0.018	0.08
17	0.019	0.08
18	0.020	0.09
19	0.021	0.09
20	0.022	0.09
21	0.023	0.09
22	0.024	0.09
23	0.025	0.10
24	0.026	0.10
25	0.027	0.10
26	0.028	0.10
27	0.029	0.10
28	0.030	0.11
29	0.031	0.11
30	0.032	0.11
31	0.033	0.12
32	0.034	0.12
33	0.035	0.13
34	0.036	0.14
35	0.037	0.15
36	0.038	0.16

Table 244-5-2 MAINTENANCE INSPECTION OF ROLLING-CONTACT RUDDER BEARINGS

Activity	Grease Lubricated Bearings	Oil Lubricated Bearings
Daily Inspection	None	Check oil level and system pressure gages.
Weekly Inspection or After Each Extended Operation	None	Check oil for water or other contaminants.
Intermediate Inspection (Approximately every 6 months)	1. Check condition of grease. Replace portion that was oxidized or discolored. 2. Check condition and operation of accessible seal mechanisms. Adjust as needed.	1. Sample oil for neutralization number test. If neutralization number is from 0.1 to 0.3, oil condition is satisfactory. If neutralization number is from 0.3 to 0.5, forward an oil sample to a tender or yard for a corrosion test as outlined by Method No. 5325 or FED Std 791, **Lubricants, Liquid Fuels and Related Products Method of Testing**. If sample passes this test, oil may be retained. If it does not pass, replace oil. If neutralization number exceeds 0.5, replace oil as soon as practical. 2. Check condition and operation of acceptable seal mechanisms. Adjust as needed.
Scheduled Overhaul Inspection	1. Clean and flush bearing and housing with a light petroleum solvent (stoddard solvent, naphtha, etc.) Wipe exposed surfaces with a clean, dry cloth. 2. Check condition of rolling element surfaces (stylus method). 3. Check condition and operation of all bearing sealing mechanisms. Replace worn parts as required. 4. Completely bearing and housing with recommended grease.	1. Clean and flush bearing and housing with a light petroleum solvent (stoddard solvent, naphtha, etc.) Wipe exposed surfaces with a clean, dry cloth. 2. Check condition of rolling element surfaces (stylus method). 3. Check condition and operation of all bearing sealing mechanisms. Replace worn parts as required. 4. Refill with oil selected in accordance with required specifications.

244-5.4.2 ROLLING-CONTACT-TYPE BEARINGS. Measurable wear should not occur in properly mounted, lubricated, and sealed rolling-contact bearings. Evidence of wear indicates some form of contamination or misalignment beyond the bearing capacity. The load-carrying function of the bearing is unaffected by uniform wear; the integrity of the sealing mechanism, however, may be seriously affected if the design bearing clearance is exceeded by a factor of three to four.

244-5.4.3 SLIDING-SURFACE-TYPE BEARINGS. Laminated phenolic bearing material may be installed dry or wet. The values given in Figure 244-5-1, column B, are minimum operating diametric clearances for laminated phenolic bearing materials that are installed wet. Add a suitable diametric swelling allowance to the clearance value of column B for bearing materials that are installed dry and expand because of water absorption.

244-5.4.3.1 Dry Installation. Make the following diametric swelling allowances when laminated phenolic bearing material is installed dry:

a. Allow 1 percent of the total wearing material thickness for stave-type bearings with cotton fiber laminations perpendicular to the journal surface. (Add this 1 percent allowance to the values of column B.)

b. Allow 3 percent of the total wearing material thickness for stave, segment, or tube-type bearings with cotton fiber laminations either parallel to or concentric with the journal surface. (Add this 3 percent allowance to the values of column B.)

244-5.4.3.2 Wet Installation. When laminated phenolic bearing material is installed wet, no allowance for diametric, longitudinal, or circumferential swelling is necessary. Laminated phenolic bearing material shall be soaked in water for at least 6 months before wet installation. After this time, all water absorption, and thus swelling, will have ceased.

244-5.4.3.3 Renewal Criteria. Replace bearings when the maximum allowable clearance given in Figure 244-5-1 column C, is exceeded. If there is evidence of excessive leakage at the stuffing boxes; excessive noise, chatter, or vibration; or other undesirable effects attributable to excessive bearing clearances, renew the bearings even though the maximum allowable clearances have not been exceeded. Whenever these or other exceptional circumstances are encountered, make a complete report to NSWCCD-SSES.

244-5.4.3.4 Standard Bearing Material. The above information pertains to metal, lignum vitae, and laminated phenolic bearings because of the past use of all three materials. The currently specified bearing material for most surface ships and submarines is laminated phenolic material conforming to MIL-P-18324. This shall be in stave form, installed with the edges of the cotton fiber laminations perpendicular to the journal surface. When laminated phenolic material is installed dry, the swelling allowances specified above shall be applied to correct for diametric, longitudinal, and circumferential swelling of the material, regardless of the type of lubrication.

SECTION 6

PROPULSION SHAFT SEALS

244-6.1 GENERAL

244-6.1.1 INTRODUCTION. This section provides information on the different types of main propulsion shaft seals installed on surface ships and submarines. Design descriptions, operation, shipboard preventive and corrective maintenance procedures, testing, troubleshooting, and repair parts information are presented for submarine mechanical face-type seals, inflatable seals, and emergency stuffing box seals. Surface ship shaft seals, inflatable seals, and bulkhead seals are also covered.

244-6.1.2 SAFETY PRECAUTIONS. Safety precautions related to operating and maintaining the shaft seal assemblies are included. **Warnings** identify an operating or maintenance procedure, practice, condition, or statement that, if not strictly followed, may result in death or serious injury to personnel. **Cautions** identify an operating or maintenance procedure, practice, condition, or statement that, if not strictly followed, could result in equipment damage or destruction, or serious impairment of operation. **Notes** highlight an operating or maintenance condition or statement that is essential but not of a hazardous nature.

244-6.2 SUBMARINE STERN TUBE SHAFT SEALS

244-6.2.1 GENERAL. The submarine stern tube shaft seal assembly provides the hull closure where the main propulsion shaft penetrates the pressure hull, preventing and controlling the entrance of seawater at that point. The seal assembly also retains the shaft if it breaks forward of the seal assembly. The assembly consists of two identical, tandem, mechanical face-type seals that under normal conditions serve on a selectable basis as the primary sealing device. This satisfies submarine safety (SUBSAFE) requirements for two identically capable boundary conditions. A typical submarine stern tube assembly is shown in Figure 244-6-1. The forward seal is usually in operation, and the aft seal is installed as a spare. This arrangement provides for the immediate operation of the aft unit if the forward seal fails. An emergency packing seal acts as a backup for the two primary seals but is intended for use only under emergency conditions. An inflatable seal is furnished (except on SSBN 726 class submarines) for use when maintaining the primary seals while the submarine is waterborne. A portable closure device (Figure 244-6-2) is available for SSBN 726 class submarines to permit repair or replacement of the forward primary seal or emergency seal while the submarine is waterborne. It is also used when hydrostatically testing either of the primary seals after installation. The closure device is used only in port and is not used for aft primary seal replacement. Installation, operation, and maintenance of the primary seals shall be in accordance with the associated Naval Sea Systems Command (NAVSEA) technical manuals. Table 244-6-1 provides leakage and flow rates for the various components and systems associated with submarine stern tube seals.

244-6.2.2 PRIMARY MECHANICAL FACE TYPE SEALS

244-6.2.2.1 Description. Each of two identical primary seals consists of a SUBSAFE Monel or Inconel 625 mating ring that is fixed, keyed, and statically sealed to the shaft, and a Monel or Inconel 625 seal ring that is flexibly attached, sealed, and keyed to the housing members by suitable springs and adapters. Dynamic sealing occurs between the stationary carbon face of the seal ring and the rotating hard face of the mating ring. Spring loads ensure contact between the faces during surface or shallow-depth operation. As operating depth increases, the faces are forced together by seawater pressure, which exerts an increasing load (much greater than spring load) because of an effective area imbalance across the seal ring. The face-type seal is essentially a hydrostatic bearing running on an extremely thin film of water. Some leakage is necessary to remove heat and provide for satisfactory wear life. Typical details of SSN 688 class and SSBN 726 class main shaft seals are shown in Figure 244-6-3 and Figure 244-6-4.

244-6.2.2.2 Operation. The two stern tube face-type seals are installed in tandem to provide greater operating reliability. During normal operations only the forward seal sustains the full differential sea pressure as the primary seal; the aft seal is allowed to idle on standby. Spring pressure on the aft seal ring ensures that the seal carbon and stellite faces remain in contact. System pressures, flow rates, and temperatures of the drain water from the seal assembly are monitored during operation and are adjusted as necessary to maintain them within prescribed limits. The flow through the primary shaft seals and stern tube must be maintained at the flow rates specified in the associated NAVSEA shaft seal technical manuals to ensure flow in the outboard direction, cool and flush the seals, and cool and lubricate the stern tube bearing. When the forward primary seal is in operation, forward seal water supply pressure should never be more than 5 psi above the aft seal water supply pressure. A higher differential pressure will reverse the flow across the aft seal, which can cause contaminants to lodge between the seal mating surfaces and cause possible damage. The drain line control valve is adjusted for a system drain water temperature of 100°F. For all operating conditions the drain water temperature, as indicated on the thermometer for the forward and aft seal drain line, should not exceed 10°F above seawater temperature. Adjust the drain valve downstream of the thermometer to regulate drain water temperature. The shaft sealing water (SSW) booster pump will run continuously to maintain the flushing flow rate whenever the auxiliary seawater (ASW) system pumps are not operating or if the distilling plant is operating with the submarine on the surface and only one ASW pump is on fast speed. Failure of the forward seal will cause the cooling water to flow past the seal face, along the shaft, and out the forward end of the seal assembly. This will reduce the pressure at the inner side of the aft seal. Sea pressure on the outer side of the aft seal will force the carbon insert against the stellite or silicon carbide face in the aft mating ring, automatically shifting operation to the aft seal. Realignment of the forward seal housing drain, supply, and vent valve is required when this occurs or when necessary to transfer operation to the aft seal. Pressure can be shifted from one seal to the other by positioning valves in the SSW system that supplies water, slightly above sea pressure, to the seal cavities through connections in the seal housings. Detailed procedures describing transfer of seal operation are contained in associated NAVSEA shaft seal assembly technical manuals.

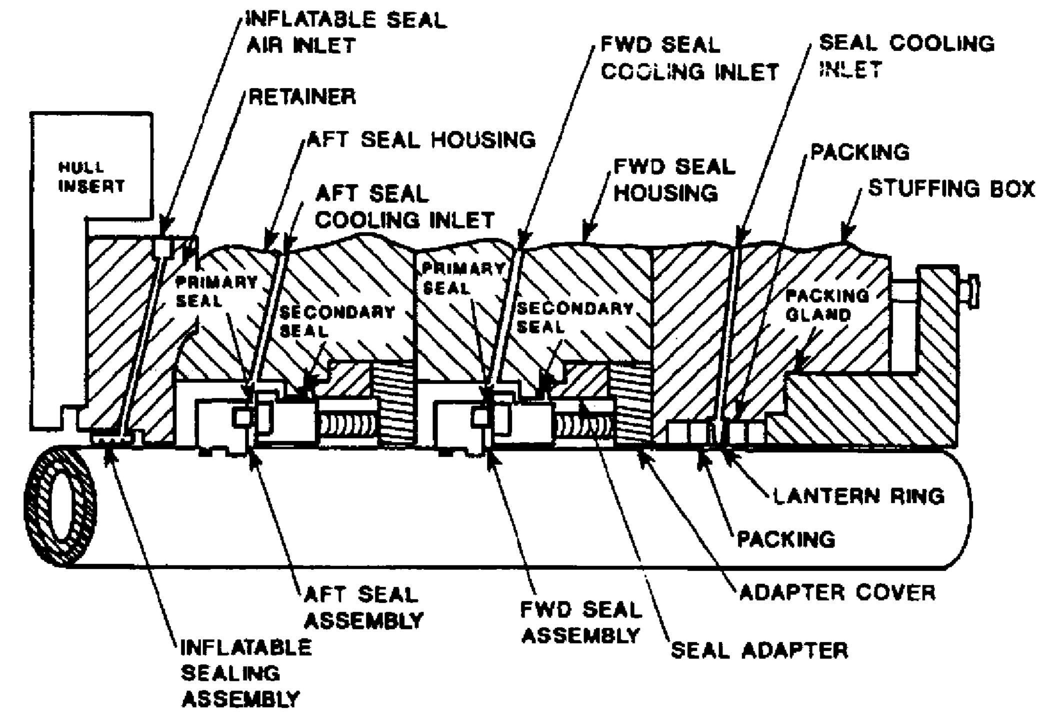


Figure 244-6-1 Typical Detail of Submarine Stern Tube Seal Assembly

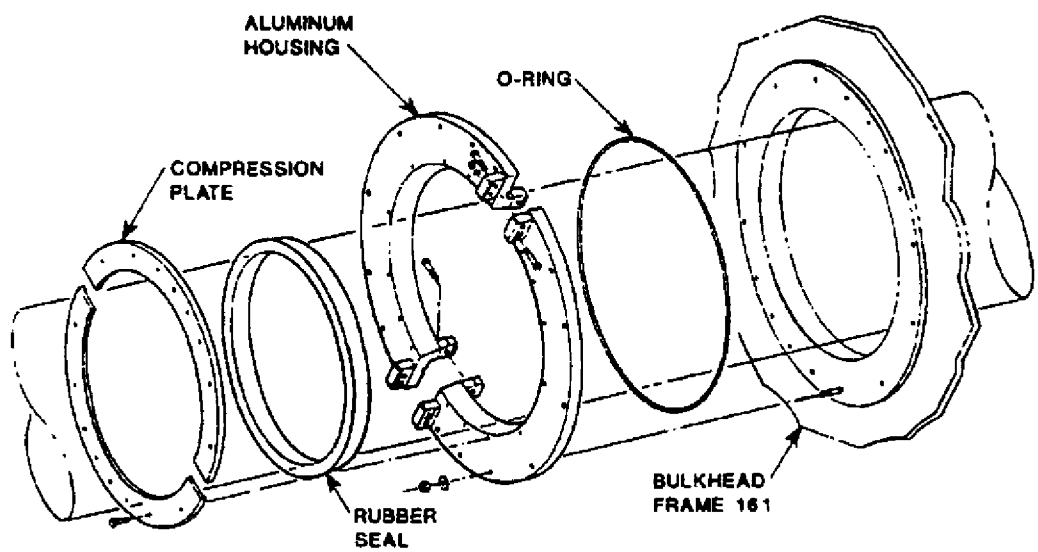


Figure 244-6-2 SSBN 726 Class Closure Device

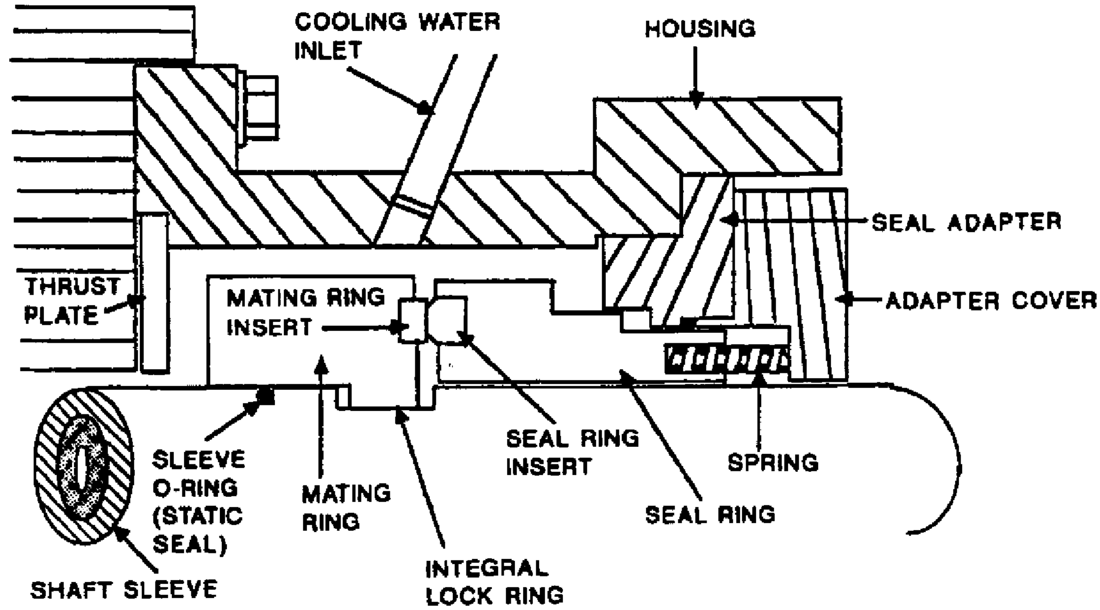


Figure 244-6-3 Typical SSN 688 Class Primary Shaft Seal Assembly

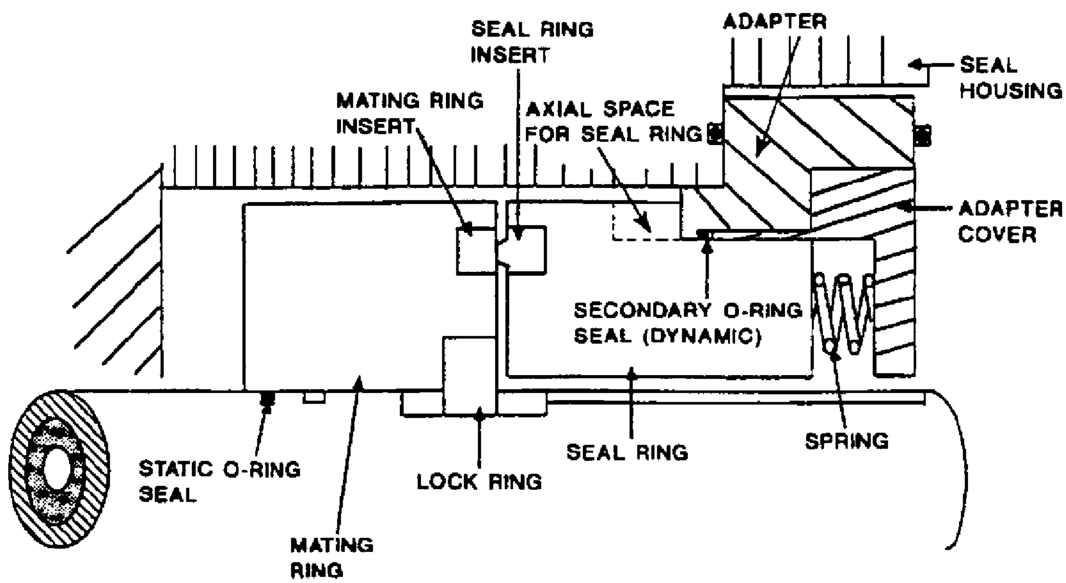


Figure 244-6-4 Typical SSBN 726 Class Primary Shaft Seal Assembly

Table 244-6-1 SUBMARINE MAIN SHAFT SEAL LEAK AND FLOW RATES

<table>
<tr><th>Seal Component</th><th colspan="2">Leakage Rates (Maximum)</th><th colspan="2">Flow Rates</th></tr>
<tr><td>Inflatable Seal (not applicable to SSN 774, SSBN 726 class)</td><td colspan="2">Air
50 psi pressure drop below 125 psi in 30 minutes
New Seal: 5 psi pressure drop below 125 psi in 15 minutes
Water
1/2 gallon per minute (gpm)
New Seal: 1 pint per minute</td><td colspan="2">------</td></tr>
<tr><td>Primary Mechanical Face Type Seals</td><td colspan="2">5 gpm (8 gpm for SSBN 726. SSN 774, SSN 21 class)
1 gpm (new seal operating)
2 gpm (new seal operating - SSN 21 and SSN 774 Classes)
1 pint per minute (new seal static - SSN 688/SSN 21/SSN 774/SSBN 726 classes)
2 quarts per minute (new seal static - pre-SSN 688 classes)</td><td colspan="2">18 gpm minimum (SSBN 726,SSN 21class)
7 gpm minimum for all other classes (see Note 1)</td></tr>
<tr><td>Emergency Stuffing Box Seal</td><td colspan="2">1 to 1-1/2 gpm
1/2 to 1 gpm (SSBN 726 class)</td><td colspan="2">Adjust cooling water supply as required for drain water, lukewarm to touch (See Note 2)</td></tr>
<tr><td>External Closure Device (SSBN 726, SSN 774, SSN 21class)</td><td colspan="2">1 gpm</td><td colspan="2">------</td></tr>
<tr><td colspan="5">Shaft Sealing Water System Flow Rates (Submarines Without Booster Pumps) (see Note 3)</td></tr>
<tr><td>ASW Pump Operating Condition</td><td>2 Pumps FAST</td><td>1 Pump FAST</td><td>2 Pumps SLOW</td><td>1 Pump SLOW</td></tr>
<tr><td>Seawater Flow Rate Through Venturi (gpm)</td><td>12</td><td>12</td><td>9.2</td><td>7.6</td></tr>
<tr><td>Seawater Flow Rate Through Stern Tube (gpm)</td><td>10</td><td>10</td><td>7.2</td><td>5.6</td></tr>
<tr><td colspan="5">Note 1: Minimum allowable flow to seals as indicated on flow gage is equal to the sum of 4 gpm through the stern tube bearing, plus measured drainage through the flow control valve, plus measured leakage into the waterguard for forward seal operation - about 7 gpm.
Note 2: Never completely stop flow through the packing gland. A 1/2- to 3/4-inch diameter stream at the water guard is adequate.
Note 3: For submarines with the booster pump installed, a flow rate through the venturi of at least 16 gpm is maintained by the differential pressure switch which automatically starts and stops the booster pump to compensate for changes in the operating mode of the ASW pumps. With neither ASW pump running at FAST speed, shaft seal booster pump operating is required to maintain a flow of 16 gpm through the venturi.</td></tr>
</table>

244-6.2.2.3 Maintenance. No intermediate or depot level maintenance can prevent seal deterioration. Maintenance consists of replacement when leakage exceeds 5 gpm (8 gpm for SSBN 726 class). In addition to replacing seals, repairs consist of inspecting and realigning the main propulsion shaft seal housing, if necessary, and inspecting the main propulsion shaft sleeve, lockring, and O-ring grooves. Inspection procedures are covered in associated NAVSEA technical manuals, Unrestricted Operation (URO) Planned Maintenance System (PMS) Maintenance Requirement Card (MRC) 028, applicable Submarine Maintenance Engineering Planning and Procurement (SUBMEPP) Technical Repair Standards (TRS), and Maintenance Requirement Procedure (MRP) cards. Seal rings and mating rings shall be repaired at the manufacturer’s plant. Monel adapters and adapter covers cannot be repaired and are listed as replacement items. Inspect Inconel adapters and adapter covers; replace them only if they fail to meet inspection criteria. Replace the seals when they are not performing satisfactorily or replace the springs, screws, studs, or nuts that are damaged during installation or removal. Repairs to other system components are covered under the associated TRS for the main shaft seal assembly.

244-6.2.2.4 Shipboard Maintenance. The following organizational level maintenance shall be performed on the main shaft seal assembly:

1. Measure the primary shaft seal leakage rate weekly. Leakage should be on the order of 1 to 5 gpm (1 to 8 gpm for SSBN 726 class), depending on the amount of seal wear. If leakage suddenly increases, the sealing faces may have separated. At the first opportunity, while operating at or near the surface, try to reseat the seal by reversing the shaft during full astern mode. If this maneuver fails to reduce leakage to acceptable limits, transfer operation to the aft seal. Schedule replacement of the forward seal at the next in-port opportunity.
2. When the system is operating normally, clean the seawater strainers in the SSW system every 4 hours by blowing them down through the drain valves. Increase blowdown frequency to every 1/2 hour if the ship is operating in contaminated or shallow water with the shaft seals aligned to the ASW system. If the system water flow rate cannot be maintained by periodically blowing down the strainers, backflushing may be necessary.
3. Regularly log the readiness of the aft seal by transferring operation to it at least once a month for a running time of at least 1 hour. Measure and log the leakage rate. If the leakage rate exceeds 5 gpm (8 gpm for SSBN 726 class) and cannot be reduced by backing down the submarine, schedule the forward and aft seals for replacement at the next drydock availability. No preventive organizational maintenance procedures can be performed other than the standard operating procedures given on mounted operating instruction plates.

244-6.2.2.5 Repair Parts. No major shaft seal assembly components listed in the Coordinated Ships Allowance List (COSAL) or the Allowance Parts List (APL) are carried on board since the only corrective action for seal failure is changeout of the seals. Parts such as spare O-rings and emergency seal packing rings are carried on board. Parts lists for seal changeout are contained in the associated NAVSEA shaft seal assembly technical manuals. These listings give the part number, description, and quantity needed. Some manuals also give the manufacturer's Federal Supply Code (FSC) number, Military Standard (MIL STD) or Military Specification (MIL SPEC) cross reference, if applicable, and parts lists for the vulcanizing and Loctite kits used to splice O-rings for installation in stern tube seals.

244-6.2.2.6 Seal Overhaul. During overhaul of the primary seals, the overhauling activity is responsible for refurbishing the seals so that they satisfy the requirements of the appropriate section of the TRS as called out in customers' work authorizing documents, such as overhaul and selected restricted availability (SRA) work packages. Where the original design requirements, such as surface finishes and tolerances, conflict with TRS requirements, the TRS shall take precedence. The TRS contains general and detailed part acceptance criteria, a planned overhaul material list identifying those parts that must be replaced regardless of condition, and a contingency material list identifying those parts that, on the basis of engineering analyses, may require some replacement. Performance requirements such as housing alignment criteria, pressures, and leakage rates for the overhauled seals are also provided.

244-6.2.2.7 Inspection. When the main seals are replaced, inspect the housings, adapters, adapter covers, and shaft sleeve. Keys and keyways, O-ring grooves and mating sealing surface, threads, and self-locking fasteners shall meet the requirements of General Acceptance Criteria, TRS 7650-086-001. Detailed acceptance criteria for wall thickness reduction, allowable surface defects in sealing areas, and allowable surface defects in nonsealing areas are described and shown in URO MRC 028.

244-6.2.2.8 Troubleshooting. Troubleshooting procedures for the main face-type shaft seals are limited to visual evidence of excessive leakage at the seal vents, the waterguard drain, or both; unusual noise or vibration from the shaft seal assemblies; and excessive heat (above 100°F) at the seal assemblies. Operating instructions provide alternative procedures to be used when a shaft seal fails to function properly. Table 244-6-2 lists the most common malfunctions of shaft seals, their causes, and corrective action.

244-6.2.3 INSTALLATION OF O-RINGS IN STERN TUBE SEALS. Maintenance of submarine stern tube seals requires periodic replacement of Buna-N O-rings. Renew the secondary seal O-ring and the mating ring O-ring at every seal changeout. Others may be reused if they are in good condition. Some submarine classes have a repair set of O-rings installed around the shaft. The practice of storing a spare set of O-rings on the shaft is being phased out. These O-rings may become stretched and misshapen. If they do, they will not fit properly and should not be used. If this is the case, if the repair set has been used, or if the shaft is coupled, install cut O-rings to avoid excessive effort or unacceptable ship delay. Using a cut O-ring requires splicing, but a properly spliced O-ring will perform satisfactorily. The two methods of splicing are:

a. Vulcanizing. This method results in a stronger O-ring and may be used to splice any of the stern tube seal O-rings. This method must be used to splice the dynamic (secondary seal) O-rings because the vulcanized joint results in a more flexible bond.

b. Adhesive Bonding. Adhesive bonding may be used only to splice O-rings in static applications.

244-6.2.3.1 Splicing by Vulcanizing. To splice an O-ring by vulcanizing with Sealol, Inc., Kit A25291, proceed as follows:

CAUTION

Do not heat above 148.8°C (300°F).

1. Connect vulcanizer to a 115-Vac source. Preheat it to 132.2° to 148.8°C (270° to 300°F). Adjust the thermostat as necessary.

2. Place an O-ring in the bottom of the groove in the skiver block, with the O-ring resting on the same surface of the block. Use a clean razor blade (cleaned with soap and water to remove any preservative oil from the blade), and cut the ring at a 45° angle.

3. Buff the cut end faces by rubbing them on abrasive cloth (80 to 100 grit) laid on a flat surface. Buff only enough to slightly roughen the cut faces.

4. Apply one drop of C-35-1 cement to the buffed faces. Slide the faces together gently to flatten them but not squeeze out the drops of cement. Separate the faces and allow the air to cure for 5 minutes.

5. Apply a second drop of cement to the buffed faces and repeat step 4, but air cure for 30 minutes.

6. Place the O-ring around the shaft and press the cemented faces together in the original position. Make sure that the rubber is not twisted. Align the stripes or mold marks.

7. Separate the two halves of the vulcanizer by removing the screw from each corner. Center the splices in the

groove in the bottom half, and assemble the vulcanizer by replacing and tightening the screws. If there is any tension in the O-ring, use a wing clamp on the vulcanizer to restrain and position the O-ring.

8. Vulcanize according to the time-temperature listed in Table 244-6-3.

9. After the time indicated, remove the O-ring from the vulcanizer and allow it to cool. When it is cool, test the O-ring as follows:
   a. Center the splice over the width of the skiver block.
   b. Grasp the O-ring at the edges of the block, and stretch it until it and the block are equal in length. The splice should show no defects when stretched for 15 seconds. If the results are unsatisfactory, repeat the process with a new O-ring.
   c. Brush the O-ring lightly with emery cloth to remove any adhesive residue or flashing from the surface at the vulcanized point.

Table 244-6-2 SHAFT SEAL TROUBLESHOOTING

Operating Mode	Malfunction	Cause	Corrective Action
Forward main seal in service, aft seal idle	Leakage at waterguard drain exceeds 5 gpm (8 gpm for SSBN 726 class) or a sudden increase in leakage	Failure of forward main seal	Transfer to aft seal; replace both main seals at first opportunity.
		Failure of O-ring in seal ring shoulder-adapter interface	Replace defective O-ring.
		Failure of O-ring at mating ring-shaft interface	Replace defective O-ring. Install O-ring in forward groove if aft groove is excessively pitted (SSBN 726 class only).
		Seal parts not sealed or binding because of contaminant buildup (seal ring hangup)	Operate main propulsion shaft in ahead and astern direction to seat seals.
Forward seal failed; operation transferred to aft seal	Leakage at forward seal vent and waterguard drain exceeds 5 gpm (8 gpm for SSBN 726 class)	Seal parts not sealed or binding because of contaminant buildup (seal ring hangup)	Operate main propulsion shaft in ahead and astern directions to seat seals.
		Excessive erosion (wear) of seal face	Transfer to emergency seal; replace both main seals at first opportunity.
Forward main seal in operation; aft seal idle	Unusual chatter from seal housing	Excessive water pressure differential (over 5 psid) between seals	Make sure that all valves in cooling water system are properly positioned and reduce cooling water flow to seals.
Either main seal in operation	Cooling water at seal drains exceeds 100°F or 10°F above seawater temperature	Insufficient cooling water flow	Make sure that all valves in cooling water system are properly positioned. Check that forward drain is fully open. Increase cooling water flow to prescribed flow rates.

Table 244-6-2 SHAFT SEAL TROUBLESHOOTING - Continued

Operating Mode	Malfunction	Cause	Corrective Action
Both main seals failed; emergency packing seal in operation	Excessive leakage at waterguard drain	Packing not sufficiently compressed or unevenly compressed	**CAUTION** Carefully tighten nuts in several steps. Tightening nuts in one step may stop cooling flow completely and cause packing to seize or overheat. Make sure that gland is not locked and tighten packing gland nuts. Adjust hydraulic pressure to compactor pistons (SSN 671 and SSBN 726 class).
		Emergency seal packing deformed or excessively worn	Stop and lock shaft. Activate inflatable seal. Replace packing. Operate with secondary propulsion motors (SSBN 726 class only).
	Insufficient leakage at waterguard drain	Packing gland nut set up too tightly	Open packing gland cooling water supply and drain valves to ensure flushing action through lantern ring. Loosen gland nuts to lessen compression of packing rings.
	Overheating or steaming of entire packing gland	Insufficient leakage of cooling water or extrusion of packing between the shaft sleeve and packing gland	Loosen gland nuts. Open cooling water supply valve to lantern ring. If adjustment of cooling water flow or gland nuts does not stop steaming, REDUCE SHAFT SPEED TO 50 RPM.
Inflatable seal activated (not applicable to SSBN 726 class)	Required air pressure on the seal cannot be maintained or excessive leakage past the seal occurs.	Air supply problems.	Check air system is energized. Check calibration of air pressure gage using a test gage or dead weight tester. Check all pressurized piping and valve joints for leaks using soap solutions (see para. 244-6.2.5.6).

Table 244-6-2 SHAFT SEAL TROUBLESHOOTING - Continued

Operating Mode	Malfunction	Cause	Corrective Action
	Leakage at main seal vents or waterguard drains	Seal faulty because of deterioration or defective O-rings.	Schedule inspection of O-rings, inflatable seal, and housings at next primary seal replacement. **NOTE** Do not remove satisfactorily operating primary seals solely to inspect or replace the inflatable seal.
		Seal faulty because of shaft operation with seal inflated.	

Table 244-6-3 VULCANIZING TIME-TEMPERATURES

Time (minutes)	Temperature °C (°F)
75	132.2 (270)
63	135 (275)
50	137.8 (280)
42	140.6 (285)
34	143.3 (290)
30	148.8 (300)

244-6.2.3.2 Splicing by Adhesive Bonding. To splice an O-ring using adhesive bonding with Loctite Corp., Kit Cat. No. 0112, proceed as follows:

1. Equipment and Material
   a. Buna-N O-ring selected to comply with applicable drawings

WARNING

Clean-up Solvent contains dimethyl formamide and is considered toxic. This solvent is provided with the kit for cleanup and is not essential to the splicing procedure. Do not carry Clean-up Solvent on board submarines. If used in the repair yard, however, apply Clean-up Solvent sparingly and limit it to areas having exhaust ventilation (i.e., under an exhaust hood). Wear eye protection and rubber gloves. In case of skin contact, wash with soap and water. In case of eye contact, flush with water and get medical attention immediately.

   b. Splicing kit consisting of:
      (1) Single-edge razor blade

(2) Cutting and splicing fixture

(3) Clean-up Solvent

(4) Adhesive, Quick-Set 404 or equivalent

(5) Loctite Waterproofing Solution

c. Plastic or brass scraping tool

2. Clean the razor blade with soap and water before each cut to remove any trace of preservative oil from the blade. Most razor blades are coated with silicone oil to prevent corrosion. The oil interferes with the bonding of the spliced joint.

CAUTION

Always make sure that the O-ring being used has the correct cross section for the groove in which it is to fit. Always use a sharp razor blade, since excess pressure during cutting will distort the rubber. Do not touch the cut ends. Prevent contamination by dirt and oil during handling.

Make a single cut in the O-ring, preferably with one slicing motion to avoid jagged edges. With the O-ring lying on a clean, flat surface, cut it vertically, approximately on the radius, to form an ″O″ section (Figure 244-6-5).

WARNING

Cyanoacrylate adhesives are eye irritants. Wear eye protection. In case of contact with eyes, flush with water only and get medical attention immediately. Cyanoacrylate adhesives bond strongly and quickly on contact. In case of skin bonding, carefully peel or cut apart contacted areas. Do not pull apart; the adhesive is stronger than skin and will tear the skin off. The bond can be softened by soaking in nail polish remover or acetone.

Apply a small drop of adhesive to one end of the cut O-ring. If an excess is applied, strike the O-ring on a hard surface to shake it off. Immediately join the ends of the rubber. Position the loose ends in splicing fixture alignment guide. Make sure that the rubber is not twisted. Align the stripes or mold marks. Slide the ends along the guide until they contact each other. Hold them in contact with firm pressure for 10 to 30 seconds.

NOTE

O-ring ends cannot be properly aligned and bonded when the O-ring is in the O-ring groove or when it is stretched. Make the bond around the shaft where the diameter of the shaft is smaller than the inside diameter of the O-ring.

After a 30-second cure, remove the adhesive residue from the surface of the O-ring by wiping it with a clean, dry rag or by scraping it with a smooth plastic or brass tool. Be careful not to cut or scuff the O-ring surfaces.

CAUTION

Do not use Clean-up Solvent to clean the O-ring. Allow the adhesive to cure for at least 1 hour at room temperature before flexing or stretching.

3. After allowing the adhesive to cure for 1 hour, flex the bonded joint and examine it for lack of bond. Do not proceed further with any spliced O-ring that shows lack of bond. Repeat the process with a new O-ring.

4. Brush a coating of Loctite Waterproofing Solution over the bond line. Since the solution is very thin, it will spread quickly. Take care to apply just enough solution to cover the bond line around the O-ring. Do not stir the solution: this could cause air bubbles to form in the coating, and air in the coating will make it porous. Allow the coating to cure for 10 minutes. If it is still tacky, the usual coating of silicone grease that is applied when installing all O-rings will ensure satisfactory installation.

5. Make sure that the spliced O-ring fits the O-ring groove properly. Spliced O-rings that leak on repressurization after installation are considered unsatisfactory: replace them promptly.

6. When the O-ring splice has been completed, remove excess adhesive from the cutting and splicing fixture by gently scraping and wiping it.

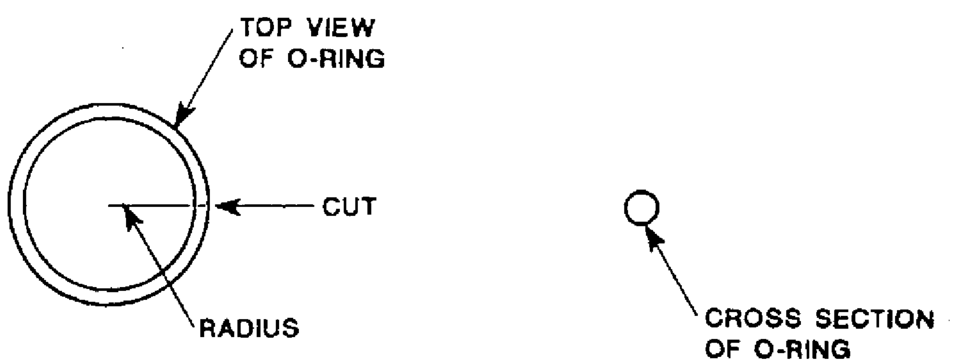


Figure 244-6-5 O-Ring Cut

244-6.2.4 EMERGENCY STUFFING BOX SEAL

244-6.2.4.1 Description. The emergency stuffing box seal (Figure 244-6-6), also referred to as the automatic compactor seal or emergency packing gland, is mounted forward of the two primary shaft seals and is contained in a stuffing box. This seal consists of four braided asbestos packing rings impregnated with TeflonTM and separated into two groups of two by a lantern ring that distributes seawater uniformly around the shaft. All four rings are used when the seal is actuated. Leakage from the shaft seal internals provides lubricating and cooling water to the emergency shaft seal when it is in use. Additional cooling water can be supplied to the seal through the lantern ring from the SSW system. In addition, on SSN 671 and SSN 688 class submarines, a two-stage compactor piston assembly (Figure 244-6-7) automatically compresses the packing in the event of excess seal leakage. It can also operate manually to compress the packing hydraulically. Hydraulic fluid under pressure for manual operation of the compactor is supplied from the main shaft seal hydraulic system.

244-6.2.4.2 Packing Rings. The stuffing box housing contains four emergency packing rings, two on each side of the lantern ring that channels cooling water to the packing. Usually, the retaining pins hold the packing rings slightly clear of the shaft. To activate the emergency seal, compress the packing rings against the shaft.

244-6.2.4.3 Compactor Position Indicator. Two indicator rods penetrate the forward end of the stuffing box and extend aft to make contact with the forward face of the second-stage compactor piston. Initial movement of the compactor assembly pushes the indicator rods forward and actuates the limit switch that energizes an alarm bell and indicator light on the propulsion plant monitoring and alarm panel in the maneuvering area. The local indicator registers the position of the second-stage compactor at all times.

244-6.2.4.4 Operation. The emergency stuffing box seal is operated automatically or manually. Both operational modes are described below:

CAUTION

Do not attempt to stop cooling flow through the packing gland. Excessive pressure will result in extrusion of the packing between the shaft and the packing gland. Insufficient cooling water will result in the formation of steam and can cause packing to seize or overheat.

1. **Automatic Operation.** The compactor assembly is designed to activate automatically and set the packing to provide adequate sealing if the primary seals fail rapidly. The compactor activates automatically when seawater pressure builds up on the first-stage piston aft face. This pressure loading forces the aft compactor assembly forward to compact the stuffing box packing rings and provides initial sealing. After the stuffing box has automatically assumed the sealing load, additional adjustment of the packing may be needed to obtain the leakage required for adequate cooling. Apply hydraulic pressure to the compactor pistons to further compress the packing with the second-stage piston. About 1- to 1-1/2 gpm leakage will permit the packing to run cool.

2. **Manual operation.** On submarines with no automatic compactor assembly, or if the assembly is inoperative or is unable to control seawater leakage satisfactorily, compress the packing by knocking out the split wooden spacers near the packing gland studs and tightening the gland nuts evenly until the desired leakage is obtained. Compress the packing gland nuts carefully, and maintain a small amount of leakage past the packing to provide lubrication and remove the heat generated by the friction between the packing and the shaft sleeve. This will also ensure that the packing will not bear hard against the shaft sleeve and cause scoring. Monitor and adjust the leakage rate to compensate for variation in submerged pressure. Water flowing from the stuffing box drain line should be lukewarm and read no higher than 100°F or 10°F higher than seawater temperature. A 1/2- to 3/4-inch stream at the water guard is adequate for cooling purposes.

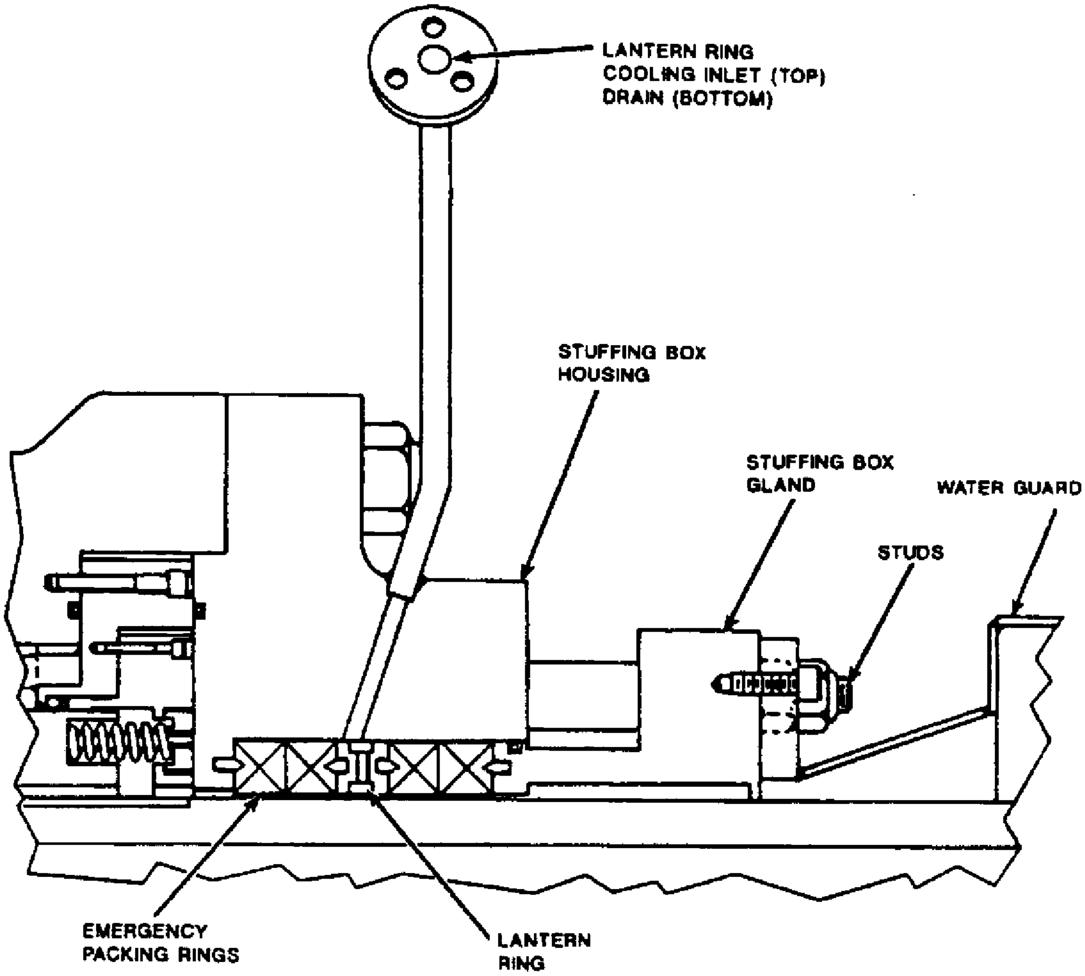


Figure 244-6-6 Emergency Stuffing Box Seal

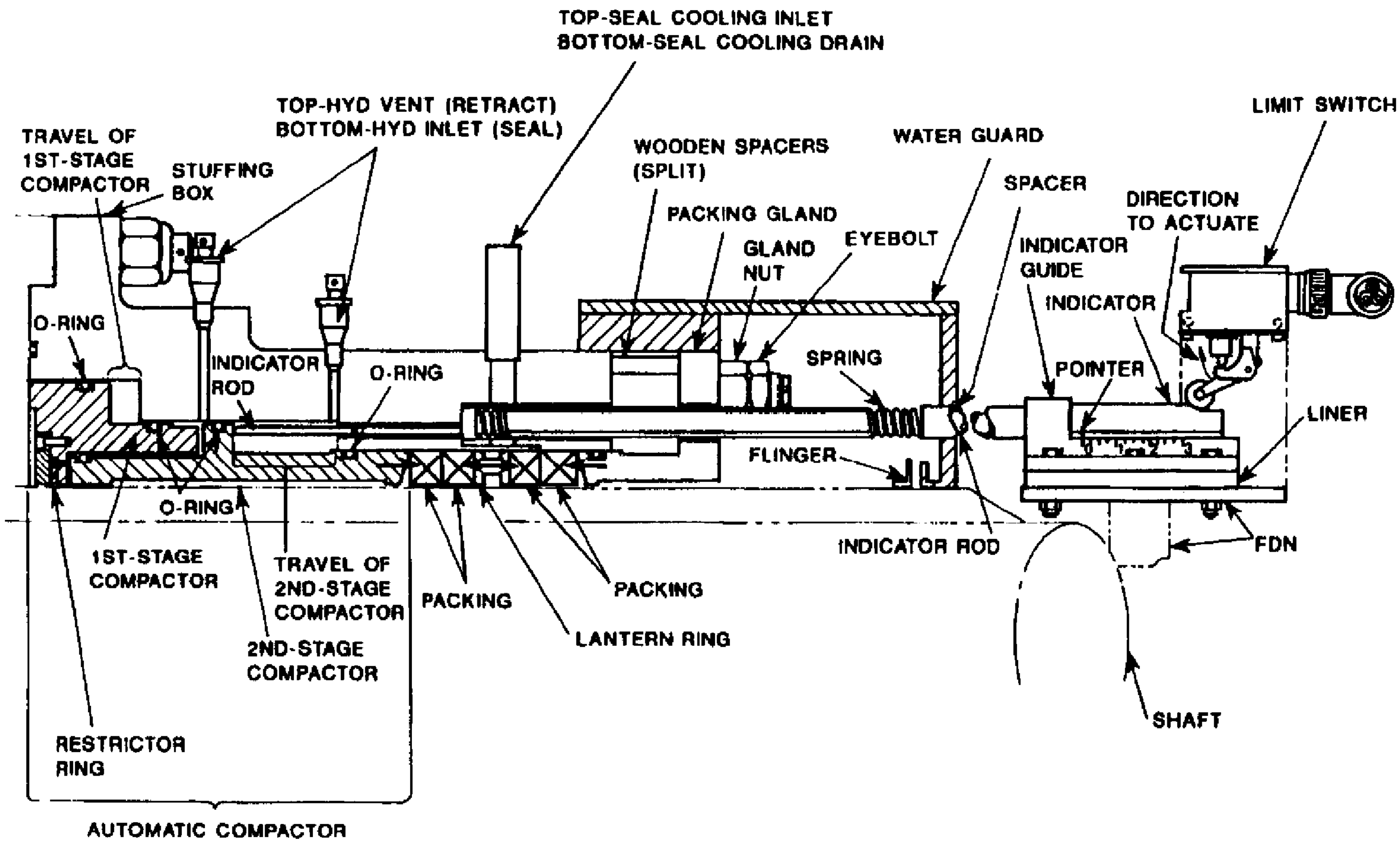


Figure 244-6-7 Emergency Stuffing Box Seal with Automatic Compactor Assembly

244-6.2.4.5 Maintenance. For those submarines with the automatic compactor assembly, the compactor stages of the emergency stuffing box assembly require periodic recycling to ensure freedom of movement and operational readiness. Do this procedure annually and in accordance with the associated NAVSEA stern tube assembly technical manuals or PMS MRC.

244-6.2.4.6 Shipboard Maintenance. There are no preventive organizational maintenance procedures other than the standard operating procedures given on the mounted operating instruction plates. Corrective maintenance procedures are necessary when, during normal operation of the main seals, the emergency seal packing rings fall off the retainer pins and become worn by friction against the rotating shaft. If this occurs, ship's force can disassemble, inspect, and reassemble the emergency seal. Detailed procedures are found in the associated NAVSEA shaft seal technical manual.

244-6.2.4.7 Seal Overhaul. The stuffing box, packing gland, and first- and second-stage compactors are inspected for corrosion and pitting in accordance with URO MRC 028. These components are included in the contingency material list of the main shaft seal assembly TRS and may be replaced during overhaul as engineering analysis dictates. The lantern ring, spacers, indicator rods, and packing gland studs are also included in the contingency material list of the TRS.

244-6.2.4.8 Inspection. No regular inspection is necessary for the emergency stuffing box seal. If water leaks excessively (see Table 244-6-1) when the emergency seal is operating, replace the gland packing. The detailed procedure and timing for replacing the gland are in the associated NAVSEA shaft seal assembly technical manual.

244-6.2.4.9 Troubleshooting. Troubleshooting procedures involve malfunctions caused by too much or too little leakage at the water guard drain or overheating of the packing gland. If the seal leaks, the packing is insufficiently compressed; tighten the packing gland nuts in several steps so as not to overtighten them and stop the cooling flow. Too little leakage indicates that the packing gland is set up too tightly and that the gland nuts need to be loosened. Overheating of the packing gland indicates insufficient leakage of cooling water. Open the packing gland cooling water supply and drain valves to ensure flushing action through the lantern ring. A leakage rate of 1 to 1-1/2 gpm is desirable (1/2 to 1 gpm for SSBN 726 class). Water flowing from the stuffing box drain line should be lukewarm, and the thermometer should read no higher than 100°F or 10°F higher than seawater temperature.

244-6.2.4.10 Stuffing Box Problems. When installing packing rings, be sure to maintain the 1/8-inch minimum clearance between the rings and the shaft sleeve. During normal operation with the primary seals, the emergency packing seal stuffing box should feel cool to the touch. If it is warmer than body temperature, open and regulate the appropriate cooling water valves to provide cool operation. If the packing continues to run hot, replace it as soon as possible. When replacing packing rings, look for causes of overheating such as packing that is cut too short, allowing the inside diameter to rub on the shaft, or a stuffing box misaligned to the shaft. Specific installation and removal procedures for different submarine classes are contained in the associated NAVSEA stern tube assembly and shaft seal assembly technical manuals.

244-6.2.5 INFLATABLE SEALS. The inflatable seal ring is mounted in its own housing, which is bolted to the aft section of the pressure hull. It is an elastomer boot that can be inflated with air pressure from the ship service air system to provide a temporary seal around the shaft when it becomes necessary to replace either face-type seal assembly while the submarine is waterborne. When replacing the aft seal while waterborne, use an approved cofferdam. The inflatable seal may be used with the cofferdam. Also use the inflatable seal ring in port to isolate the primary seals from contaminated harbor waters, but only when clean dockside flushing water is unavailable. The inflatable seal ring and associated service air system are not installed on SSBN 726 class submarines. A provision is made on SSBN 726 class submarines to install a closure device (Figure 244-6-2) at the after side of the stern tube in the free-flood area. The device consists of a two-piece aluminum housing, a split rubber seal, an O-ring, and assorted assembly hardware. It is used to perform hydrostatic testing of the main shaft seals or when waterborne maintenance or seal replacement is required. When the submarine is waterborne, the closure device seal must be installed and removed by a diver. The closure device is a shore-based item available only at dedicated refit facilities.

244-6.2.5.1 Description. The two primary inflatable seals are the Sealol bonded seal and the Crane high-pressure seal. A description of each inflatable seal type is provided below:

1. The Sealol inflatable seal (Figure 244-6-8), installed on most pre-SSN 688 class submarines, is a tongue-and-groove design manufactured in two halves: one end joint is bonded at the factory before shipment, and the other end joint is left separated for assembly around a coupled shaft. Procedures for bonding a Sealol inflatable seal ring with Chemlock 305 are found in associated NAVSEA shaft seal technical manuals. The inflatable seal ring is designed to function while the submarine is waterborne with shaft stopped and locked. Air supplied by the ship service air system inflates the seal ring. Figure 244-6-9 shows the Sealol inflatable seal released and inflated.
2. The Crane-type inflatable seal (Figure 244-6-10) consists of an inflatable elastomer sealing ring with an internal metallic support ring to prevent the elastomer ring from collapsing when it is subjected to submergence pressure. Both the elastomer sealing ring and the metallic ring are of split construction to allow installation without uncoupling the propeller shaft. The elastomer ring requires bonding at the split when it is installed around the shaft. Air supplied by the ship service air system inflates the seal ring.

244-6.2.5.2 Operation. When used to inspect, remove, or replace the forward main shaft seal at dockside, pressurize the inflatable seal to 125 psig (75-125 psig for SSN 688 class). Two criteria will determine the suitability of the inflatable seals:

a. Air leakage: New: 5-psi pressure drop below 125 psi in 15 minutes Max: 50-psi pressure drop below 125 psi in 30 minutes
b. Water leakage: New: 1 pint per minute Max: 1/2 gallon per minute If either maximum limit is exceeded, replace the inflatable seal at the earliest opportunity. If only maximum air leakage is exceeded, remove and replace the forward primary seal if pressure of 75 psi or greater can be maintained despite the leakage and if the aft primary seal is sealing satisfactorily. The pressure gage should have a range of 0 to 300 psi, and the relief valve should be set, depending on the type of inflatable seal installed. The charging air connection, if used, should have a detachable connection for disconnecting it from the inflatable ring valve stem, or housing connection, when not in use to avoid inadvertent pressurization when the shaft is operating. Hand or foot pumps shall not be used for pressurizing the inflatable seal rings, since the pressure obtained will be insufficient for sealing. Procedures for inflating and deflating the inflatable seal are as follows (refer to Figure 244-6-11):
c. Inflation Procedure.
    1. Position and lock the shaft so that the No. 1 coupling bolt is exactly top dead center. (This places the split-type seals in the correct horizontal position for disassembly.)
    2. Close and lock the system vent valve, and check to make sure that the supply globe valve and the two valves leading to the pressure gage are open.
    3. Check the setting of the relief valve - it should be set to relieve at 270 psi maximum for Sealol seals and at test depth pressure plus 100 psi for Crane seals.
    4. Unlock and slowly open the main supply needle valve that bleeds air from the ship air service system into the inflatable seal.
    5. Slowly inflate the seal to 125 psig, which is determined from the pressure gage.

NOTE

Never allow air inflation pressure to exceed the relief valve setting.

    6. Allow at least 15 minutes for the system to stabilize, adjusting the main supply needle valve, as required, to maintain the pressure at 125 psig.
    7. Shut the main supply needle valve once the pressure is stabilized.

8. Continually monitor the pressure gage when repairing the seal assembly while the submarine is waterborne. Do not allow air pressure to drop below 75 psig.

d. Deflation Procedure.

1. Secure and lock the main supply needle valve.
2. Slowly open the system vent valve and lock it open.
3. Check the pressure gage to make sure that the system pressure slowly drops to zero.
4. Leave the two globe valves to the pressure gage and the supply globe valve open.

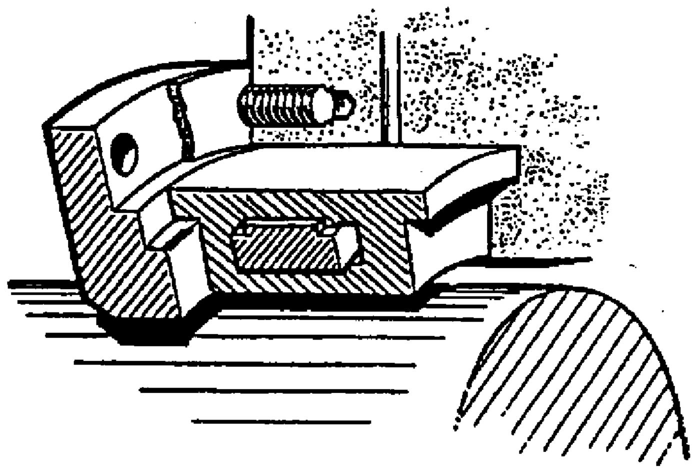


Figure 244-6-8 Sealol Inflatable Seal Assembly

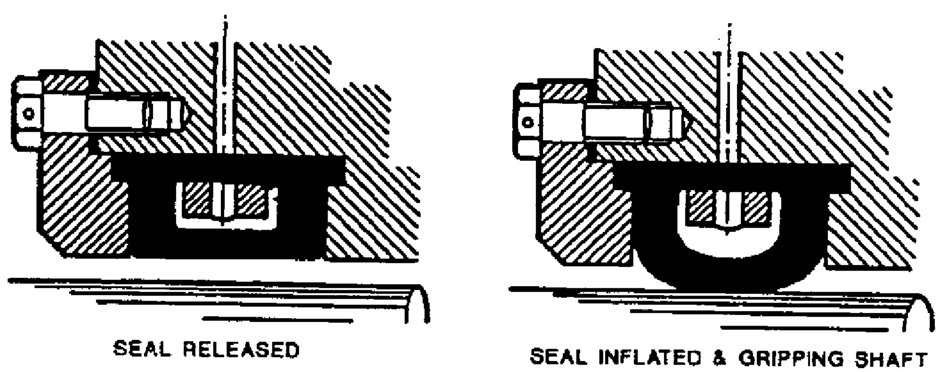


Figure 244-6-9 Sealol Inflatable Seal Released and Inflated

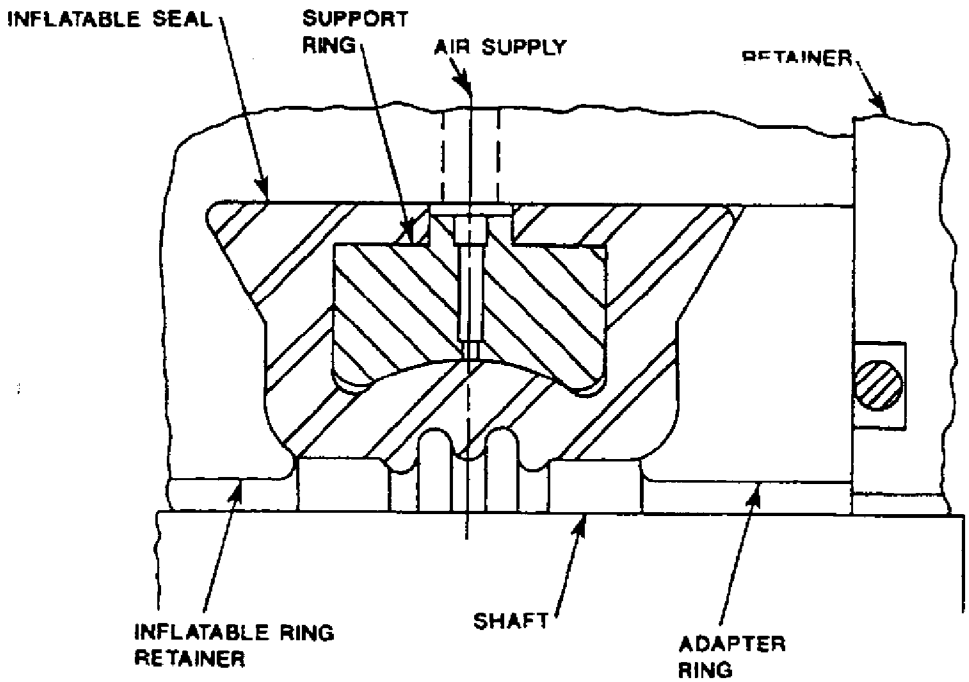


Figure 244-6-10 Crane Inflatable Seal Assembly

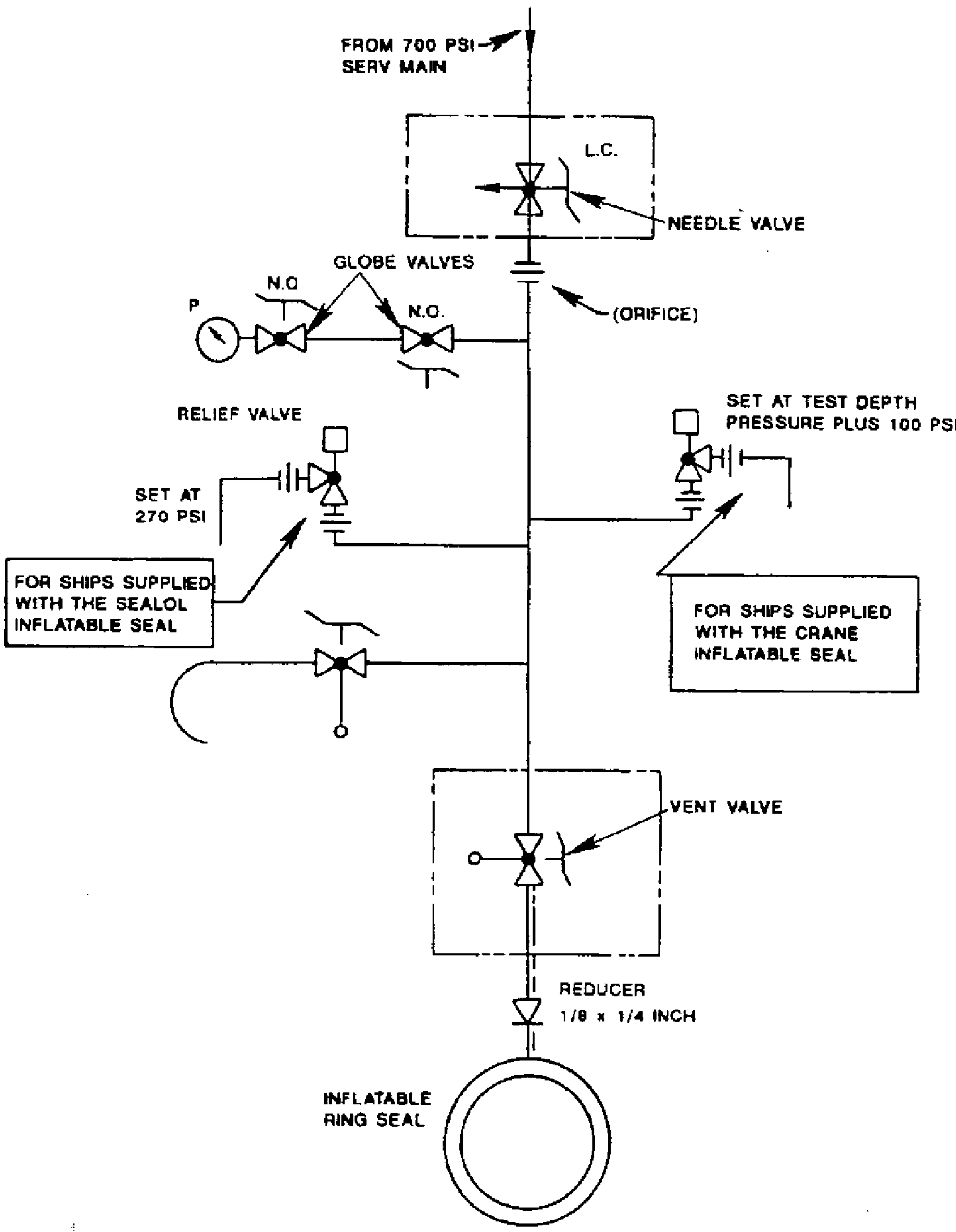


Figure 244-6-11 Inflatable Seal Air Service System

244-6.2.5.3 Maintenance. No maintenance can prevent deterioration of the inflatable seal. Maintenance actions are limited to replacement and routine pressure checks with the shaft stopped and locked. Replacement consists of inspecting and realigning the inflatable seal housings, if necessary, with the submarine dry-docked. All actions require securing the main propulsion shaft, locking the turning gear, and tagging them out. Determining the need for realignment requires taking measurements with the shaft loaded. Install the propeller or a dummy weight, make up the shaft coupling, and install the coupling cover. Procedures for replacing and aligning the inflatable seal housing are included in the shaft seal assembly technical manuals.

NOTE

Never disassemble an entire shaft seal assembly solely to replace a defective inflatable seal boot.

244-6.2.5.4 Seal Overhaul. The main shaft seal assembly TRS contains the planned overhaul material list and the contingency material list for overhaul of the inflatable seal assembly. The planned material list identifies those parts to replace regardless of condition, and the contingency material list identifies those parts to replace, depending on engineering analysis. Cracks or breaks visually detected in parts not listed in the detailed part acceptance criteria of the TRS are unacceptable. The overhaul activity is responsible for overhauling the inflatable seal assembly so that it satisfies the requirements of the TRS as specified by the customer work authorizing document. The overhauling activity is also responsible for using current National Stock Numbers when ordering material.

244-6.2.5.5 Inspection. The inflatable seal housing and retainer are inspected when the shipyard completes URO MRC 028. The MRC contains criteria for general corrosion, partial corrosion, and the random pitting allowed on selected inspection areas.

244-6.2.5.6 Troubleshooting. If the required operating pressure cannot be maintained on the inflatable seal, follow the procedure below before assuming that the seal has developed leaks (see Table 244-6-2):

1. Check that the service air system is energized.
2. Check the calibration of the air pressure gage using a test gage or a dead weight tester.
3. With vent and housing inlet valves closed, crack open the main air supply valve until the pressure gage reads 125 psig; then close the inlet valve. Observe if steady pressure is indicated on the gage. If the pressure is not holding, check all piping and valve joints in the pressurized system with soap solution for leaks. Check all around the valve stems. Check the integrity of the seats in the vent valve and the relief valve by looking for air leakage through the soap solution out the respective vent lines.
4. With air pressure open to the inflatable seal, check the piping joints at the vent valve and the air inlet connection to the housing flange with soap solution.
5. Repair any deficiencies observed in the above steps and repeat the inflation the procedure. If it is still impossible to maintain the required operating air pressure on the inflatable seal, schedule inspection of the O-rings, inflatable seal, and housings at the next complete primary seal replacement.

NOTE

Never remove satisfactorily operating primary seals solely to replace the inflatable seal. The submarine must be dry-docked to remove inflatable seals.

244-6.2.5.7 Testing. Test the inflatable seal every 6 months or as directed by the associated PMS MRC. To avoid rupturing the inflatable seal, pressure for inflating the seal ring shall not exceed 125 psi for surface conditions and shall not exceed 270 psig (Sealol seal) or test depth pressure plus 100 psig (Crane seal) for any submerged conditions. Ten minutes is adequate for the inflation test. The charging air connection for pressurizing these seals should have a needle valve, a pressure gage, and a relief valve. Incomplete sealing may occur under the above test conditions or if the inflatable seal is operated for repairing or replacing the primary seals. Restrict the flow of water past the inflatable seal, however, to 1/2 gallon per minute or less in order to permit repair or replacement of the seals. Install and operate the inflatable seal in accordance with the associated technical manual.

244-6.3 PIPING SYSTEMS

244-6.3.1 General. The two main piping systems associated with the shaft seals are the shaft seal water system and the inflatable seal air service system.

244-6.3.2 SHAFT SEAL WATER SERVICE. The shaft seals are operated, cooled, and lubricated by a supply of seawater from the shaft seal water (SSW) system. The seawater to the SSW system is supplied by the auxiliary seawater (ASW) system and associated SSW booster pump. When operating in contaminated waters, it is supplied by the trim system. Refer to associated ship system manuals and shaft seal technical manuals for instructions on operating a particular SSW system.

244-6.3.2.1 Description. The SSW system is similar in the different submarine classes; a typical mode of operation (SSN 688 class) is described below:

a. Water enters the shaft seal system through a separate ball valve, depending on whether the shaft seal booster pump is operating or if the ASW system is the selected supply. Water can also enter through another ball valve, a portable hose, flow control valve, and a normally locked-shut globe stop check valve when the trim system is the selected supply. Upon entering the shaft seal system, the seawater flows through a venturi-type flowmeter. The rate of flow is measured by a differential pressure gage and switch that sense the pressure drop across the venturi. The gage indicates the flow of seawater in gallons per minute, and the pressure switch controls the automatic starting and stopping of the shaft seal booster pump. Desired flow rate through the stern tube is based on worn seals and engineering calculations. Seawater flow through the venturi should be no less than the maximum combined flow through the stern tube, drain valve, and water guard.

b. The seawater flow rate to the shaft seal system is a function of the differential pressure to sea or head available from the ASW system, plus that of the shaft seal booster pump. The head available from the ASW system depends on the number and speed of ASW pumps in operation. The booster pump automatically operates if the head is insufficient to provide a minimum flow rate through the venturi. One of the ASW pumps must be operated in fast speed when the booster pump is inoperative.

c . When water is being supplied by the trim system, flow is maintained by adjusting the flow control valve from the trim tank. The forward and aft seals are protected by continuously flushing the stern tube bearing with uncontaminated water from the trim system.

d. Water flows through one of two 125-micron strainers to a header from which individual lines go to the shaft seals. Each strainer has isolation valves to permit isolation and cleaning of either strainer without disrupting system operation. Water flows to the aft seal through a locked-open globe valve and to the forward seal through a normally open globe valve. Each line has a supply pressure gage with two normally open valves. Water supply differential pressure to the aft and forward seals is shown on a separate gage. Never allow the water supply pressure to the forward seal to be greater than 5 psi above the aft seal water supply pressure when the forward seal is operating, otherwise, the direction of flow will be reversed across the aft sealing face. Any contamination that may have accumulated between the forward and aft seals could then be drawn into the aft sealing face, causing scoring of the seal face and ultimate seal failure.

244-6.3.2.2 Protection from Contaminants. The shaft seals must operate using a relatively clean supply of cooling water to prevent scoring of the seal components. When operating in shallow or contaminated water, the trim system supplies the flow of cooling water to the seals. This supply of clean water from the trim tanks usually lasts about 40 hours, enough time to travel to a clean seawater environment. Shaft seal water, whether supplied from the trim system or the auxiliary water system, is routed through filters or strainers before entering the seal housings, thus providing additional protection from contaminants. When in port, use a dockside water supply. If a clean water supply is unavailable, stop the shaft and use the inflatable seal.

244-6.3.3 INFLATABLE SEAL AIR SERVICE. The service air system supplies air to the inflatable seal ring from the 700-psi air main. The service air system is used to pressurize the inflatable seal ring to provide a temporary seal around the shaft when replacing either of the primary shaft seals while waterborne. It is also used to inflate the seal ring to test for system leaks at seal installation and to hydrostatically test the stern tube O-ring seals. A needle valve is used to regulate the inflation of the ring, and a relief valve set at test depth pressure plus 100 psi (if a Crane inflatable seal is installed) or at 270 psi (if a bonded-type Sealol seal is installed) prevents overpressurization of the seal. System piping is designed for a flow of no more than 150 standard cubic feet per minute (scfm) of air. The service air system from the 700-psi air main is absent from the SSBN 726 class, since no inflatable seal is installed.

244-6.3.3.1 Controls and Indicators. The seal air service system contains a main supply (needle) valve that bleeds air from the ship service air system into the inflatable seal. Two gage valves supply air to the pressure gage, and a vent valve vents the system when it is not in use. A relief valve prevents overpressurization of the seal.

244-6.4 PIPING SCHEMATICS

244-6.4.1 A schematic of a typical inflatable seal air service system is provided in Figure 244-6-11. A schematic of a typical shaft seal water system is provided in Figure 244-6-12.

244-6.5 SURFACE SHIP STERN TUBE SHAFT SEALS

244-6.5.1 GENERAL. The surface ship stern tube shaft seal assembly provides the hull closure where the main propulsion shaft penetrates the pressure hull, preventing and controlling the entry of seawater at that point. The maximum allowable leakage rates for surface ship shaft seals are shown in Table 244-6-4. Various designs are used on surface ship classes, but the designs are for two seal types: mechanical-type and rubber-lip-type face seals.

244-6.5.1.1 Mechanical-Type Face Seals. This seal consists of a single seal assembly in which a nonmetallic ring wears against a bronze ring. Under emergency conditions the seals can be converted into conventional packing-type stuffing boxes. Principal manufacturers are John Crane-Lips and EG&G Sealol. The EG&G Sealol mechanical seal is used on some older ship classes . The majority of all surface ships are outfitted with the John Crane seal.

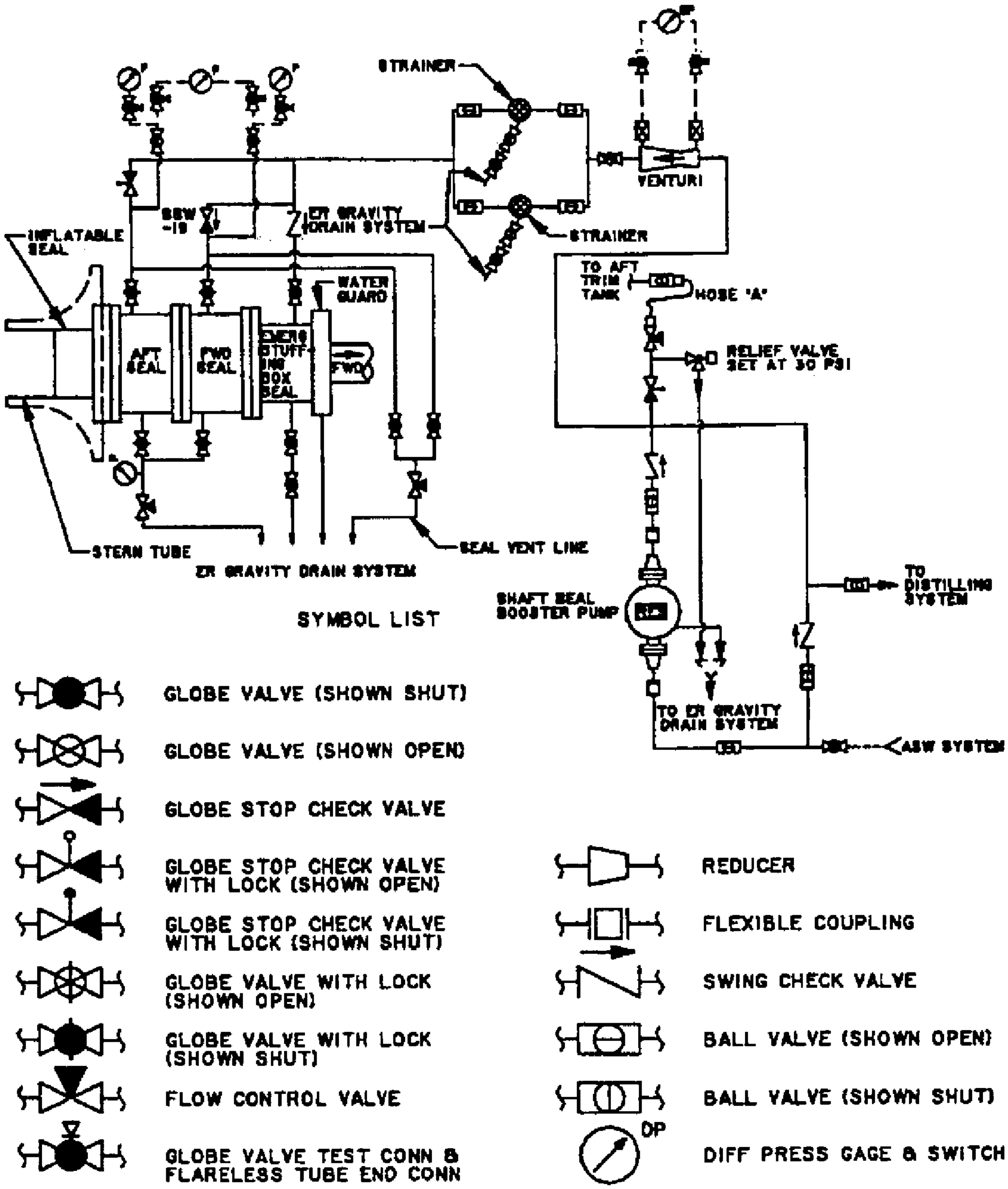


Figure 244-6-12 Shaft Seal Water Service System

244-6.5.1.2 Rubber-Lip-Type Face Seals. This seal assembly consists of two identical tandem rubber seals held in contact with the shaft by encircling garter springs. The forward seal is the primary sealing element. It contacts a gland ring. The aft seal serves as a spacer ring to ensure proper alignment of the forward seal. It can be used as a replacement when repair is required. The principal manufacturer is FMC Corporation.

244-6.5.2 CRANE MECHANICAL FACE SEALS

244-6.5.2.1 Description. The Crane MX9 stern tube shaft seal (Figure 244-6-13) is a fully split, water-lubricated seal located on the inboard side of the stern tube. It is a balanced, mechanical, end-face seal that uses axial spring and hydraulic forces to control the face contact pressure. Primary sealing occurs in a plane perpendicular to the shaft centerline and is accomplished by the continuous contact of the stationary seal components with the rotating seal components. The type MX9 stern tube shaft seal incorporates an emergency packing gland for operation as a conventional stuffing box should the seal be damaged. An inflatable seal is also provided to allow for waterborne inspection, adjustment, or repair of the stern tube seal.

Table 244-6-4 SURFACE SHIP SHAFT SEAL LEAKAGE RATES

Seal Type	Condition	Leakage Rates
Mechanical-Type Face Seal	Maximum static leakage, (at installation, after alignment)	1 pint per minute
		1.5 pints per minute (CV/CVN only)
	Maximum static leakage (at 300-hour break-in period)	1 quart per hour
		1 gallon per hour (CV/CVN only)
	Maximum dynamic leakage (at 300-hour break-in period)	2.5 gallons per hour for shaft seal/sleeve diameters less than 20 inches (i.e. MCM-1/AGF-3/LPD-4/LSD-36)
		4 gallons per hour for shaft seal/sleeve diameters 20 inches and greater (i.e. LSD-41/49/DD-963/LCC-19/LHA-1/LHD-1/AS-39/CG-47/FFG-7/DDG-51/AOE-1/6)
		8 gallons per hour (CV/CVN only)
	Replacement leakage	More than 2.5 gallons per hourfor 1 week for shaft seal/sleeve diameters less than 20 inches (i.e. MCM-1/AGF-3/LPD-4/LSD-36) or 3 gallons perminute at any time
		More than 4 gallons per hour for 1 week for shaft seal/sleeve diameters 20 inches and greater (i.e. LSD-41/49/DD-963/LCC-19/LHA-1/LHD-1/AS-39/CG-47/FFG-7/DDG-51/AOE-1/6) or 3 gallons per minute at any time
		More than 8 gallons per hour (CV/CVN only)
Rubber-Lip-Type Face Seal	Maximum static leakage	1 ounce per minute
	Maximum dynamic leakage	1 gallon per minute
	Replacement leakage	3 gallons per minute

244-6.5.2.2 Operation. The MX9 stern tube seal will operate without operator adjustments once the system water flush valves have been aligned to the proper operating condition. MX9 seals are typically designed for a seawater flush rate of 15 gpm at 20 psig or 20 gpm at 25 psig, depending on the seal model. A vent line is required to allow for air trapped in the stern tube and seal housing to pass to the atmosphere. Face-to-seat contact pressure is maintained by the spring forces developed in the bellows assembly and by the hydraulic forces induced onto the seal components by ambient seawater pressure. This combination of spring and hydraulic forces maintains consistent face contact pressure and consistent seal leakage throughout the seal life despite changing draft conditions and seal wear. The bellows assembly is a flexible member of the seal that allows the seal to accommodate shaft or hull movements caused by thermal differentials, thrust loads, vibrations, bearing wear, and hull or shaft misalignment. For normal and emergency operating procedures, consult the applicable NAVSEA technical manual for the seal model installed.

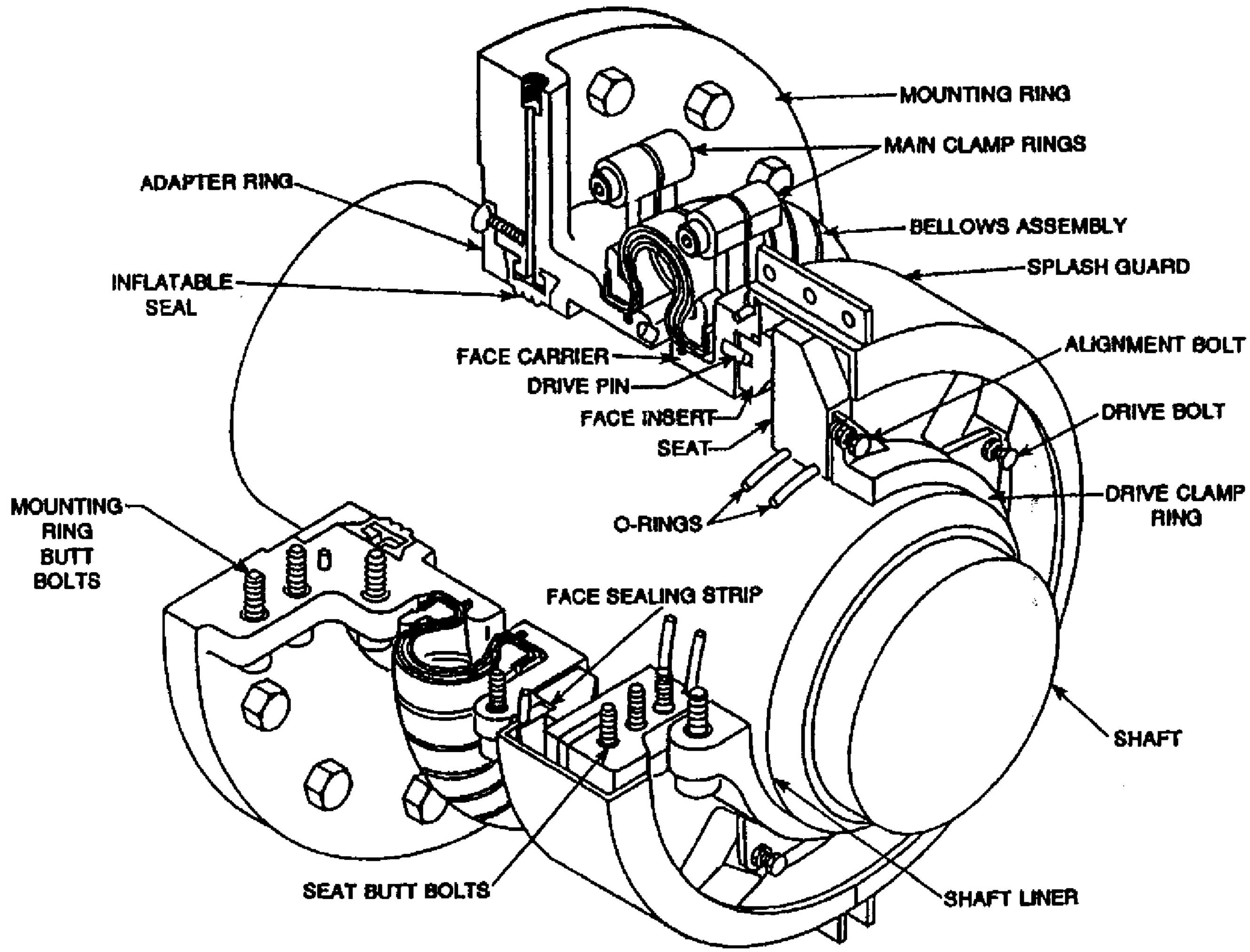


Figure 244-6-13 Crane Type MX9 Stern Tube Shaft Seal

244-6.5.2.3 Controls and Indicators. The following controls and indicators are installed in the stern tube seal water flushing lines and inflatable seal air supply for the MX9 stern tube seal:

a. Water flow indicator to detect a loss of lubricating seawater to the seal. A no-flow alarm should be located in Central Control.

b. Gages to indicate seawater flush pressure.

c. Gages to indicate inflatable seal air pressure.

244-6.5.2.4 Maintenance. No maintenance can prevent the seals from deteriorating. Scheduled shipboard maintenance procedures are in the applicable NAVSEA MX9 stern tube seal technical manuals and the Planned Maintenance System (PMS) for the stern tube assembly. The PMS procedures take precedence in case of conflicts. In addition to scheduled shipboard maintenance, condition base maintenance may be performed by either Ship's Force or an authorized field service activity (i.e. FTSCLANT/FTSCPAC, SIMA, etc.) as required between scheduled overhaul periodicities, generally indicated by excessive static and/or dynamic leakage past the mechanical sealing interface. The seal may be disassembled up to, but not including, the face carrier, and the face insert and seat inspected for excessive wear and/or deterioration. The face insert may be repaired via machining by an Intermediate Maintenance Activity (IMA) under FTSCLANT/FTSCPAC guidance, although replacement of this component is preferred. Likewise, the seat may be repaired via machining by an Intermediate Maintenance Activity (IMA) or replaced, depending on its thickness. A new face sealing strip as well as new seat o-rings shall be used during reassembly of the seal.

244-6.5.2.5 Shipboard Maintenance. The recommended shipboard maintenance schedule for the Crane MX9 stern tube seal is shown in Table 244-6-5. Detailed procedures for conducting scheduled maintenance are provided in applicable NAVSEA MX9 stern tube seal technical manuals and PMS Maintenance Requirement Cards (MRC) for a particular ship class.

Table 244-6-5 MX9 STERN TUBE SEAL SHIPBOARD MAINTENANCE SCHEDULE

Maintenance Requirement	Frequency
Test the inflatable seal for air and water leaks with the shaft stationary	Semiannually
Visually inspect the seal exterior and components. Measure relative face and seat wear and check alignment.	When excessive leakage is noted.

NOTE

Relative seal face and seat wear limits differ, depending on shaft size. Refer to applicable NAVSEA MX9 stern tube seal technical manuals for the correct face insert and seat wear limits.

244-6.5.2.6 Seal Overhaul. The maintenance schedule requires the stern tube seal to be completely overhauled every 10 years. A departure from specification (DFS) must be submitted in request of extending the overhaul periodicity beyond the 10 year requirement and will be evaluated by either NAVSEA or NSWCCD-SSES on a case-by-case basis. The seal must be disassembled and the face sealing strip, seat O-rings, interlayer, inflatable seal, bellows assembly, drive clamp ring fasteners, and face insert replaced. During scheduled overhauls, the seat may be repaired via machining by an Intermediate Maintenance Activity (IMA) or replaced, depending on its thickness. Table 244-6-6 provides an example illustrating typical seat wear limits for the type MX9 stern tube seal installed on AOE 6 class ships, and Figure 244-6-14 provides the machining details for the seat. The table provides the dimensions of the seat for initial thickness, allowable wear, and replacement thickness. Consult the NAVSEA MX9 stern tube seal technical manual for a particular ship class to determine wear limits for a particular seal application.

Table 244-6-6 MX9 STERN TUBE SEAL WEAR LIMITS (AOE 6 CLASS)

Component	Initial Thickness (in.)	Allowable Wear (in.)	Replacement Thickness (in.)
Face	0.590	0.276	0.315
Seat	0.984	0.314	0.669

244-6.5.2.7 Repair Parts. Table 244-6-7 lists the installation repair parts supplied with the MX9 stern tube seal. Table 244-6-8 lists the repair parts needed to accomplish a complete overhaul of the stern tube seal. Refer to the applicable NAVSEA MX9 stern tube seal technical manual for a complete parts list and location reference.

NOTE

Consult the applicable NAVSEA technical manual for a particular seal model to verify the number of drive ring butt bolts.

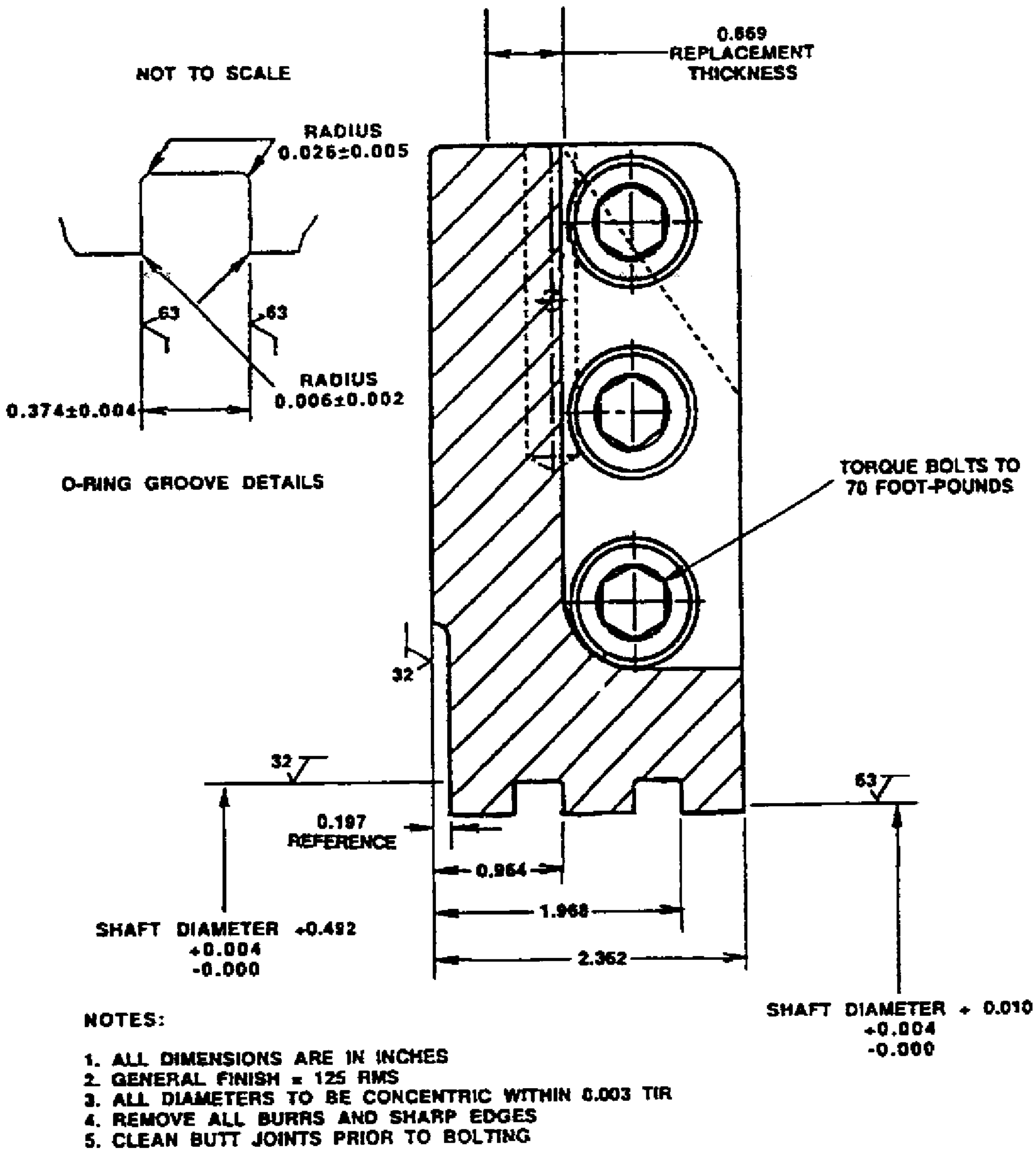


Figure 244-6-14 Machining Details for the Seat (AOE 6 Class)

244-6.5.2.8 Corrective Maintenance. Table 244-6-9 provides a list of repair procedures for the stern tube seal and level of maintenance required to accomplish the repair.

WARNING

To avoid serious injury or death, the stern tube seals must never be serviced or adjusted alone. Always ensure the presence of someone who can render assistance.

Table 244-6-7 MX9 STERN TUBE SEAL INSTALLATION SPARE PARTS

Quantity	Description	Material
1	Interlayer	Manetex 3
2	Seat O-rings	Neoprene
1	Face Sealing Strip	Neoprene
1	Tool Box	See tech manual for contents

Table 244-6-8 MX9 SPARE PARTS FOR OVERHAUL

Quantity	Description	Material
1	Face Insert	Manetex I
1	Face Sealing Strip	Neoprene
1	Backing Spring Assembly	Monel
1	Bridging Spring Assembly	Monel
1	Support Spring Assembly	Monel
2	Seat O-rings	Neoprene
1	Interlayer	Manetex 3
2	Drive Ring Butt Bolts	Alum-Bronze
1	Inflatable Seal	BUNA-N

Table 244-6-9 MX9 STERN TUBE SEAL REPAIR PROCEDURES

Repair Procedure	Maintenance Level
Setting Compression	Organizational
Seat Alignment	Organizational
Replacement of Face Insert	Intermediate
Repair of Seal Seat	Intermediate

a. **Setting Compression.** The stern tube shaft requires setting seal compression during installation or when any component is removed. The amount of compression varies with shaft temperature because of thermal expansion of the shaft. The amount of compression also varies with a particular MX9 seal application (difference in shaft sizes). Refer to the applicable NAVSEA stern tube seal technical manual for the amount of compression required (cold shaft). The procedure for adjusting the working length of the seal follows. (Refer to Figure 244-6-13 and Figure 244-6-15.)

CAUTION

Be sure that the main shaft is tagged out (″Do Not Rotate″) while installing or replacing seal components or whenever the inflatable seal is inflated. Confirm that the shaft alley communications to Central Control are in proper working order before proceeding.

CAUTION

Be careful not to overcompress the bellows spring or it will be damaged.

1. If the ship is waterborne, operate the inflatable seal as outlined in paragraph 244-6.5.6.2 and the applicable NAVSEA technical manual. Leakage past the inflatable seal should be near zero to less than 1 pint per minute.
2. Open the seal drain valve to drain the seal cavity.
3. Install the compression tools (adapters, studs, washers, and nuts) as shown in Figure 244-6-15 and hand-tighten the nuts.
4. Remove the splash guard by pulling it away from the lip at the outside diameter of the face carrier. For fiber-reinforced plastic (FRP) or steel-type splash guards, loosen the bolts, and remove the guard.
5. Thoroughly clean the shaft surface forward of the drive clamp ring. Loosen butt bolts and slide the drive clamp ring and seat forward.
6. Allow the bellows assembly including the face insert to extend forward its full travel by releasing the compression evenly.
7. Measure the free-length distance from the stern tube mounting flange surface to the forward side of the face insert.

NOTE

Use Dow Corning silicone grease No. 4, MIL-S-8660, or the equivalent, whenever grease or lubricant is required. This grease will not affect the polymers used in the stern tube seal.

8. By adjusting the compression tools, evenly compress the bellows assembly the amount specified in the applicable NAVSEA technical manual. Measure in four places, 90° apart, to check the straightness of the face surface.
9. Thoroughly clean both seal faces; then grease the shaft liner and slide the seat aft until the seat contacts the face insert. Check 360° around the mating faces for irregular contact (see paragraph 244-6.5.2.8b on seat alignment).
10. Thoroughly clean and degrease the shaft liner forward of the seat and the inner surface of the drive clamp ring that contacts the shaft. Apply a thin coating of Loctite 635 retaining fluid around the shaft liner and the bore of the drive clamp ring, ensuring that the fluid just wets both surfaces.

NOTE

Position the drive clamp ring and secure it quickly (within 1/2 hour) to prevent the retaining fluid from curing prematurely.

11. Back off on all drive and alignment bolts. Make sure that the drive clamp ring is flush against the seat. Engage the drive bolts with their mating holes in the forward side of the seat.
12. Torque the drive clamp ring butt bolts the amount specified in the applicable NAVSEA technical manual and remove the compression adapter.
13. Install the splash guard by snapping the groove in the splash guard over the lip on the face carrier. Make sure that the drain hole in the splash guard is positioned at bottom dead center (BDC). For FRP or steel-type splash guards make sure that the O-ring is installed in the groove at the outside diameter (OD) of the face carrier, and reinstall the guard using the fasteners removed in step 4.

14. Secure the inflatable seal for normal operation and realign the water flush to seal as outlined in the applicable NAVSEA stern tube shaft seal technical manual.

15. Align the seat by following the instructions in paragraph 244-6.5.2.8.b.

b. **Seat Alignment.** The seal seat requires alignment to run true to the shaft, and prevent fatiguing of the bellows springs and excessive leakage. The procedure for performing seat alignment follows: (Refer to Figure 244-6-13 and Figure 244-6-16.)

1. Mount a dial indicator, capable of at least 1/4-inch travel, to the forward side of the mounting ring or a suitable rigid surface.
2. Place the dial indicator to indicate at the aft side of the seat.
3. Set the indicator at the midpoint of its travel by adjusting the indicator's position.
4. Engage the turning gear to rotate the shaft in either direction.
5. Turn the drive and alignment bolts as required to achieve 0.002-inch total indicated read-out (TIR). This will usually require three to five revolutions of the shaft.
6. Tighten the drive and alignment bolt locknuts.
7. Verify the alignment through one complete revolution.
8. Disengage the turning gear.

c. **Face Insert Replacement.** Replace the face insert when excess leakage is noted (see Table 244-6-4) or when the face insert thickness measures less than that specified in the applicable NAVSEA stern tube seal technical manual. The seat requires the sealing face to be machined whenever the face insert is replaced. Off-ship assistance is required to replace the face insert. The detailed procedure for replacing the face insert is in the applicable NAVSEA technical manual for type MX9 stern tube seals.

d. **Repairing the Seat.** The seat requires remachining whenever excess leakage is noted, and replacement if its thickness is less than that specified in the applicable NAVSEA stern tube seal technical manual. Replace the face insert whenever the seat is remachined or replaced (see paragraph 244-6.5.2.8.c.). Refer to the applicable NAVSEA type MX9 stern tube seal technical manual for detailed disassembly, machining, and installation procedures.

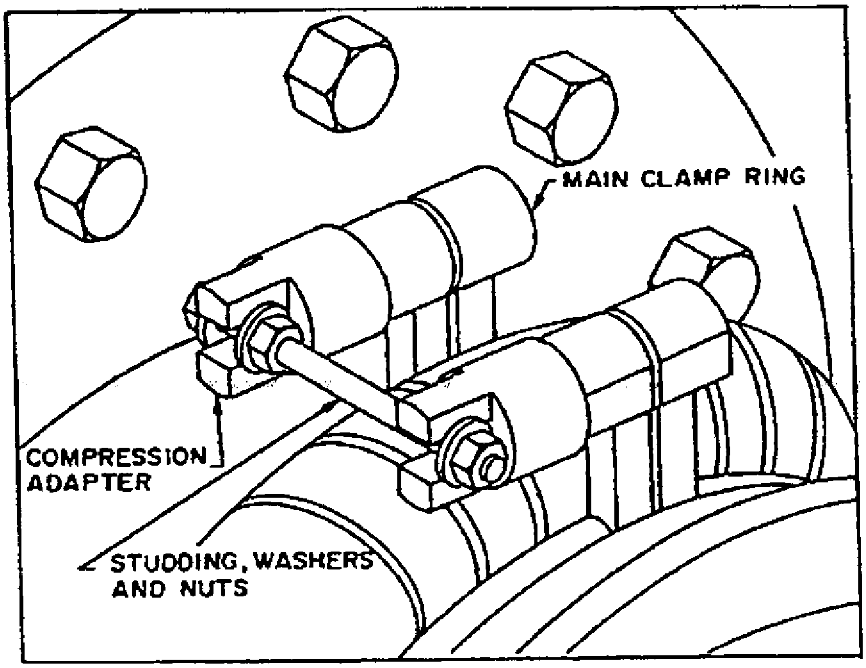


Figure 244-6-15 Compression Tool Installation

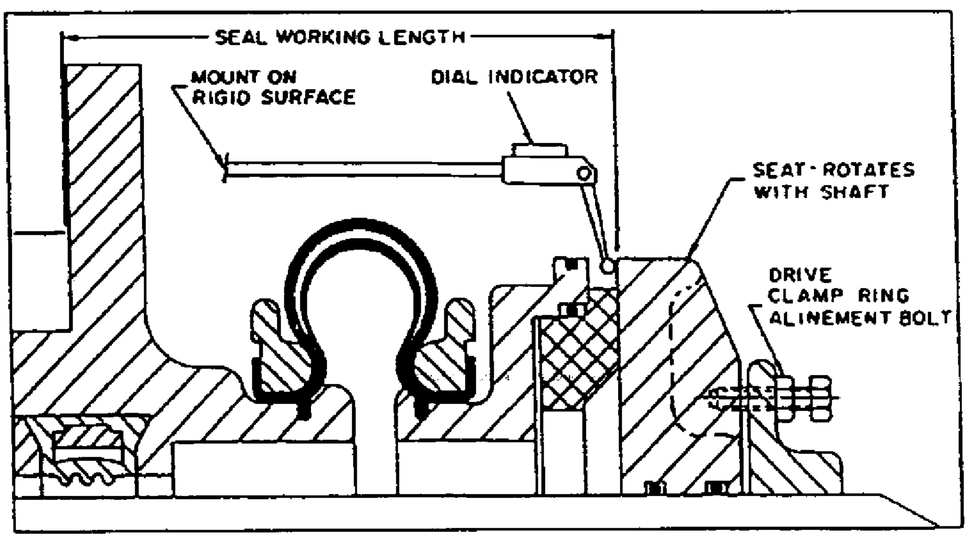


Figure 244-6-16 Seal Seat Alignment

244-6.5.2.9 Inspection. Routine inspections of the MX9 stern tube seal are conducted to ensure proper operation. Typical procedures for pre-underway, underway, and shutdown inspection are as follows:

a. **Pre-underway Inspection -**Perform the following procedure before rotating the shaft.
   1. Verify that the inflatable seal air supply and CO_2 bottle shutoff valves are closed.
   2. Verify that the inflatable seal vent valve and the pressure gage inlet valve are open.
   3. Disconnect the flexible hose from the inflatable seal.
   4. Close the stern tube flush valve and drain valve.

5. Open the valves to the seal's vent line.
6. Open the pressure gage valve and water supply valve, and adjust the pressure regulator to obtain 20 to 25 psig.
7. Inspect the seal to verify that static leakage does not exceed the requirements specified in Table 244-6-4 for the applicable seal.

b. **Underway Inspection -**Perform the following inspections at least once every 8 hours.
   1. Inspect the entire seal for excessive leakage.
   2. Verify that the water supply pressure gage indicates a pressure of 20 to 25 psig.

c. **Shutdown Inspection -**During all periods of inactivity inspect the stern tube seal for leakage once every 24 hours. Refer to Table 244-6-4 for the maximum static leakage allowed.

244-6.5.2.10 Troubleshooting. The stern tube shaft seal is designed to function without any operator adjustments. Troubleshooting is required only when malfunctions are detected during scheduled maintenance and inspections. Table 244-6-10 is a guide for troubleshooting the stern tube shaft seal.

Table 244-6-10 MX9 STERN TUBE SEAL TROUBLESHOOTING

Symptom	Probable Cause	Corrective Action
Seal Running Hot	Lack of flush water	Check flushing system alignment. Check flush system strainer.
	Overcompression	Check working length dimension on original installation drawing. Readjust, if necessary, according to paragraph 244-6.5.2.8a.
	Seal vapor bound	Be sure that vent line is open and clear.
	Clogged by hydropads	Inspect face insert and clear hydropads.
Excessive Leakage (more than 3 gpm)	Out of alignment	Align seal according to paragraph 244-6.5.2.8b.
	Too little compression	Check working length dimension on original installation drawing. Readjust, if necessary, according to paragraph 244-6.5.2.8a.
	Faulty secondary sealing O-rings or sealing strips	Replace faulty parts.
	Face insert damaged	Replace face insert and machine seat.
Excessive Vibration	Out of alignment	Align seal according to paragraph 244-6.5.2.8b.

244-6.5.2.11 Conversion to a Stuffing Box. In the event of a major seal failure, the MX9 stern tube seal may be converted to a stuffing box, using the auxiliary packing. Refer to the applicable NAVSEA technical manual for the parts required for emergency operation. The procedure for converting the seal follows: (Refer to Figure 244-6-13 and Figure 244-6-17.)

1. Inflate the inflatable seal and disassemble the seal according to the emergency disassembly instructions in the NAVSEA type MX9 stern tube shaft seal technical manual.
2. Remove the eight plugs from the forward end of the mounting ring and install the gland follower studs into the holes from which the plugs were removed.
3. Slide the first backup ring into the stuffing box, which is incorporated into the mounting ring.
4. Install the three rings of packing into the stuffing box, ensuring that all butt joints are staggered 90° apart. (The packing rings supplied are too long and will have to be cut to fit the shaft.)
5. Install the second backup ring. (Not all seal models incorporate a second backup ring)
6. Install the studding into the mounting ring.
7. Assemble the gland follower halves around the shaft, and install the butt bolts hold the halves together.
8. Position the gland follower onto the studding. Add washers and tighten slightly with nuts. Use locknuts to hold nuts in place. (Not all seal models use locknuts)
9. Secure the inflatable seal for normal shaft seal operation by following the directions in the NAVSEA stern tube shaft seal technical manual.
10. Align the water flush for operation with emergency packing installed by following the instructions in the applicable stern tube seal technical manual.
11. Notify Central Control to begin rotating the shaft at operational speed.
12. Observe the leakage between the shaft and the packing. Adjust the gland follower tightness to obtain leakage of 1 to 2 gallons per minute between the shaft and the packing. Adjust by tightening all eight gland follower nuts 1/4 turn at a time, considering only the leakage between the shaft and the packing.

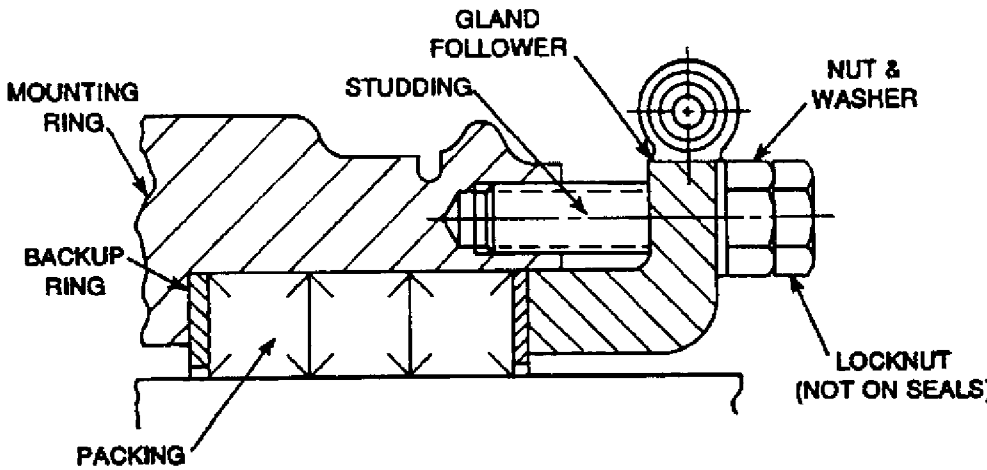


Figure 244-6-17 MX9 Stern Tube Seal with Packing Installed

244-6.5.3 SEALOL MECHANICAL FACE SEAL

244-6.5.3.1 Description. The EG&G Sealol stern tube seal assembly (Figure 244-6-18) is a nonmagnetic, water-lubricated, mechanical face-sealing arrangement comprising five major assemblies: housing, seal ring shell, mating ring, drive ring, and inflatable seal. The housing assembly is bolted to the aft bulkhead with mounting nuts and studs. The other components are positioned around the ship's propulsion shaft and mounted to the housing assembly and to each other with the mounting hardware provided. Space is provided for emergency packing installation in case the seal fails or if both the seal ring insert and the mating ring assembly are worn beyond repair and no replacement seal elements are available. An air connection on the inflatable seal, a connection assembly, and a hose assembly are provided to attach to the ship's low-pressure air supply or to a CO_2 bottle assembly when it is necessary to pressurize the inflatable seal before servicing the seal elements. A detailed description of each major assembly follows. (Refer to the applicable NAVSEA technical manual for the illustrated parts breakdown for the seal.)

a. **Housing Assembly.** The housing assembly is a precision-machined bronze casting that attaches to the forward end of the stern tube. Its split construction allows for installation around the propeller shaft without shaft disassembly. The two halves of the assembly are aligned with taper pins and held together by fitted bolts and nuts. Ports are provided in the upper half of the housing for seawater cooling and lubrication. The top and bottom halves contain flanged connections for the bearing flushing water supply. The top half also contains a connection for the inflatable seal connection and a threaded hole for seal cavity vent line piping. Internally, the housing contains the inflatable seal and attaching hardware. Externally, it houses the recesses for the spring assemblies.

b. **Seal Ring Shell Assembly.** The seal ring shell assembly is a bronze casting, precision machined for attaching to the forward end of the housing assembly. This assembly is also of split construction to allow for installation over the propeller shaft. The two halves are held together and aligned with socket-head capscrews, shoulder bolts, and nuts. Internally, the seal ring shell assembly houses the seal ring insert, Teflon support ring, and secondary O-ring. This assembly provides the dynamic O-ring seal between the housing assembly and the seal ring shell assembly. The seal ring shell assembly also houses and aligns the seal ring insert that provides the stationary aft portion of the dynamic seal face.

c. **Mating Ring Assembly.** The mating ring assembly is a precision-machined bronze casting that attaches to the aft end of the drive ring. Its split construction allows for installation around the shaft. The two halves are held together and aligned with taper pins and socket-head capscrews. This assembly is in constant contact with the seal ring insert forming a mechanical seal. An O-ring with backup ring prevents leakage between the mating ring assembly and the propulsion shaft.

d. **Drive Ring Assembly.** The drive ring assembly is also a precision-machined bronze casting split into two halves for installation around the shaft. Its two halves are held together and aligned with fitted bolts, nuts, and washers. The drive ring assembly clamps around the propeller shaft and aligns and secures the mating ring assembly with the antirotation pins. Threaded bores for capscrews are provided for mating ring adjustment.

e. **Inflatable Seal Assembly.** The inflatable seal assembly is a hollow elastomeric ring housed in the annular space in the aft part of the housing assembly. It has an air connection assembly for connection to the ship's low-pressure air system or to a supplied CO_2 bottle assembly. Inflating this ring forces it down against the shaft sleeve to form a static seal against seawater entry. Pressure is relieved from the inflatable seal by opening the air drain valve. See paragraph 244-6.5.6 for more information on inflatable seal operation and maintenance.

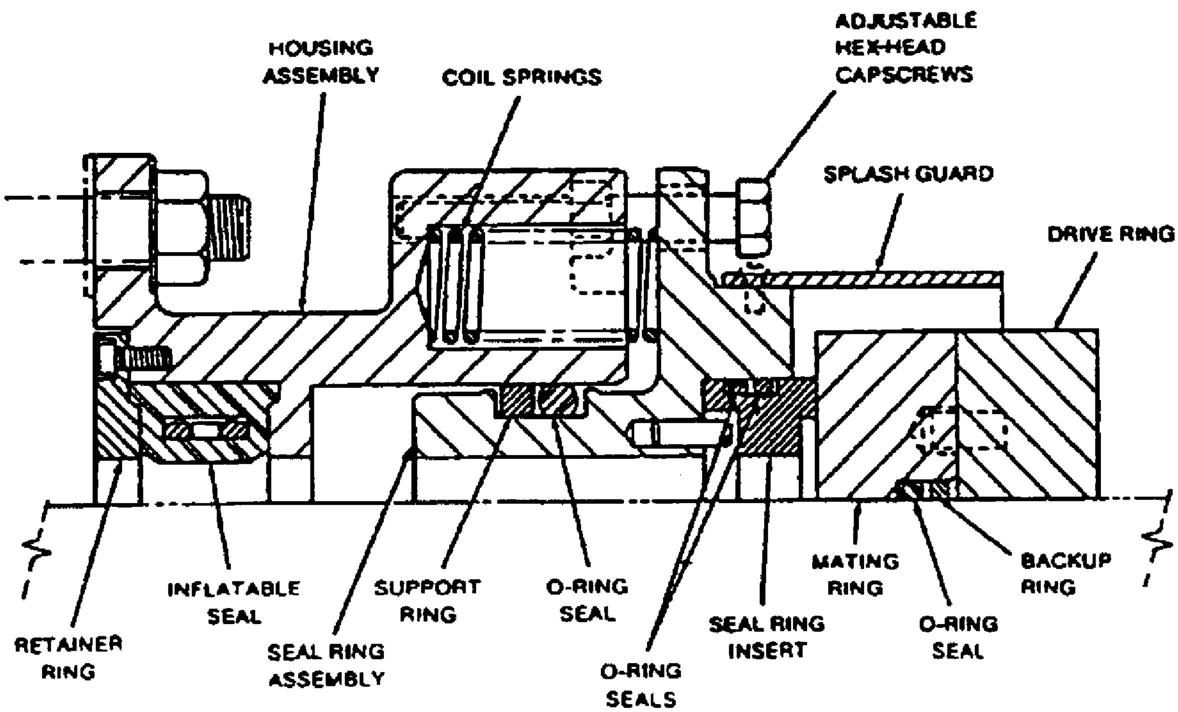


Figure 244-6-18 EG&G Sealol Stern Tube Seal Assembly

244-6.5.3.2 Operation. During operations the forward-facing seal ring insert runs against the rotating aft-facing face of the mating ring to provide the dynamic sealing contact surfaces. Springs in the housing assembly maintain thrust to ensure that the sealing faces remain in continuous contact; hydraulic loading is negligible. The inflatable seal, when inflated with ship's service air or the CO_2 bottles, forms a static seal with the shaft to prevent the entry of seawater whenever it is necessary to service the dynamic seal elements while the ship is waterborne. The Sealol stern tube seal is self-adjusting for wear, axial shaft movement, and radial shaft excursions caused by stern tube bearing clearances. The face seal principle involves no relative rubbing motion of the stationary parts and the rotating shaft sleeve, thereby reducing wear and costly shaft sleeve replacements. The stern tube seal can maintain watertight integrity when subjected to nominal seawater pressure of 25 psig with the shaft either rotating or stationary. During normal operations, the stern tube seal requires only periodic inspections to determine if there is adequate cooling and lubrication water flow and minimal leakage past the seal assembly.

CAUTION

During operation of the propulsion shaft, the inflatable seal must be deflated to prevent it from rubbing on the shaft sleeve surface. Never inflate the seal while the shaft is turning.

244-6.5.3.3 Maintenance. There is no intermediate- or depot-level maintenance to prevent deterioration of the seals. Once the stern tube seal is installed, it becomes an integral part of the ship's stern tube bearing structure. Corrective maintenance at the organizational level consists of performing adjustment and alignment procedures and replacing the seal element.

244-6.5.3.4 Scheduled Maintenance. The only routine shipboard maintenance required is making sure that the inflatable seal is completely deflated during shaft operation and that there is a continuous supply of bearing flushing water. Scheduled maintenance involves measuring the seal monthly for excessive leakage and testing the inflatable seal for air and water leakage. See paragraph 244-6.5.6.3 for inflatable seal testing procedures. Scheduled shipboard maintenance procedures are in the applicable NAVSEA shaft seal technical manuals and the PMS MRC. The PMS procedures take precedence in case of conflicts.

244-6.5.3.5 Seal Overhaul. The EG&G Sealol stern tube seal should be overhauled every 5 years. This includes removing and refurbishing the inflatable seal, replacing O-rings and seal insert, and refurbishing the housing assembly and mating ring assembly. The removal and installation of the inflatable seal and the seal housing are authorized for depot-level repair only.

⚠ WARNING

Replacing the inflatable seal ring while waterborne can be accomplished only with the use of an approved cofferdam. Any attempt to replace the inflatable seal without the cofferdam could result in flooding and potential injury or death of personnel.

CAUTION

The plastic seal ring insert and the gun metal mating ring are critical sealing components and considered long lead items. Use extreme care when handling to prevent their sealing faces from being scratched or damaged.

244-6.5.3.6 Repair Parts. The applicable NAVSEA technical manual for the EG&G Sealol stern tube seal contains an illustrated parts breakdown (IPB) and a group assembly parts list (GAPL) with item description, part number, Federal Supply Code for Manufacturers (FSCM) number for each part, and quantity per assembly. The ship's allowance parts list (APL) and coordinated ship's allowance list (COSAL) contain information on the repair parts carried onboard ship.

244-6.5.3.7 Corrective Maintenance. Organizational-level repairs to the stern tube seal are limited to disassembly, component removal, and installation of shaft packings in the event of O-ring or mechanical seal failure (see paragraph 244-6.5.3.10). Corrective maintenance of the stern tube assembly is limited to refurbishing or replacing the seal ring insert and the mating ring when seal leakage exceeds 3 gallons per minute. These maintenance actions are authorized for accomplishment by intermediate- or depot-level maintenance activities.

a. **Replacement of Seal Elements.** If the seals no longer operate effectively with the rate of leakage exceeding 1 gpm for one week or 3 gpm at any time, the seal ring inserts and O-rings may be replaced with the ship afloat and the shaft stationary. They can be disassembled with the use of the inflatable seal while the ship is waterborne. Seal elements are replaced by an intermediate- or depot-level maintenance activity. Detailed procedures for replacing the seal ring insert and O-rings are in the applicable NAVSEA technical manuals.

b. **Seal Assembly Compression.** Overcompression of the seal assembly can cause the seal to operate at excessive temperatures (above 110°F). Undercompression can cause excessive leakage. If temperature or leakage is excessive, the spacing between the forward face of the housing assembly and the after face of the seal ring shell assembly shall be adjusted. This spacing is set during installation or during seal element removal and replacement. Consult the applicable NAVSEA technical manual for compression adjustment procedures for different seal models. The following is a typical procedure for adjusting seal assembly compression for the model 70509 EG&G Sealol seal installed on MCM 1 class ships. (Refer to Figure 244-6-18.)

1. Remove the water splash guard and eight socket-head screws from the seal ring assembly.
2. Remove the four hex-head capscrews from the seal ring assembly and replace them with four all-threaded studs, washers, and eight hex nuts as shown in Figure 244-6-19.
3. Screw the studs four to six full threads into the housing assembly, and tighten the aft hex nuts.
4. Install the forward hex nuts and washers and run the nuts up the studs until they are against the seal ring assembly flange.
5. Remove the two hex nuts and washers from the drive ring fitted bolts, and use a hammer and soft drift to drive out the fitted bolts.

WARNING

Use proper lifting equipment when removing drive ring halves to avoid damaging equipment or injuring personnel.

6. Using a hoist and straps, remove both drive ring halves from the propulsion shaft.

NOTE

Consult the applicable NAVSEA technical manual for the required spacing between the seal ring and housing assembly for a particular EG&G stern tube seal model.

7. Loosen the four all-threaded studs installed in step 2 and insert four locally manufactured spacers, 0.437 inch thick by 1.0 inch wide by 4.0 inches long, equidistant between the forward face of the housing and the aft face of the seal ring assembly. If the seal ring assembly will not unseat by loosening the studs, it may be necessary to slide the mating ring forward by hand.
8. Tighten the four all-threaded studs until contact is made with the spacers and remove the spacers. Be sure to measure the 0.437 (± 0.062)-inch clearance equally at all four stud locations. Reposition the mating ring aft, if necessary, until it mates with the seal ring insert.
9. Position the drive ring halves around the propulsion shaft and secure the drive ring firmly against the mating ring using the two fitted bolts, nuts, and washers. Torque the bolts, nuts, and washers to 90 ft-lb.
10. Replace the four all-threaded studs in the seal ring assembly with the four hex-head capscrews and hex nuts removed in step 2.
11. Before tightening the four hex-head capscrews, install the spacers used in step 7 between the seal ring assembly and the underside of the capscrew heads. Tighten the capscrews evenly until they contact the spacers; remove the spacers.
12. Verify that the 0.437 (± 0.062)-inch clearance obtained in step 8 is within tolerance, and secure the four hex-head capscrews with the hex nuts.
13. Install the water splash guard on the seal ring assembly with the eight socket-head screws.

c. **Mating Ring Repair**. The mating ring is a precision bronze casting that provides the rotating forward portion of the dynamic face seal. While replacing the seal element, inspect the sealing surface (aft facing surface of the mating ring assembly) for face wear. If face wear is 0.015 inch deep or more, refurbish the mating ring assembly. To maintain machined tolerances, refurbish the mating ring at the manufacturer's facility or with the manufacturer's guidance.

d. **Mating Ring Alignment.** The flatness of the mating ring is critical when installing the EG&G Sealol stern tube seal. For this reason, never coat the split joints of the mating ring with gasket cement (Permatex). Make a final adjustment at installation to be sure that the seal faces are running true to each other. The adjustment can be made only when the ship is waterborne and the propeller shaft is rotated with the jacking gear. A long-stem dial indicator is installed at the aft end of the mating ring. After installing the hex-head capscrews and nuts into the forward end of the drive ring, rotate the propeller slowly, and adjust the hex-head capscrews in the mating ring to a zero setting on the dial indicator. Maximum runout should be 0.010 total indicator reading (TIR).

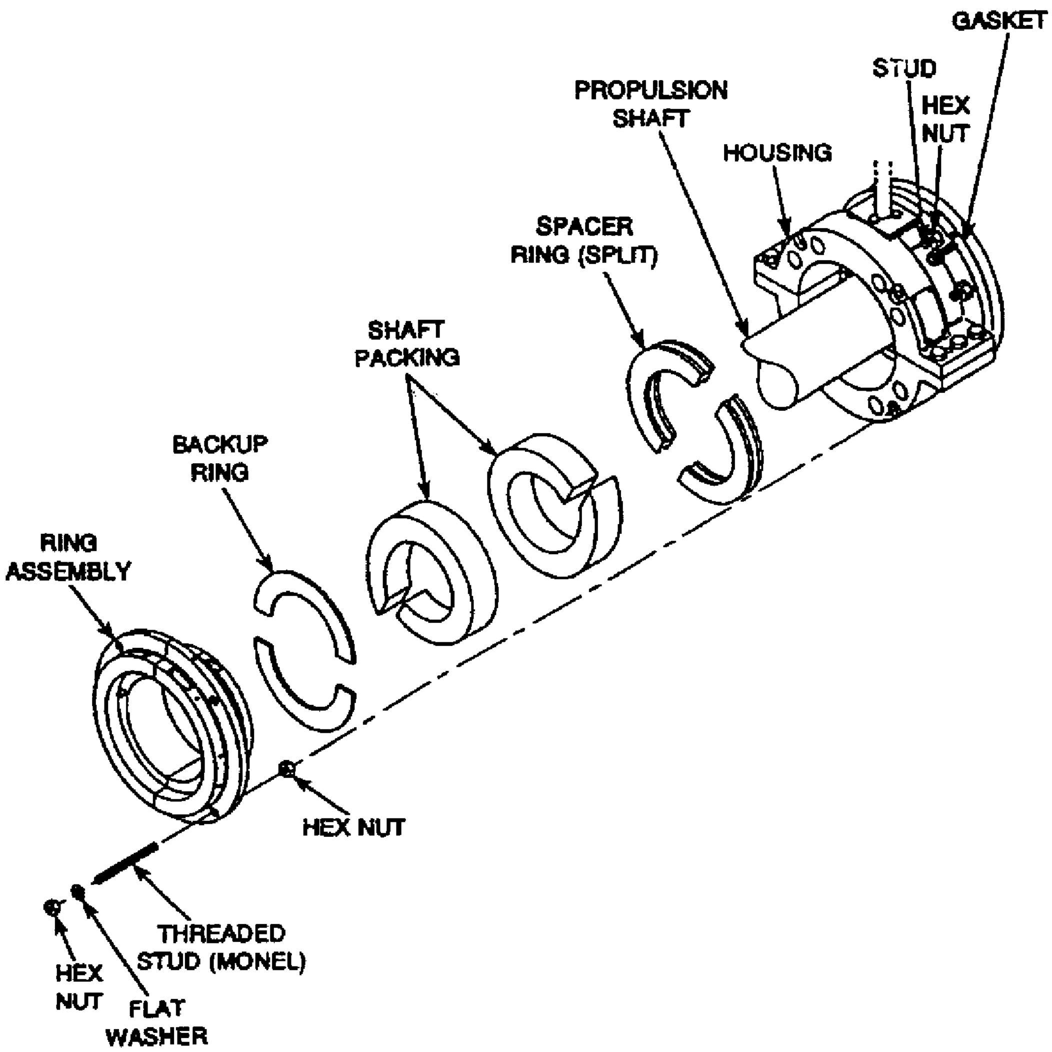


Figure 244-6-19 Sealol Repair Packings (Exploded View)

244-6.5.3.8 Inspection. Conduct inspections on a routine basis to ensure proper seal operation. The pre-underway, underway, and shutdown inspections for the EG&G water-lubricated mechanical face seal are as follows:

a. **Pre-underway Inspection** -Conduct the following inspection before rotating the shaft:

1. Verify that the shutoff valve on each CO_2 bottle, if installed, is tightly shut and that the water drain shutoff valve is closed.
2. Disconnect the CO_2 bottle quick-disconnect fitting, if installed.
3. Open the ship's air supply relief valve to eliminate air pressure on the inflatable seal.
4. Verify that the lubricating water control valve is open.

5. Inspect the seal to be sure that static leakage does not exceed 1 pint per minute.

b. **Underway Inspection -** Conduct this inspection at least once during each 8-hour period.
   1. Inspect for excessive leakage at the seal ring insert to the mating ring mechanical seal. See Table 244-6-4 for the maximum leakage rate.
   2. Inspect the opening between the housing assembly and the seal ring shell assembly for leakage past the dynamic O-ring.
   3. Inspect the propulsion shaft at the drive ring for leakage past the static O-ring seals.
   4. Verify that the lubricating water pressure gage is indicating 20- to 25-psi indicated pressure.

c. **Shutdown Inspection -**Following underway operations with the engines shut down and the shaft brake engaged, no specific tasks are required. The cooling and lubricating water flow should circulate continually to flush any dirt or silt from the seal housing cavity. During all periods of inactivity inspect the stern tube seal for leakage at least once during each 24-hour period. (The maximum allowable static leakage is 1 pint per minute.)

244-6.5.3.9 Troubleshooting. Troubleshooting of the EG&G Sealol stern tube seal is limited to inspection for a hot seal (above 110°F) and excessive leakage. Table 244-6-11 lists the probable causes and corrective action for these two conditions. Refer to Table 244-6-4 for the maximum leakage allowed in the static and operational (propulsion shaft rotating) condition.

244-6.5.3.10 Conversion to a Stuffing Box. If the seal fails or if both the seal ring insert and the mating ring assembly are worn beyond use and no replacement seal elements are available, remove and replace the worn units with repair packing (refer to Figure 244-6-19). The procedures for installing repair packing are essentially the same for all Sealol mechanical seals. The following procedures apply to the MCM 1 class. Consult the applicable NAVSEA technical manual for a particular model application.

WARNING

Be sure the propulsion shaft brake is engaged during all maintenance to prevent injury to personnel or damage to equipment from the rotating shaft.

CAUTION

Use of packing may score the shaft sleeve. Replace the shaft packing with the proper seal elements as soon as possible to prevent wear on the shaft sleeve.

Table 244-6-11 TROUBLESHOOTING PROCEDURES (SEALOL FACE-TYPE SEAL)

Symptom	Probable Cause	Corrective Action
Seal Running Hot (above 110°F)	Lack of bearing flushing water	Check duplex filters and strainers for clogging.
	Overcompression of seal assembly	Make sure that seal shell assembly spacing is correct.
	Seal vapor bound	Make sure that vent line is clear.
Excessive Leakage	Worn seal faces	Replace seal elements.

Table 244-6-11 TROUBLESHOOTING PROCEDURES (SEALOL FACE-TYPE SEAL) - Continued

Symptom	Probable Cause	Corrective Action
	Lack of compression on seal assembly	Make sure that seal ring assembly spacing is correct.
	Damaged O-ring	Replace damaged O-ring; make sure leakage is from between the sealing faces.
	Incorrect lip deflection	Machine gland ring to provide 0.060- to 0.120-inch lip deflection.
	Shaft sleeve grooving	Install sleeve epoxy insert. Make sure lip deflection and spring force are correct.
	Misaligned mating ring	Check mating ring for excessive runout. Maximum allowable runout is 0.010-inch TIR.

1. Shut the water supply control valve to the stern tube seal housing assembly.
2. Make sure that all tag-out procedures are in accordance with current shipboard instructions.
3. De-energize the turning gear motor controller out of service.

CAUTION

To avoid damage to the inflatable seal, do not exceed 125 psig gage on the air pressure gage while inflating the seal.

4. Connect the low-pressure air supply to the inflatable seal housing air connection, and open the air supply control valve to pressurize the inflatable seal. Shut the control valve when the air pressure gage indicates 125 psig.
5. Open the drain port on the bottom of the housing assembly to remove water from the housing assembly internal cavity.
6. As described in the appropriate NAVSEA technical manual, disassemble the stern tube seal to install shaft packings.
7. Clean the propulsion shaft and housing internal cavity thoroughly.
8. Insert the spacer ring in the housing assembly cavity, with split joints on the vertical centerline. Move the spacer ring into the cavity until it is seated against the internal shoulder.
9. Wrap the first shaft packing ring around the propulsion shaft.

NOTE

Position the shaft packing scarf cut on the port side of the shaft with the scarf cut upward and the inside end of the scarf cut on the horizontal centerline.

10. Push the first packing ring into the housing assembly cavity until it contacts the spacer ring that was installed during step 8.

11. Wrap the second shaft packing ring around the propulsion shaft, with the scarf cut opposite the first shaft packing ring scarf cut.

12. Firmly seat both shaft packing rings in the housing assembly cavity.

13. Place both halves of the backup ring around the shaft over the second shaft packing ring.

14. Move the seal ring assembly onto the assembly studs, with the split joint on the vertical centerline, until it contacts the backup ring.

CAUTION

Do not overtighten shaft packing rings. Excessive pressure will cause grooving damage to the propulsion shaft during operation.

15. Install four nuts and washers on the assembly studs and tighten them evenly to compress the packing rings.

16. Open the water supply to the housing assembly cavity, and shut the stern tube seal housing assembly water drain valve.

CAUTION

An inadequate lubricating water supply may cause the shaft packing to burn or cause scoring of the shaft sleeve.

17. Open the air pressure drain valve to relieve pressure on the inflatable seal and allow cooling and lubricating water to flow through the housing assembly. Disconnect and restow the air hose.

18. Evenly adjust the nuts that were installed during step 15 evenly to prevent excessive leakage through the packings. Measure the gap at four different locations between the seal ring assembly and the housing to make sure that the ring assembly does not cock during tightening.

19. Monitor the leakage rate to ensure a leakage rate of about 1/2 gallon per minute. Adjust the lubricating water control valve to maintain the proper leakage rate.

244-6.5.4 RUBBER-LIP FACE SEALS. Rubber-lip face seals are no longer installed on newer ship classes, but they are still used on some older surface ships. The most widely used rubber-lip seal is the Syntron seal manufactured by FMC Corporation.

244-6.5.4.1 Syntron Seal Description. The Syntron split marine shaft seal (Figure 244-6-20) is constructed of a sectional marine bronze casting that houses two flexible sealing elements available as a replacement element when interchange is required. Sealing contact is lubricated by a slight flow of clean water injected through the gland ring into a recess in the forward sealing element. A split inflatable sealing ring is located in a recess in the seal housing just aft of the sealing element cavity. The sealing ring is inflated from ship's air supply and forms a seal around the stationary shaft, permitting shaft repair while the ship is waterborne. The seal is never inflated while the shaft is rotating. After repairs are completed, the inflatable seal is deflated, receding back into its recess and losing contact with the shaft.

244-6.5.4.2 Operation. The Syntron seal functions automatically once water is supplied to the stern tube flush, seal cavity flush, and gland ring lube ports. To start the water flowing to all inlet ports, open all water inlet valves to flush the seal and stern tube and check the pressure gage to be sure that the water pressure is correct. (Reset the needle valve to obtain the proper water pressure, if necessary.) The shaft can now be rotated. The shaft seal can be shut down by closing all the water inlet valves. Do not shut down the system except for maintenance. Maximum allowable leakage rates for rubber-lip seals are shown in Table 244-6-4. See the applicable NAVSEA technical manual for detailed operating instructions.

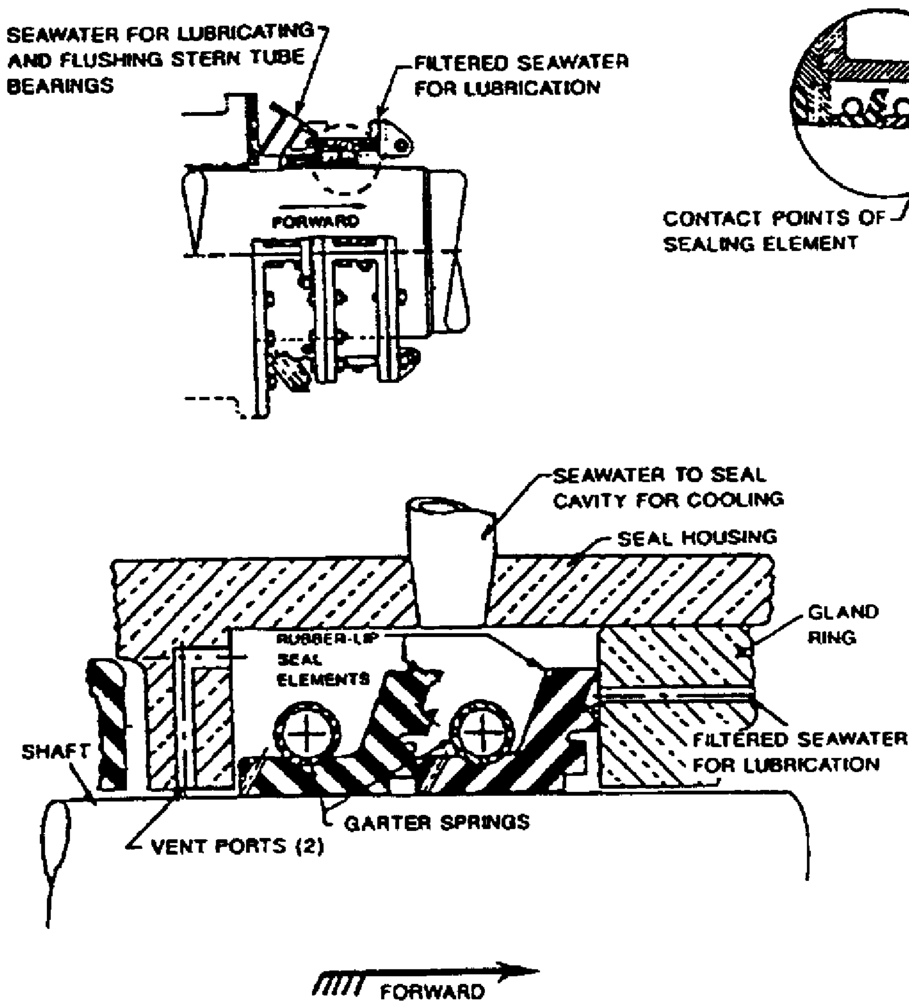


Figure 244-6-20 Syntron Rubber-Lip Stern Tube Shaft Seal

244-6.5.4.3 Emergency Seal Operation. Syntron rubber-lip seal models provide for the installation of seal packing to control leakage if both sealing elements fail while the ship is waterborne. Up to three rings or turns of flax packing are usually installed near the seal housing for emergency use. The packing is installed in the seal housing cavity usually occupied by the sealing elements. The inflatable seal permits packing installation while the ship is waterborne. Detailed procedures for operating the inflatable seal and installing the emergency packing are in the applicable NAVSEA technical manuals for rubber-lip stern tube seals.

NOTE

Do not use emergency packing if an additional face-type seal or sealing element can be obtained.

244-6.5.4.4 Controls and Indicators. Table 244-6-12 lists the controls and indicators for a typical rubber-lip face seal lubricating-water and compressed-air system. See paragraph 244-6.5.7 (Figure 244-6-23) for a schematic of a typical lubricating-water and compressed-air system for a Syntron rubber-lip face seal assembly.

Table 244-6-12 RUBBER-LIP FACE SEAL CONTROLS AND INDICATORS

Indicating Device or Control	Purpose or Function	Location	When Used	Normal In-Use Position, Reading, or Condition
Stern Tube Flush Inlet Valve	Allows seawater to enter stern tube	Inlet to stern tube	Open during startup; closed during shut-down	Open
Seal Cavity Flush Inlet Valve	Allows seawater to enter seal cavity	Inlet to seal cavity	Open during startup; closed during shut-down	Open
Needle Valve	Reduces auxiliary seawater cooling system pressure before water enters seal cavity	Between auxiliary seawater cooling system and shaft seal	Regulators flow of water into gland ring and seal cavity	15 to 18 psi
Pressure Gage	Indicates pressure at needle valve outlet	In line between needle valve and shaft seal	During operation	15 to 18 psi
Leakage from Seal	Indicates water flow through seal	Below seal	During operation	3 gpm maximum for existing installations; up to 1 pt per min for new installations

244-6.5.4.5 Maintenance. Rubber-lip face seals are designed for many years of trouble-free service if preventive maintenance procedures are performed at specified intervals. The amount of leakage determines the condition of the seals. The only corrective maintenance that can be performed is replacing seals, replacing springs, nuts, screws, or studs during installation and removal, and replacing or refurbishing gland ring sealing surfaces, if badly worn. If excessive leakage (3 gpm) occurs, replace the sealing elements on the Syntron seal. Preventive maintenance consists of testing the inflatable seal assembly for air and water leakage, replacing the lubricating-water system filter element, and periodically checking the seals, cooling and lubricating piping, and pipe component condition.

NOTE

Do not attempt to open the seal housing just to inspect the seal faces.

Table 244-6-13 shows a typical preventive maintenance schedule for the Syntron seal. Detailed procedures to accomplish these maintenance requirements are in the PMS for rubber-lip seal installations and in the applicable NAVSEA technical manual. The PMS procedures take precedence in case of conflicts.

Table 244-6-13 TYPICAL SYNTRON SEAL PREVENTIVE MAINTENANCE SCHEDULE

Maintenance Requirement	Frequency
Monitor Seal Water Leakage Rate	Daily
Monitor Water Inlet Pressure and Valve Settings	Daily
Clean and Inspect Stern Tube Cooling Water Strainer and Filter Shell Assembly	Quarterly
Test Inflatable Seal Assembly	Semiannually

244-6.5.4.6 Seal Overhaul. Replace the inflatable seal assembly and forward and aft sealing assemblies every 4 years when the ship is drydocked. Have an off-ship repair activity replace the seal assembly since this action is beyond the capability of the ship's force. The technical repair standard (TRS) for the applicable ship class contains the general inspection, acceptance, and repair criteria for the seal components. The overhauling activity is responsible for adhering to the requirements called out in the applicable overhaul work document. The TRS also contains the planned overhaul material list that specifies material that must be replaced at each overhaul and the contingency material list, that specifies on the basis of wear analysis, the parts that may be replaced. The TRS requirements take precedence over the manufacturer's original design requirements if a conflict between the two arises.

244-6.5.4.7 Repair Parts. The applicable NAVSEA technical manual for rubber-lip seals contains a complete parts listing to help maintenance and supply personnel identify, requisition, store, and issue replacement parts for the Syntron stern tube seal. The parts lists give the manufacturer's part number, description, quantity per assembly, and the Federal Supply Code for Manufacturers (FSCM) number. Consult the applicable APL and COSAL for the listing of onboard repair parts for the rubber-lip seal assembly.

244-6.5.4.8 Inspection. Inspection of rubber-lip seals is necessary when the leakage rate becomes excessive (see Table 244-6-4). This will require some disassembly. For the Syntron seal, activate the inflatable seal, remove the hex nuts from the forward studs, and position the gland ring forward along the shaft. A cofferdam or fast-acting pumps may also be installed to prevent flooding should the inflatable seal fail during seal removal. Once this is done, the seal elements may be removed from the housing for inspection. If defective, the seal elements may be replaced by packing for emergency use while the ship is waterborne. Install new sealing elements at the earliest opportunity and remachine the wear face of the gland ring perpendicular surfaces to the prescribed finish. If the sealing element is replaced and the gland ring machined, make sure that the gland ring is machined to provide the correct lip deflection with the sealing element. A lip deflection between 0.006 inch and 0.120 inch is needed to ensure satisfactory operation. In addition, shaft sleeves have been grooved by improper operation of the Syntron seal where the shaft turned within the sleeve. Ship alterations (SHIPALT) were developed to improve the sealing function by placing an eccentric epoxy insert in the shaft sleeve so that the seal wiped the gland ring in an eccentric pattern. These SHIPALT's also eliminated the lubricating water to the gland ring because the seal was essentially self-lubricating, using seawater in the housing during the wiping motion. Installation of the epoxy insert in shaft sleeves is covered in the appropriate SHIPALT for each ship class and in **NSTM Chapter 9430.**

244-6.5.4.9 Troubleshooting. Table 244-6-14 provides troubleshooting procedures for rubber-lip face-type seals.

244-6.5.5 INSTALLATION OF O-RINGS

244-6.5.5.1 Mechanical Seals. Different stern tube seals have different bonding requirements for installing O-rings. EG&G seal model 70509, installed on the MCM 1 class, has four O-rings, and only the dynamic O-ring in the seal ring assembly requires bonding by vulcanizing. The other O-rings are bonded using Loctite 0112. Vulcanizing is the preferred method of binding because it results in a stronger bond. It is also the method used to bond the inflatable seals during installation of both the Crane and the EG & GSealol stern tube seals. The applicable NAVSEA technical manuals contain procedures for bonding the inflatable seals during installation. Bonding instructions and precautions for seal assembly O-rings are on instruction sheets enclosed with the bonding kits. The O-rings used in Crane MX9 stern tube seals are not bonded but are supplied overlength so the ends can be pressed hard together during seal installation.

Table 244-6-14 RUBBER-LIP FACE SEAL TROUBLESHOOTING

Symptom	Probable Cause	Corrective Action
Premature Wear of Seal Face	Lack of lubrication and cooling water	Inspect system cooling supply water.
	Contaminants in seal cavity	Disassemble gland and inspect seal elements.
	Gland face damaged during installation	Disassemble and inspect seal elements.
Overheating of Seal Housing with Packing Installed	Excessive force on packing gland preventing cooling water from passing through to the seal housing	Ease pressure on packing, increase cooling water flow, or both.
Little or No Leakage	Clogged filter or strainer	Replace filter cartridge or strainer.
	Needle valve misadjusted	Adjust needle valve to increase water flow.
Excessive Leakage	Seal elements worn	Disassemble seal and inspect sealing elements/rings. Replace if wear exceeds limits.
	Defective O-rings	Replace O-rings.
	Incorrect gland ring lip deflection with the sealing elements	Machine gland ring to ensure a 0.060- to 0.120-inch lip deflection.

244-6.5.5.2 Rubber-Lip Seals. The sealing elements and the O-rings in rubber-lip seals are also bonded at installation. On Syntron seals, quick-set adhesives such as Eastman 910, Loctite 404, or Goodyear Pliobond No. 20 cement may be used. Consult the applicable NAVSEA technical manual on rubber-lip seals for detailed instructions on adhesive bonding of O-rings.

244-6.5.6 INFLATABLE SEALS

244-6.5.6.1 Description. The inflatable seal is an integral component of most surface ship stern tube seal assemblies. On the type MX9 seal, the inflatable seal is an elastomeric channel incorporated into the mounting ring. On the EG&G Sealol mechanical face seal, it is a hollow elastomeric ring housed in the annular space in the aft part of the housing assembly. The inflatable seals have an air connection assembly for connecting to the ship's low-pressure air supply or to a CO_2 bottle assembly. Inflating the seal forces the elastomeric ring down against the shaft or expands the channel and seals the radial gap between the stern shaft and the seal housing. This creates a static seal against seawater entry. The inflatable seal is to be used for stationary sealing only since rotating the shaft with the seal pressurized will damage the rubber components and cause loss of function. The inflatable seal can be replaced only in drydock or while waterborne, with the proper cofferdam or shaft wrap. Install and operate the inflatable seal in accordance with the appropriate NAVSEA technical manual.

CAUTION

Always deflate the inflatable seal during normal primary seal operation. Do not attach the ship's air supply or the CO_2 bottles to the inflatable seal while the shaft is rotating. Use the inflatable seal only while servicing seal elements. Do not inflate over 125 psig.

244-6.5.6.2 Operation. Detailed operating instructions for the inflatable seals are in the applicable NAVSEA technical manual for the particular seal make and model. Following is a typical inflatable seal operating procedure for the Crane MX9 mechanical face-type seal. (Refer to Figure 244-6-21.)

1. Shut off the seawater supply to the affected seal.
   a. Follow all tag-out procedures in accordance with the current shipboard instructions. De-energize the turning gear motor controller out of service.
   b. Close the water flush inline valve (A) and the water flush to seal and bearing valve (F).
   c. Verify that the water flush to bearing valve (H) is closed.

CAUTION

Do not rotate the shaft while the inflatable seal is inflated. Rotating the shaft will damage the inflatable seal and cause loss of function.

2. Activate the seal by aligning the air supply to the affected seal.
   a. Close the inflatable seal vent line valve (1).
   b. Verify that valve (2), which closes the seal air supply line, is closed.
   c. Verify that valve (3), which opens the pressure gage valve, is open.
   d. Vent the pressure relief valve (8) and set it to open at 75 psig.

NOTE

If the ship's low-pressure (LP) air supply is used, proceed with step 3 through step7. If the air bottle is used, proceed with steps step 8 through step 12.

3. Remove condensate from the LP air trap at the LP air station.
4. Set the pressure regulator (10) at 40 to 50 psig.
5. Open the valve (9) from the ship's LP air supply.
6. Slowly open the inflatable seal air supply line valve (2).
7. Verify that the air pressure gage (4) is showing 40 to 50 psig gage.
8. Open valve (7) to the compressed-air bottle.
9. Set the pressure regulator (6) to 40 to 50 psig gage.

10. Open valve (5) that supplies air from the compressed air bottle.

11. Slowly open valve (2) that opens the inflatable seal air supply line.

12. Verify that air pressure on the pressure gage (4) is 40 to 50 psig.

13. Drain the seal by opening drain valve (G) and the water flush to seal and bearing valve (F) that was closed previously in step 1b.

NOTE

Water flow should reduce to near zero in a few minutes. The seal can now be inspected or partially disassembled for repairs or adjustments.

WARNING

If the inflatable seal is to remain activated and unattended for an extended period of time, ensure the drain valve is closed to prevent potential flooding of the space.

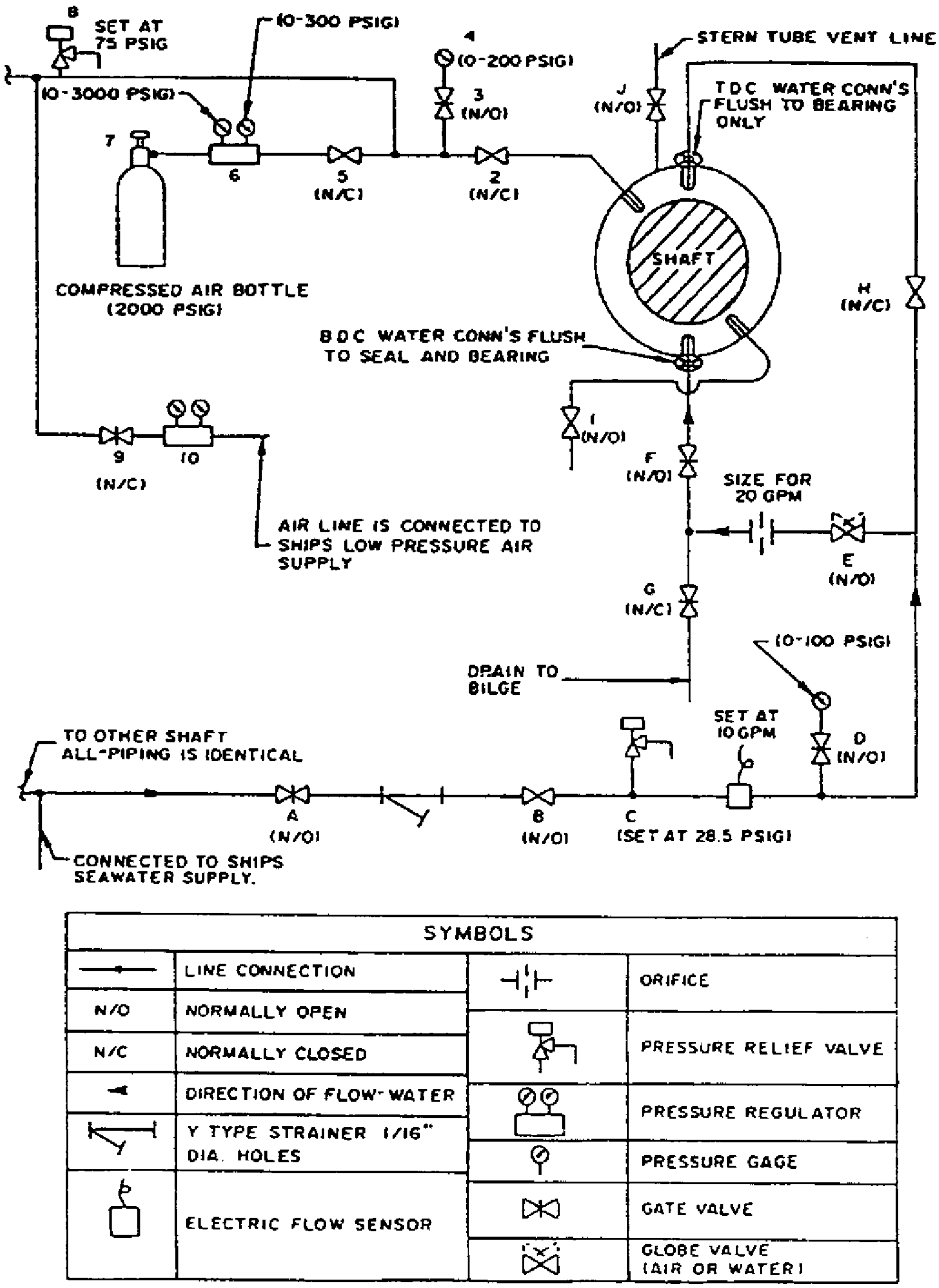


Figure 244-6-21 Typical Crane MX9 Stern Tube Seal Air and Water Piping Arrangement

244-6.5.6.3 Testing. Test the inflatable seal assembly every 6 months for air and water leakage as follows:

1. Stop the shaft and post ″out of service″ warning signs to be sure that the shaft will not be rotated until the inflatable seal has been deflated.
2. Engage the shaft brake and de-energize the turning gear motor controller, if appropriate.
3. Shut the applicable cooling water valves to the stern tube.

CAUTION

To avoid damage to the inflatable seal, do not pressurize the seal above 125 psi while performing the test.

4. Inflate the seal in accordance with the procedures in the applicable NAVSEA technical manual.
5. Check for leaks in the inflatable seal piping.
6. Close the air supply and monitor the air leakage at the pressure gage. The pressure drop should not exceed 5 psig in 15 minutes for a new seal and 30 psig in 15 minutes for an in-service seal.
7. Open the seal drain valve and drain the seal cavity.
8. Measure the water leakage past the inflatable seal by collecting any water dripping from the drain line. Water leakage should be near zero to less than 1 pint per minute, but never exceed 1/2 gpm.
9. Clean and reinstall the shaft seal drain plug and shut the drain valve.
10. After testing, relieve the air pressure and disconnect the air supply from the inflatable seal.
11. Shut the low-pressure air supply line drain valve.
12. Remove ″out of service″ warning signs, notify Central Control that testing has been completed, and fill the CO_2 bottle if necessary.

244-6.5.7 PIPING SYSTEMS. The two main stern tube seal piping systems are the shaft seal water system and the air system to the inflatable seal assembly. The ship's seawater system supplies the seawater to lubricate the stern tube bearing and cool and lubricate the seals. The ship's LP air supply or CO_2 storage bottles supply the air to the inflatable seal. Typical air and seawater piping arrangements for the Crane MX9 is shown in Figure 244-6-21 and for the EG&G mechanical face-type stern tube seals, in Figure 244-6-22. Figure 244-6-23 shows a typical air and water piping arrangement for a Syntron rubber-lip stern tube seal.

244-6.6 SURFACE SHIP BULKHEAD SEALS

244-6.6.1 GENERAL. Bulkhead seals are located where the main shaft passes through watertight bulkheads to minimize leakage in the event of compartment flooding or seal work spaces during firefighting. Some ship classes also impose airtight restrictions on bulkhead seals. This enables compartments protected by the collective protective system (CPS) to maintain a slightly higher air pressure for protection during chemical, biological, or radioactive (CBR) attack. The airtight bulkhead seal also prevents the firefighting agent discharged in one compartment from leaking into another compartment. There are many bulkhead seal designs, depending on the seal's intended use. Most older class ships use packing-type stuffing boxes as bulkhead seals. Newer ship classes use various mechanical seal designs that may have features such as self-actuation or water lubrication. Because of the differences in the newer bulkhead seal designs, the seals must be installed, operated, and maintained according to the manufacturer's manuals.

244-6.6.2 MECHANICAL BULKHEAD SEAL

244-6.6.2.1 Description. Most mechanical bulkhead seal designs allow for automatic and continuous sealing action under flooded conditions. Certain models, however, require manual activation. Maximum water leakage rates differ with seal model and type. Refer to the applicable NAVSEA technical manual for seal leakage rates and testing requirements. Following are descriptions of an automatic and a manually activated bulkhead seal.

244-6.6.2.1.1 · The type-ND bulkhead shaft seal (Figure 244-6-24), manufactured by John Crane-Lips, is an automatically operated seal comprising a seal housing, diaphragm, O-cord, dirt excluder, Teflon spacer, and housing drain plug. All components are constructed of seawater-resistant materials and supplied in a fully-split configuration to make installation and maintenance easier without removing the shaft. The housing is the major cast component and is bolted to the bulkhead. Its functions include positioning the diaphragm, providing a secondary sealing element between the diaphragm and the housing, and acting as a pressure boundary element. Under normal operating conditions, both the diaphragm and O-cord turn in unison with the shaft, but once displaced axially along the shaft because of a pressure differential across the bulkhead, the diaphragm stops rotating because of the friction between the housing and the diaphragm face. The O-cord is then deformed into the diaphragm groove because of the higher pressure on one side of the seal and also becomes stationary. The O-cord now operates dynamically as the shaft rotates and the diaphragm likewise remains stationary. Once the pressure differential diminishes, the axial force holding the diaphragm against the housing also reduces, and the diaphragm begins to rotate. The O-cord is lifted out of its wedged position and returns to the center of the diaphragm groove when the pressure differential is removed and once again begins to rotate with the shaft. The dirt excluder and Teflon spacer allow for relatively large axial shaft movements while protecting the sealing elements from foreign matter. The maximum water leakage rates for the type ND seal is 1 pint per minute for newly installed diaphragm assemblies and 2 pints per minute for in-service diaphragm assemblies. This equates to air leakage rates of 4.2 cfm and 8.4 cfm respectively.

244-6.6.2.1.2 The Tyton TR 261 bulkhead seal (Figure 244-6-25) is a manually activated seal consisting of a base ring, retaining ring, seal housing, clamp ring, inflatable seal, spacer ring, O-ring, and a water inlet stem. The inflatable seal provides the sealing function and is clamped in the seal housing by the clamp ring. The base and retaining ring hold and the seal housing between them and the housing is free to slide up and down to accommodate radial shaft movements. A single self-aligning stop, mounted with an O-ring over the water inlet stem, prevents the seal housing from rotating. The maximum water leakage rate for the TR 261 bulkhead seal is 1/2 pint per hour.

244-6.6.2.2 Operation. Many makes and models of mechanical bulkhead seals are installed on ships throughout the fleet, and all operate in one of two modes: automatic or manual. The automatically operated seals have no operating controls or indicators, need no electrical or mechanical power, and startup and shutdown procedures do not apply. The manually activated seals, however, require external activation. The manually activated TR 261 bulkhead seal requires a pressurized water supply (40 psi maximum) and must be connected to the ship's fresh water supply at all times for operation. In the normal standby mode, the inflatable seal, which supplies the sealing function, is depressurized to clear the shaft, thus preventing wear and conserving fresh water. The valves supplying water to the bulkhead seal must be closed when the seal is not being used. In the event of flooding, firefighting, or CBR attack, the seal is activated manually by fully opening one of two globe valves, each located on opposite sides of the bulkhead, depending on which compartment is to be isolated. The operator must also ensure that the pressure regulator valve downstream of the inline filter is preset to 40-psi maximum operating pressure. To deactivate the seal, fully close the globe valve.

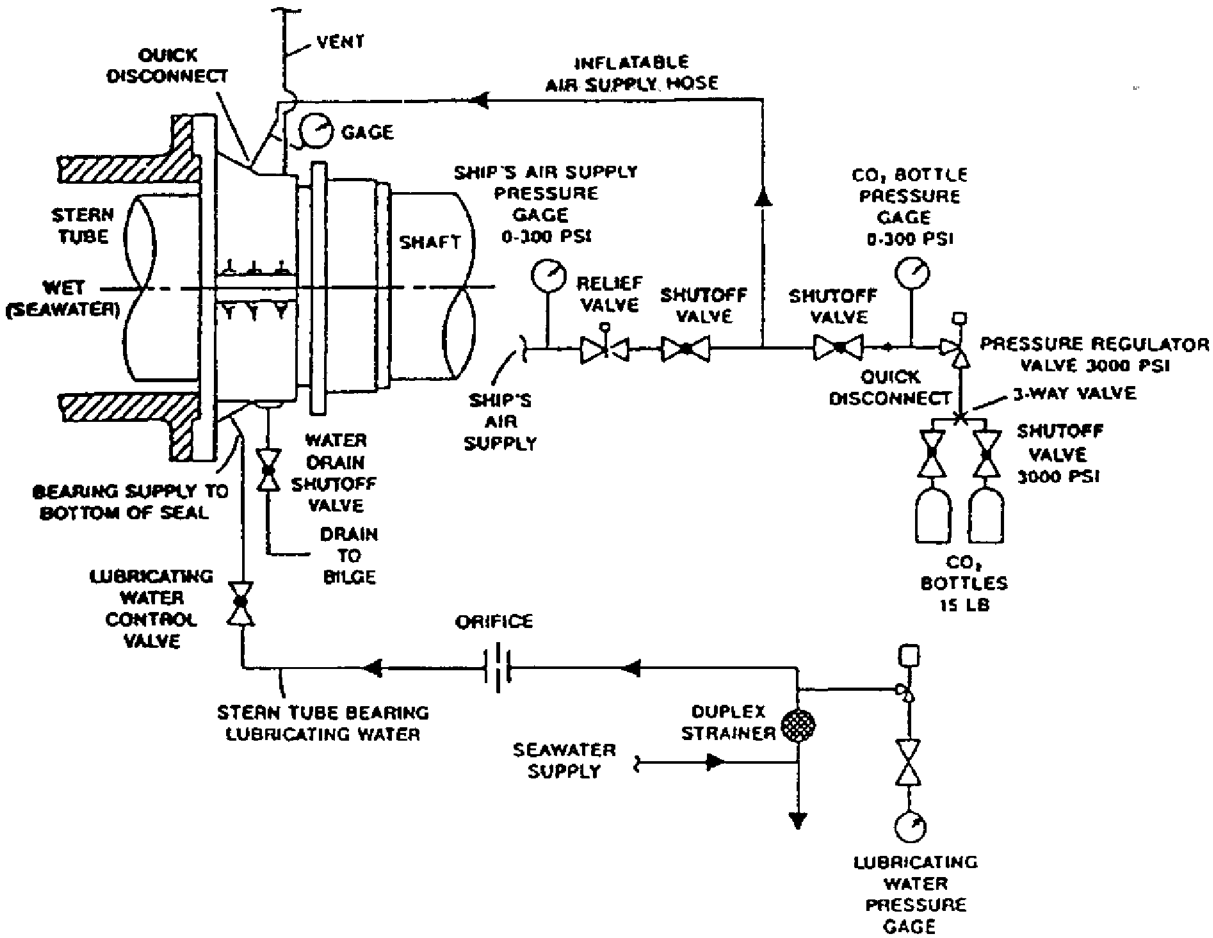


Figure 244-6-22 Typical Sealol Seal Air and Water Piping Arrangement

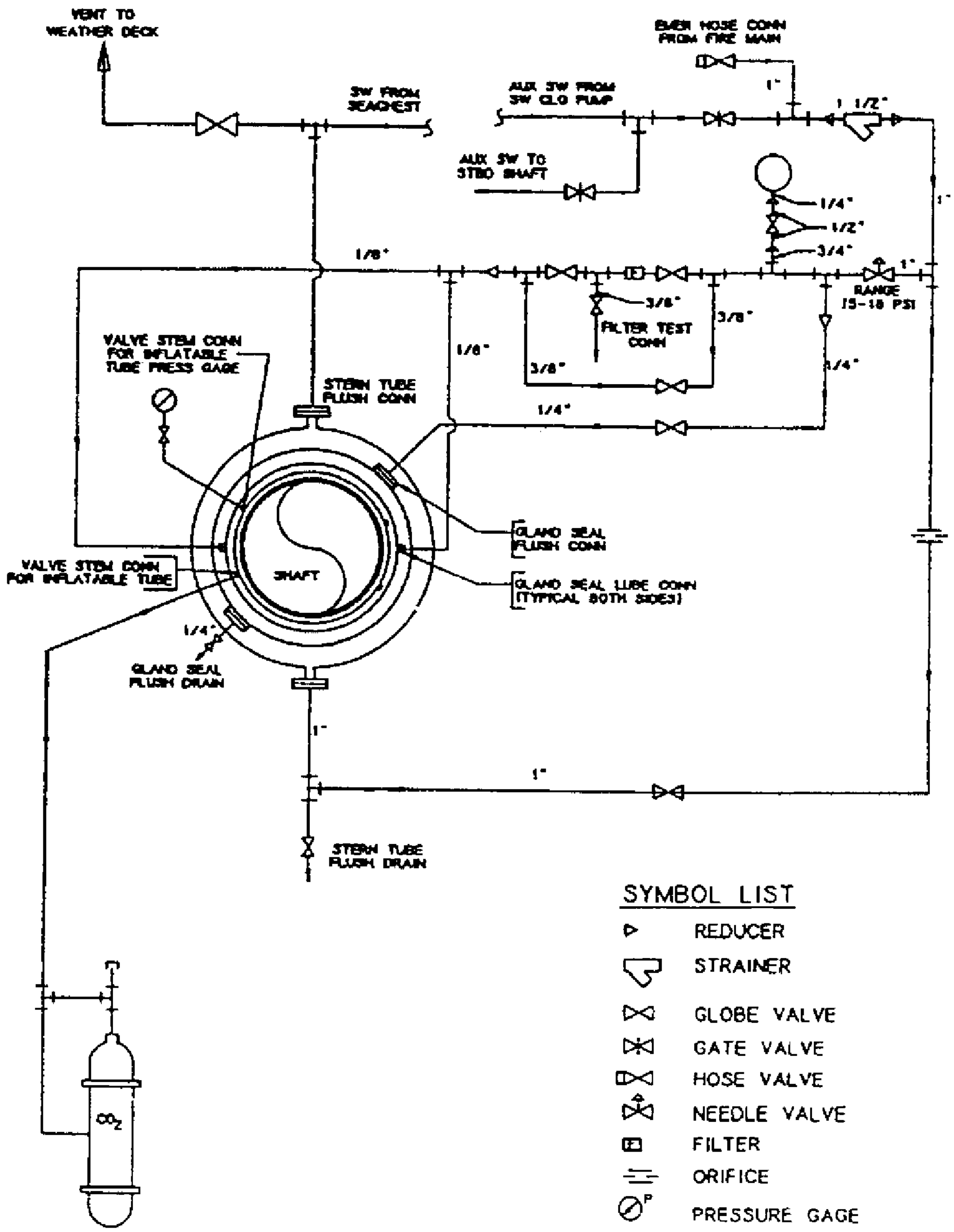


Figure 244-6-23 Typical Syntron Rubber-Lip Seal Air and Water Piping Arrangement

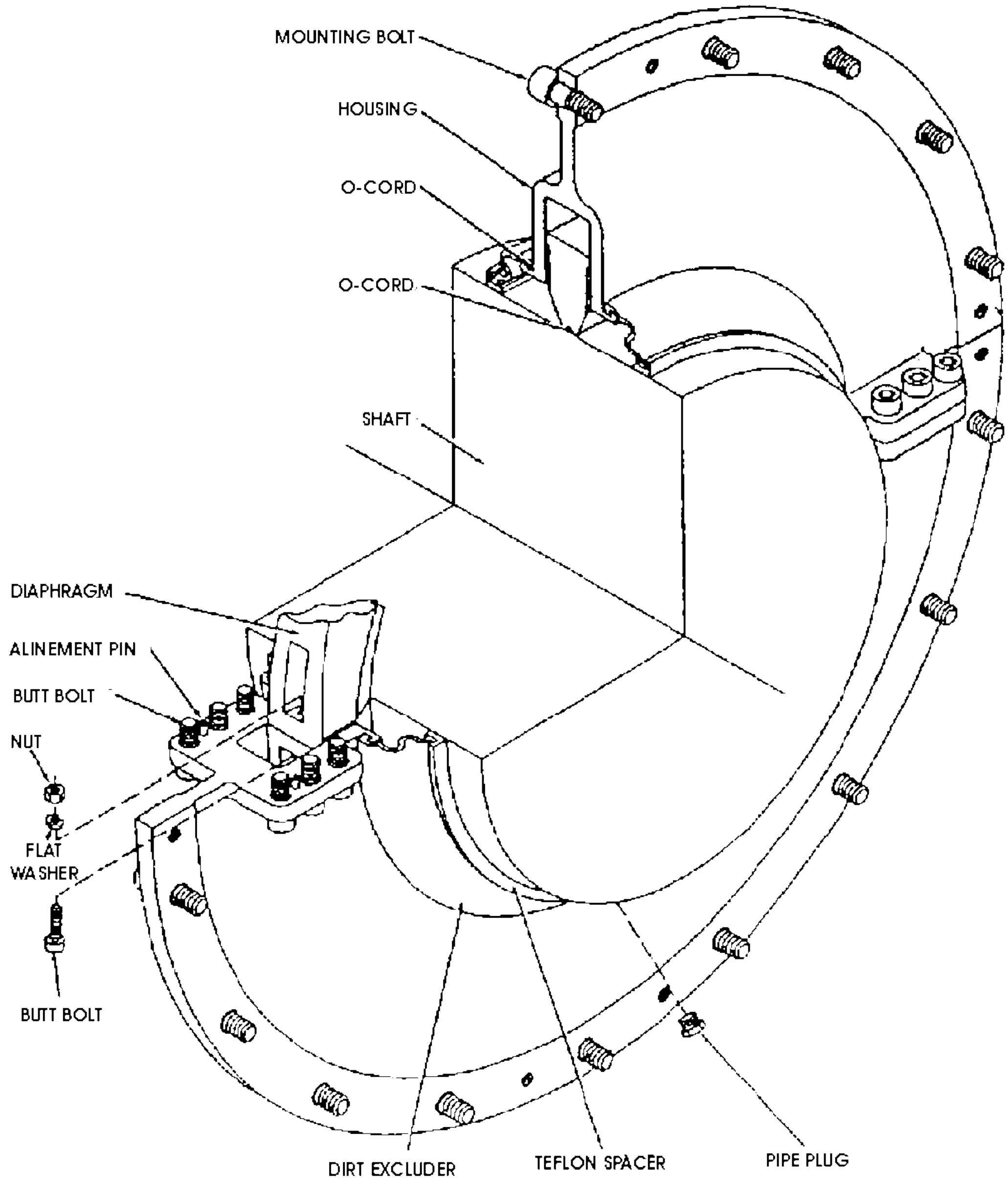


Figure 244-6-24 John Crane Type ND Automatic Bulkhead Seal

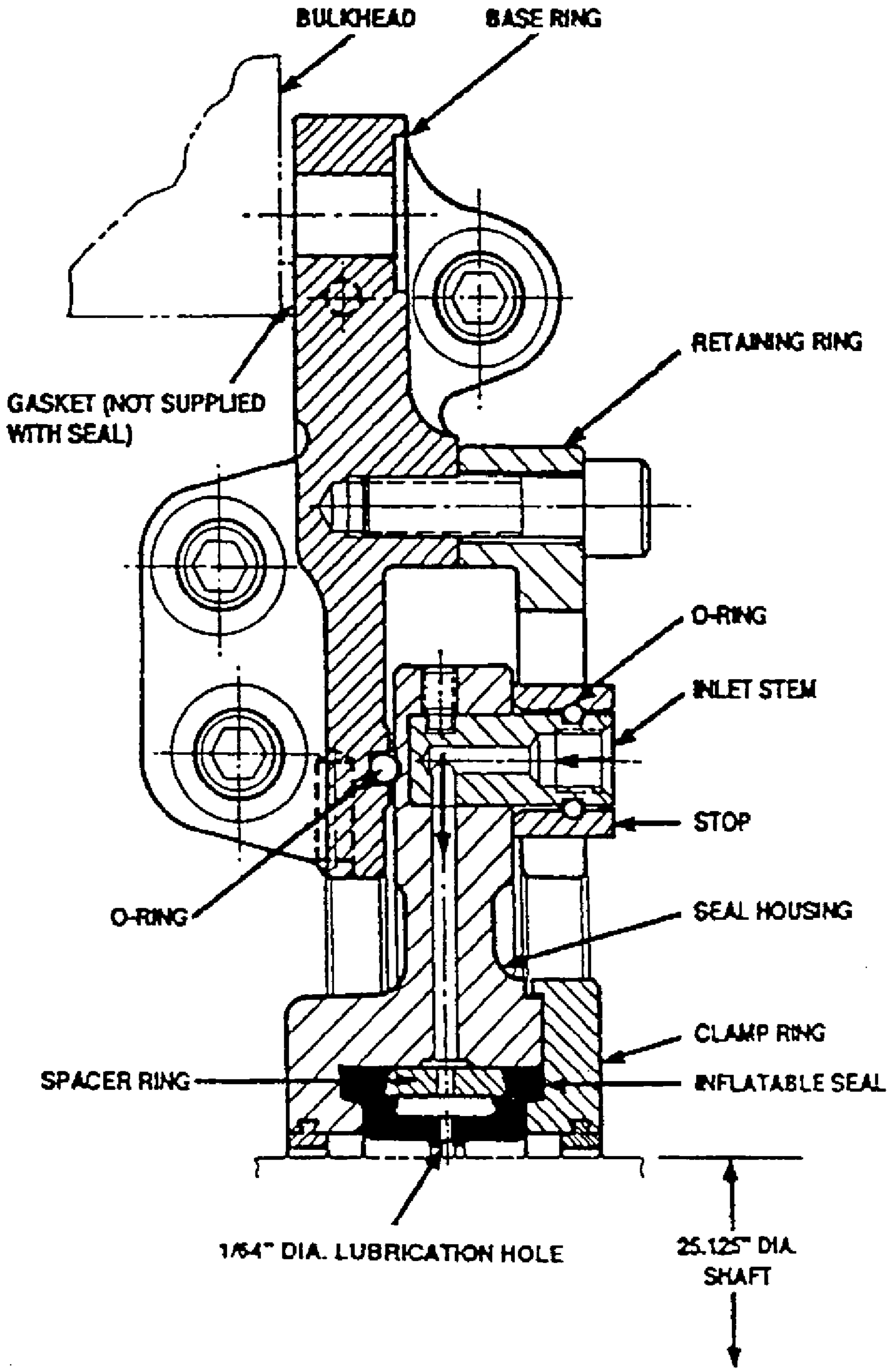


Figure 244-6-25 Tyton TR 261 Manually Activated Bulkhead Seal

244-6.6.2.3 Maintenance. Examples of the types of maintenance and how often they are performed for both the automatic and manual bulkhead seals follow.

244-6.6.2.3.1 Automatically operated mechanical bulkhead seals require preventive maintenance, mainly inspection, cleaning, and, if needed, lubrication. The CENTRAX type-B seal requires inspection and cleaning annually or every 5,000 hours, whichever comes first. Parts replacement is on an as-required basis as a result of inspection. The type-ND bulkhead seal requires cleaning of its exterior, a visual inspection of exterior components, and leakage testing every 24 months, before overhaul, or before deployment, whichever comes first. Consult manufacturers' manuals and the applicable PMS procedures for detailed maintenance instructions on each bulkhead seal model. The PMS procedures take precedence in case of conflicts.

244-6.6.2.3.2 Manually operated bulkhead seals also require periodic (usually monthly) inspection and performance testing to make sure that the seal is in proper working condition and ready for operation when required. Drydocking is not required for any of the scheduled maintenance tasks. Consult manufacturers' manuals and the applicable PMS procedures for detailed maintenance instructions on each bulkhead seal model. The PMS procedures take precedence in case of conflicts.

CAUTION

Make sure that no abrasive materials, dust, or dirt particles enter the seal housing during maintenance of the bulkhead seal. Abrasive material and/or dirt particles will score the shaft and reduce the life of the sealing assembly.

244-6.6.2.4 Seal Overhaul. 244-6.6.2.4 Seal Overhaul. When excessive leakage occurs, the bulkhead seal may be at the end of its useful life. Defective O-rings, deteriorated inflatable seals, or cracks and fractures in other major seal components can also cause excessive leakage. Corrective maintenance consists of replacing the seal at the intermediate or depot level. Bulkhead seals are typically overhauled every 4 years. However, the periodicity of type-ND bulkhead seal overhauls is condition based as determined by the leakage measured during testing of the seal; leakage in excess of the maximum allowable criteria warrants an overhaul. (See paragraph 244-6.6.2.1.1 for leakage criteria.) The applicable NAVSEA bulkhead seal technical manual contains comprehensive inspection and repair instructions to be utilized during overhaul as well as a material list of those parts typically requiring replacement. Seal removal and installation instructions are also contained in the applicable NAVSEA technical manuals for bulkhead seals.

244-6.6.2.5 Troubleshooting. Mechanical bulkhead seals are designed to operate without needing any operator adjustments or realignment. Some of the most common problems are excessive water or air leakage, overheating, and noisy operation. A typical troubleshooting guide for the type-ND bulkhead seal is provided in Table 244-6-15. Other bulkhead seal models require checking the water supply line filters, valves, and gages; and inspecting the inside of the seal for blockage if the seal overheats or fails to close around the shaft. Consult the applicable NAVSEA technical manual for troubleshooting procedures on a particular bulkhead seal model.

244-6.6.3 PACKING-TYPE STUFFING BOX BULKHEAD SEAL

244-6.6.3.1 General. Most packing-type stuffing box bulkhead seals have been replaced on newer ships with mechanical bulkhead seals. The packing-type seals are of simple design, requiring no shaft seal water or air systems and very little maintenance except for periodic repacking of the stuffing box. The seals are activated by manually depressing the packing against the shaft from either side of the bulkhead.

Table 244-6-15 BULKHEAD SEAL (TYPE ND) TROUBLESHOOTING

Symptom	Probable Cause	Corrective Action
Excessive Water or Air Leakage	Damaged O-cord	Replace O-cord
	Damaged diaphragm	Damaged diaphragm
	Seal full of water	Remove drain plug, drain water, and reinstall plug
	Damaged housing	Replace housing
Noisy Operation	Damaged or worn O-cord	Replace O-cord
	Damaged or worn diaphragm	Replace diaphragm
Rubber Smoking	Burned O-cord	Replace O-cord

244-6.6.3.2 Description. The packing-type stuffing box bulkhead seal usually allows the box to be aligned with the shaft by a tongue-and-groove arrangement, without seal disassembly. In most designs, the tongue-and-groove assembly has a grease fitting to allow the box to move more easily. Packing is installed on the inside diameter of the seal to provide a limited or controlled clearance with the shaft during normal operation.

244-6.6.3.3 Operation. The stuffing box bulkhead seal is used (tightened) only in the event of compartment flooding or compartment air testing. Grease is never applied to the packing area under normal operation and shall be used only during compartment flooding to better seal the packing to the shaft.

244-6.6.3.4 Troubleshooting. Bulkhead seal problems usually occur because the clearance between the shaft and the stuffing box packing is insufficient, resulting in one or more of the following situations:

a. Lineshaft may be bound by the bulkhead seals. It is common procedure during new ship construction or overhaul to check the airtightness of a compartment by tightening the packing around the lineshaft and pressurizing the compartment. This procedure may damage the lineshaft unless a 1/16-inch shim is installed around the shaft before tightening the packing to ensure proper clearance, as shown in Figure 244-6-26. Otherwise, the seal will have to be repacked after the test because just loosening the packing bolts will not free the shaft. Also, the packing may grip the shaft as the packing deforms over its service life. Merely loosening the bolts will not free the shaft in this instance. New packing should be installed so that it is free of the shaft.

b. The shaft may grip at the bulkhead seal at any speed and at different circumferential locations during shaft rotation. When gripping does not repeat regularly, this is called stick-slip. It is best to replace the seal when shaft stick-slip occurs.

c. Bulkhead stuffing boxes can also cause extreme shaft runout. If only one area on the shaft rubs the packing and rubs hard enough to overheat, the shaft will bow and a severer rub will result. If the bulkhead stuffing box is next to the reduction gear, the shaft bow can be so severe that the reduction gear journal lifts out of its bearing. If this condition occurs, remove the packing, cool the shaft with air blowers or other suitable means until the temperature is equalized around the shaft, and repack the stuffing box as described in paragraph 244-6.6.3.5.

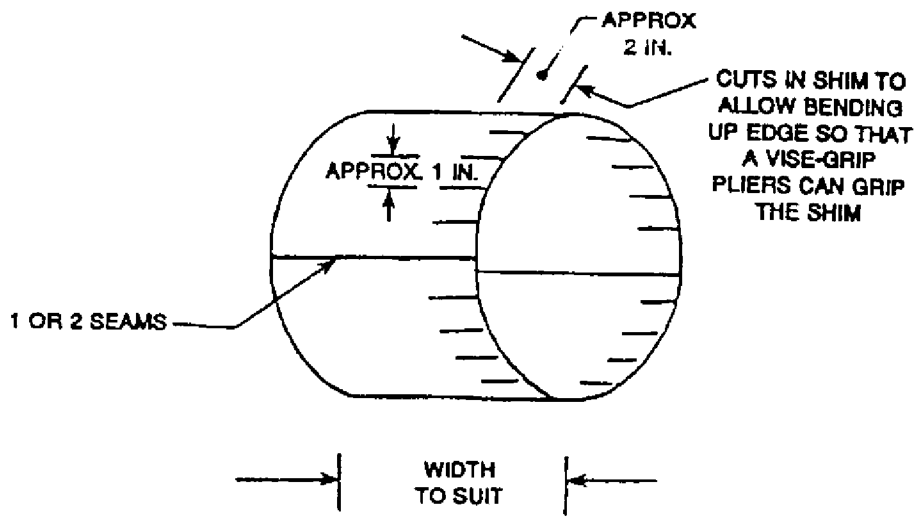


Figure 244-6-26 Packing Installation Shim

244-6.6.3.5 Repacking the Stuffing Box. Repack the stuffing box as follows:

1. Remove the existing packing and clean the antirotation grooves (usually four per box). Review the applicable drawing for the correct packing size. Use micrometers to determine that the stuffing box is centered within 1/16 inch around the shaft (all readings 90° apart; both sides of the bulkhead agree within 1/16 inch).

2. To be sure the final clearance between the packing and the shaft is at least 0.040-inch, install 1/16-inch shims around the shaft (use two shims, one on each side of the bulkhead). Hold the shims in place with a large hose clamp. The shims should be long enough to be gripped with vise-grip pliers (Figure 244-6-26). Make shims of a soft material such as tin, aluminum, copper, or gasket material.

3. Measure the distance between the shim and the stuffing box inside diameter to determine the required packing thickness. If required, cut the packing ring long enough to allow a 1/8- to 1/4-inch interference (long) as measured with the packing seated against the bore of the box to allow for shrinkage. The butt end should be seized (wrapped with twine) to prevent unbraiding and to ensure an effective butt joint.

4. Install the first ring of packing from one side of the bulkhead with the butt joint near the top. Lightly seat the first ring all the way back against the lantern ring, using a piece of wood to tap it into place. Be sure that the lantern ring is centered in the middle of the box. Install the first ring from the other side of the bulkhead. Alternately install additional rings, staggering the butt joints.

5. Install the gland ring and tighten the nuts to set the packing in the antirotation grooves. Back off the nuts to allow removal of the shim. Retighten the gland nuts hand-tight to hold the packing in place.

6. Remeasure the packing-to-shaft clearance to be sure the clearance between the packing and the shaft is at least a 0.040 inch.

WARNING

Do not apply grease to the packing area during normal operation. Apply grease only during compartment flooding to better seal the packing to the shaft. Applying grease may cause the packing and lantern ring to seal around the shaft, causing too much friction and heat.

244-6.6.4 COMPARTMENT AIR TESTING. If a compartment that has a bulkhead stuffing box requires air testing, operate the bulkhead stuffing box as described in Section IV of **NSTM Chapter 9880, Damage Control; Compartment Testing and Inspection.**

APPENDIX A

TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT(TMDER)

NOTE

Ships, training activities, supply points, depots, Naval Shipyards, and Supervisors of Shipbuilding are requested to arrange for the maximum practical use and evaluation of NAVSEA technical manuals. All errors, omissions, discrepancies, and suggestions for improvement to NAVSEA technical manuals shall be reported to the Commander, NAVSURFWARCENDIV, 4363 Missile Way, Port Hueneme, CA 93043-4307 in NAVSEA/SPAWAR Technical Manual Deficiency/Evaluation Report (TMDER), NAVSEA Form 4160/1. To facilitate such reporting, print, complete, and mail NAVSEA Form 4160/1 below or submit TMDERS at web site https://nsdsa.nmci.navy.mil. All feedback comments shall be thoroughly investigated and originators will be advised of action resulting therefrom.

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NAVSEA/SPAWAR TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT (TMDER)

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