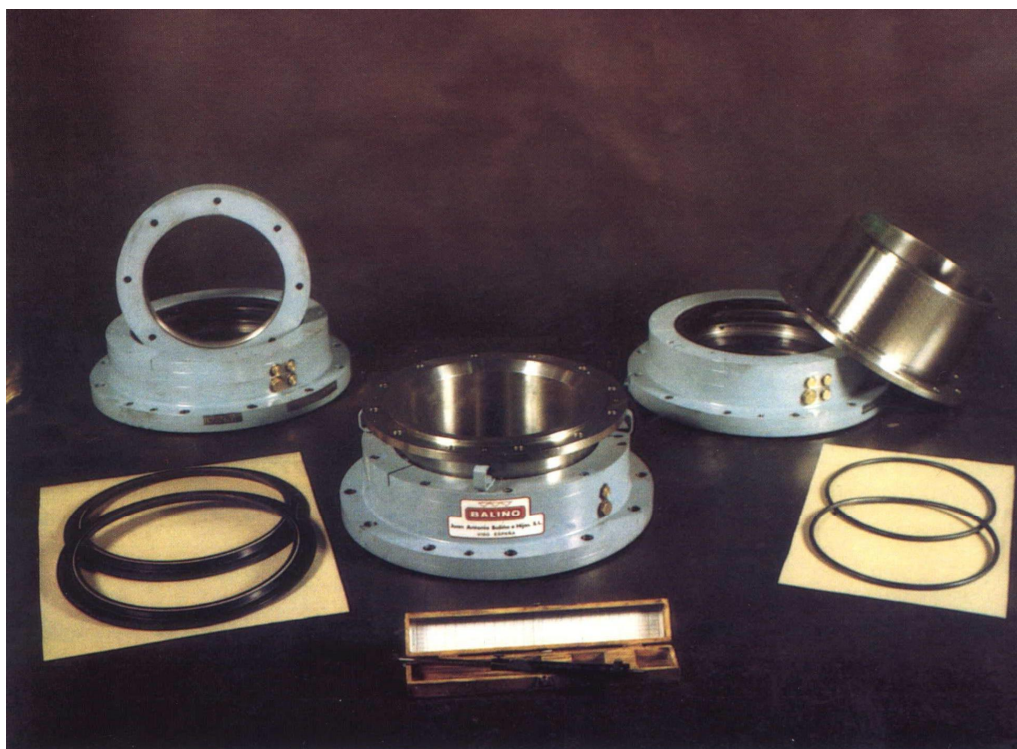


# **STERN TUBE SEALING**

## **MANELIP**

### **INSTRUCTION & INSTALLATION MANUAL**



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## **1. INTRODUCTION**

The equipment described in this manual and the materials selected are the result of many years of research and experience in this field

However, the care and attention paid during installation, testing, operations and maintenance, do to a large extent determine the long-term operational reliability of the equipment.

Thus, whilst it is our policy to allow the Installation and Maintenance of this equipment to be carried out by 3rd parties (in accordance with the guidance contained within this Technical Manual) we would always recommend that one of our Service Engineers is present to oversee any Installation or Maintenance.

When using this manual refer to the specific general arrangement drawing(s), delivered separately, which give the dimensions and data for the correct assembly and operation of the equipment.

For further assistance please contact:

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## **2. VESSEL SPECIFICATION**

When spare parts are needed, indicate the following data:

**VESSEL NAME.**

**SHIPYARD and NEWBUILDING Nº.**

**SIZE OF SEAL AFT and FORWARD (\*)**

**SERIAL NUMBER (\*)** It coincide with the drawing number

(\*) it can be read on the label located on the seal body

### 3. DESCRIPTION OF THE EQUIPMENT

#### 3.1. *AFT SEAL*

##### 3.1.1. **Operation**

The Aft seal assembly is of the lip-seal type with three sliding contacts between seal rings and the chrome steel liner.

The Aft seal ring (seal #1) points towards, and keep out, the seawater. It also prevents ingress of dirt, large particles and other foreign matter, which might damage the sealing ability of the centre seal ring.

The second seal ring (seal #2) also faces towards the seawater and prevents its passage into the stern tube.

The third seal ring (seal #3) points into the stern tube and prevents oil from passing into the seawater.

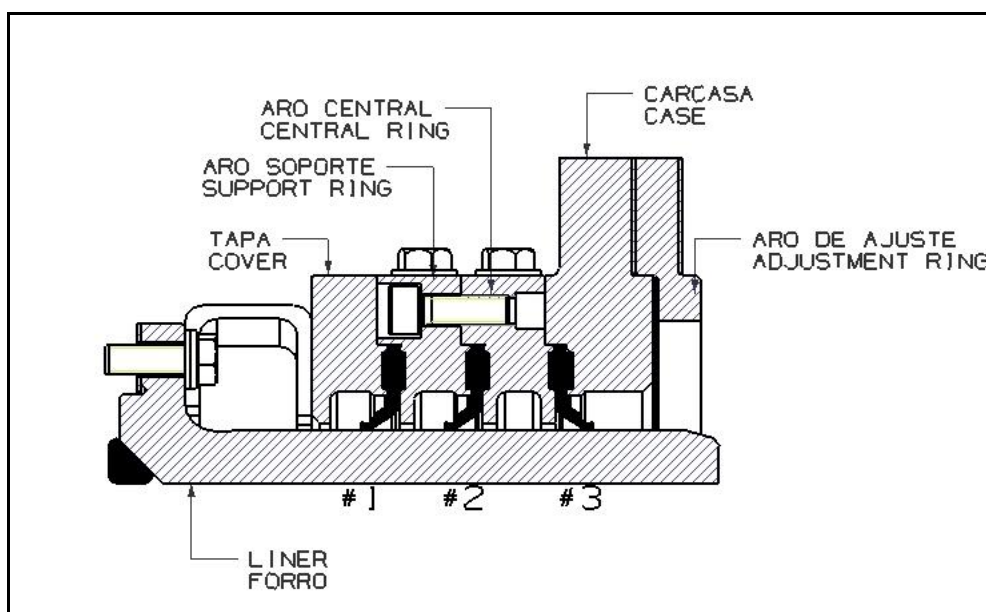
The sealing rings seal against the liner due to a combination of factors:

- The size of the bore of the seal ring is smaller than the O.D. of the liner. This plus the natural elasticity of the rubber causes it to grip the liner.
- The effect of water and oil pressures on the seal rings enhances this sealing effect.
- The garter spring (see Construction) around each seal ring further assists in maintaining an effective seal.

##### 3.1.2. **Description**

The Aft Seal comprises three major assemblies

- Three rubber seal rings.
- A metal housing or casings which hold the rubber seal rings
- A chrome steel liner, which rotates with the propeller and shaft



The metal Housing/Casing is made up as a series of rings, which are identified in order from the stern frame moving Aft, as:

- Adjustment ring
- Case
- Central ring
- Support ring
- Cover

The Three rubber Seal Rings are fitted between these metal housing/casing rings and bolted together. The clamp section (the root) of each rubber seal ring is securely fitted into the inner diameter of the metal rings and the small circumferential grooves in the inner surfaces of the same metal rings.

When firmly bolted and clamped together, this ensures an oil and watertight join between each ring.

The Liner is of a high quality chromium steel that is highly resistant to corrosion and wear

### **3.2. FORWARD SEAL**

#### **3.2.1. Operation**

The Forward stern tube seal is of the lip-seal type having two seal rings riding on a rotating liner. Both seal rings point toward the stern tube and assist in containing the oil therein.

The sealing rings seal against the liner due to a combination of factors.

-The size of the bore of the seal ring is smaller than the O.D. of the liner. This plus the natural elasticity of the rubber causes it to grip the liner.

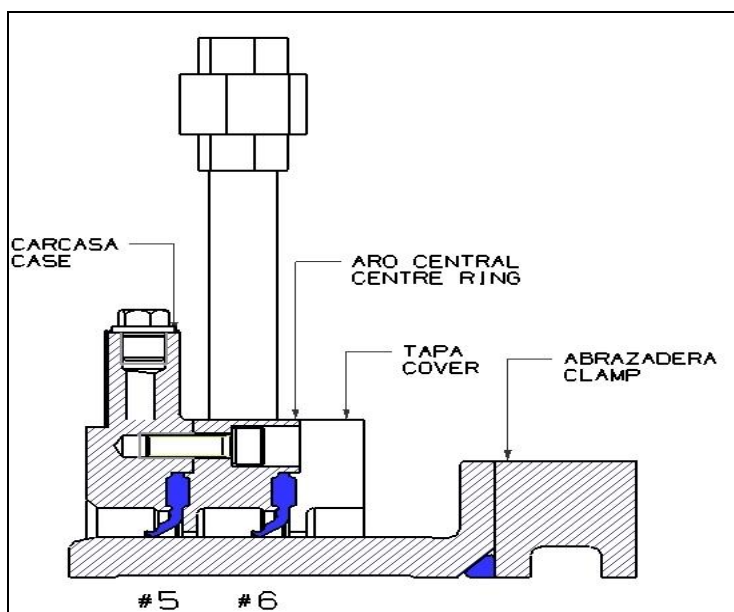
-The effect of the oil pressure on the seal rings enhances their sealing effect.

-The garter spring around each seal ring further assists in maintaining an effective seal.

#### **3.2.2. Description**

The Forward seal comprises four major assemblies:

- Two rubber seal ring
- A metal housing or casing which holds the rubber seal rings
- A liner which rotates with the shaft
- A clamp ring, which holds the liner



The metal Housing/Casing is made up of a series of rings, which are identified in order from the stern tube moving forward, as:

- Case
- Centre ring
- Cover

As with the Aft seal, the seal rings are fitted between the casing/housing rings to form an oil tight seal when the assembly is bolted together.

The intermediate ring system incorporated an oil circulating system as standard to improve the circulation of oil between sealing rings #4 and #5.

The Liner material provides excellent wear resistance and lip lubricating properties.

The Split Clamp ring, when fitted, clamps to the shaft providing rotation to the liner, which is bolted to it.

## **4. STORAGE AND HANDLING**

### **4.1. EQUIPMENT**

All assemblies and components have been carefully inspected before shipment.

Each component is suitably packed and protected to prevent damage or deterioration during shipment, transit or storage.

Goods should be examined on receipt to verify the contents and their condition.

BALIÑO should be immediately advised of any damage or discrepancy in the scope of supply. Damage clearly due to handling in transit should be notified to the carrier (copy to us).

Keep goods in their original packing until just prior to installation in order to best protect them.

Until instructed to do so, do not remove the transit strap fasteners (clamps) that hold the Aft seal cartridge in place or the Fwd Seal transit bolts, which lock the liner flange to the cover.

If goods have to be stored for long periods, they should be kept in their original packing, stored flat and unobstructed (i.e. nothing stored or stacked on top on the bearing) in a dry, cool and dark environment.

Care must be taken during handling to prevent any mechanical damage occurring due to dropping, crushing etc. Particular care and attention should be paid to the running surfaces of the liners and the rubber seal rings. Any protective coverings, tape, plugs etc. should only be removed when the seals are ready to be installed.

### **4.2. SPARE PARTS**

It is not recommended that spare seal rings are kept onboard. They should be ordered in advance of a known requirement. However: if seal rings (or any other spares) are stored onboard for long periods, they must be kept in their original packing, stored flat and unobstructed in a dry, cool and dark environment. To ensure a satisfactory life expectancy for any rubber components, exposure to sunlight, ultraviolet light and ozone should be prevented.

If liners are to be stored over a long period, it is best that they are stored on a horizontal surface, resting on the mounting flange.

#### **4.2.1. Service**

It is recommended that a Service Engineer is present to ensure proper assembly and on site fitting of the seal assembly and for any maintenance procedures.

It is possible to replace worn or damaged seal rings in both seals by bonding without removal of the propeller or the shaft. This is a specialised job, requiring specialist tooling and can only be carried out by a qualified Service Engineer. If you wish to take advantage of this service, the customer must ensure the availability of the following:

- New seal rings.
- Substantial staging.
- 220 Volt supply for bonding equipment.
- Sufficient lighting
- Good workshop/machining facilities.

- Vessel to be dry docked or shaft needs to be a minimum of 0.5 m above the waterline.

***IMPORTANT***

Where the forward seal is being overhauled, it is essential to refer to the ***IMPORTANT*** note at the end of section 8.2. regarding the need to re-check the centralisation of the case assembly).

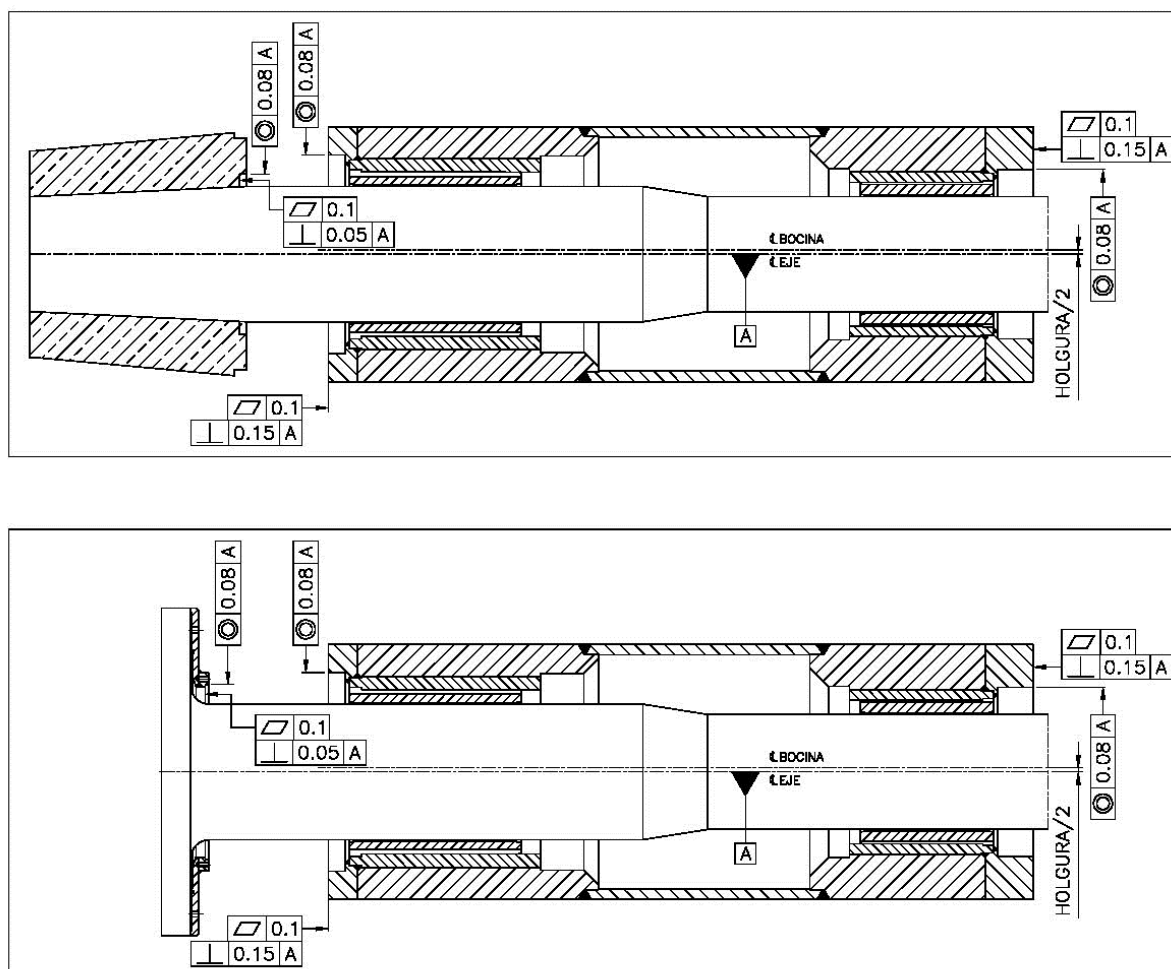
Every time the tail shaft / screw shaft is de-coupled and/or withdrawn, the centralisation of the forward seal case assembly must be re-checked, (with the vessel afloat).



## 5. PREPARATIONS

Remove all burrs and sharp edges over which the seals (inboard and outboard) must pass. The surface of the shaft, local to each seal, should be clean and to the specified diameter and tolerance.

### 5.1. STERN TUBE / STERNFRAME AND PROPELLER MACHINING.



**Figure 1**

In the figure 1 is shown the condition for concentricity, perpendicular and flatness required for the stern tube, both in aft and forward side.

#### 5.1.1. Measurement of spigot and surface tolerances of the Stern tube/Sternframe in way of the forward and aft seals

**Note:** The deflection has to be measured at the position of the outside diameter of the flange of the forward and aft seal. Place the propeller for every measurement in the same position, e.g. blade 1 at the top.

Where the Forward and/or Aft seal casing flange is not a tight spigot location, (i.e. a loose spigot fit or none at all) then the references to spigot measurement above should be ignored. However, in these circumstances, the centralising and checking of the seal assembly itself referenced in section 8.3 plus elsewhere in the manual become even more important.

### 5.1.2. Eccentricity of propeller shaft, and checkpoints concerning stern boeing.

When the propeller shaft is in the stern tube bush (es), it will settle at the bottom of the bearing, by half the total bearing clearance. Thus, if the bushes and seal casings are concentrically arranged, the seal rings and propeller shaft/liner will move in an eccentric manner. Non-concentric running of the shaft within the seal may lead to oil leakage and excessive wear on the lower half of each seal ring. The shipyard must decide on the best method to overcome this, and re-align the shaft to ensure concentricity within the Fwd and Aft seals.

Some options to consider are:

- Machine the bearing bore eccentric to the O/D by half its clearance.
- Bore the stern tube seal spigot location eccentric to the stern tube bearing centre by half the bearing clearance.
- Machine the Aft seal spigot eccentric by half the bearing clearance.
- If resin is used, raise the bearing sleeve by half the bearing clearance.

**Note:** Where the seals are either loose spigot mounted or have no spigot location at all, the standard procedure of centralising the liner to the shaft (which will be sat in the bottom of the stern tube bearing) and then centralising the seal casing to the liner will ensure the concentric running of the shaft with the seal.

### 5.1.3. Measurement of spigot and surface tolerances for the forward face of the propeller.

After fitting the propeller, measure the part where the Aft liner is attached to the propeller boss, (in case of a fixed pitch propeller), or flange covers, (in case of a controllable pitch propeller), as shown on figure 1.

Where the Forward and/or Aft seal casing flange is not a tight spigot location, (i.e. a loose spigot fit or none at all) then the references to spigot measurement above should be ignored

Ensure that all mating faces with the seal, i.e. the end face of the stern tube/housing, the forward face of the propeller boss f.p.r. and the propeller shaft are machined to the following parameters:

# Surface finish	0.8 mm Ra or finer	- Propeller Boss /Stern tube/ Housing. - Shaft in way of O-cord
# Flatness	0.1 mm	- Propeller Boss/Stern tube -Housing.

All mating surfaces should be clean with no debris or old gasket material, etc. present. The shaft (In way of the forward and aft seals) should be lubricated with clean oil just prior to the installation of the seals.

The propeller boss/f.p.r. and the stern tube mounting surfaces must be machined to provide the mounting holes detailed on the respective seal G.A. drawings.

The aft end of the stern tube must be machined if indicated on the seal or system drawing to provide the pipework connections/passages for any oil supply/vent and drain lines.

It is essential that the critical surfaces of the, liner and seal rings are protected at all times during storage, transit and installation to promote correct operation of the assembled unit. Even minor damage to these surfaces can promote leakage.

The lubrication piping/system should be installed as per the system diagram. The Header Tank and other tanks should be installed in accordance with the guidance contained in the system diagram and given in section 6 (Head Tank Location).

After the assembly is finish, in both of the next cases described, a measurement of the shaft wear down should be carried out with the tool supplied as it is described in the section 8 of this manual.

After mounted the seals must be protected from dust and sand while the vessel is in the shipyard, both during construction or in dry dockings.

## 6. HEAD TANK LOCATION

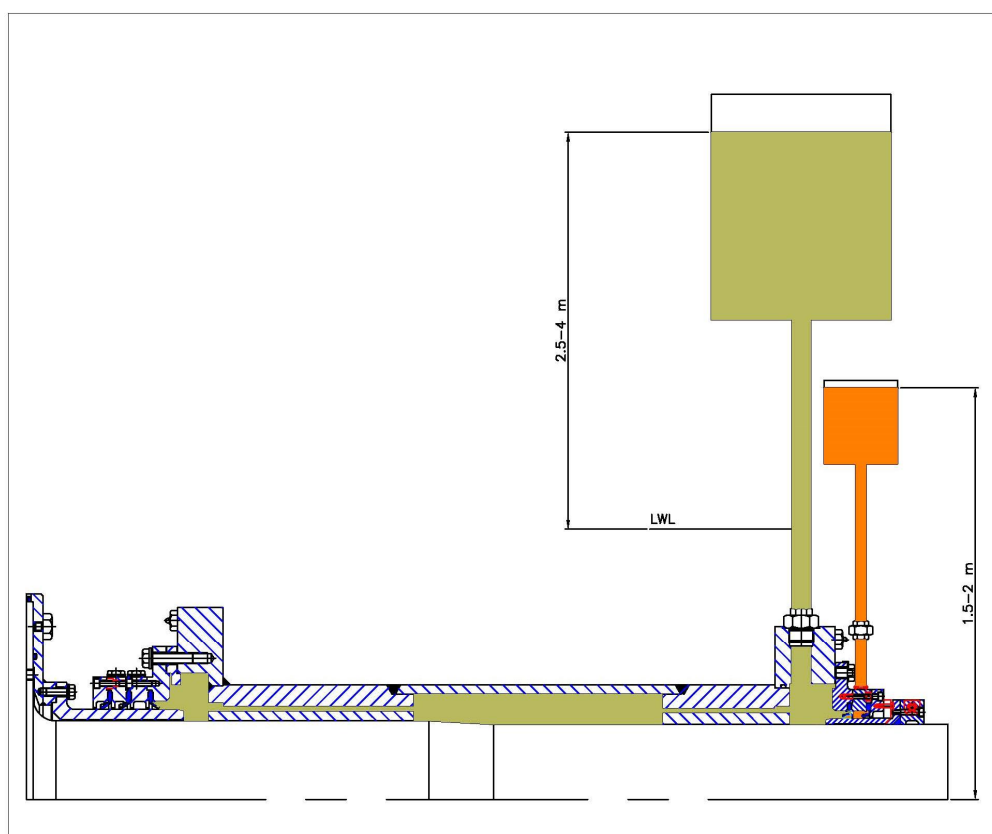
### 6.1. TANK HEIGHTS

The main header tank must be positioned at a height of approximately 2.5 to 4 metres (to the surface of the oil) above the Full Load water line

This height “H” is usually expressed at  $H = 1.2 X + (2.5-4 \text{ m})$  where X = the distance from the full load water line to the Propeller Shaft centre line.

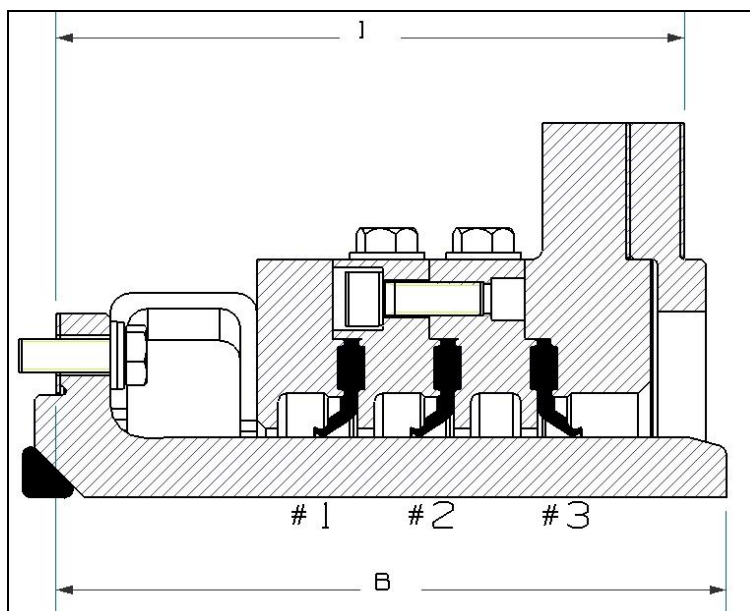
**Note:** For deep draft vessels, where X (the distance from the shaft centre line to the load water line) equals or exceeds 10 metres, two stern tube header tanks should be provided.

The forward seal lubricating tank must be positioned at a height of approximately 1.5 to 2 metres (to the surface of the oil) above the propeller shaft centre line.

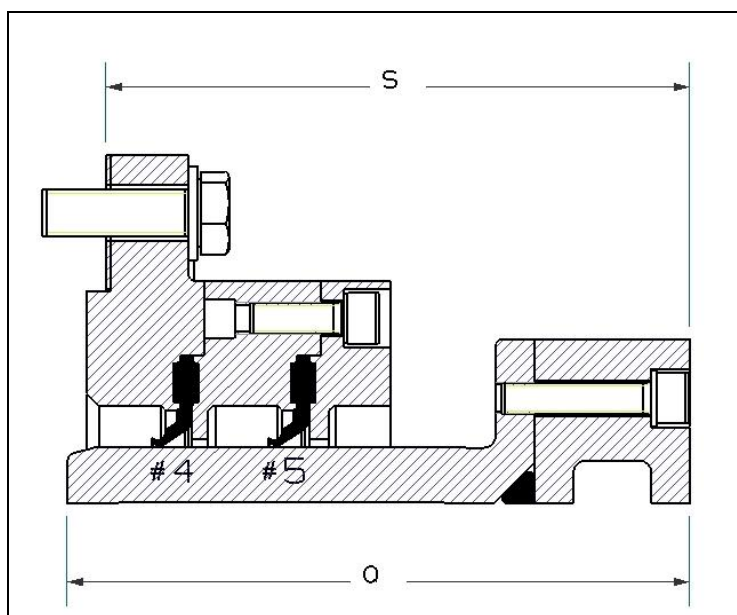


## 7. SPECIAL INTERFACING REQUIREMENTS

The Aft seal is designed to fit into a specific axial space (referred to on the G.A.drawing).



The Forward seal does not require a specific axial space; rather it requires space for installation as referenced on the G.A. Drawing.



Three areas of interfacing are relevant:

### **7.1. THE BORE/I.D. OF THE FORWARD AND AFT SEALS TO THE SHAFT**

The seals will be supplied with the bore of the liners and the forward seal clamp, sized to suit the stated shaft diameters.

### **7.2. THE PROPELLER BOSS TO THE AFT LINER**

This interface provides the drive for the liner. The propeller boss/f.p.r should conform to the requirements of the General Arrangement Drawing and section 5 of this manual.

Tapped holes to connect the liner to the propeller boss/f.p.r. must be provided and any other holes/recesses suitably filled.

The Liner will usually be spigot located to the propeller (but this is not always the case).

**IMPORTANT:** The controllable pitch propellers, that are lubricated with the stern tube oil, requires not O-Ring mounted between the aft liner and the shaft flange to permit the oil pass through a space, specially designed for these cases, between the liner and the shaft towards the propeller hub.

Once the liner is bolted to the shaft or the propeller and the adjusting ring / spacer mounted, the shaft cannot be moved more than 15 mm. towards aft from its working position, otherwise the liner should get out from the most forward lip seal #3 and can cause damages when the shaft is placed in position again.

To move the shaft more than 15 towards aft, the liner must be dismantled and the transit clamps mounted.

### **7.3. THE STERN TUBE TO THE SEALS INTERFACES (INBOARD AND OUTBOARD)**

The surface of the stern tube and spigot locations (where provided) should conform to the requirements of the General Arrangement Drawing and the section 5.1 of this manual.

Tapped holes to connect the aft and forward seals to the stern tube must be provided, and the spigot recess bores for both seals must be machined as detailed on the G.A. Drawings.

Any other holes/recesses must be suitably filled.

**IMPORTANT NOTE:** If the Seals are being fitted to a shaft that will run in non-metallic bearings, please refer to section 8.6. before commencing Installation procedures.

## 8. INSTALLATION

### 8.1. *AFT SEAL ASSEMBLY*

***(Note: Refer to the G.A. drawing)***

The complete aft seal will be supplied as a cartridge, completely assembled with the liner held in position by steel transit strap fasteners. These transit straps should not be removed until the seal casing flange has been mounted on the stern tube/frame of the vessel and the propeller is within approximately 25 mm of its final position.

Check the accuracy of the spigot (where applicable) and stern tube surfaces as per section 5.

Mount the Aft seal assembly to the stern tube. Ensure that the oil inlet & air vent plugs are at the "TOP" position (either side of TDC) and that the joint is lightly greased on both sides and correctly positioned on its spigot.

Tighten the casing bolts in a progressive, even and diagonal sequence to achieve the torque as shown on the G.A. Drawing.

Check surface accuracy of the forward end of the propeller boss or flange protecting ring, according to section 5 and ensure that the liner joint is greased and fitted in position over the shaft. In most (though not all) FPP installations, an O-ring is fitted behind the liner flange to seal it to the propeller boss and the shaft. In most (though not all) CPP Installations, the O-ring is omitted to allow oil to flow under the liner and through to the propeller hub.

If required (shown on the G.A. Drawing), fit the propeller O-ring over the exposed shaft so that it will be positioned between the propeller and the liner flange.

Move in the shaft and/or propeller until the fwd face of the propeller boss is within approximately 25 mm of its final position.

Remove the (transit) strap fasteners and leave onboard with the Chief Engineer.

***IMPORTANT:*** Care must be exercised so that the liner is not drawn out of the assembled seal, in order to prevent damage to the sealing rings.

Bolt the liner to the propeller (ensuring that the liner spigot location fits fully and evenly into the recess bore of the propeller boss) with the bolts as shown, on the G.A. Drawing. Again tighten the securing bolts in a progressive even and diagonal sequence to achieve the torque specified on the drawing. The propeller O-ring if fitted will now be compressed between the shaft, the liner and the propeller boss, forming an oil and water tight seal at this point in conjunction with the joint behind the liner flange.

After the shaft is in its final position with measurements confirmed, then if the Aft seal casing is not a tight spigot location fit to the stern tube, parallel pins or dowels should be used to maintain the position of the housing to the liner once it has been centralised.

Pilot holes will normally be provided in the Casing Flange if it is not spigot located. Using these, drill through the case and into the stern tube

Fix the casing flange in it's centralised position using suitable dowels or parallel pins, then a wear down reading should be taken as described in Section 8.4.

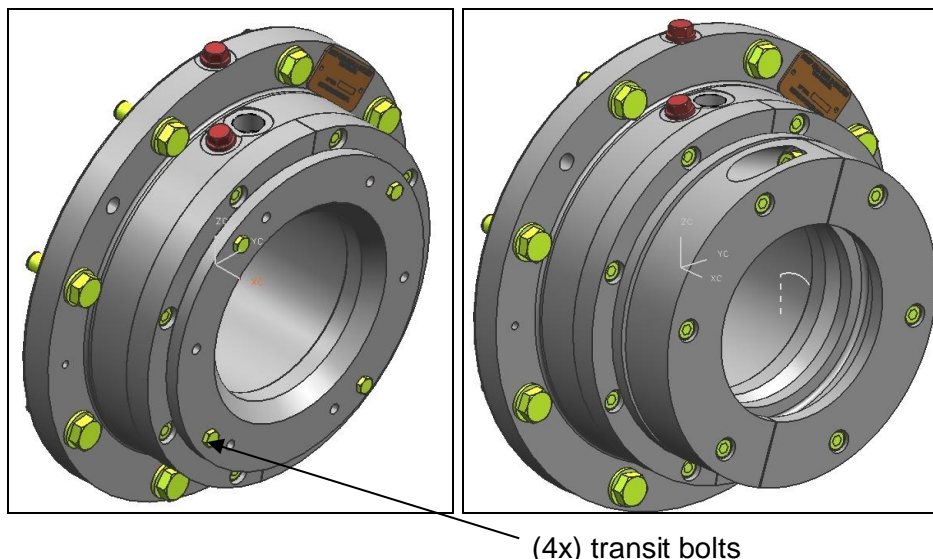
Thoroughly flush the cavity between the fwd. and centre seal rings with oil.

Fill the seal and stern tube according to Section 8.5.



## 8.2. FORWARD SEAL ASSEMBLY

(Note: Refer to the G.A. drawing)



The forward seal is normally supplied with the liner assembled into the spigot of the housing cover by 4 small transit bolts and the clamp provisionally screwed to liner to avoid losing it during transportation, but the clamp must be removed before assembly.

The alignment of the forward liner is critical.

A combination of the spigot fit of the liner flange to the spigot recess in the housing cover and the close fit of the liner on the shaft, are normally used to automatically centralise the seal assembly.

For this reason transit bolts for the liner must not be removed until the seal casing has been mounted on the stern tube.

The Inboard seal is supplied assembled and ready to fit as a cartridge.

Check the accuracy of the stern tube mounting surface (including the spigot if one has been provided) according to Section 5.1. (A spigot location is not normally provided for an Inboard seal, but if it is, the accuracy requirements are the same as for an identically sized aft seal).

Slide the Fwd. seal assembly with its joint, O-ring & clamp-ring, along the shaft.

Because of the normally small clearance between the liner and the shaft, the housing being fixed to the liner by the transit screws, is already centralised to the shaft (see above).

Do not disassemble the liner from the housing at this stage.

Grease the joint and O-ring before fitting.

Mount the casing flange to the stern tube (and spigot location if provided) using the bolts and spring washers. Tighten the screws evenly and diagonally to the torque on the G.A. Drawing.

Do not secure the casing flange with parallel pins/dowels at this stage.

See **IMPORTANT** note regarding re-checking case centralisation.

Tighten the clamp-ring sufficiently in its final position (Refer to the G.A. Drawing for the S (Setting) distance). Ensure that an even gap is maintained at both butts.

Disassemble the liner from the cover by removing the small transit bolts and moving the liner forward.



**IMPORTANT:** Take care that the liner is not drawn out of the assembled seal, as the sealing rings may be damaged if this is allowed to happen.

Mount the liner to the clamp-ring. Check the measurement points according to section 7.3.

If necessary, adjust the seal axial length. Tap the clamp-ring with a lead (soft) hammer and wooden block, moving the clamp-ring until the specified axial seal length is achieved. Re-tighten the clamp-ring on completion.

Also if necessary, any radial run out can be corrected by turning the shaft until the part of the liner which is furthest from the shaft, points straight down. Place a wooden block against the liner flange outside diameter and use a small hand jack to lift the liner until it is centred. The bolts can be then tightened and the jack removed.

Finally tighten the clamp butt screws and the liner/clamp mounting screws to the torque values as shown on the G.A. Drawing. Ensure that the gaps at the clamp ring butts are evenly maintained.

Mount the Fwd seal gravity tank.

Fill the Fwd seal according to section 8.5.

**IMPORTANT:** Re-checking case centralisation.

The forward seal casing is centralised to the shaft on installation as described earlier by fitting and positioning the casing flange to the stern tube whilst the liner is still fitted into the tight spigot location in the cover. The liner is thus centralising the whole forward seal assembly to the shaft by virtue of the close fit of the liner bore to the shaft. This is normally done in a dry-dock. Due to the fact that the shaft to stern tube bearing/stern tube positional relationship can change when the vessel is afloat, the following must be understood.

The seal must be centralised to the shaft in the normal manner.

This should only be done with the shaft in its final operating position and fully coupled to the intermediate shafting.

Any changes in the shaft line position may impact on the centralisation of the forward seal and in extreme cases could cause severe damage to it.

After installation with the shaft line fully installed, coupled and aligned, it is important that the centralisation of the housing to the liner O.D. is re-checked. (Section 8.3., Forward Seal, measurement B. This should be done once the vessel is afloat, in case hull distortion has affected the centralisation.

This check must be done as soon as the vessel is floated and "before" the shaft is turned.

If the seal is found to need re-centralisation, this should be done and the liner re-checked regarding its alignment/run-out etc. (Section 8.3., Forward Seal, measurements C. & D. "before" the shaft is rotated.

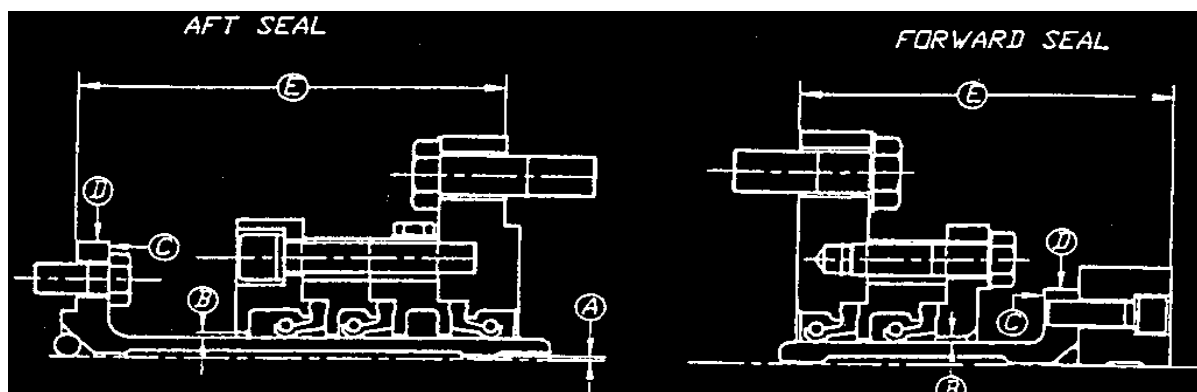
Once the case and liner centralisation/alignment have been re-checked, then drill the locating parallel pin/dowel holes using the pilot holes in the case flange and fit suitable pins/dowels to fix the position of the case.

If the timescale between seal installation and float up/out prevents the attending engineer from being present when the vessel is floated, it is essential that the senior customer technical representative is advised of what must be done. They must be advised of the reasons for the re-check and how to conduct it, the accuracy required and how to re-centralise/re-align the seal if required.

### 8.3. MEASUREMENTS AT INSTALLATION.

- Attach a wear down gauge to the aft seal and take measurement (See Section 8.4.)
- Measurement points of forward and aft seals with tolerances are as follows:

**IMPORTANT:** Where the liner and/or casing flange are not spigot located (forward liners normally are not spigot located and forward seal casings have only a false spigot to help when mounting, aft seal casing and liners normally are), then the need to check the centralisation of the liner to the shaft and then the casing/housing to the liner becomes doubly important.



Allowance	Measuring method	Subjects for measurement	Propeller shaft diameter (mm)			
			≤500	501-700	701-1000	1001-1250
A	Measure gap at 4 points on the circumference on the forward side (use searcher)	Difference between maximum and minimum values	Max.0.2	Max.0.3	Max.0.4	Max.0.5
B	Measure gap at 4 points on the circumference (use searcher or wooden wedge)	Difference between maximum and minimum values	Max.0.3	Max.0.5	Max.0.7	Max.0.9
C	Measure deflection of liner (use dial gauge)	Reading on dial gauge	Max 0.1	Max.0.14	Max.0.2	Max.0.2
D	Measure circumferential eccentricity of liner flange	Reading on dial gauge	Max.0.1	Max.0.14	Max.0.2	Max.0.2

E	Confirm that the spacing is as indicated on the drawing (use scale)	Comparison with dimensions on drawing	±3	±3	±3	±3
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Please note that the above measurement allowances are based on the seals being concentric to the propeller shaft described in Section 5.1.2.

#### 8.4. WEAR DOWN MEASURING INSTRUCTIONS

##### *(Only applicable to the Aft seal)*

**IMPORTANT:** Bearing wear down measurements are comparative measurements, thus it is essential that readings are taken with the propeller and shaft in the same position (normally with the blade number 1 at the top) and using the same measuring equipment installed in exactly the same manner each time.

Initial measurement readings taken when the vessel has had its bearings, shafting, propeller and seal installed are used as the basis for comparative future readings.

Each time the basis for the initial reading is changed, (e.g. new bearings, seal overhaul/disassembly, liner renewal, re-machining or re-positioning), then new readings should be taken after completion of all work. These new readings are then used as the new basis for future comparative readings.

##### **Standard (dry-dock)**

Ensure that the area around them is thoroughly cleaned, then remove the stainless steel threaded plugs located at the top and bottom of the aft seal intermediate ring and drain the lubricating oil.

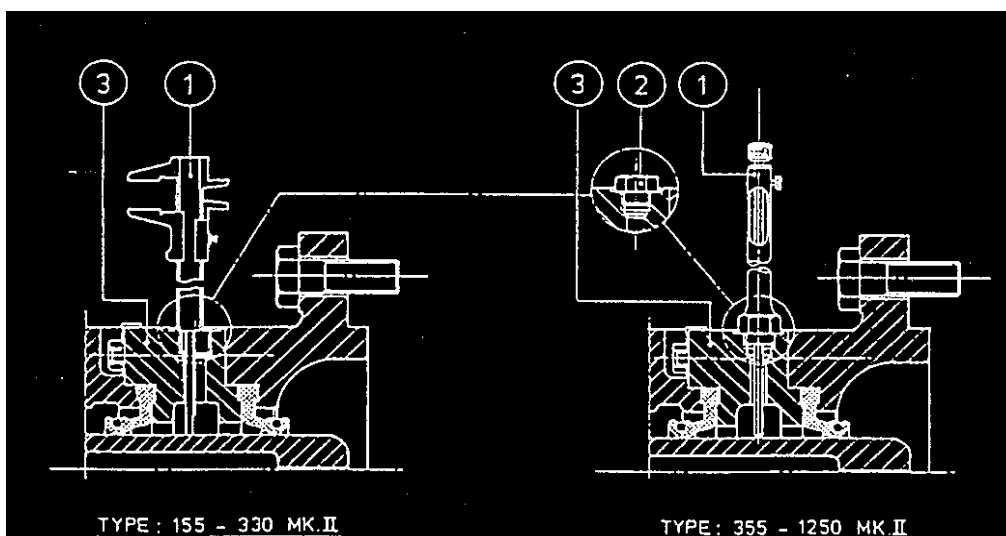
Locate the Weardown Gauge or Vernier Callipers firmly into the threaded hole. Chisel mark both casing and wear down gauge (screw in type only) so that the gauge can be screwed into exactly the same position for future readings.

Carefully measure the depth to the liner O.D. and record in the table below.

The measuring procedure must be executed at both top and bottom positions.

Remove the gauge and replace the lower threaded plug.

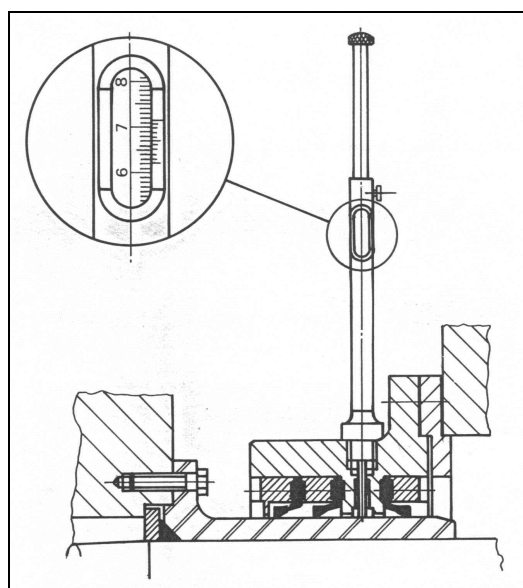
Replace the lubricating oil through the upper hole and allow all trapped air to escape. Replace filler and vent plugs.



	Medición			Medición	
Fecha	Parte superior/parte inferior	Por	Fecha	Parte superior/parte inferior	Por

**Vernier Slide Calliper, Gauge weardown gauge**

**Vernier Screwin Roscado**



### **8.5. LUBRICATION OF STERN TUBE AND SEALS**

(See also any drawing of the L.O. system and recommended stern tube lubricant oils as referenced in Sections 11 and 12)

**Note:** Charge the Forward and aft seals only after the stern tube have been filled.

#### **8.5.1. Lubrication Oil charging of the aft seal**

Supply oil to the space between the Nos. #1 and #2 and between #2 and #3 seal rings via the plugged hole at the top of the casing where one is provided.

#### **8.5.2. Lubrication of the Forward seal**

The forward seal assembly is lubricated and cooled by means of a natural oil system connected to an oil reservoir mounted on the after peak bulkhead.

- Fill the forward seal lubricating oil tank up to the MAX level.
- Leave the system to stand for 4 hours
- Check the leakage from the #5 seal ring. Leakage of less than 1 litre in those 4 hours can be considered normal, but a larger leakage requires investigation of possible causes.
- After the forward seal has been installed, a periodical check should be made to see that the oil temperature in the forward seal tank remains below 60°C and that the oil reservoir remains full.
- After one week of operation the forward seal tank and seal cavity should be drained, flushed and refilled with fresh oil. The reason for this is that new rubber will always have surface carbon deposits, which rub off during the first days of operation. These should be flushed from the system to prolong seal life.

#### **8.5.3. Precautions before launching**

- Keep the Forward seal covered to prevent entry of foreign particles from the space between liner and casing..
- Keep the Aft seal covered until just prior to launching. If there is a lengthy outfitting period, take necessary preventive measures against marine growth on the Aft sealing assembly.
- In the case of a large ship (X - >10 metres) with two header tanks, use only the lower header tank or remove oil down to an appropriate level in the piping. In either way, application of high oil pressure on the seal rings should be prevented.
- Do not supply oil to the aft seal when the outfitting period is long. Wait until just prior to launching, otherwise the absence of the counter pressure of seawater will probably result in some small oil leakage from the aft seal.
- Before launching or floating up, check that all fasteners on the aft seal that should be wire locked in place (e.g. Liner Flange and Case) are secured with locking wire.

#### **8.5.4. Maintenance of lubrication systems**

Periodically check the levels of the lubricating oil tanks, and have the quality of the stern tube oil tested by sampling/analysing by your oil supplier to detect any possible oil degradation.

It is advised that during dry-docking the whole lubricating oil system is drained and refilled with fresh oil.

#### **8.6. INSTALLATION INSTRUCTION WHERE NON-METALLIC BEARINGS ARE FITTED**

***Note: This installation instruction is applicable to seal assemblies that are fitted in combination with other than white metal bearings.***

Non-metallic bearings are subject to swelling after installation due to lubricant influences and thermal expansion, causing the bearing clearance to decrease. Since this happens after installation of the seal assemblies and during the first weeks of operation, it is essential that the seals are adapted to allow for this decreasing bearing clearance. Furthermore the clearance requirement for this type of seals is usually larger than the normal clearance for white metal bearings.

Installation follows the normal procedure as described in section 8.1. onwards. The only difference will be the alignment of the seal housing. Normally with a white metal arrangement, the seal housing is mounted onto the stern tube using a tight spigot as the alignment tool. However, the use of non-metallic bearings means that this is not possible. The seal housing will have to be mounted taking the changing/decreasing clearance in consideration.

Two executions of seal assemblies are possible:

- Without a spigot location
- With a loose spigot location

With no spigot, the seal housing is centralized to the shaft and then raised a certain amount to cope with later swelling (see example). The seal is then fixed in position using parallel pins.

If the seal assembly is supplied with a spigot, then it will be supplied specially machined 2 mm smaller than the spacer spigot. The spacer is a standard product, which can be replaced using stock material so this is kept at standard dimensions. The seal assembly is mounted onto the stern tube using the spigot of the spacer. The enlarged clearance between seal casing and spacer allows adjustment of the complete seal housing. This will have to be centralized to the shaft and then raised a certain amount to cope with later swelling of the bearings. The seal is then fixed in position using parallel pins.

The amount with which the seal housing will have to be raised in both cases is dependant on the bearing supplier's calculated theoretical swell for the bearing.

## **9. TESTING**

### **9.1. STERN TUBE**

Filling the lubricating system and the Header tank to the maximum level tests the stern tube.

In this case, do not feed (charge) the aft seal as advised in Section 8.5.1.

Open or keep open the drain plugs/oil connections at the bottom of the forward and aft seal casings and check for leakage from the drain holes and from the stern tube/system.

The duration of the test is 8 hours.

Leakage from the forward and aft seal drain holes of less than 3 Litres (total) in these 8 hours can be considered as acceptable, but a larger leakage figure requires investigation as to its possible causes.

### **9.2. INBOARD SEAL LEAKAGE TEST**

The Stern tube should now be filled (see Section 8.5.) and the system set as for normal operation (see Section 10). The Inboard Seal should then be checked for oil leakage.

Confirm that the stern tube lubricating tank, which lubricates the Inboard seal is at the MAX level.

Leave the system to stand for 4 hours

Check the leakage from the forward seal ring. Leakage of less than 1 litre in these 4 hours can be considered normal, but a larger leakage requires further investigation.

After the forward seal has been installed, a periodic check should be made to confirm that the oil temperature in the forward seal tank remains below 60°C and that the tank remains full.

After 1 week of operation, the forward seal cavity should be drained, flushed and refilled with fresh oil. This is because new rubber will always have surface carbon deposits, which rub off during the first few days of operation. These should be flushed from the system to prolong seal life.

### **9.3. OUTBOARD SEAL LEAKAGE TEST**

Charge or feed the aft seal as described in Section 8.5.1. Once the seal is charged and the plugs refitted, the space becomes hermetically sealed. Also due to the orientation of sealing rings #1 and #2 and because the #3 sealing ring is tested in the stern tube test (Section 9.1.), there is no need to conduct a further leakage test.

## **10. NORMAL OPERATION**

With the system functioning within parameters, all conditions should be stable.

### ***10.1. STABLE OPERATION CONDITIONS***

Header Tank and Forward Seal Lubricating Tank Levels steady. No change in the level should be seen.

Lubricant conditions good. Analysis figures within the oil manufacturer's acceptable range.

Bearing temperature normal.

### ***10.2. ROUTINE CHECKS THAT SHOULD BE CONDUCTED AT THE FREQUENCY INDICATED***

#### **Daily**

- Check the stern tube header tank level
- Check the forward seal L.O. tank level
- Check and record a bearing/stern tube oil temperature
- Visually inspect the forward seal for signs of leakage
- Check the temperature of forward seal lubrication oil or the forward seal casing

#### **Weekly**

- Check that all valves and cocks in the system are in the correct position for normal operation.
- Check the level alarms in the Header, Forward Seal and Aft Seal Monitoring tanks for correct operation.
- Open the sample/test cocks to: The Stern tube/Header tank line.



## **11. LUBRICATION SYSTEM**

The lubrication oil system to be installed is normally of a natural circulation type. We recommend that the system is operated as per the drawings and instructions provided by the building yard as the majority of the components are of their supply.

### **11.1. AFT SEAL**

For the oil chamber between seal rings #1 and #2, refer to section 8.5.1. during installation.

For the oil chamber between seal rings #2 and #3, charge with oil as described in section 8.5.1. during installation.

### **11.2. FORWARD SEAL**

The oil chamber between the two forward seal rings #4 and #5 is cooled and lubricated by connection to a small cooling/header tank situated some one to two metres above the forward seal.

Refer to Section 8.5.2. during Installation.

### **11.3. OTHER**

Test the lubricant in accordance with the manufacturers recommendations.

Take and Record stern tube bearing wear down readings as required by Class (Refer to Section 8.4. for description and procedure).

## **12. RECOMMENDED STERN TUBE LUBRICATING OILS**

The lubricating oil used in the stern tube must be of type mineral gear oil with EP additives (Extreme Pressure) single grade oil.

The oil must fulfil the requirements stated in DIN 51517 part 3 for CLP lubricating oils. Oils specially intended for stern tube systems can also be used. In that case the oil must be tested to make sure that it suits both the bearings and the nitrile or viton seal rings. Oils which contain excessive amounts of chlorine or sulphide have been found to adversely affect this type of material.

### **Viscosity Grade**

The viscosity grade must meet the requirements of ISO VG 100 ( 100 cSt at 40°C). If other viscosity grade is to be used an approval from Rolls-Royce must be granted.

### **Degree of Cleanliness**

We know from experience that gear oils are sensitive to contamination. That can deteriorate the filterability. It is therefore of utmost importance that the oil is clean at first filling of the system and therefore the following directions must be followed:

- New gear oil must not be mixed up with other oils, even in very small quantities.
- Equipment used to fill the oil must be clean.
- External piping of the hydraulic systems must be carefully cleaned
- New gear oil must be filtered before filling. Rolls-Royce AB recommends as a minimum requirement a cleanliness level of 18/16/13, according to ISO 4406:1999. This is an approximate equivalent of contamination classes NAS 1638 class 7 and SAE AS 4059 class 8. This cleanliness grade will normally be obtained when using a 6 to 8 micron filling filter.

### **Oil Types**

Example of recommended oils are shown on a separate document 0074.

### **13. TROUBLES AND COUNTERMEASURES**

Frequent and careful inspection of stern tube bearings and sealing system not only helps to prevent trouble happening, it also assists, (in case of a problem) in the provision of adequate counter measures, which will minimise any damage or disruption.

The following table lists abnormal conditions and their possible causes with recommended countermeasures.

If you have any special problem, do not hesitate to contact us. We can offer a rapid, flexible response to your needs and questions.

## COMPROBACION DE ELEMENTOS Y LOCALIZACIÓN DE AVERIAS

Item.	Checking item	Checking interval	Abnormal if:	Troubles	Countermeasures
1	Temperature of stern tube bearings or stern tube L.O.	Once a day	Temperature of stern tube bearings is higher than 70°C or that of stern tube L.O. higher than 60°C.	L.O. deterioration	Purify or renew L.O.
2	L.O. temperature of forward seal or temperature of casing.	Once a day	L.O. temperature is higher than 70°C or the temperature of casing surface higher than 65°C when NBR seal rings are in use. L.O. temperature is higher than 90°C or the temperature of casing surface higher than 85°C when Viton seal rings are in use.	Damage to bearing. (White metal debris found in L.O. strainer and/or drain samples is evidence of damage to the bearing and will normally accompany the elevated temperatures).	Slow down shaft speed (repair or re-metalthe bearing upon dry docking).
3	Oil level of forward seal L.O.tank.	Once a day	Oil level rises by 12 litres or more a day.	Damage to seal ring #4 or debris trapped under it.	Close valves in the piping of forward seal L.O. tank, so that the oil can be sealed by seal ring #5 temporarily. Clean or replace seal ring #4 when the shaft is stopped.
4	L.O. level of stern tube L.O. head tank.	Once a day	Oil level falls by 12 litres or more a day Oil level rises by 12 litres or more day.	Damage to seal ring #3 Damage to seal ring #1 and #2, or debris trapped between them and the liner.	Lower the level of the lub. oil in order to lower the stern tube L.O. pressure. Raise the level of the lub. oil tank in order to raise the stern tube L.O. pressure. Drain seawater from the stern tube.
5	L.O. Strainer	Once a day.	Seawater is present. A little seawater is not abnormal.	Malfunction of L.O. system or L.O. cooler.	Repair the faulty components.

6	Oil level of Aft seal #2 – #3 monitoring header tank (where tank is fitted).	Once a day	Oil level rises by 12 litres or more a day.  Not steady, oil level falls.	Damage to seal ring #1 and #2, or debris trapped between them and the liner.  Damage to seal ring #3 or debris trapped under it.  Vessels draft is light.	Close valves in the piping of the Aft seal L.O. tank. Drain off seawater from the Aft seal. Raise the stern tube oil pressure.  Close valves in the piping of the Aft seal tank  Drop stern tube L.O. pressure.
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## **14. MAINTENANCE**

All seals may be maintained/repared In-Situ with the Propeller and Shaft still installed, as long as, in the case of the Aft Seal, the shaft can be raised clear of the water.

Following are descriptions and procedures for the In-Situ and Workshop overhaul of both the Aft and Forward seals.

In all instances the Shaft must be stopped and locked, the stern tube oil system drained, including the stern tube Header Tank and the Forward and Aft seal Lubricating.

Further, the oil retained within the seals themselves should be drained using the vent and drain plugs provided in the Aft seal, and the Lubricating tank inlet and outlet connections for the Forward seal.

### **14.1. IN SITU REFURBISHMENT (AFT SEAL).**

With the propeller and shaft installed, basically only one level of repair/replacement may be conducted on the aft seal.

#### ***Replacement of Elastomers***

The Elastomer Sealing rings can be replaced in-situ. Also the running tracks of the new seal rings on the liner can be adjusted by the fitting or removal of a spacer.

##### **14.1.1. REMOVAL OF ELASTOMERS**

**IMPORTANT** Before cutting or removing any elastomer seal rings etc. ensure that new replacement spares are available (along with the means to bond/join them around the in-situ shaft). Bonding requires specialist tooling and can only be carried out by a Service Engineer.

**IMPORTANT** When removing seal rings etc. with the liner remaining in-situ, great care must be taken to ensure that the running surface is not damaged during this procedure, especially when moving the metal housing/casing rings along it.

The cover is held to the support ring, the support ring to the intermediate ring and the intermediate ring to the casing flange by individual sets of hex. head bolts.

**Note:** During an in-situ refurbishment the casing flange can remain bolted to the stern tube unless there is a need to replace the joint that fits between the casing flange and the stern tube, or the spacer needs fitting or removing.

Starting with the cover, undo and remove the bolts and lock washers holding it to the support ring.

**Note:** The cover is a split component (without butt screws) and should now be removed from the shaft/liner.

This exposes the #1 seal ring. Undo and remove the garter spring, pull the seal ring out of the support ring then cut and remove it.

Proceed by undoing and removing the bolts and washers in the Support ring. Carefully move this ring aft along the liner to expose the #2 sealing ring. Remove this as for the #1 seal ring

Continue in the same manner with the Intermediate ring and the #3 sealing ring.

Thoroughly clean all removed/separated metal housing components paying particular attention to the areas where the seal rings and O-rings fit.

By working between the separated metal rings of the housings, carefully clean the liner surface.

We recommend using a nylon-scouring pad soaked in clean oil to remove all deposits from the liner surface.

If after cleaning, the liner surface condition is such that the new sealing rings have to be repositioned (so as to run an unworn liner surface), then a split spacer must be removed (or if already removed, the spacer must be fitted). If the liner is so badly worn that no unworn areas remain and it requires machining or replacing, then it must be removed from the shaft.

With all in-situ components clean and in a satisfactory condition, rebuild the seal.

#### **14.1.2. REFITTING OF NEW ELASTOMERS**

Commence by bonding the #3 seal ring around the liner between the casing flange and the intermediate ring. Ensure before bonding that the seal ring is in perfect condition with no evidence of flaws, damage or poor condition and that it is orientated correctly as shown on the G.A. drawing.

Fit the garter spring to the bonded seal ring and carefully position the ring so that its root fits fully and squarely into the recess in the casing flange as shown on the G.A. Drawing.

Lightly grease new O-rings and fit these into the grooves around the oil holes in the casing flange aft surface.

Now carefully locate the next casing housing ring (the central ring) against the casing flange ensuring that the #3 seal ring (and the 2 O-rings if fitted), are still correctly positioned.

Bolt the central ring in place using the bolts and lock washers. Carefully, evenly and in a diagonal sequence, tighten the bolts to the torque specified on the G.A. Drawing

Repeat the process for the #2 and #1 seal rings plus their associated housings, (the support ring and the cover). The split line of the cover must be arranged so that it is horizontal to T.D.C.

#### **14.1.3. REMOVAL / REFITTING OF ADJUSTMENT RING**

**Note:** Removal of an already fitted adjustment ring will have the effect of moving the running tracks of newly fitted sealing rings forward (by the thickness of the spacer + one joint) along the liner. Conversely, fitting a spacer will move the running tracks aft by the same amount.

If the condition of the in-situ liner makes it necessary to remove an already fitted spacer, then the casing flange must first be separated from the stern tube.

Undo and remove the main securing bolts holding the casing flange to the stern tube.

Separate the casing flange and spacer from the stern tube. Jacking positions are provided that may assist in this.

Normally the spacer is unsplit, so it needs to be carefully cut in order to remove it from the in-situ shaft/ propeller.

With the adjustment ring removed, clean the stern tube flange surface and the casing flange surface to remove any remnants of the two joints that fitted between them.

Fit a new split joint (using a single dovetail cut between bolt holes) greased on both sides over the cleaned spigot location of the casing flange.

Refit the casing flange to the stern tube as described in Installation.

Refit new elastomers and re-build the seal.

#### **14.2. WORKSHOP REFURBISHMENT (AFT SEAL)**

With the propeller and or shaft removed, the complete seal may be removed from the shaft/stern tube and transported to the workshop for a complete overhaul.

Proceed as follows:

- For a FPP Installation:

Prior to removal of the propeller, undo and remove the main liner securing bolts holding it to the propeller boss f.p.r.

Use jacking bolts in the threaded holes in the liner flange to separate it from the propeller boss f.p.r.

Locate and fix the transit clamps/strap fasteners (they should have been left in the care of the Chief Engineer) between the liner and the case.

Now remove the propeller.

- In a CPP Installation:

Prior to removing the shaft, undo the main casing flange securing bolts and secure the seal with the transit clamps/strap fasteners.

Now remove the propeller shaft with the seal attached.

Remove the seal assembly from the shaft using suitable lifting gear attached to the positions provided. Undo the securing bolts holding the casing to the stern tube/sternframe in the case of an FPP Installation. Undo the securing bolts holding the liner to the propeller boss/f.p.r. in the case of a CPP installation. Use bolts in the threaded holes in the casing flange/liner flange to separate it from the stern tube/f.p.r. if necessary, (remember the casing flange may have been secured in place using parallel pins/dowels if it was not spigot located).

Once in the workshop, remove the liner from the seal housings. This is best done with the seal resting on the liner flange and lifting the housings by the casing flange vertically to clear the liner.

With the liner removed it should be cleaned as previously described using a nylon scouring pad and clean oil to remove all traces and deposits of dirt, debris and rubber from the seal rings.

The decision should now be made based upon inspection and measurement whether to:

- Re-use the liner as is
- Re-use the liner as is, but inserting/removing the spacer to move the running track.
- Refurbish the liner by machining.
- Replace the liner



Carefully disassemble the seal assembly, removing the seal rings and the O-rings

Thoroughly clean all components then proceed to rebuild the assembly using new seal rings Proceed as follows:

Mount the liner on a suitable surface with its flange at the bottom. Insert the liner flange mounting bolts through the holes in the liner flange. Then, mount the seal as previously mentioned.

### **14.3. IN SITU REFURBISHMENT (FORWARD SEAL)**

With the shaft in situ, only one level of repair/replacement work may be carried out on the forward seal.

#### **14.3.1. Replacement of seal rings and liner O-ring**

**IMPORTANT:** When removing seal rings etc. with the liner remaining in situ, great care must be taken to ensure that the running surface is not damaged during this procedure.

First undo the oil connections on the intermediate ring of the forward seal.

Undo and remove the socket head cap screws and spring washers fixing the clamp ring to the liner flange.

Undo and remove the socket head cap screws and spring washers holding the two halves of the clamp ring together around the shaft.

Carefully remove the two halves of the clamp ring from the shaft, then cut and remove the clamp/liner O-ring.

Carefully slide the liner forward using a rotary motion until it is clear of the seal rings and housing.

Thoroughly clean the liner especially its running surface using a nylon-scouring pad soaked in clean oil.

Inspect it for wear or damage and note the positions of any wear tracks caused by the #4 and #5 Seal rings.

If after cleaning, the liner surface condition is such that it requires machining or replacing, then it must be removed from the shaft.

Starting with the cover, undo and remove the hex head bolts and lock washers holding it to the intermediate ring. These bolts also secure the Intermediate ring to the casing flange, so that with their removal, the cover can be separated from the intermediate ring, which can be separated from the casing flange.

This provides access to the seal rings #4 and #5.

Undo the garter springs from the 2 exposed seal rings and remove them. Then cut and remove the two old seal rings.

With the seal rings removed, thoroughly clean all exposed surfaces of the casing flange, intermediate ring and cover, paying particular attention to the mating faces between rings and where the roots of the seal rings are gripped.

**Note:** Unless there is a specific need to replace the joint between the casing flange and the stern tube, there is no need to remove the casing flange during an in-situ refurbishment.

With all components clean and in a satisfactory condition rebuild the seal using new elastomers as follows:

Commence by bonding the #4 seal ring around the liner between the casing flange and the Intermediate ring. Ensure before bonding that the seal ring is in perfect condition, clean and that it is orientated correctly as shown on the G.A. Drawing.

Fit the garter spring to the bonded seal ring and carefully position the ring so that its root fits fully and squarely into the recess in the casing flange as shown on the G.A. Drawing.

Now carefully locate the Intermediate ring against the casing flange (aligning the holes in the ring and oil connections as shown on the G.A. Drawing) ensuring that the #4 seal ring is still correctly positioned.

Repeat the bonding process for the #5 Seal ring locating the cover so that it is correctly aligned and fully supports the ring.

Using the long through bolts and the lock washers previously removed, fit them to secure all housings and seal rings together as shown on the G.A. Drawing. Evenly, tighten the bolts in a diagonal sequence to the torque shown on the G.A. drawing.

Lubricate the surface of the cleaned liner with clean oil, then re-position the liner in its approximate running position. Be very careful when entering the liner through the new sealing rings. The orientation of the sealing rings and the lead in chamfer on the end of the liner will assist as will the oil used to lubricate the liner surface. It is recommended that the liner is pushed slowly through the sealing rings using a rotary motion to assist entry.

An unworn liner in good condition may be put back in its original position.

If the liner is worn, then its axial position may be adjusted so that the new Seal rings run on unworn liner surfaces. The liner must not be moved too far forward so that the #4 seal ring runs on the liner chamfer or too far aft so that the liner flange is too close to the housing/bolts.

With the liner positioned, bond a new liner O-ring around the shaft forward of the liner flange, lightly grease it and roll it under the liner flange chamfer.

Join the clamp ring around the shaft (orientate it correctly) using the 2 socket head cap screws and locking washers. Move it aft so that it just contacts the liner flange, orientate the holes in both so that they are aligned and tighten the clamp ring butt screws sufficiently to grip the shaft, keeping the gap at both butts even.

Mount the liner to the clamp ring by inserting the socket head cap screws and spring washers through the clamp ring and into the liner flange.

Check the measurement points according to section 8.3.

If necessary, adjust the seal axial length. Tap the clamp-ring with a lead (soft) hammer and wooden block, gently tapping the clamp-ring until the specified axial seal length is achieved. Re-tighten the clamp-ring on completion.

If necessary, the radial run out can be corrected by turning the shaft until the part of the line which is furthest from the shaft, points straight down. A wooden block is placed against the liner flange outside diameter and a small hand hydraulic jack used to lift the liner until it is centred. At this point the bolts can be tightened and the jack removed.

Finally tighten the clamp ring butt screws (maintaining an even gap at both butts) and the liner/clamp mounting screws, to the Torque value as shown on the G.A. Drawing

Reconnect the oil connections to the central ring.

Fill the Forward seal according to Section 8.5.2

#### **14.4. WORKSHOP REFURBISHMENT (FORWARD SEAL)**

With the propeller shaft removed or decoupled the complete forward seal may be removed and transported to the workshop for overhaul.

First disconnect the oil connections to the Forward seal centre ring.

Now proceed as follows:

Prior to the removal of the propeller shaft, undo and remove the socket head cap screws holding the clamp ring to the liner flange.

Undo and remove the 2 socket head cap screws holding the two halves of the clamp ring together around the shaft. Remove the halves of the clamp ring from the shaft.

Cut and remove the liner/clamp O-ring.

Move the liner aft so that its flange fits into the recess in the cover as shown on the G.A. Drawing. Align the holes and fit the four hex head (transit) bolts to secure the liner to the cover.

Connect suitable lifting gear to the lifting position provided.

Undo and remove the main casing flange securing bolts and jack or lever the casing flange from the stern tube surface (remember – the case flange will normally have been fixed in position using parallel pins or dowels).

Carefully remove the shaft leaving the forward seal hung on its lifting gear. Now remove the seal to a workshop.

Once in the workshop, undo the transit bolts and remove the liner from the seal assembly.

This is best done with the seal resting on the case flange and lifting the liner, by its flange, vertically to clear the housings.

With the liner removed it should be cleared as previously described using a nylon scouring pad and clean oil to remove all traces and deposits of dirt, debris and rubber from the seal rings.

The decision should now be made based on inspection and measurement whether to:

- Reuse the liner as is
- Refurbish the liner by machining
- Replace the liner

Thoroughly clean all components then proceed to rebuild the assembly using new seal rings.

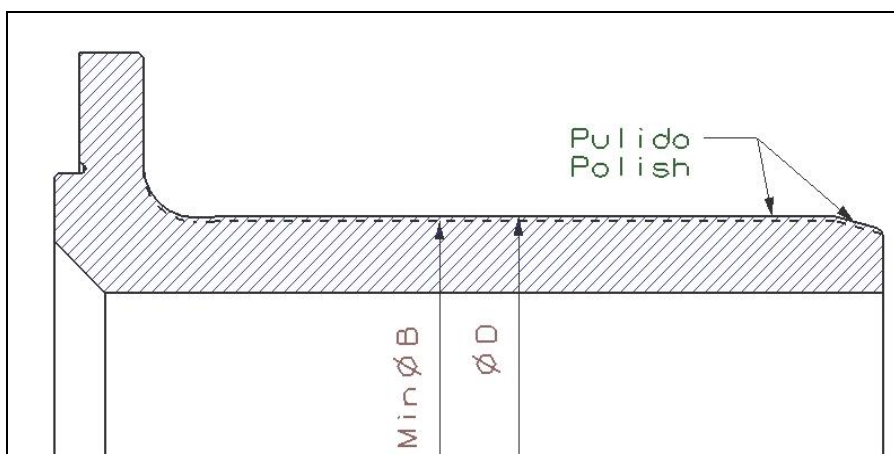
The Forward seal is now ready for re-installation as described in Installation, but instead of mounting the forward seal gravity tank, with the tank already installed, simply re-connect the oil connections to the central ring.

## IN SERVICE MAINTENANCE OF SEAL LINER

Due to the normal wear or abnormal abrasion of the liner caused by the intake of foreign objects etc., re-machining of the liner by grinding and finally honing or polishing to maintain correct operation is possible.

The following figures are the limits to which diameter reduction can be carried out to ensure proper functioning of the system.

For each 1 mm reduction in diameter of the liner running surface, the garter spring around the sealing lips should be shortened by 3 mm prior assembling.



$\varnothing D$ (mm)	Min $\varnothing B$ (mm)	$\varnothing D$ (mm)	Min $\varnothing B$ (mm)
95	92.6	480	476.6
115	112.6	500	496.6
135	132.6	530	526.5
155	152.5	560	556.4
170	167.5	600	596.3
190	187.4	630	636.2
200	197.4	670	666.1
220	217.3	710	706.0
240	237.3	750	754.9
260	257.2	800	795.8
280	277.2	850	845.6
300	297.1	900	895.5
330	327	950	945.2
355	352	1000	995.2
380	376.9	1060	1055.1
400	396.9	1120	1115.0
420	416.8	1180	1174.8



Limited

Deep Sea Seals

0130-EN

450	446.7	1250	1244.6
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