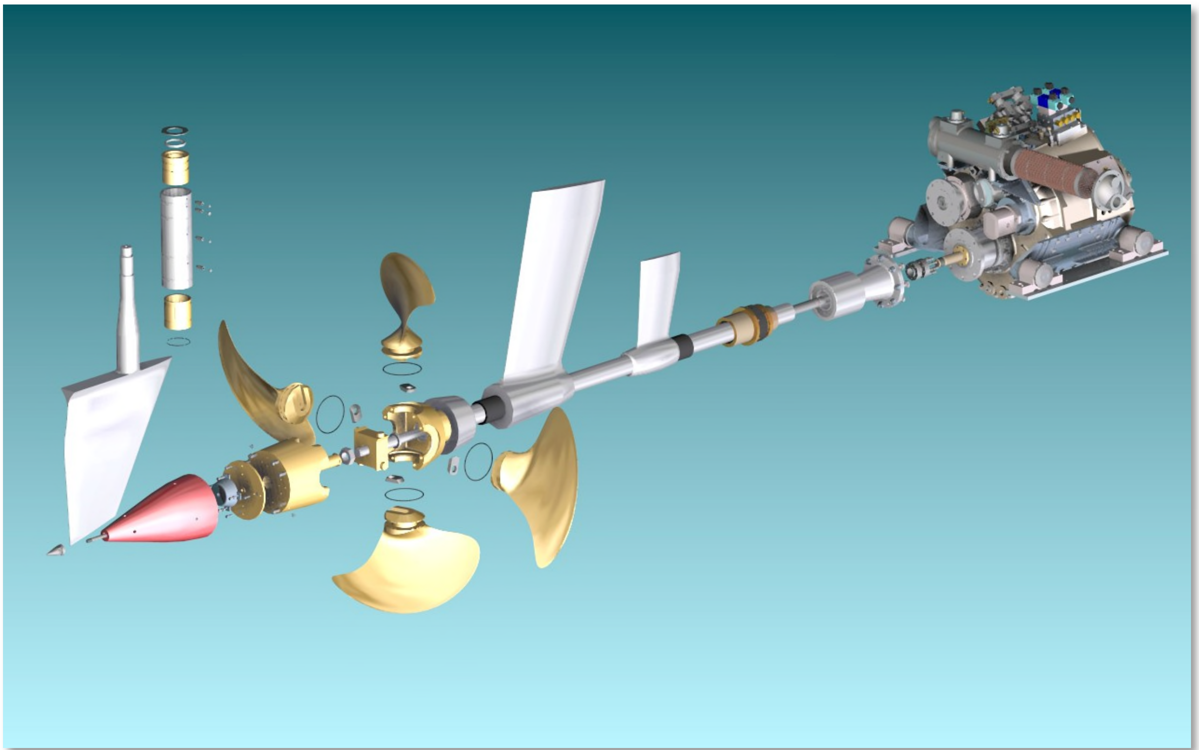
Instruction Manual

Part III, rev.3



Operation and Maintenance

SERVOGEAR EcoflowPropulsor™

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Identification plate

The identification plate for the complete delivery from Servogear can be found on the top of the gearbox housing or the OD-box. Please refer to this ID when contacting Servogear for service.

Please Help Us Improve This Manual

We would be very interested to hear any comments you might have on this installation manual. We are particularly interested in learning of mistakes or omissions and subjects that are unclear. Please call, fax, or e-mail and direct your comments to: main.office@servogear.no.

Thank you very much for your assistance.

1 SERVOGEAR GEAR SYSTEM AND SERVOGEAR ECOFLOW PROPULSOR™

Since 30 year Servogear represent a continuous development for improving the propulsion efficiency for especially fast ferries, workboats of different types. This is not only limited to the propeller, but also include shaft supports, rudders and hull shape. Together this gives a complete propulsion conception named ServogearEcoflowPropulsor™

The **Servogear EcoflowPropulsor™** is a propulsion system based on Gear, propeller, shaft support, part of hull lines (propeller tunnel) and rudders. This will give the ultimate propulsion efficiency, not only to the gain of vessel speed, but also for the operational economy and environmental reason.

The manoeuvrability is outstanding and makes it possible to handle the vessel with highest degree of accuracy.

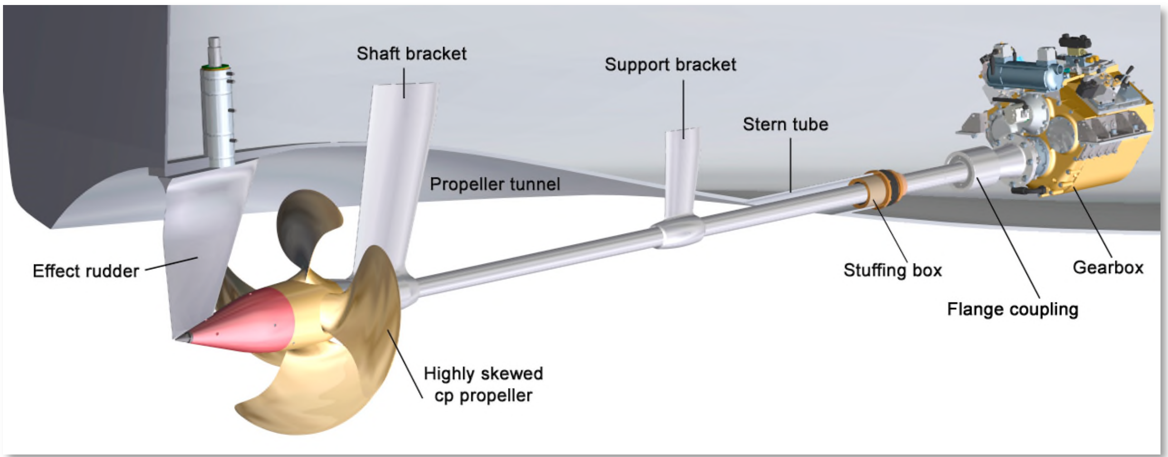


Fig 1-1 The picture shows the main parts in the Servogear EcoflowPropulsor™ system

1.1 Preface.

Operation of Servogear propulsion line is including reduction gear complete with shaft, propeller and rudder. These components is to be consider as an integrated unit.

The total result of the investment is depending on a correct operation and maintenance.

To give the customer the best base for integrating the equipment in the vessel, Servogear has worked out the manual in three parts.

- **Servogear Instruction Manual Part I. Engineering**
- **Servogear Instruction Manual Part II. Installation and Testing**
- **Servogear Instruction Manual Part III. Operation and Maintenance**

There will be some overlap between the different parts of the instruction manual. This will probably occur more often between part one and part two. The general description of different installations and components is similar in all three volumes.

The purpose of these **Operation and maintenance manual** is to give the ship owners administration and vessels crew necessary information to carry out a proper operation maintenance. Following the advice and demand in the manual will give the best start for a long-lasting operation period without any unplanned off-hire.

As mentioned above, Servogear deliver the complete propulsion-line from the engine drive shaft, the propeller and rudder included. This **Operation and maintenance manual** will therefore include instruction for maintenance of all Servogear components in the propulsion-line. In addition, the manual includes some explanations for special methods and instructions for different tools, equipment and components in connection to the propulsion line installation. This will partly be integrated in the manual text, partly appear as appendix to the manual.

This book alone cannot give you all information needed for the operation and maintenance of the equipment. A number of drawings listed in **PART II** and the appendix to this book will give you the complete documentation needed for a long-lasting operation of the Servogear equipment.

1.2 Warranty and Non-disclosure agreement. *

All parts delivered by Servogear are covered by Servogear warranty conditions. However, Servogear can only honor warranty claims if the handling, installation and operation are according to the description and limit values in the different volumes of the manual.

We will also underline that Servogear `s warranty will not be responsible for or cover any damage caused by external impact or vibrations from connected systems. This reservation cover also claims that can be addressed to acoustic or structural noise caused by any other system, delivery or components.

To prevent (reduce) the risk of dangerous vibrations, Servogear in certain cases can recommend vibration analyses of the drive system during the trial.

NOTE!
Torsional oscillation tension and critical RPM-window has to be calculated for the entire drive systems, and the results are to be within limits given by the different manufacturers of different parts and class society (authority). The calculation is often carried out by the deliverer of elastic couplings as they are able to adjust the results through choice of elastic elements.

***Non-disclosure agreement**
A non-disclosure agreement (NDA), also called a confidential disclosure agreement (CDA), is a contract between Servogear and the customer or persons the customer employ to fulfill the engineering, installation and operation of work of the complete delivery which outlines confidential materials or knowledge the parties wish to share with one another for certain purposes, but wish to restrict from generalized use.

1.3 Type of installation.

The normal Servogear delivery include following main components:

- Gear including servo system (or other gear types equipped with Servogear servo system an oil distribution box)
- Propeller shaft with flange coupling
- Complete propeller (hub and blades)
- Stern tube with seal
- Main shaft support
- Secondary shaft support
- Rudder

NB! For the particular installation, please see separate part list

1.4 Shipping

1.4.1 Wooden packaging

Servogear packs all equipment in wooden boxes (fig. 1-2).
The wood meets the IPPC standard and is marked with ISPM logo.

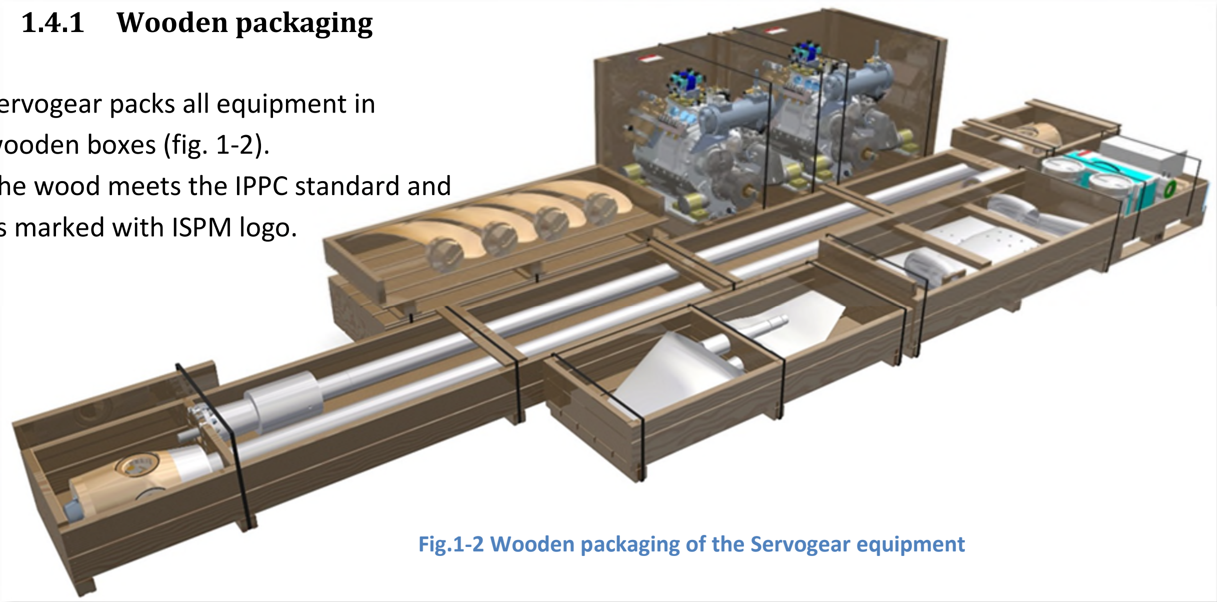


Fig.1-2 Wooden packaging of the Servogear equipment

2 DESCRIPTION

2.1 General

Servogear EcoflowPropulsor™ include a number of individual solutions for different types of vessels.
The following description and illustrations show some of the most common configuration and arrangements

2.1.1 H-gear configuration (straight line installation)

This configuration is recommended wherever the space in the vessel or the vessel's trim allows it.
The configuration is relatively simple to install as the gear is mounted directly on the engine flywheel housing and the shaft is flanged directly to the gear output flange. The arrangement is simple with low weight. It is also relatively easy to predict noise and vibration.

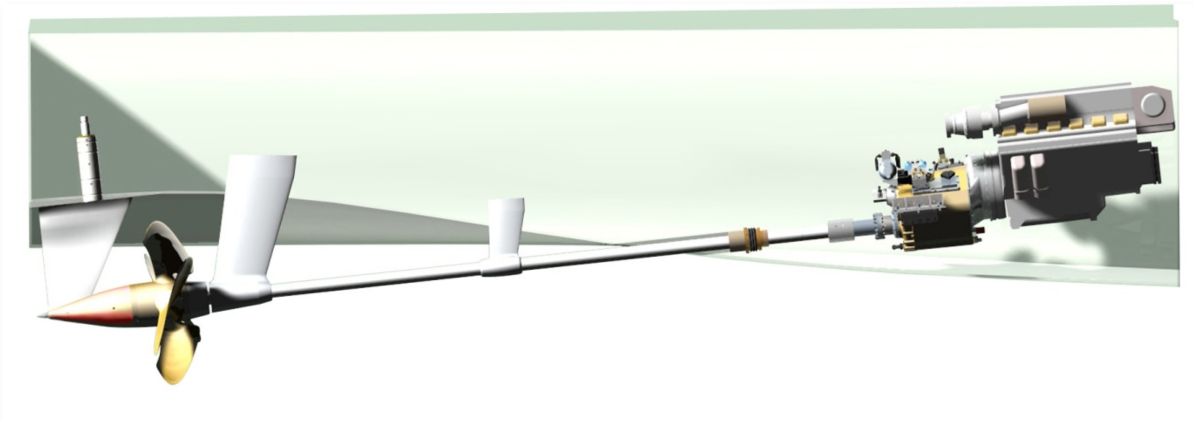


Fig 2-1 H-gear configuration

2.1.2 U-gear configuration

This solution is applicable where it is necessary to place heavy components (main engine) as close to vessels transom as possible.
This type of installation will demand a kind of flexible shaft or universal joint between engine and gear.
The installation seems to be complicated as far as alignment is concern, but a straight alignment procedure will make this relatively easy.

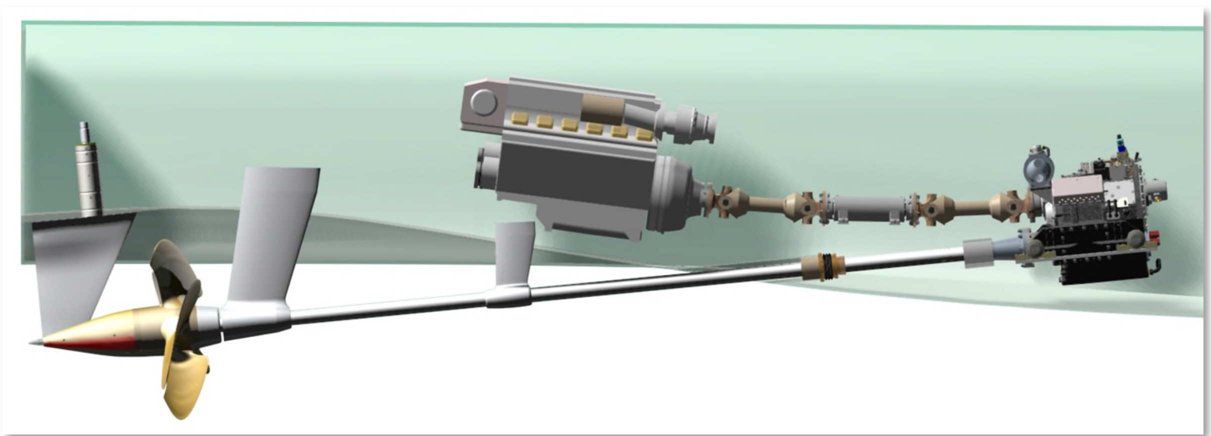


Fig 2-2 U-gear configuration

2.1.3 PTI-gear configuration

This is a very flexible configuration which fits into the “low-beam” waterline hull of a catamaran. The propeller can be run optimally from one or two engines depending on the required propeller output. The arrangement gives a high operating reliability.

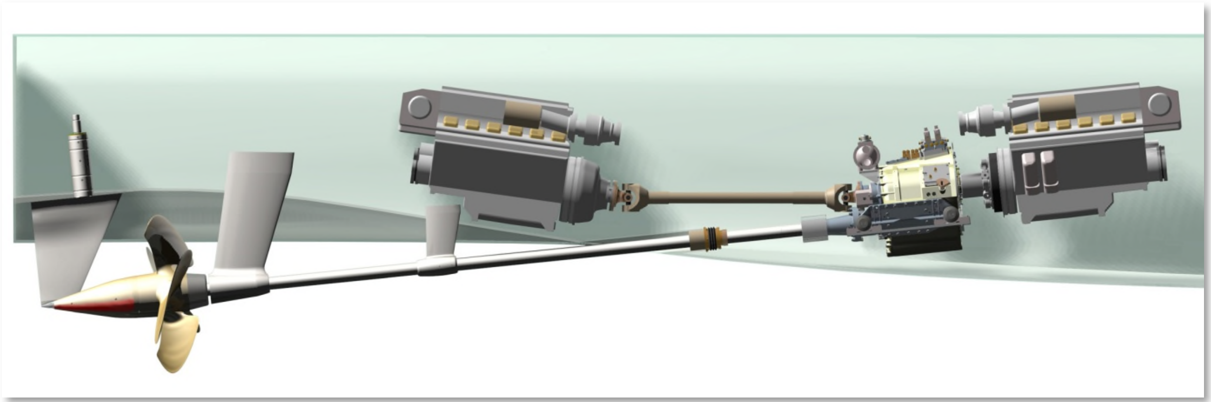


Fig 2-3 PTI-gear configuration

2.1.4 Servogear integrated into other gear types.

Servogear EcoflowPropulsor™ can be integrated to other gear types.
The choice of gear types has to be according to Servogear approval.
The servo cylinder is then mounted between tail shaft flange and gear output flange. The pilot valve and oil distribution box is mounted in the front of the gearbox. The gearbox is to be prepared for CPP propeller operation by the following: A special flange at the forward end of the gearbox for fitting of the Servogear OD-box. The output shaft is hollow bored for oil distribution to the CPP’s servo motor which is mounted between gear flange and propeller shaft flange. One power take offs (PTOs) are to be configured to drive the CPP oil pump.

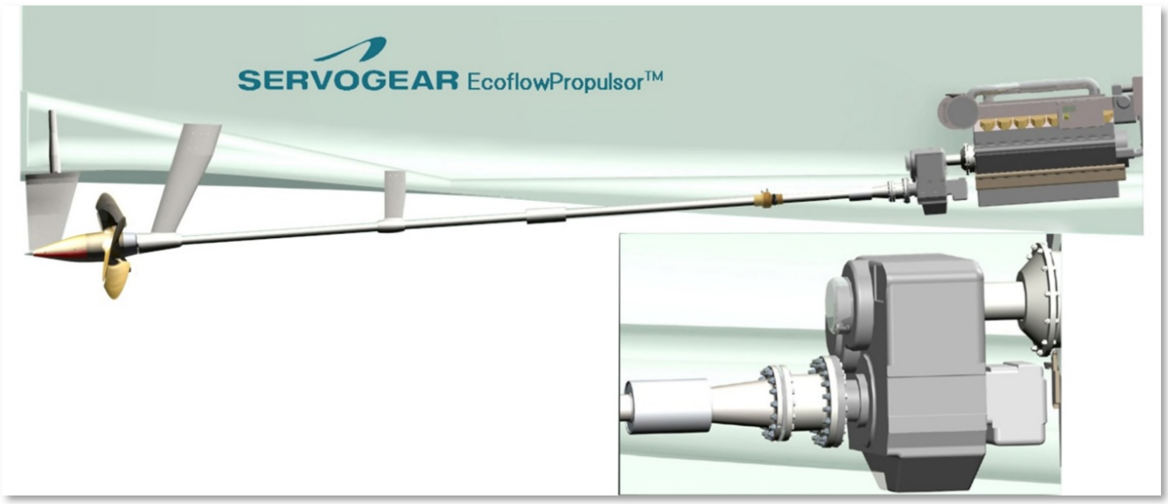


Fig.2-4 Servogear servo system connected to other gear type

2.1.5 Optional design

Servogear can give an optional offer on tailor made gearboxes. To an example is gear box with overlaying output shaft. This can be to advantages in SWATH vessels.

3 COMPONENT DESCRIPTION

3.1 Gear description

Outside the Servogear looks like an ordinary reduction gear in which the engine rpm by one or two gearing stages is reduced to a suitable propeller speed. However, the Servogear philosophy includes a hydraulic power system for steering and control of a controllable pitch (CP) propeller. This hydraulic power system is built in the gear`s secondary (output) shaft. A hydraulic piston is transferring an axial movement to the push-pull rod. This piston movement is piloted by a valve in front of the secondary shaft which in its turn is controlled by an outside mechanical lever or proportional valve system. This hydraulic piston rod is connected to the push – pull rod in the propeller shaft. The gear is not reversible.

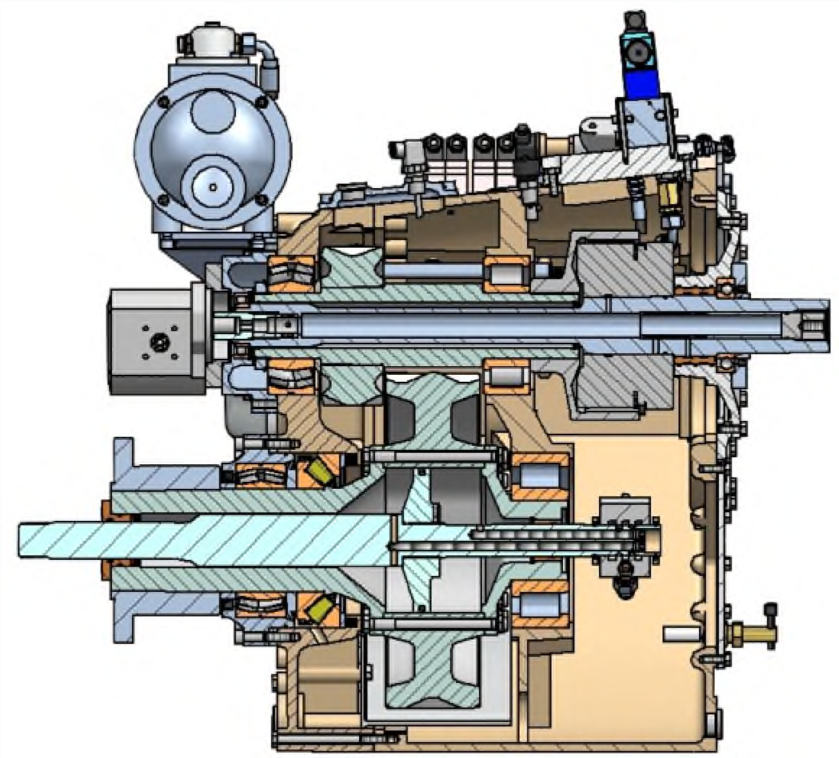


Fig. 3-1 Cross section of gear box.

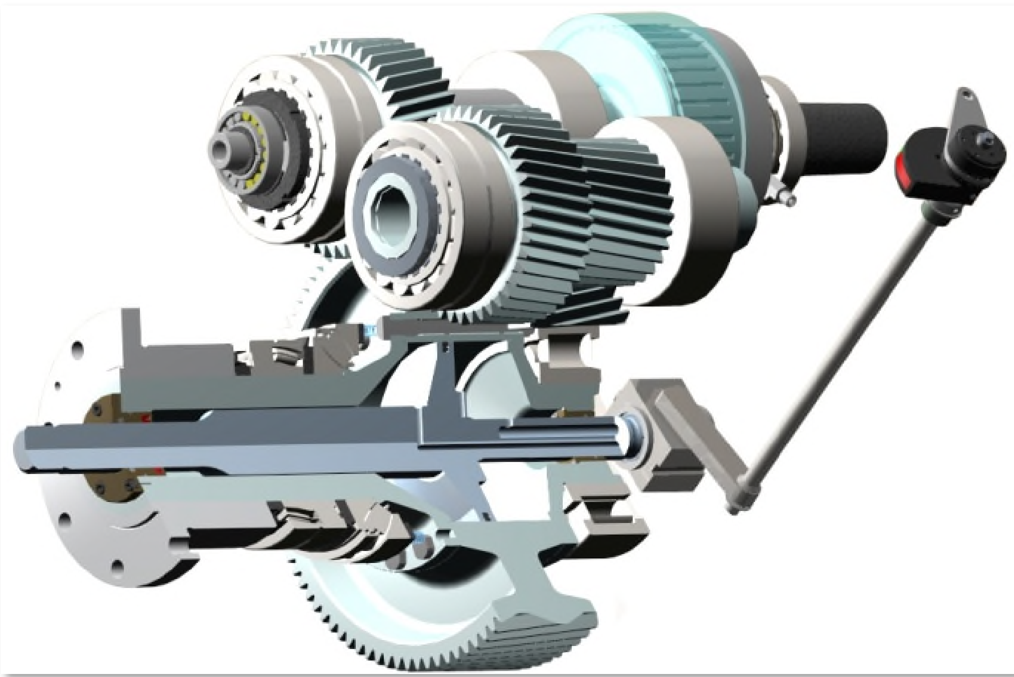


Fig.3-2 3D drawing showing the gear and servo mechanism.

3.2 Propeller description

A controllable pitch propeller allows for- and- aft manoeuvre without turning direction of rotation. Therefore, there is no reverse function in the Servogear Gearbox.
An internal rod in propeller hub which is connected to the push – pull rod, operate the blades. A yoke is mounted to this rod to transfer the movement to turn the propeller blades. The yoke is transferring the servo force to the blades in order to turn them to give needed thrust forward or astern.
The hub is lubricated by grease which also lubricating the push-pull rod.
Propeller blades are sealed by O-rings in the hub.

Servogear controllable pitch propeller has normally four propeller blades.

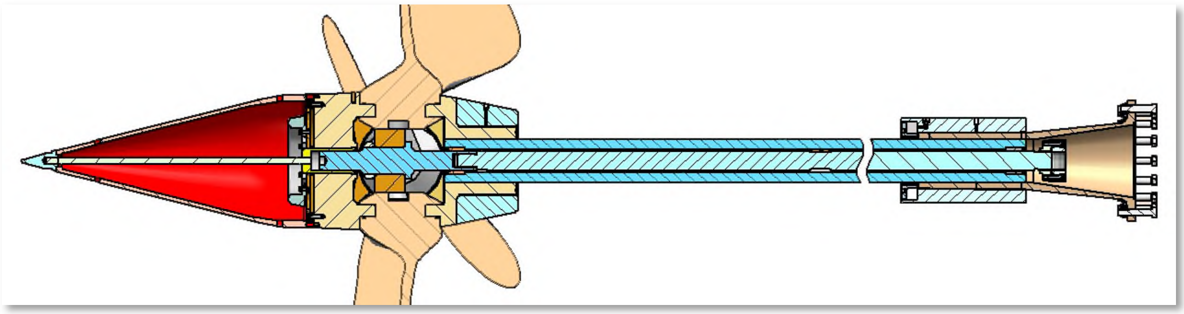
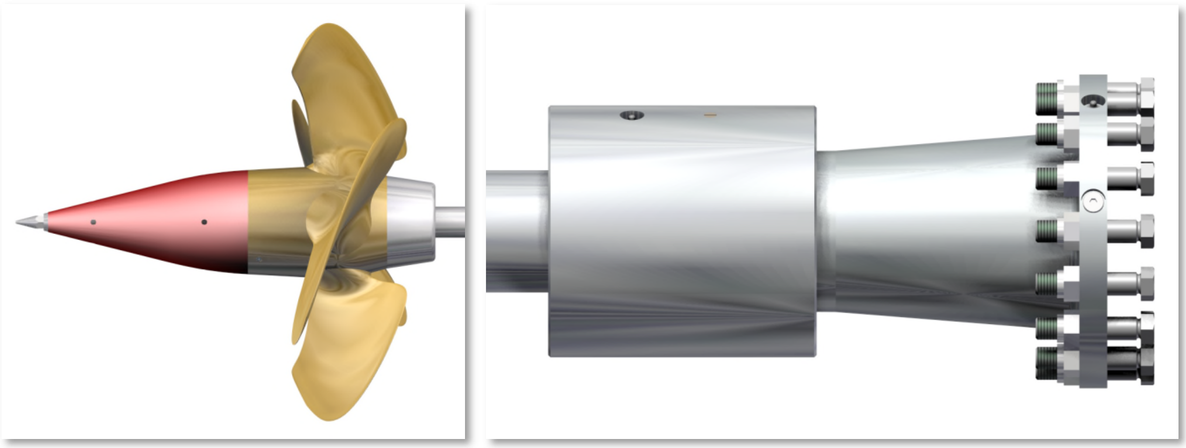


Fig.3-3 Cross section of propeller and shaft (above) and outside picture of propeller and flange coupling.



3.3 Propeller shaft description

Propeller shaft have a central axial bore for push-pull rod. The ends are prepared for fitting propeller hub in one end and gear connecting flange in the other end. The push –pull rod is connected to the hydraulic servo piston in the forward end and to the yoke in the propeller hub.

The shaft bore is filled with grease for common lubrication of moving parts in propeller hub and shaft bore.

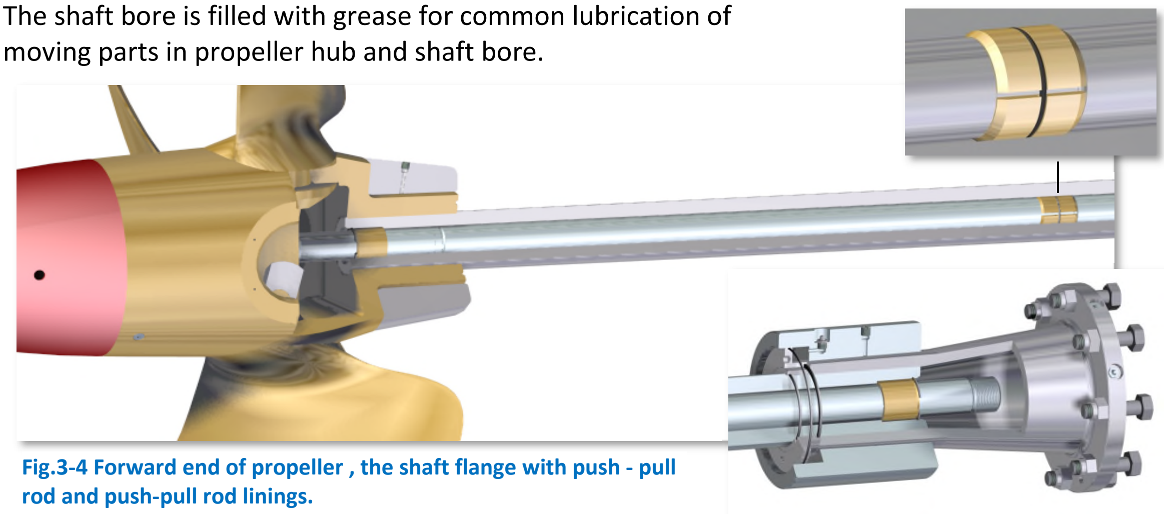


Fig.3-4 Forward end of propeller , the shaft flange with push - pull rod and push-pull rod linings.

3.4 Propeller cone

All Servogear propeller are fitted with a propeller cone on the propeller hub. The propeller cone is to improve the total hydrodynamic shape of propeller hub. The cone which is made of composite is connected by pre-tension between the propeller hub and the end nut. The tension is transferred by a tie-bar. The cone is to be mounted on a complete propeller. The tie-bar nut connection is important to secure. (torque)

The zinc anode inside must be replaced when it is worn out (less than 50% left). Please check the condition of the zinc anode every maintenance docking. Zinc anodes for replacement can be supplied on short notice by Servogear.

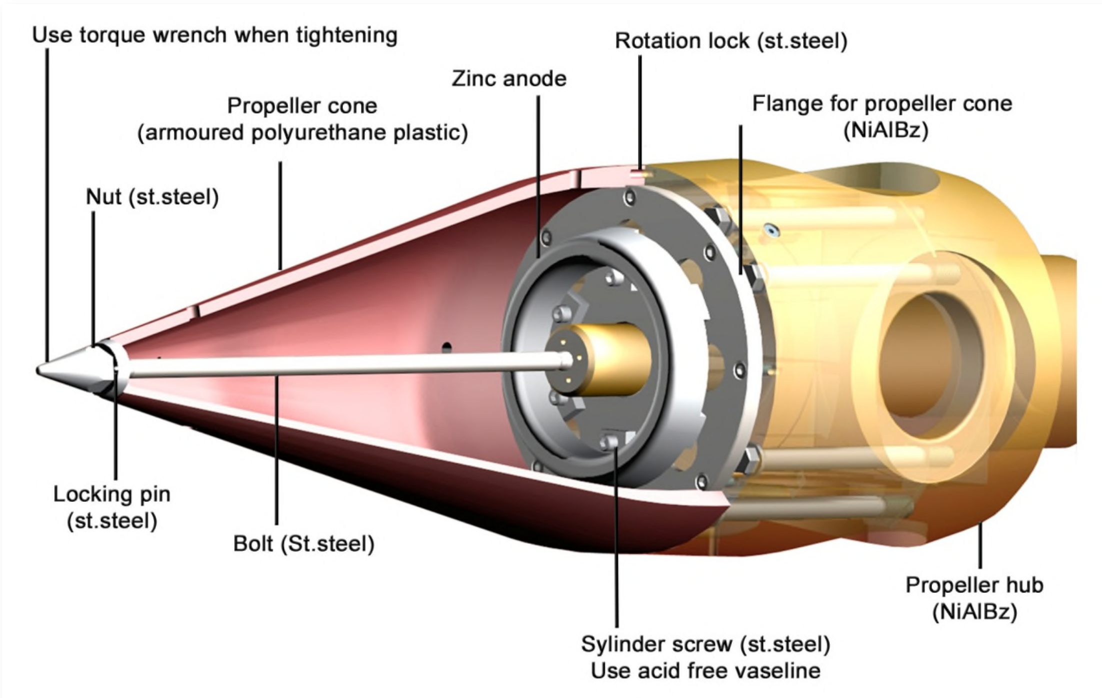


Fig 3-5 Cross section of the propeller cone and sacrificial zinc anodes.

3.5 Rudder description.

Servogear Effect rudder is a part of **Servogear EcoflowPropulsor™**. It is optimized to give low flow resistance. The main idea with effect rudder is to generate rotational loss in the water behind the propeller into positive thrust. Therefore, the rudders are dedicated to the propellers direction of rotation.

The lower edge of the rudder is equipped with a slip seal to the propeller cone

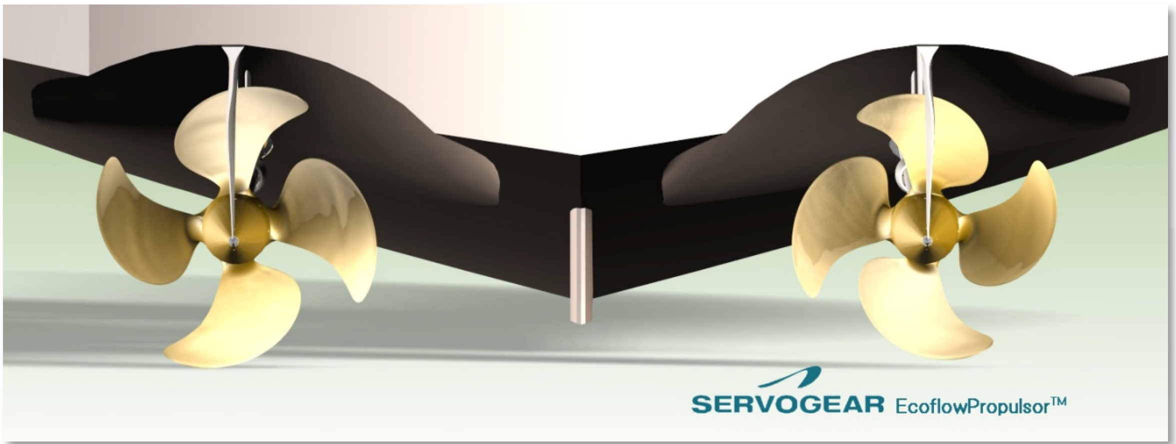
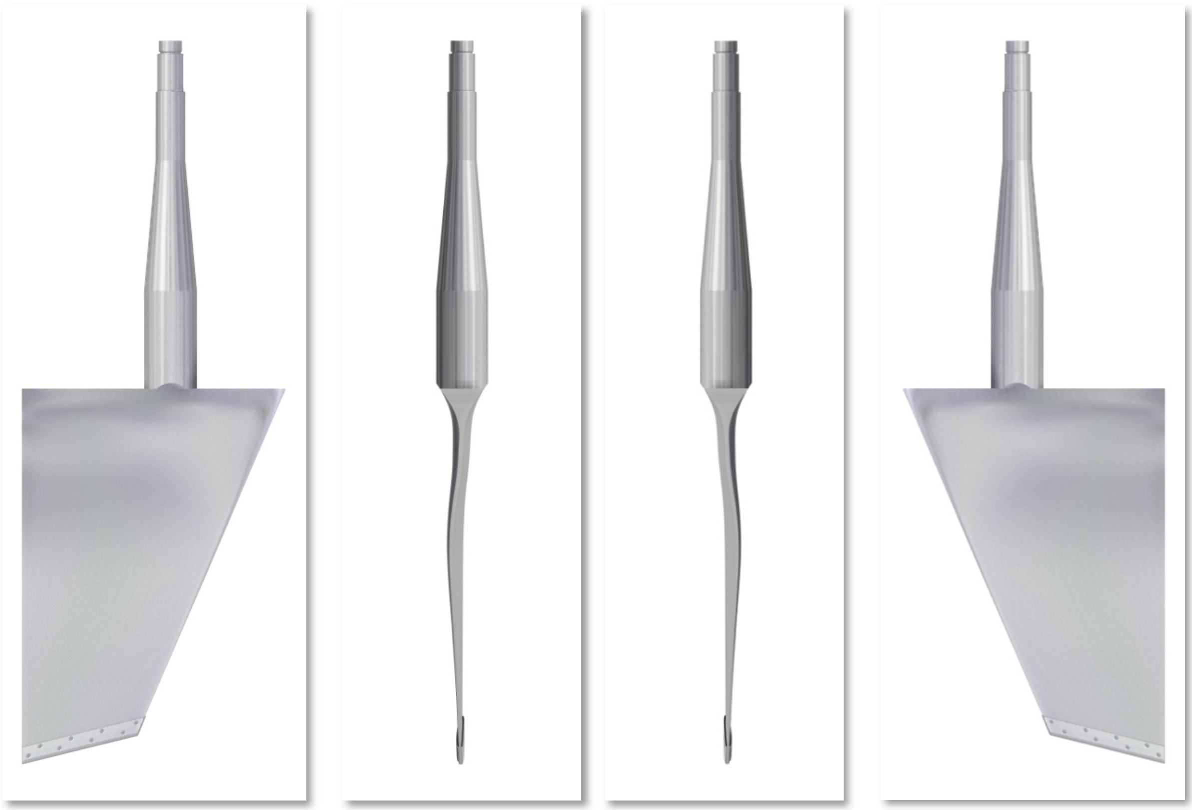


Fig 3-6 Twin propelled single hull with propeller and rudder.

Note! SB and Port rudder are "mirror image twins" and is designed according to the propellers direction of rotation. (marked by Servogear)



For LEFT rotating propeller. **For RIGHT rotating propeller.**

3.6 Stern tube description

The stern tube arrangement is of great importance to the shafts lifetime.
Normally the stern tube is based on an outer and inner water lubricated rubber lining.
The tube itself can be integrated (welded or mold) directly into the hull, or it can be mold into a wider tube by epoxy resin. Type of material in the stern tube can be metallic made of aluminum, bronze alloy or composite, GRP or carbon. Bearing liners are equipped. The inner end of the stern tube is equipped with a seal box. The seal is water lubricated and has a water inlet for this purpose.

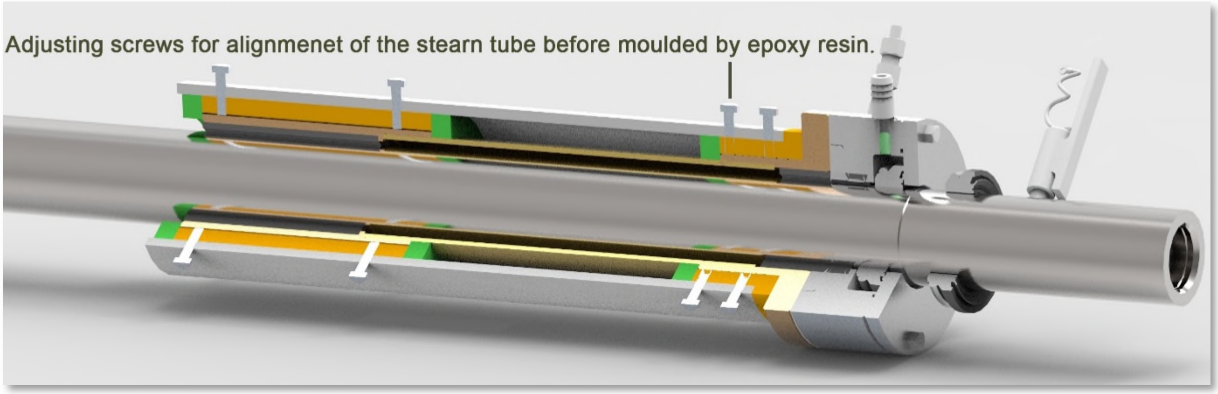


Fig 3-7 Complete stern tube with outer and inner shaft bearing with shaft seal. An inner tube connects the outer and inner bearing.

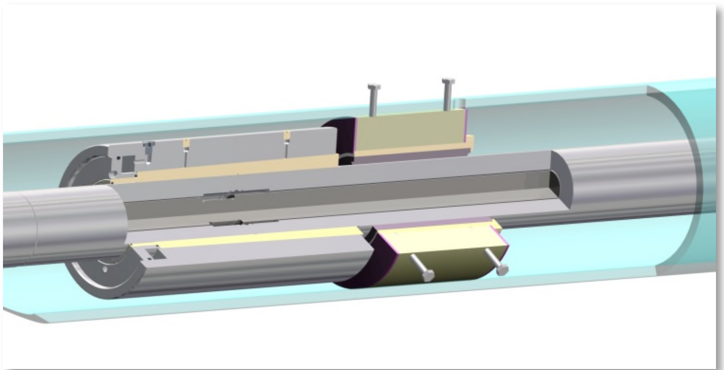


Fig.3-8 Outer stern tube shaft bearing and shaft coupling.

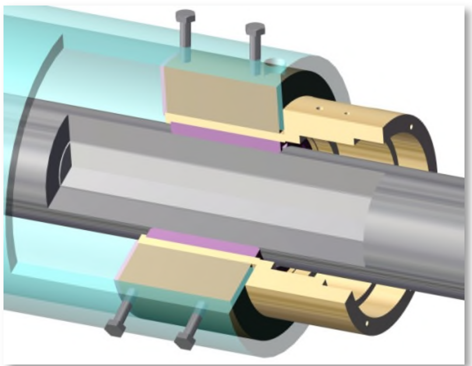


Fig.3-9 Inner stern tube shaft bearing.

NB! It is important that there always is a shaft bearing just in front of the shaft coupling.

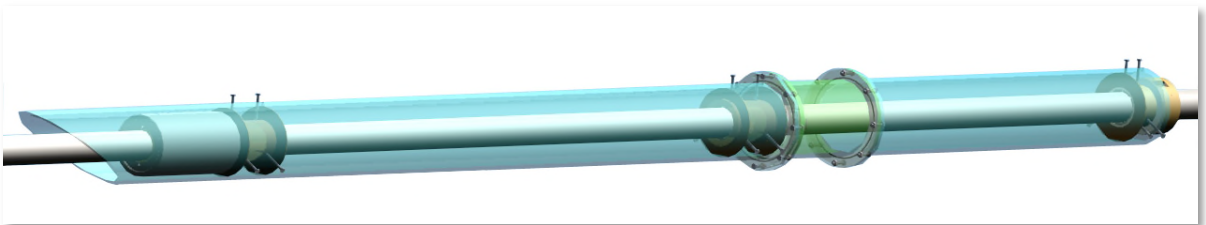
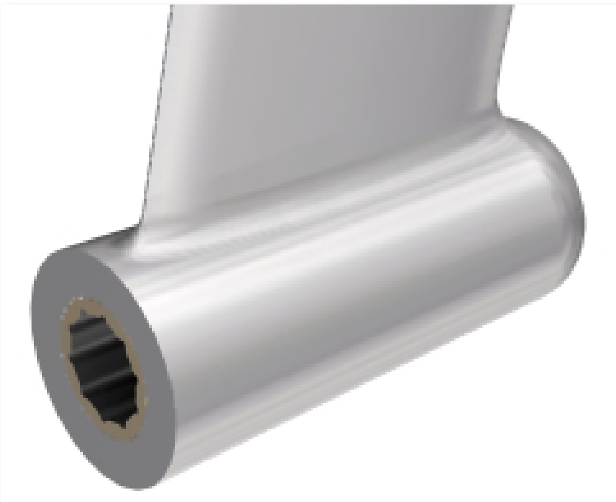


Fig.3-10 The figure shows a complete stern tube with inner, intermediate shaft bearing and outer shaft bearing. Just behind the outer bearing there is shown a shaft coupling. For applications with intermediate shaft bearing there has to be an inspection zone for inspection and evt replacement of the shaft bearing.

3.7 Shaft support description

Shaft support (strut) is in one piece mould either in bronze alloy or stainless steel. Welded shaft support can occur. The shaft end of the support is mould into the hull by Epoxy resin.
Shaft support bearings are water lubricated rubber or composite bearing.



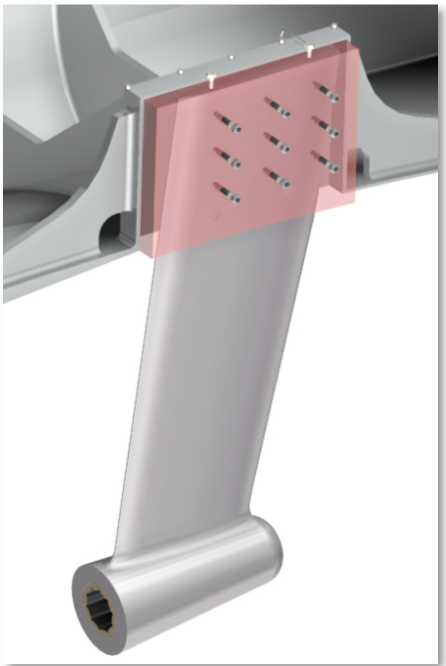
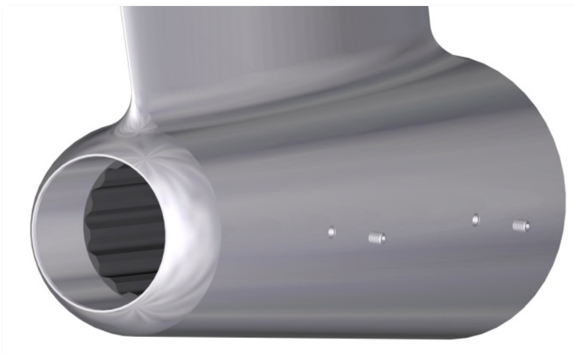


Fig.3-11 Shaft support installed in the hull. Note the integrated Epocast mold.

Note: The bearing can be secured by lock screw.
Do not tighten the screw to hard.
It can cause deformation of the liner.



4 OPERATION

4.1 Normal operation

4.1.1 Starting

Before starting, be sure that all the rotating parts are covered or secured for access.

Be sure that gear clutch is in disengaged position and the pitch lever is in neutral position before engine start. In all circumstances the propeller pitch must be in neutral position when engaging the clutch. Normally this function is blocked through the remote-control system, but in sake of good safety, do this manually anyhow.

4.1.2 Manoeuvre

The remote-control system can be arranged in two ways:
Separate levers for pitch and engine speed or one combination lever for both functions.
With a combination lever the engine speed will conduct the pitch along a programmed function curve which not allow overload of the engine.

With separate levers the master has to adjust pitch manually when increasing speed. It is important to first increase the engine speed and follow-up the pitch simultaneously to the correct engine load. Reaching 80% engine speed you can increase the pitch to 100%. Then you will avoid overloading the engine.

In manoeuvre modus, normal engine speed is approximately 1000-1400rpm. Setting the engine lever at 1200 rpm, you can easily manoeuvre the vessel in normally conditions by operating only pitch levers.

For going astern, you have to reduce the engine speed to the recommended rpm and then move the lever slowly to astern. By slowly moving you will always have full control of the vessel.

With two engines and two propellers you can turn the vessel by setting one propeller forward and the other astern.

When using too much engine speed you can release very strong manoeuvre forces which can reduce your control over the vessel.

4.1.3 Normal stop

For a normal stop for approaching a quay.
Reduce the engine speed. Then reduce the pitch slowly to zero. This will give an efficient reducing of vessels speed. When the vessels reach 5- 6 knot, increase the pitch forward to maintain the vessel speed level. This will give necessary water flow into the rudder for efficient steering. When the vessel is to approach the quay, control its position and speed by using both propeller pitch and rudder.
Under normal weather condition, engine speed can remain. It will give necessary force to manoeuvre the vessel.
For smooth manoeuvre, use slow and controlled moving of the lever. Don`t use full pitch when it not is necessary.

4.1.4 Emergency stop.

To avoid collision, it can be necessary to carry out an emergency stop. For the most efficient stop you have to reduce the engine speed to approx. 50% and then move lever to zero position and then slowly further to astern. This will avoid cavitation and low efficiency and the propeller in the astern position. Only training and experience will give a necessary knowledge of the best stopping procedure for your vessel. We will recommend this to be a part of the training procedure for the officers.

Please compare this procedure to what the engine manufacturer recommends. This to prevent a situation either where the engine will overload, or worse; choking the engine.

4.2 FMEA Emergency operation.

With a twin-engine installation, it is possible to run the vessel with one propeller. By compensating unsymmetrical propulsion moment by using rudder, it can be possible to reach 6-10 knots by running one propeller. A twin-engine installation therefore is representing a high degree of safety.

When running the vessel with one of two propellers there is a following precaution to be taken:

- Turn the free propeller into max forward pitch by using the electric driven stand-by pump. Water flow will make the propeller rotating which will minimize the drag.
- With main engine stopped there will be no cooling water flow to the gear. The rotation energy will cause heat in the gearbox and overheating can occur. Therefore, it is important to monitor the temperature by touching the gearbox by hand or by a portable temperature gauge. 45-65°C is acceptable (you can still hold your hand on it). Further increasing of temperature should be met by reducing the boat speed until the temperature is stabilizing on an acceptable level.

If stand-by pump not is installed, disconnect the pith actuator. The servo slide will then move free and the propeller will go automatically to forward pitch. The rotation will give necessary lubrication from the oil sump.

The procedure for running the vessel by one engine should be a part of the FMEA test.

4.2.1 Adjusting of pitch lever

From time to time, it happens that the lever for pitch adjustment will come out of position. The most common reason for this is reduced hydraulic power in the gearbox when the vessel has to close down an engine. If the vessel has an electrical driven stand by pump this should be started at once. When this lever has come out of position, from different reasons, do as follow to get it back in right position. Before starting the adjustment, start the engine and then move the pitch to zero by use of backup mode. Use the manual dial to read of zero pitch (between green and red scale). Stop the engine, and do as follows.

4.2.1.1 Disconnect the electrical pitch actuator

Picture shows what bolt to disconnect. The illustration shows a Scana Mar-El actuator that is connected with one M12 bolt secured with a locking nut (Nylock). Actuators from other brands can have slickly different connection, but in principle the same.

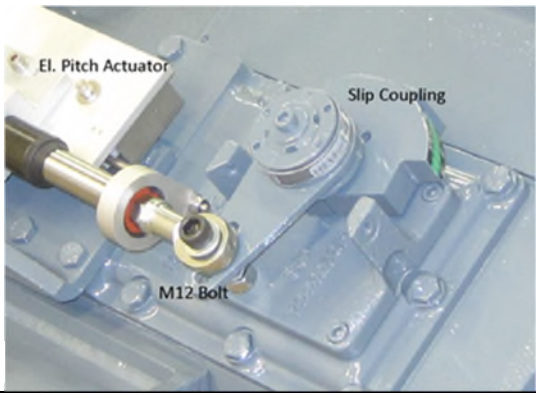


Fig.3-12

4.2.1.2 Pitch lever

The best way to do an accurate adjustment of the lever is to loosen it from the brake forces that hold it in position. The lever is mounted in a special hub, "locked" between two brake discs. The brake force is applied by two disk springs inside this hub. See exploded sketch to for details.

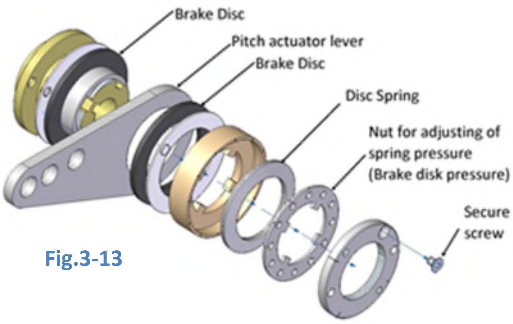


Fig.3-13

4.2.1.3 Loosen the lever

- Unscrew firs the secure/ locking screw, a small M4 Allan screw, shown on sketch.
- Loosen the nut/ ring that are pressing up the springs, until the lever is loose. There is a special spanner for this, but if this is unavailable it is also possible to loosen it by making an arrangement with two screws in the pin holes, and turn by use of a screw driver between these screws.

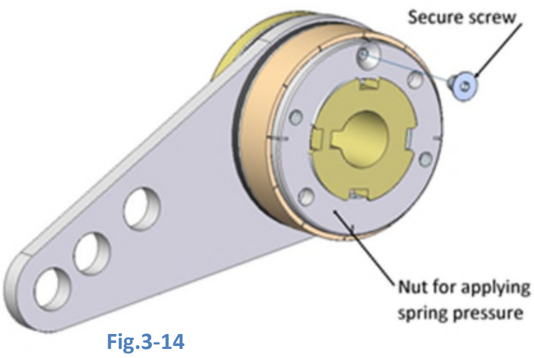


Fig.3-14

4.2.1.4 Adjusting the lever.

Now that the lever is free to move, connect it to the Electrical actuator again in same hole as before. Switch the remote-control system from backup mode to normal mode. Check that levers on bridge is set to zero pitch. The actuator will now move to the programed zero position.

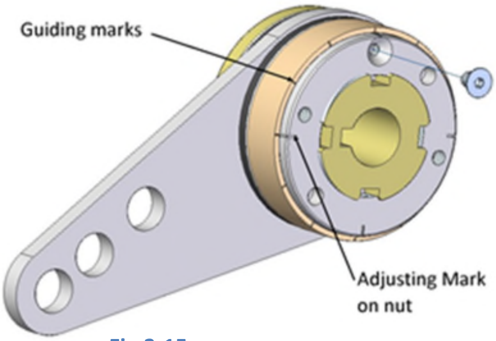


Fig.3-15

Now make sure that the propeller position still is in zero, by controlling the manual pitch scale (green and red scale). Screw in the spring pressure applying nut until it starts to press on the lever. Tighten up the nut 5 marks (approx. 160° CW), se sketch for details. Control that the counter sinkhole for the secure screw in the nut, match with a hole in the disk underneath, if not tighten a little bit more so it will match with the closest

Start up the engine and see that the pitch is still on zero, and that nothing has moved while tightening up the nut. Secure the nut by mounting the M4 countersink screw again.

Fig.3-16 Fig.Spanner for slip coupling.

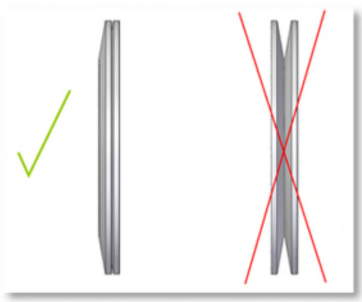


Fig.Disk Spring mounting

4.3 Operation limits.

Using full pitch manoeuvre when engine is idling can give engine speed drop, possible overload and stop the engine. Therefore, you have to clutch in at zero pitch and increase engine speed before starting the manoeuvre operation.

4.4 Possible failure.

Indication	Possible failure	Remedial action
Vibrations in Propeller System	Possible damages on propeller blades	
	The yoke or the sliding shoe in the propeller hub is worn	
	Misalignment in components or shafts in the propulsion system	
	Propeller shaft may be bent.	
	Resonance caused by torsion vibration	
Difficult to control the pitch	Possible failure in remote control system	
	Lack of grease in the propeller system.	
	Lack of oil flow	Check oil filter
	Oil flow leakage in the slide caused by pollution in oil	
	Low oil level in gearbox.	Check by dipstick
Forward Pitch Possible-Astern Pitch Impossible	Push-pull rod or its flange connection is broken	
Unstable pitch control	Possible failure in pitch feedback	
	Possible failure in remote control system	
Propeller Pitch or Engine RPM is varying	Flange connection between piston rod and push-pull rod is loose.	
	Loose bolts in propeller hub	
	Possible wear on sliding shoe or blade root of the propeller	
	Lack or variation of oil flow and pressure	
	Possible failure in remote control system	
	Computerized manoeuvre system has built- in overload function. This can reduce pitch “without any reason”.	
Propeller Pitch Suddenly Changing at Full Speed	Oil pressure can lie close to or over opening pressure of relief valve	

	Floating debris hit the propeller	
Full Astern, but very little Response in Boat	This can be caused both by too much or too little pitch. Too much pitch can cause low efficiency caused by cavitation. Not enough astern pitch gives no or little efficiency	Adjust pitch
Propeller is not engaging when clutching in	No electric signal to the solenoid valve	
	Solenoid valve out of function	
Propeller is not disengaging when clutching out	No electric signal to the solenoid valve.	
	Solenoid valve out of function	
	Clutch have been overheated	
Warm Gearbox.	Too much oil in gearbox will cause overheating of gearbox.	Check oil level
	Sensor for temperature alarm is not correct calibrated	Check sensors set point
	Water flow through cooler is too low.	Check cooling water system. Increase water flow (if possible)
	Oil cooler is not effective	Clean oil cooler
	Note: Be aware of the fact that a gearbox with 3 gearwheels normally have approx. 8-10°C higher temperature than a gearbox with 2 gearwheels. There can be different number of wheels in port and starboard gearbox	Check temperature by hand on the gearbox
Oil temp too low	Water flow through cooler is too high.	Reduce water flow
Clutch does not engage	No signal or signal fault to the solenoid valve. Defect solenoid valve	
Clutch does not disengage	No signal or signal fault to the solenoid valve. Defect solenoid valve Clutch has been overheated and fixed.	
Clutch slips at normal load	Operating pressure too low	
Oil level sinks	Leakage through shaft sealing rings.	Carry out a careful visual inspection
	Leakage in pipe systems	
	Leakage in oil cooler	
Oil level increase	Water leakage from oil cooler.	
Unusual noise from gear	Torsional vibration on certain speed. (idling speed correspond to critical speed)	

	Hydraulic noise caused by air leakage on suction side.	
	Wear or damage on gear wheel	
Engine stalling when rapid manoeuvre occurs	Too low idling speed on engine	

The reasons listed here are known indicators and based on empirical registration. However, other occasional situations and reasons may occur and cause problems that are not in the list above. Observe all fault indications before you ask for assistance from Servogear AS. This will help our service department to you provide you the best service.

4.5 Monitoring.

Normally the Servogear delivery extend monitoring and alarms for clutch oil pressure, lubricating oil pressure and oil temperature.

See project drawings.

5 MAINTENANCE.

5.1 Precautions

5.2 The qualification of the maintenance personnel.

Maintenance can be classified into four qualification level:

1. Servogear service engineer
2. Trained and checked personnel (can also be vessels engineer)
3. The vessels engineer
4. Skilled mechanical craftsmen

It is important that untrained personnel not start out complicated work.
For operation where it is necessary to call to Servogear service engineer, see below.

If maintenance work uncovers failure or damages that is intended to be covered under Servogear warranty condition, do not hesitate to contact Servogear before further repair work is carried out. See also Servogear standard warranty conditions.

5.3 Regular maintenance.

5.3.1 Maintenance plan Gear (MPG)

Level	Interval	Operation	Remarks
MPG 1	Daily	**Engine standstill**: • Oil level **Engine running:** • Check diff. pressure sensor on oil filter. • Oil temperature • Check visually gear and systems. Actuator connections • Listen for irregular noise	When manual diff. pressure sensors. Between 45°C to 65°C. Bolt connection or wire connection to the pitch lever.
MPG 2	After first 100 hour (or one year, whichever comes first)	• Change oil • Replace filter elements • Check diff. pressure sensor on oil filter. • Check visually gear and systems. Actuator connections • Retighten torque and thrust transmitting bolt connections. • Check oil hoses and pipe fittings • Visually check flexible coupling	Approved oil types: **Mobil, Mobilgear 600 XP 100** **Castrol, Alpha SP 100** **BP, Energol GR-XP 100** **Shell, Omala Oil 100** **Exxon, Spartan EP 100** **Texaco, Meropa 100** **Fina, Giram 100** **Statoil, Loadway 100** When manual diff. pressure sensors. Bolt connection or wire connection to the pitch lever.

			Bolts between output flange and flange coupling. Bolts between input flange and cardan shaft. Bolts for gearbox foundation. Tightening torque, see project drawings.
MPG 3	Every 1000 hours (or one year whichever comes first)	• Change oil or oil sample. • Replace filter elements after alarm form diff. pressure sensors. • Clean outside of transmission • Clean Oil cooler • Check visually gear and systems. Actuator connections	If oil sample result is not satisfying, change oil. Cleaning of oil cooler tube stack, check for cavitation, erosion. Bolt connection or wire connection to the pitch lever.
MPG 4	Every 5000 hours	• Retighten torque and thrust transmitting bolt connections. • Check oil hoses and pipe fittings • Visually check flexible transmission mounting (if fitted) • Visually check flexible coupling • Check of shaft seals	Bolts between output flange and flange coupling. Bolts between input flange and cardan shaft. Bolts for gearbox foundation. Tightening torque, see project drawings. Check input and output shaft seal for leakage.
MPG 5	Class period (5 year)	• Visually check clutch discs • Visually check gearing, gear wheel meshing • Check oil pump • Check control unit • Re-calibrate gauge • Check earth cable connections	This five-year inspection should be carried out by an authorized Servogear Engineer.

5.3.2 Maintenance plan. Propeller and stern tube system. (MPP)

Level	Interval	Operation	Remarks
MPP 1	Weekly	The propeller system should be lubricated once a week by pumping grease through the grease nipple on flare of the propeller shaft flange coupling.	Remember to remove the ventilation plug before pumping grease and replace the ventilation plug after filling.

MPP2	When docked	Always when dry docked we recommend checking the amount of grease in the propeller hub. If the amount of grease is too small more frequent intervals between grease pumping are recommended	Fill up the propeller hub and the shaft bore with grease. Recommended and approved grease types: Mobilith synthetic grease: **K- NATE NLGI 1, SHC 460** Esso synthetic grease: **Fliess**
		Check the propeller blades for wear/slack in the blade-root bearings.	
		Check the condition of sacrificial anodes on the propeller hub, rudder, bracket and stern tube. If necessary, these must be changed.	Use acid free Vaseline for the bolts for the sacrificial anodes to ensure good connection.
		Check bearings in bracket and stern tube for wear/damage	
		Check propeller, shaft, bracket and rudder for galvanic corrosion	If metal has a red colour, this indicates insufficient contact with sacrificial anodes, or grounding fault on electrical system. Connections must be checked.
		Check for damage at the propeller blades	
		Check for propeller shaft damage	
		Check earth cable connections	

NB! When delivered the propeller, plant is filled with grease K NATE NLGI 1, unless other types of grease are agreed upon with customer.

5.3.3 Maintenance plan rudder (MPR)

Level	**Interval**	**Operation**	**Remarks**
MPR 1	Daily	Check for leakage around the rudder tube.	
MPR2	Weekly	Lubricating of rudder bearing	Recommended and approved grease types: Mobilith synthetic grease: **K- NATE NLGI 1, SHC 460** Esso synthetic grease: **Fliess**

5.3.4 Maintenance plan intermediate shaft (MPI)

Level	Interval	Operation	Remarks
MPI 1	After first 200 h	Re- tight bolts in the intermediate bearing foundation. Re- tight bolts in intermediate bearing/shaft flanges.	Tightening torque for the flange bolts, see project drawings.
	Every 500 h	Filling of grease in grease nipples on cardan shaft.	For cardan Shaft use **Shell Retinax LX 2** **Fuchs Renolit MP** For other types of shafts/joints: Contact Servogear for type of lubrication.
	Every 2900 h	Lubricating intermediate bearing.	SKF bearing grease **LGMT 2** 18 gr. grease /per. grease nipple
	Yearly	Check the shaft for wear.	

5.3.5 Corrosion and protection against corrosion

5.3.5.1 Factors that aggravate the corrosion process.

Most corrosion resistant metals rely on an oxide film to provide protection against corrosion. If the oxide is tightly adherent, stable and seif-healing, as on many stainless steels, then the metal will be highly resistant or immune to corrosion. Even so, the most stable oxides may be attacked. If the film is loose, powdery, easily damaged and non-self-repairing, then corrosion will continue unchecked. Seawater, by virtue of its chloride content, is a most efficient electrolyte.

Crevices which allow ingress of water and chlorides but from which oxygen is exciuded rapidly become anodic and acidic and are hidden start points of corrosion.

Sea water, if not destructive enough on its own, has several powerful allies assisting the breakdown of metals and non-metals alike. Living allies in sea water also enhance its destructive power. Microbiological organisms, clustering of weed, limpets as well as deposits of sand, silt or slime not only exclude oxygen but also often create locally corrosive conditions under these deposits, which aggravate attack. Sulphate reducing bacteria, left undisturbed in marine silt or mud deposits, will produce concentrations of hydrogensulphide, which are particularly aggressive to steel and copper based alloys.

Pitting attack in stagnant seawater may be as much a problem as erosion or cavitation attack at higher velocities.

Temperature alter the corrosion rate of a material, and a good rule of thumb is that 10°C rise, double the corrosion rate.

5.3.5.2 Protection against corrosion

5.3.5.2.1 Cathodic protection

Sacrificial anodes enable the potential of the system to be changed, and will provide protection to steel exposed to seawater. Systematic location of the anodes is critical to their overall effectiveness. They must likewise be regularly serviced and replaced when spent.

For more info see Servogear < Instruction Manual Part II. Installation and Testing > part 4.14 *Corrosive and Galvanic protection.*

5.3.5.2.2 Stagnant water

On vessel where the vessel for periods will be out of service (laid up), but still on sea, it is of most importance that the problem with stagnant water is taken into account. This is especial important in the stern tube area where there can be a problem with limpets, sand or slime and where the tail shaft is laying in the bearing (this can act as a slit). This will normal also cause poor oxygen content in the sea water, that is important for the stainless steel to keep (self-healing) the oxide film. Between tail shaft-surface area and the water-lubricated bearing there will be a big chance of crevice corrosion when the vessel is laid up. This is normally caused by lack of oxygen in the slit and thereby the oxide film on the stainless-steel shaft will be damaged, that results in corrosion attack.

5.3.5.2.3 Maintenance plan

Seawater temp.	Interval	Operation	Remarks
Winter <20°C	Every 10th day	Flushing	
	Every 14 nights	Rotation of shaft	
Summer 20-28°C	Weekly	Flushing	
	Weekly	Rotation of shaft	
Tropical >28°C	Every 2nd day	Flushing	
	Weekly	Rotation of shaft	

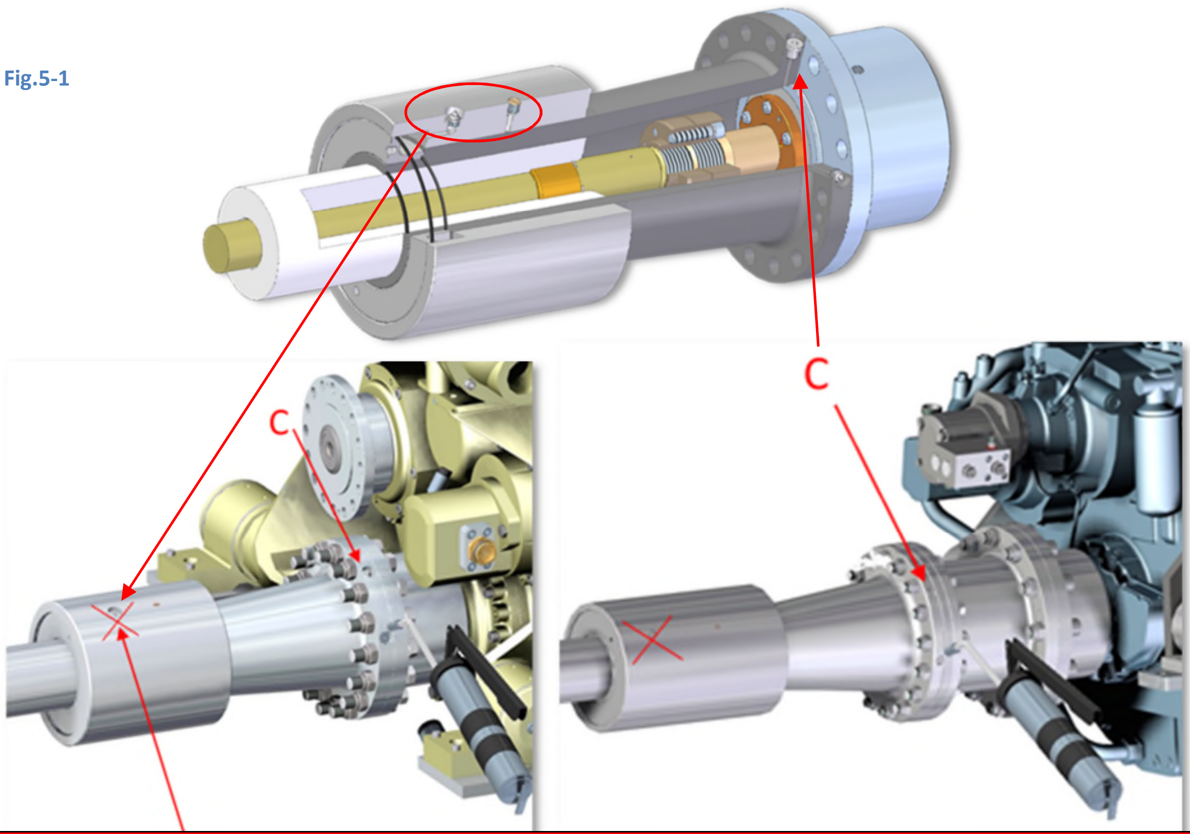
5.4 Lubricating

5.4.1 The propeller system

The propeller system shall be lubricated once a week by injecting the grease through the grease nipple on the rim of the propeller shaft flange coupling.

Remark: Remember to remove the ventilation plug C before pumping grease and reinsert it after refilling

Fig.5-1



REMARK: DO NOT FILL ANYTHING IN SHAFT FLANGE.

THIS IS ONLY FOR DISMANTLING AND ASSEMBLING OF COUPLING!

When docked:

Check the amount of grease in the propeller hub. If amount of grease is too small, more frequent intervals between refilling are recommended. We recommend filling up the propeller hub and shaft bore with grease from outside. Air driven pumps are recommended for this job. Start by turning propeller shaft, so that you have one hole underneath propeller hub and 2 holes on top. Remove the 2 ventilation plugs A and B on top, and C inside on the rim of propeller flange. Start filling until grease comes out from first ventilation hole A and plug it. Start filling again until the grease comes out from second ventilation hole B, and finally fill the grease until it comes grease out from ventilation hole C, inside the vessel. Reinsert the last ventilation plug. It is important that the grease is tempered to have a good filling and to avoid high pressures.

Recommended and approved grease type: K-Nate NLGI 1, Mobilith SHC 460.

Remarks: Plugs on the outside are out of stainless steel. Do not mix these with plugs from inside/engine room.

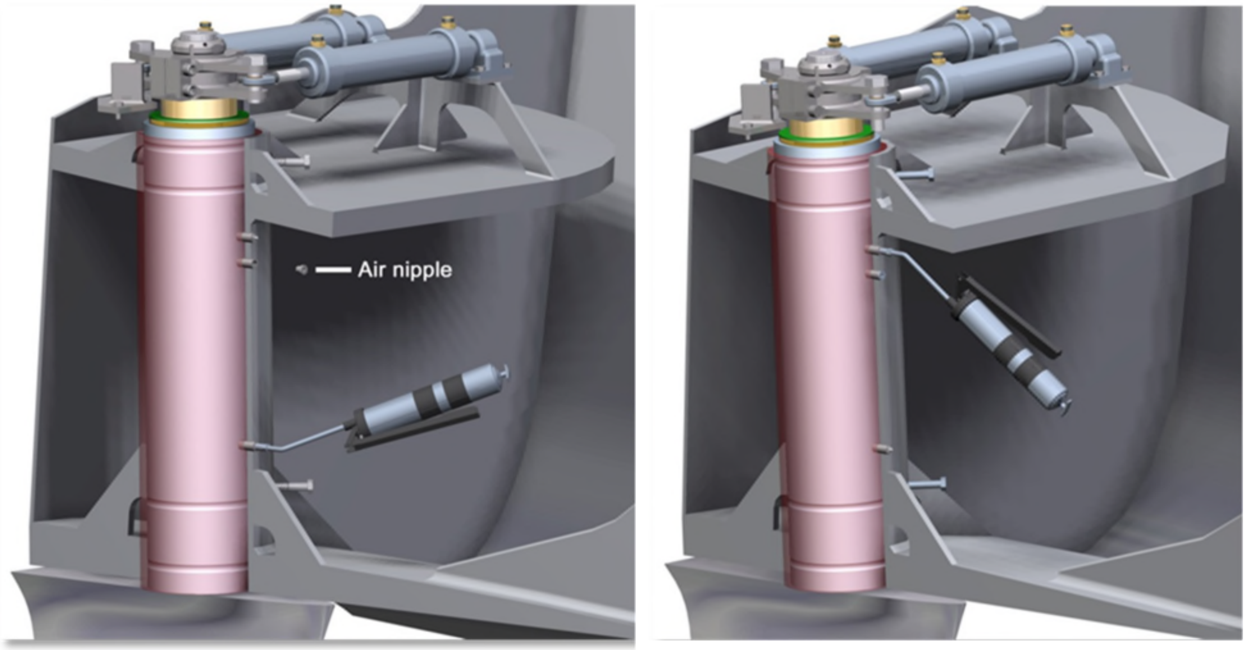
Figur 5-2

Precautions:

Go through procedure with crew, to ensure maintenance has been done properly. If not greasing of propeller shaft are done correctly from inside, greasing from outside are recommended, to be able to fill system. We also recommend to order new shaft couplings to have in spare if needed for next demounting.

5.4.2 Rudder box

The rudder stock and linings are lubricated by grease. Grease can be supplied through grease nipples on outer rudder box. Remember to open for airing when filling grease in the lower grease nipple.



Figur 5-3 Rudder box

Recommended and approved grease type: K-Nate NLGI 1, Mobilith SHC 460.

5.4.3 Stern tube

The stern tube arrangement is of great importance to the shafts lifetime.
Normally the stern tube is based on an outer and inner water lubricated rubber lining.
The tube itself can be integrated (welded or mold) directly into the hull, or it can be mold into a wider tube by epoxy resin. Type of material in the stern tube can be metallic made of aluminum, bronze alloy or composite, GRP or carbon. Bearing liners are equipped. The inner end of the stern tube is equipped with a seal box. The seal is water lubricated and has a water inlet for this purpose.

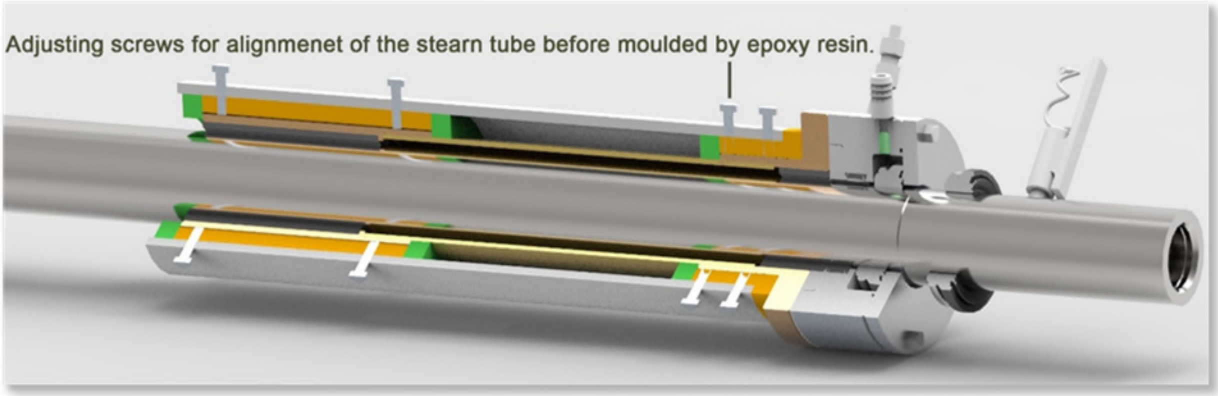
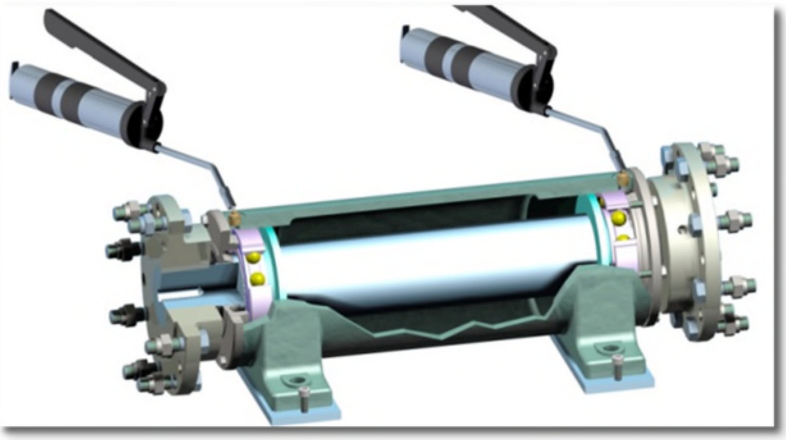


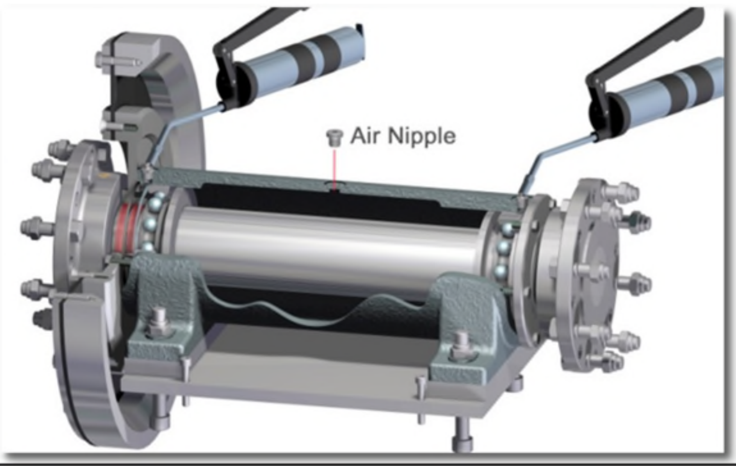
Fig. 5-4 Stern tube

5.4.4 Intermediate bearing

The intermediate shaft bearings are lubricated by grease.



Figur 5-5 Intermediate bearing



NB.

Do **NOT** use propeller lubricating grease. Use only SKF bearing grease **LGMT 2** or equivalent**.**

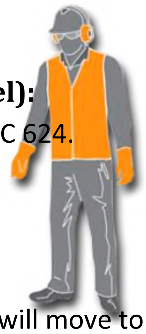
5.5 Dismantling and assembling instructions.

5.5.1 Inner flange coupling

For the Oil shrink procedure see the instruction below. Se also Manufacturers manual

5.5.2 General Oil shrink instructions.

The flange connection is based on shrink friction between shaft and flange. The shrink is initiated by a clamp ring outside the flange coupling. A tapered outside of the flange coupling fit with a similar tapered inside of the clamp ring. A very high oil pressure initiated by a separate pump gives radial force which allows the clamp to be axially moved by a pressure in a grease pressure chamber. Releasing the high oil pressure when you have fulfilled the pulling length, the radial pretension of the clamp ring will be transferred to the flange and give the necessary shrink against the shaft for absorbing the torque.



5.5.2.1 Necessary equipment (should be a standard tool on board in the vessel):

- 1 pc.Manual Oil-injector (max. pressure 3000 bar)Fill the pump with oil, use Mobil SHC 624.
- 1 pc. Manual Grease injector.

5.5.2.2 Procedure for Dismantling.

1. Remove the grease nipple on pos. 1.
2. Pump oil pressure through pos. 2. When certain pressure is reached, the clamp ring will move to neutral position and stop in end cover. This will generate a very high grease pressure and the grease will drain by high force through the open hole. Cover the grease opening to avoid physical damage. Use protection glasses
3. At drive up and drive down the relieve valve on the pump must be opened before removing the pump.
4. Problems by releasing the shrink might be caused by to low oil viscosity. Then try higher viscosity oil or heat the clamp slightly outside while pumping pressure.

IMPORTANT!! Be careful and keep distance from the clamp ring when pumping oil into it. The Oil-injector can give a pressure up to 3000 bar, and strong forces are involved.

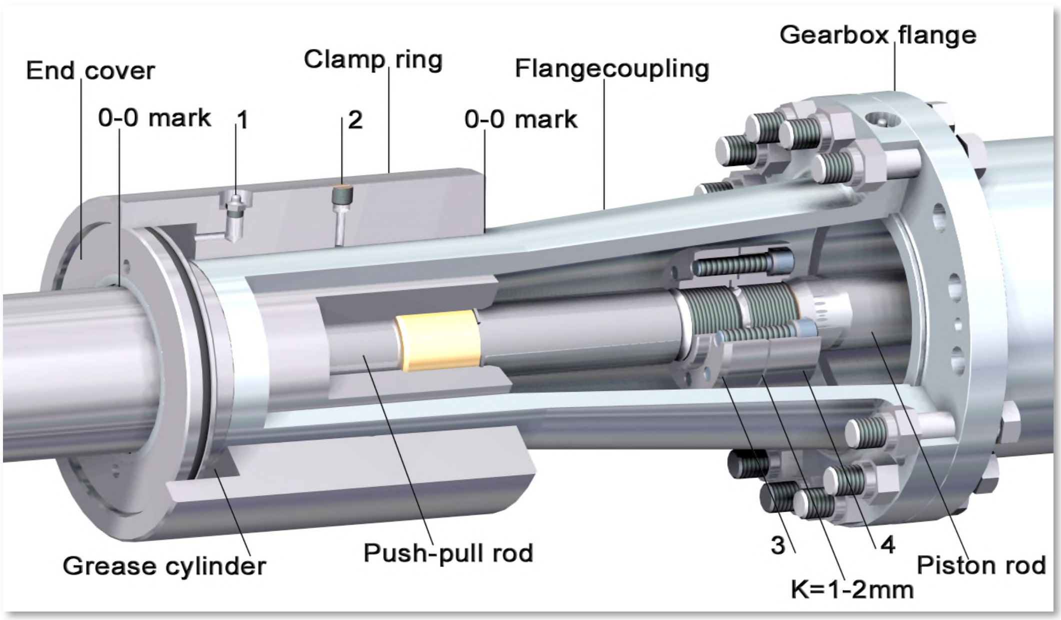


Fig 5-6 The different parts of inner shaft flange and push-pull rod connection to the piston rod

5.5.2.3 Procedure for mounting

1. The contact surfaces between shaft and flange coupling has to be cleaned thoroughly. To achieve the calculated friction, it is important that surfaces is complete clean and free of oil.
2. Position the flange coupling, with clamp ring (loose), on the propeller shaft. A "0-0" sign on the

The different parts of inner shaft flange and push-pull rod connection to the piston rod

3. Start pumping the grease through the grease nipple (pos 1). This will initiate axial force to move the clamp ring. Reaching a certain pressure, pump oil pressure with the oil injector until the clamp move, then increase the grease pressure. Alternate pumping grease pressure and oil pressure until the clamp reach the "0-0" sign on the flange. Control that there leaks oil between clamp and flange. This indicate that that the surface between clamp ring and flange is lubricated.
4. When the clamp edge is reaching the "0-0" sign, release the **oil pressure**.

Note! Do not release the grease pressure before 5 min after releasing oil pressure.
Wait one hour before transferring torque through the transmission.
NB! Do not use grease for smoothening the shaft as it can emulsify and close the water groove in bearing.

- When the tail shaft is in, its position to assembly the flange.

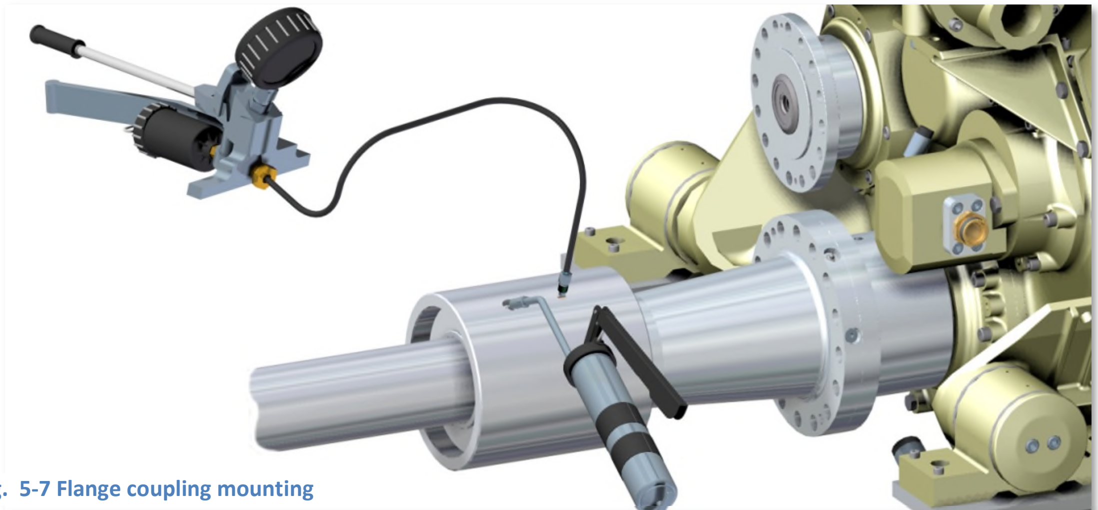
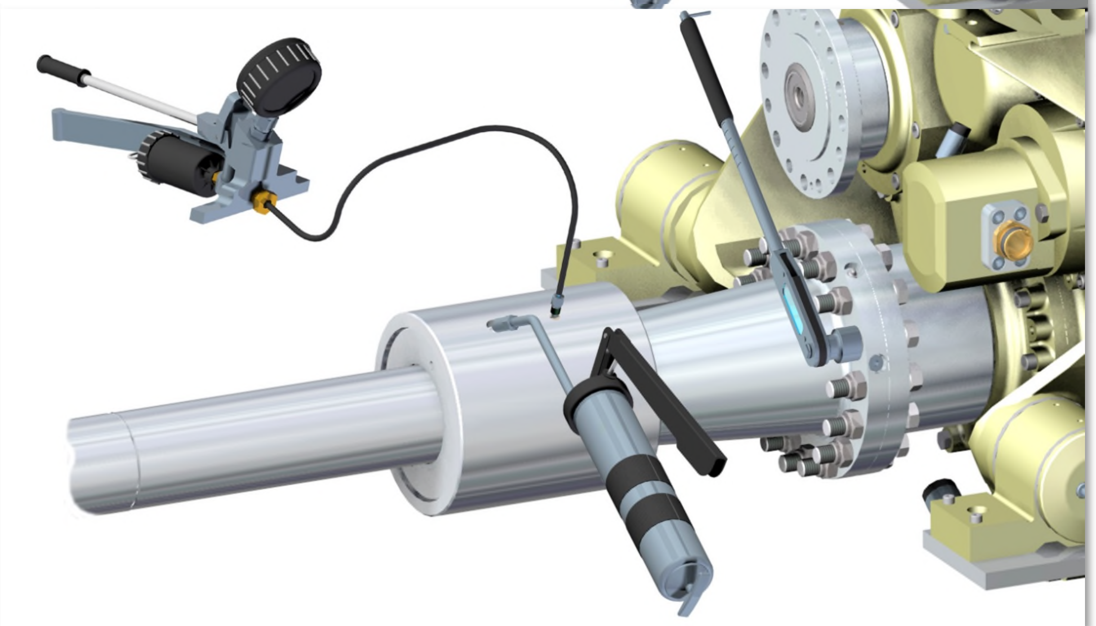


Fig. 5-7 Flange coupling mounting



5.5.3 Connection of push-pull rod

Inside the flange coupling the push-pull rod in the shaft is connected to the piston rod in the gear by a “nut flange” connection.

5.5.3.1 Procedure for dismantling

1. To disconnect the two rod-ends, the shaft flange must be pushed backwards to get an opening for access to the pushrod flanges.
2. When you have necessary distance between gear flange and propeller shaft flange, you can disconnect the “nut flange” connection by loosen and remove the connection bolts.

5.5.3.2 Procedure for mounting

1. To connect the two rod-ends, the shaft flange must be pushed backwards to get an open access for mounting the pushrod flanges.
2. The propeller pitch should be in center, or better, in forward position.
3. Screw the nut-flanges into its respective rod ends. The rod end should pass the flange face with approx. 1mm. This is to get a necessary pre-tension of the joint.
4. Then pull the two flange parts together, either by operating the pitch control or by long thread bolts.
5. Use the only original bolts for the final connection. Be careful to get the flanges to enter the guiding edge and avoid misalignment when tightening the bolts. See table below for the correct tightening torque.
6. After reaching the correct torque check that the gap “K” is equal around the flange.
7. Replace the bolts after each dismounting of push-pull rod coupling.

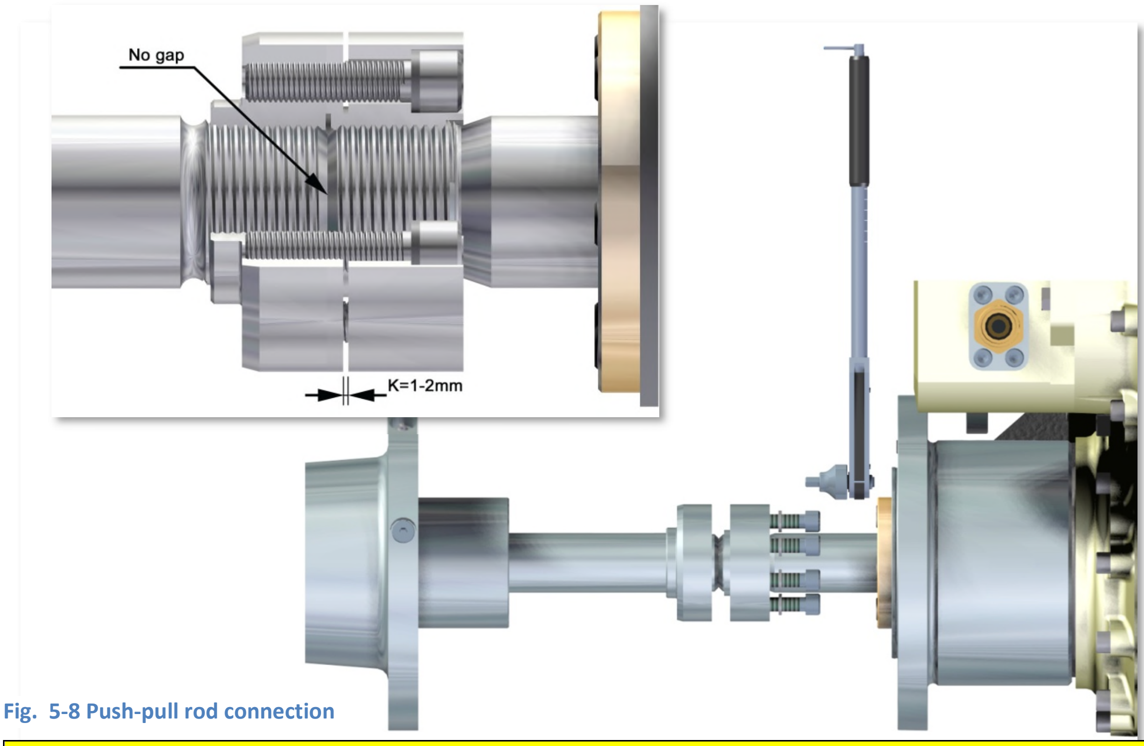


Fig. 5-8 Push-pull rod connection

Tightening torque for push-pull rod connection.		
Thread dimension in flange bolts	Tightening torque	
M 10	35 Nm	*see 5.5.3.2 /7
M 12	57 Nm	*see 5.5.3.2 /7

5.5.4 Push-pull rod connection for intermediate shaft.

Long distance between gear and the propeller can entail that the propeller shaft has to be made in two parts. The two parts will be connected either outside or inside the hull by a common oil shrink fit. The push-pull rod has then to be connected inside the shaft. The connection is made by a split-hub with a number of tangential bolts. This can connection is to be done before connecting the shaft ends. This push-rod joint has to be carried out with the highest attention to a correct procedure. A loose connection can give a propeller complete out of control.

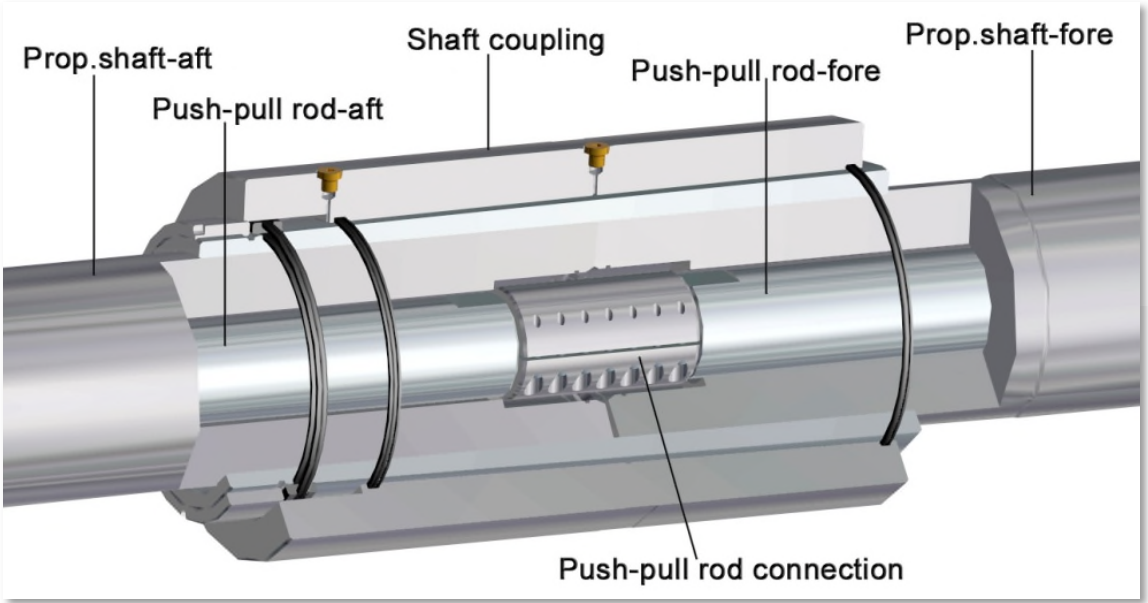
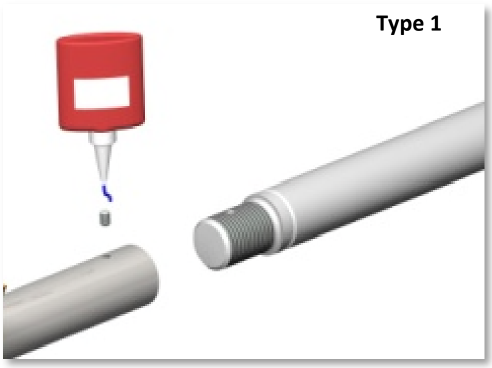


Fig. 5-9 Splitted connection piece

The inside shaft connections are made in two ways:

Type 1: Screw fitting	Securing: Liquid tread lock and set screw
Type 2: Split/screw connection piece	Securing: Liquid tread lock and clamping bolts



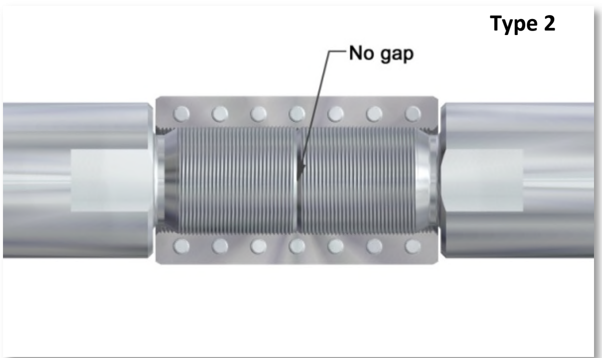


Fig. 5-10 Inside shaft connection

5.5.5 Propeller Hub (forward part)

The connection between forward part of propeller hub and shaft is based on shrink friction between shaft and hub. The shrink is initiated by a clamp ring outside the hub. A tapered outside of the hub fit with a similar tapered inside of the clamp ring. See also 5.4.2.

The dismantling and mounting operation demand a special dog-iron tool (pulling tool) which include the forward and aft drawplate and the tension bolts. In addition, the Manual Oil-injector (max. pressure 3000 bar) is needed.

5.5.5.1 Procedure for dismantling

Mount the pulling tool and tighten up the bolts to a position where the clearance between forward drawplate pos. 1 Fig 3.1 and clamp ring is pull-up length plus approximate 10 mm.
Mount the oil- injector and start pumping. The oil need time to distribute. Do not force the pumping. After pumping 2-3 stroke by the pump, the clamp ring may suddenly "shoot off", and clamp ring will stop against the forward plate on pulling tool. When clamp ring now is loose, the pulling tool can be removed. Normally the hub now is loose from the shaft. If not, heating the outside of the hub by a propane or acetylene flame will have effect.

IMPORTANT!! Be careful and keep distance from the clamp ring under the work. Do not have fingers or hand between clamp ring and drawplate. The release force is very high and can course personal injury.

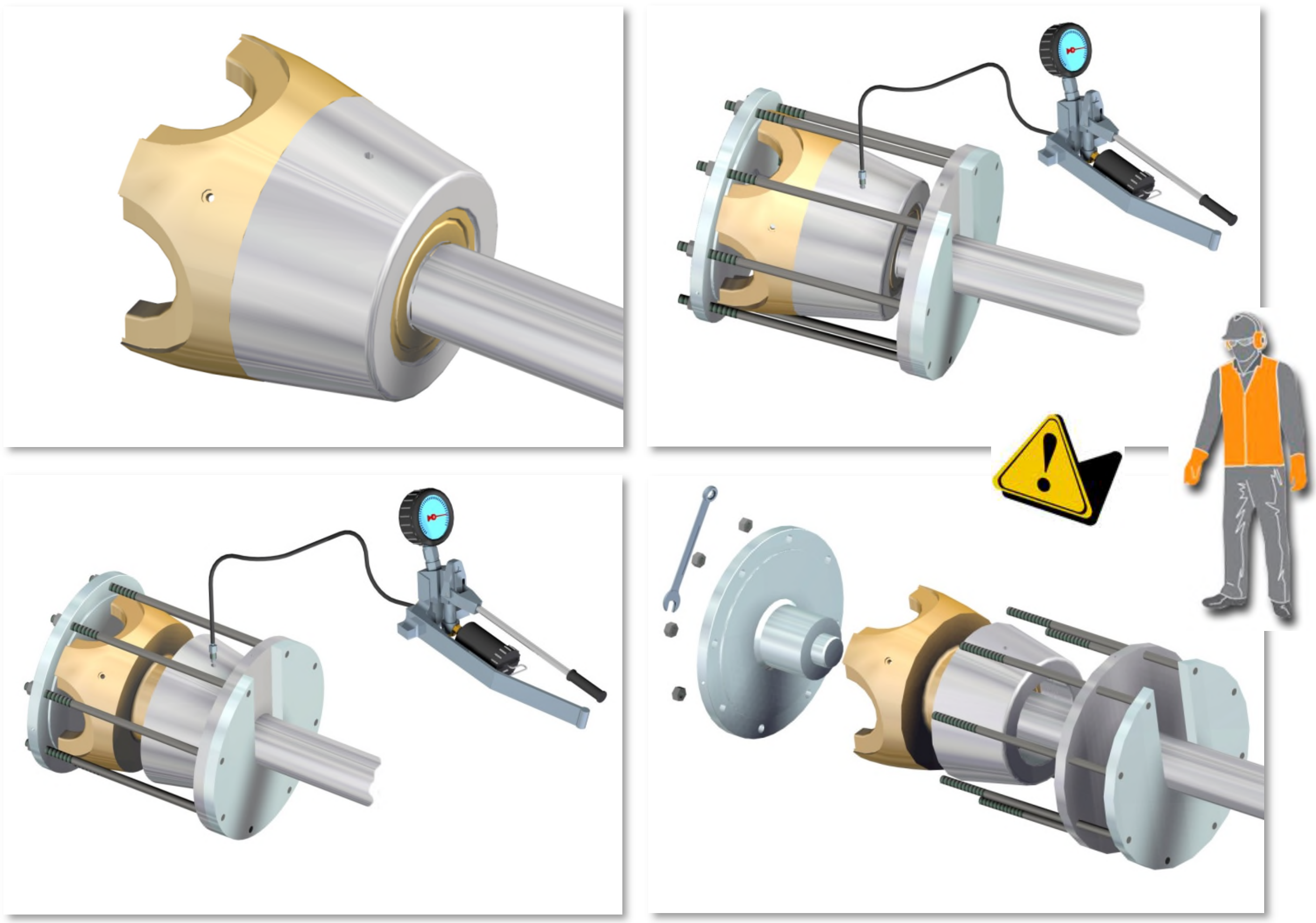


Fig. 5-11 Different steps of dismantling propeller hub from shaft.

5.5.5.2 Procedure for mounting hub to shaft.

For oil shrink instruction see 5.4.2

The contact surfaces between shaft and hub has to be cleaned thoroughly. To achieve the calculated friction, it is important that surfaces is complete clean and degreased. It depends both outside shaft and inside hub.
Position the hub, with clamp ring (loose), in accurate position on the propeller shaft. If the hub is too tight, heat it to get the desired position.
Be sure that the surfaces between the clamp ring and the propeller hub are completely clean.
Fit the mounting tool, and connect oil pump.
Start pulling up the clamp ring with the pulling tool. Pump oil until oil penetrate between the clamp ring and hub. Then tighten up the tool.
Start continuous pumping with the high-pressure pump while is pulling up the clamp ring with the pulling tool. Tight up the clamp ring to meet the propeller hub. Release the pressure from the oil pump.

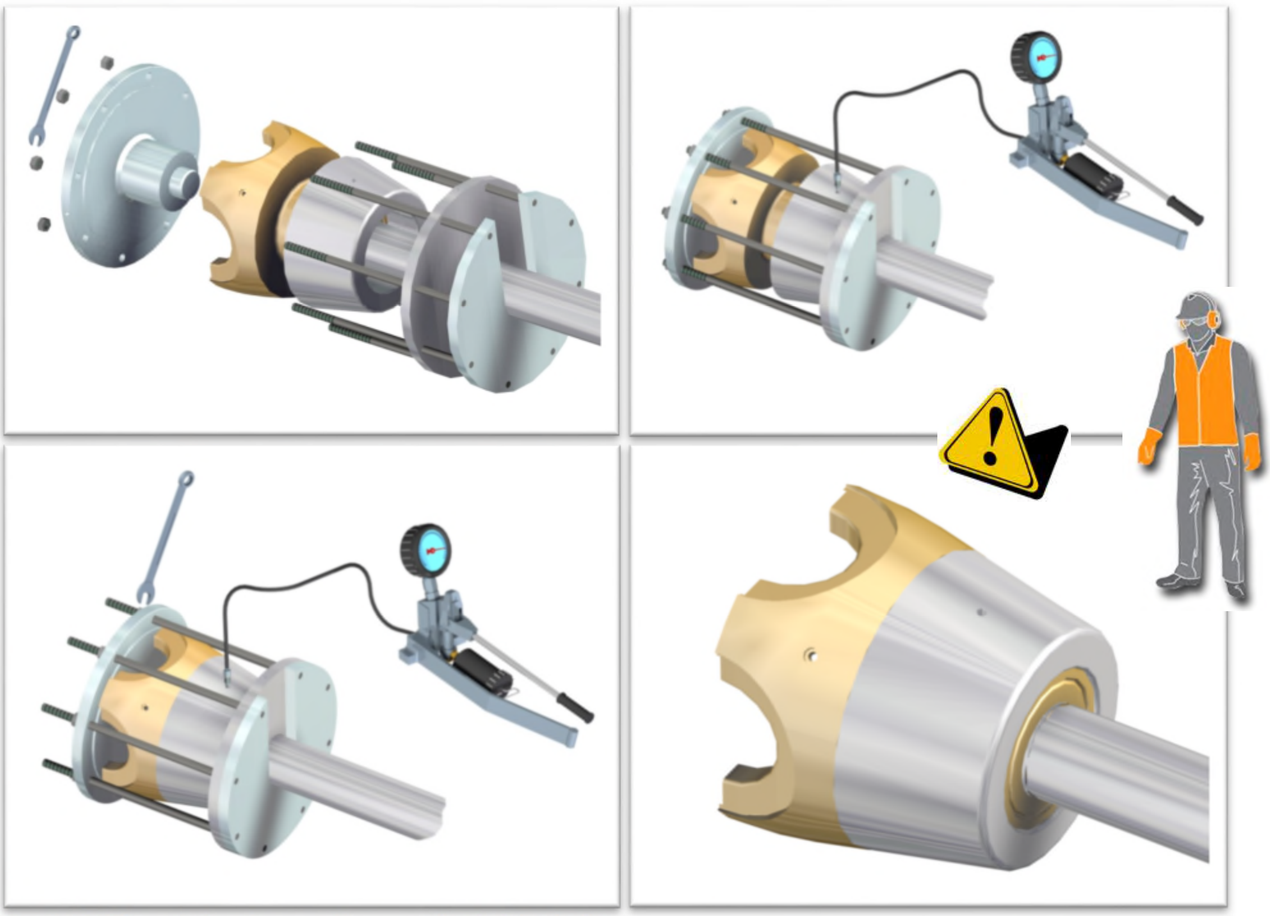


Fig. 5-12 Different steps in mounting propeller hub to shaft.

NOTE! Do not release the grease pressure before 5 min after releasing oil pressure.
Wait one hour before transferring torque through the transmission.

5.5.6 Propeller

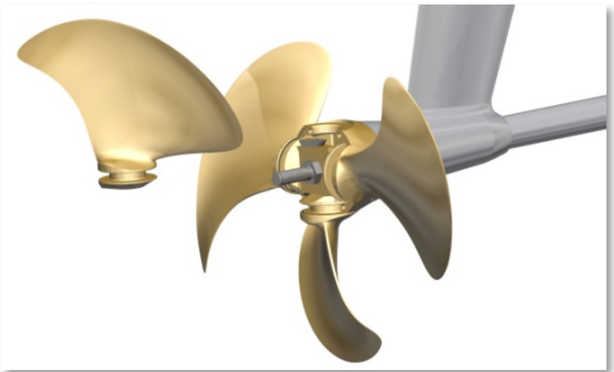
5.5.6.1 Procedure for dismantling propeller

Unscrew the axial connection bolts.
Aft part propeller hub and can now carefully be removed. Try to keep the propeller blades in position while removing the hub. If it is difficult to loosen the hub, try to twist the blades. Avoid a situation where the propeller blades fall to the ground, as it can damage the edge of the propeller, or worse, it can course serious personal injury.

Observe if there is water inside the hub. If so, it is indicating worn O-ring seals between blades and hub. Anyhow, Servogear recommend replacing O-ring seals with new whenever dismantling the propeller hub. Remember to clean the seal groves carefully before assembling.

If the docking is caused by vessels grounding or debris collision, all the propeller parts has to be carefully checked for deformation or other damages.

The quadruple propeller blades are carefully balanced and have the same weight. This is to be taken into consideration when replacing one or more of the blades. Different weight, balance or shape will give vibration and wear.



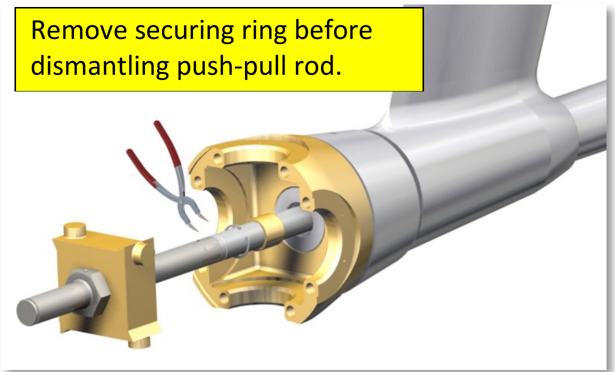


Fig.5-13 Different stages in dismantling the propeller blades

NOTE: Start removing the propeller blades from the top, and continue in the propeller rotation direction

Following important information are stamped in the propeller blade:

Information	Explanation
ID -number	ID number (usually six figure) must always be given by contacting Servogear
Class society	Stamps Showing the name of the class society
Number 1,2,3,4	Blade number. Corresponding number in the propeller hub
SB , P	Letters showing which side of vessel the blades belong to
Drawing no.	Drawing no. must always be given by contacting Servogear

5.5.6.2 Procedure for mounting propeller

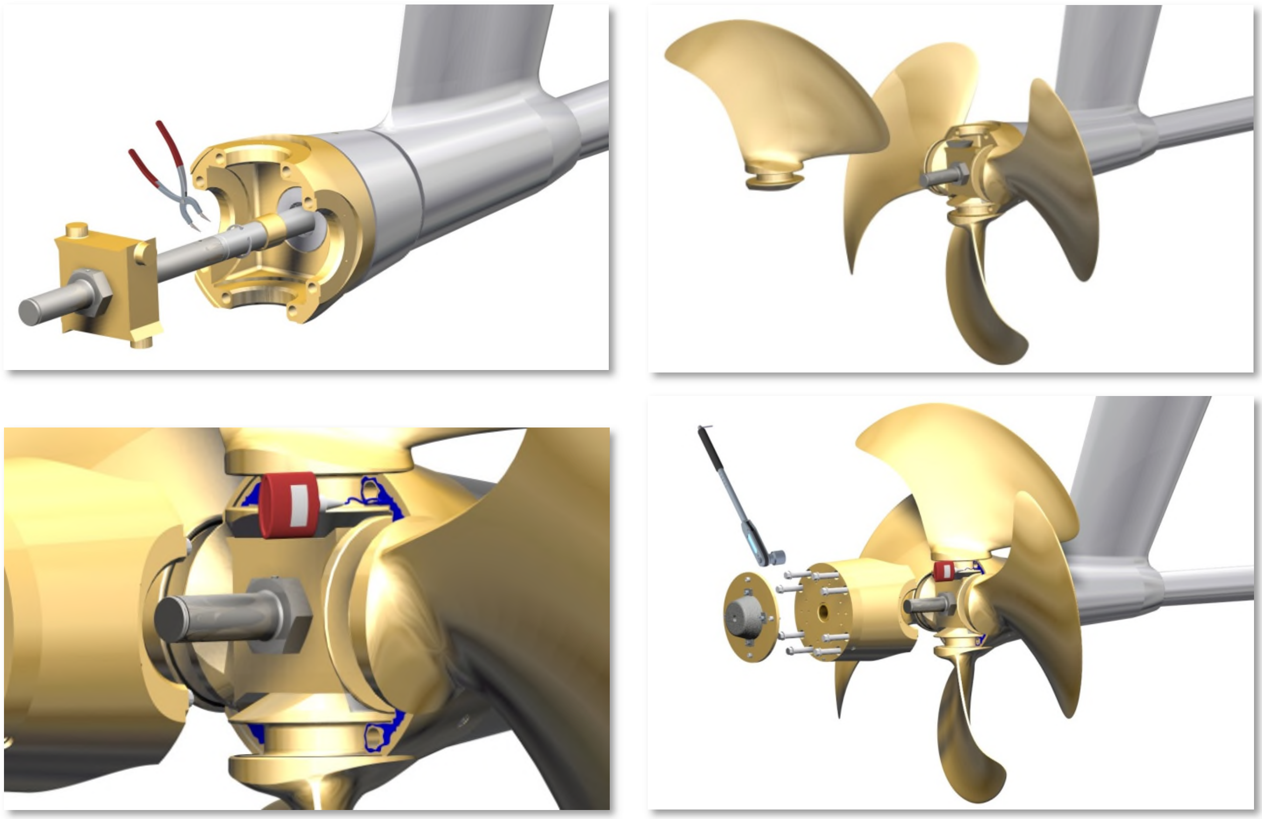


Fig.5-14 Different steps in mounting the propeller hub to shaft

The surface between fore and aft part of the hub have to be carefully cleaned degreased
Cover the surfaces with high quality floating gasket (Loctite gasketno.574)

Apply the key on the yoke pins in position that fit the groove in the propeller blades. Then enter the propeller blades, one by one, into the key and turn them into their respective bearings.

Then mount aft part of propeller hub.

The fore and aft parts of the hub is machined together. The stamped number on the two parts shall correspond.

NOTE: Do not allow sharp edges to damage the O-ring seal.

5.5.6.3 Propeller hub. Marks

Following marks are stamped in the different parts of the propeller. The marks have to be corresponding when assembling the propeller.

Marks 2 - 2: Corresponding marks on each of the two hub parts.

Marks SB1- SB4 / BB1- BB4: Corresponding marks on the blades and the hub. The letters indicate starboard (SB) and port (P) propeller.

Mark 0 pitch: Marks on the blades for zero pitch. When this mark is corresponding with the line where the hub parts are divided, the propeller blades have theoretical zero pitch.

Marks KS: Corresponding marks for designed forward pitch. When this mark is corresponding with the line where the hub parts are divided, the propeller blades have a theoretical design pitch.
See also figure.

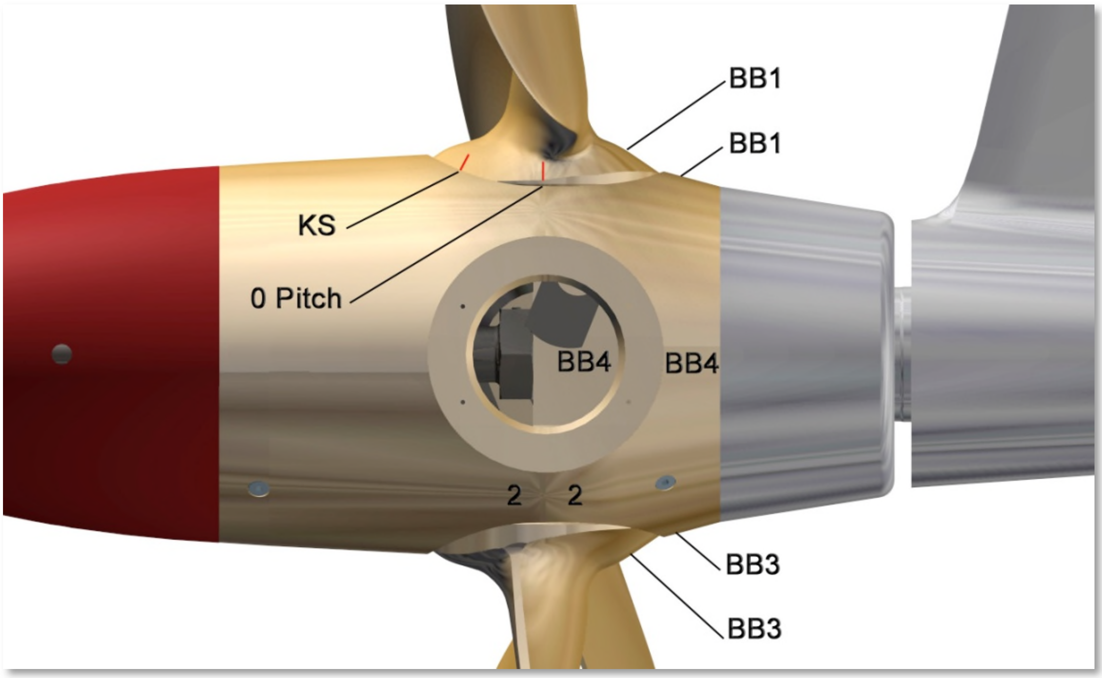


Fig.5-15 Propeller hub marks

The bolts connecting the two parts of propeller hub have to be tightened with a certain torque. See table below.

Torque table for axial bolts in the propeller hub

Propeller hub	Number of blades	Thread dimension	Torque (Nm)
VD 770	3	M 12	60 Nm
VD 780	3	M 16	140 Nm
VD 790	3	M 20	200 Nm
VD 800	4	M 12	70 Nm
VD 805	4	M 14	100 Nm
VD 810	4	M 16	140 Nm
VD 820	4	M 20	200 Nm
VD 830	4	M 24	450 Nm
VD 840	4	M 27	700 Nm

5.5.7 Yoke for control of propeller pitch.

An internal rod in propeller hub which is connected to the push – pull rod, operate the blades. A yoke is mounted to this rod to transfer the movement to turn the propeller blades. The yoke is transferring the servo force to the blades in order to turn them to give needed thrust forward or astern.
The yoke is fitted by shrinkage to an extension which is threaded on the end of push-pull rod.
The shrinkage is secured by a nut.

5.5.7.1 Procedure for dismantling the yoke.

Dismantle aft propeller hub and propeller blades.
Remove the securing pin for the nut. The nut is also secured with tread locker (ex. Loctite 638), therefore the nut should be heated to approx. 150°-200°C before loosening.

Heat the yoke to approx. 100°-150°C and pull it off.

5.5.7.2 Procedure for mounting the yoke

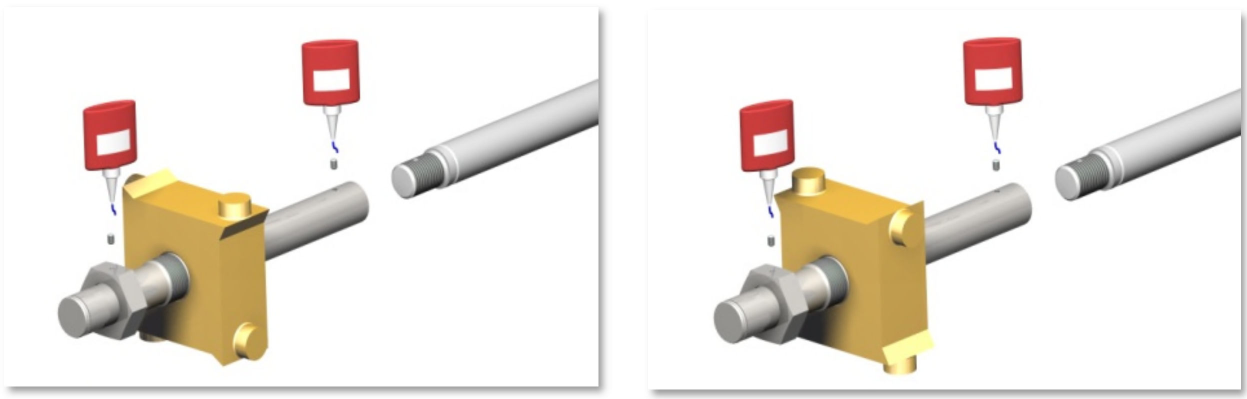


Fig.5-16 Mounting yoke. ACW-rotation propeller (left). CW –rotation propeller (right)

Clean and degrease carefully the surfaces between push-pull rod extension (also called push-pull rod amplifier) yoke and nut.

Heat the yoke to 100°-150°C and place the yoke in its accurate position towards the shoulder at push-pull rod extension.

Apply a liquid tread lock on the threads of the push-pull rod extension, such as Loctite 638 or equivalent.

Wait until the yoke is cold before tightening the nut (2) (moment) and secure it with locking pin.

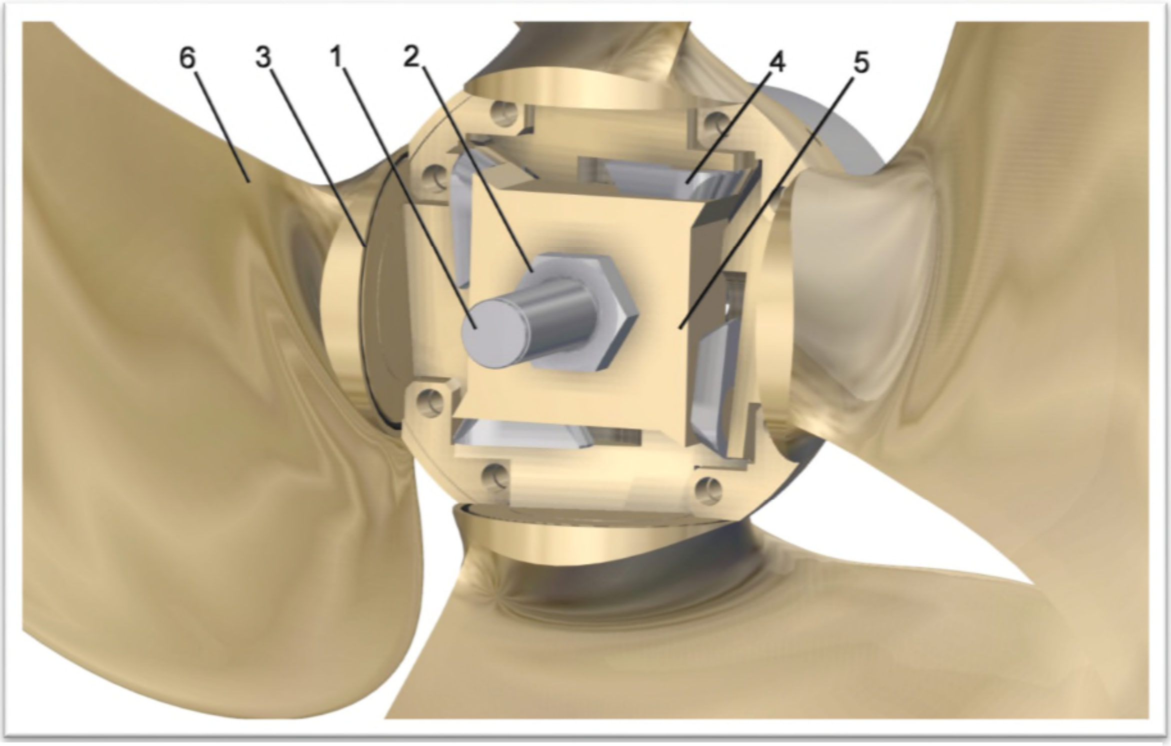


Fig.5-17

1. Push rod extensions
2. Nut
3. O-ring seal
4. Key
5. Yoke
6. Propeller blade

5.5.8 Push-pull rod

5.5.8.1 Procedure for dismantling Push- pull rod

Loosen and remove the bolts keeping the two flange parts together. Unscrew the flange part from the push-pull rod. Then it is possible to pull the rod backwards out of the shaft. Be careful not bending the rod when pulling it out.

5.5.8.2 Procedure for mounting Push- pull rod

When mounting push-pull rod, start by pushing it carefully through the center hole in shaft. When it is in position mount the flange, and connect according to description at 5.5.3.2.

5.5.9 Rudder

Rudder and rudder stock is made in one piece. When docking the vessel, it is therefore necessary to arrange enough height in dock for removing the rudder.
The tiller *keeps* the rudder in axial position and a spacer between tiller and upper rudder bearing have the axial thrust bearing function.

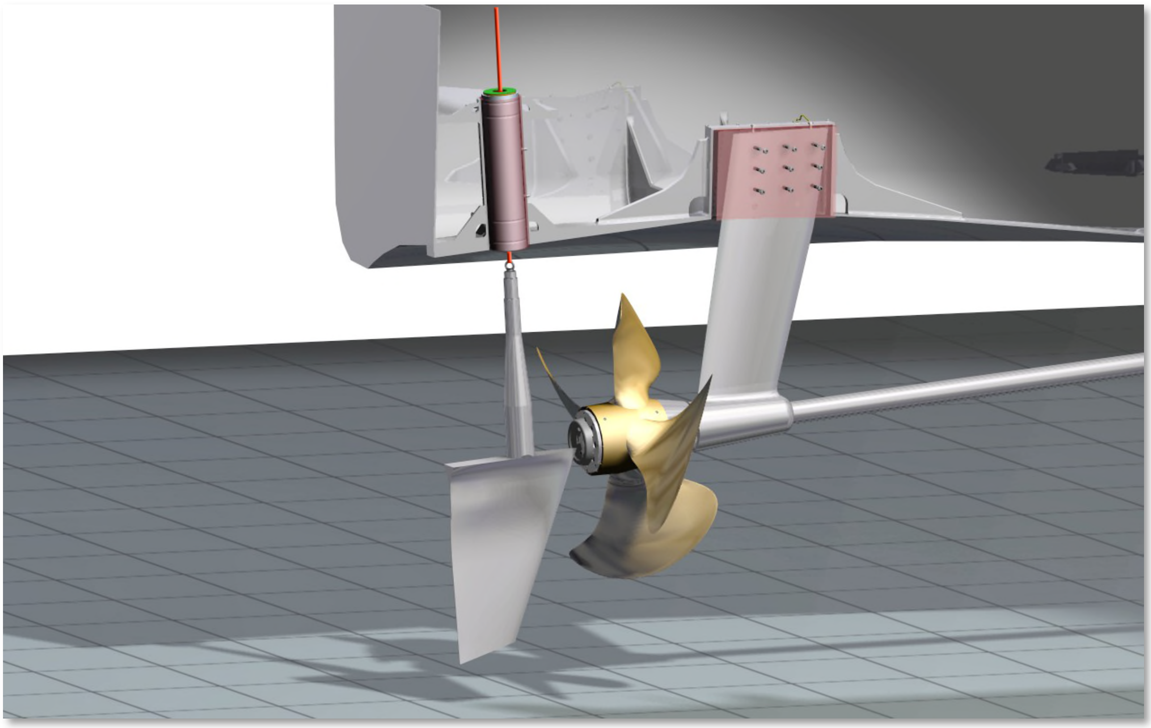


Fig.5-18 Figure shows removing of rudder

5.5.10 Procedure for dismantling Rudder

Secure the rudder with a lifting gear and a tackle. (see also Part II pt. 4.1.6)
Remove the propeller cone.
Loose carefully the transverse bolts on tiller and remove the tiller. Keep the lifting gear tight during the operation to avoid uncontrolled and dangerous movement.
Lower the rudder down to the dock ground.

5.5.11 Procedure for mounting Rudder

When mounting the rudder, it is very important to be careful not to damage the bearings when lifting the rudder into the rudder tube.
Keep a clearance between rudder fairing and rudder as recommended.
(approx. 5 mm)

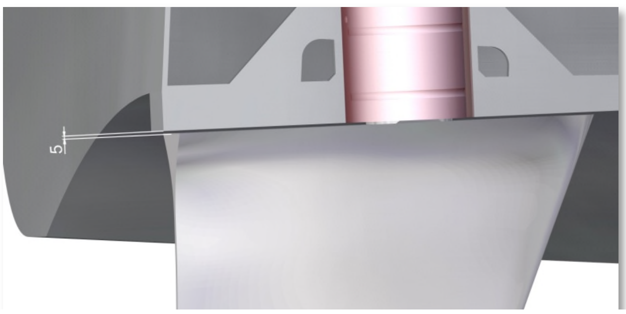


Fig.5-19 Figure shows the clearance between rudder fairing and rudder.

The rudder stock and linings are lubricated by grease. Grease can be supplied through grease nipples on outer rudder box. Remember to open for airing when filling grease in the lower grease nipple.

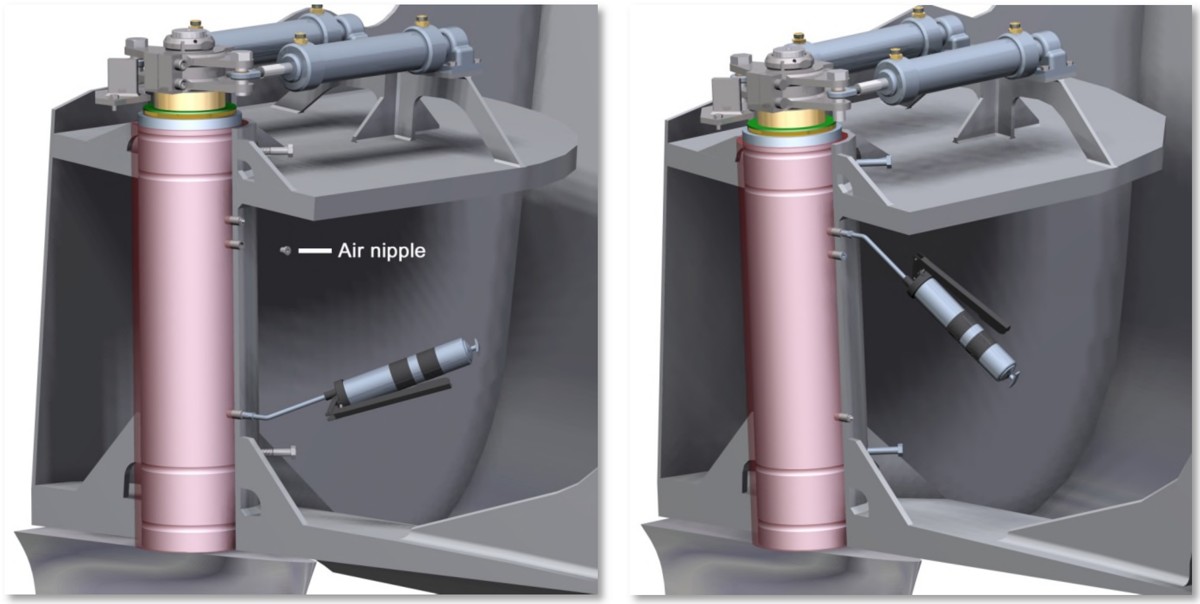


Fig.5-20 Lubricating

For mounting instructions see also Part II pt. 4.9

Steering gear with two hydraulic cylinders. Can also be with only one hydraulic cylinder.

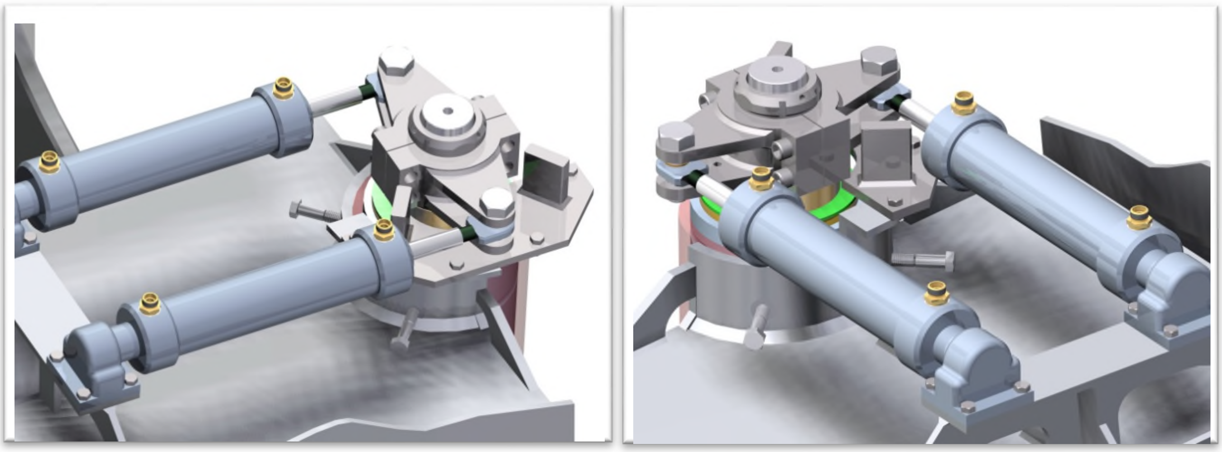


Fig.5-21 Steering gear.

5.5.12 Gear-flange coupling

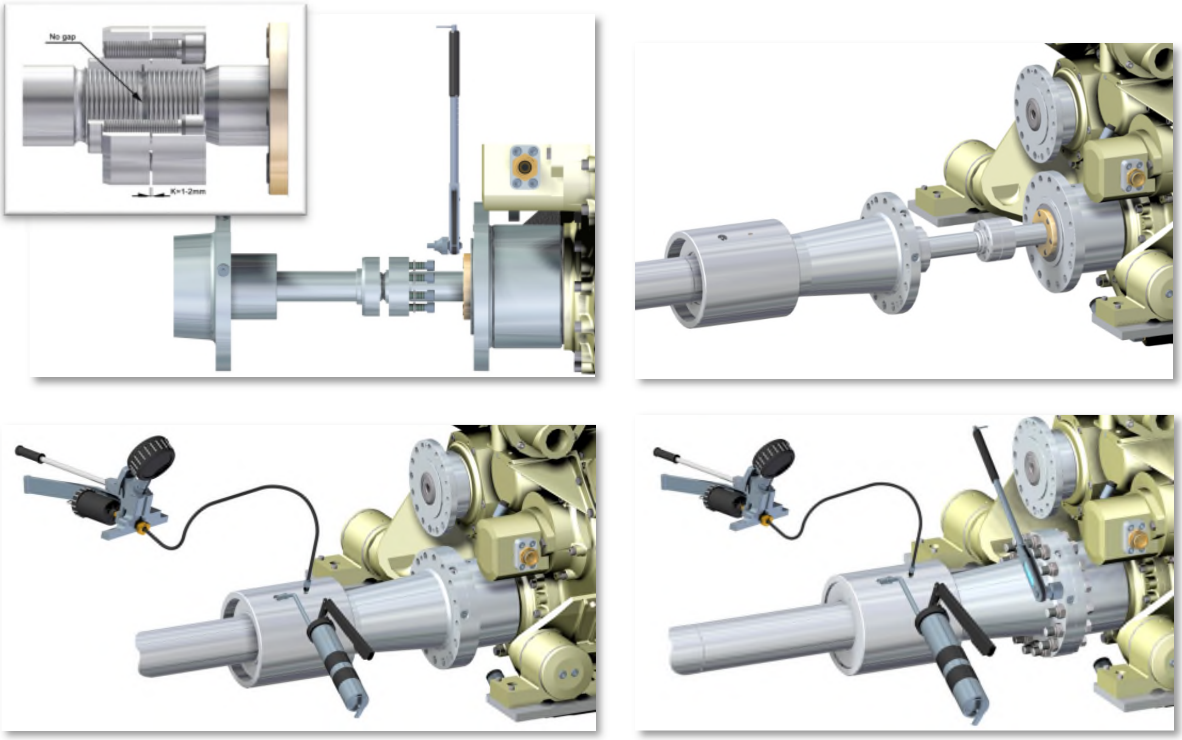


Fig.5-22 The picture above shows four stages of mounting the push pull rod and gear flange coupling.

For detail description see Instruction Manual Part II Pt.4.5 and 4.6

5.5.13 Gear flange coupling when connected to other gear types.

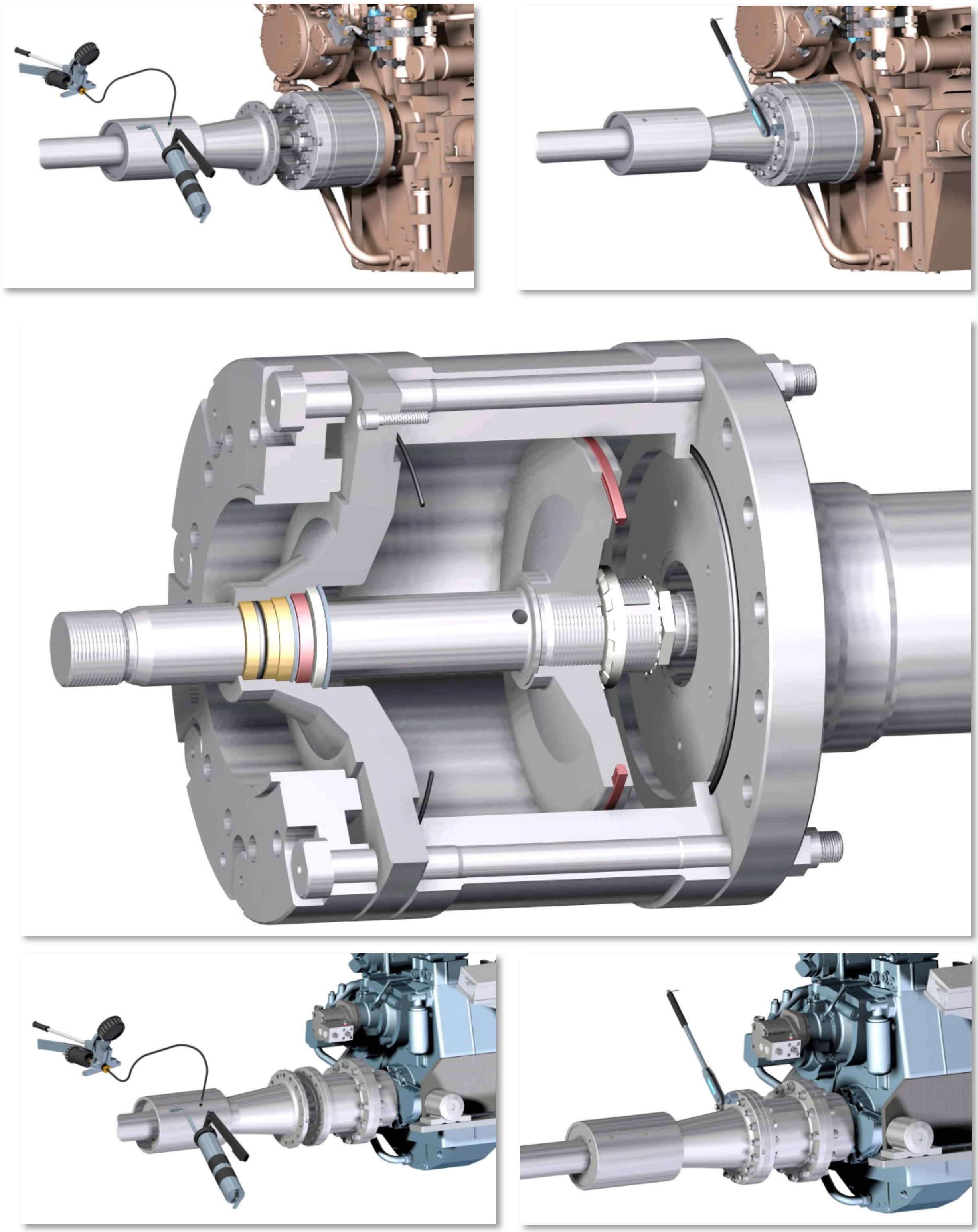


Fig.5-23 The figure shows connection to different types of gear.

5.5.14 Shaft support bearing.

5.5.14.1 Segment bearing.

Sometimes the bearing in shaft support is of a type with segment bearing where it is possible to replace segments staves individually. In this cases the shaft support is equipped with an inside step to stop the segment and a compression ring in back face of the support.

This type of bearing make it possible to replace the bearing without removing the shaft.

For replacements of bearing follow this procedure:

- Remove the compression ring. (The ring is divided in two parts)
- Insert a thread bolt in the hole in one of the upper staves. For removing the first stave you may have to use a pulley. The remaining staves can easily be removed by hand.
- Jack up the shaft in order to remove the lower staves.
- Clean the shaft and inside the shaft support carefully.
- Insert the rubber staves in the lower half of the bearing housing (the staves seems to be too long for the housing, but this is correct so **do not cut the staves**) Lubricate the running surface of the staves only.
- Install the lover half of the compression ring and tighten the ring slightly.
- Lower the shaft and insert the upper staves. Lubricate the sides of the last stave so it fit easy.
- Install upper part of compression ring and tighten the bolts lightly.
- Jack up the shaft against the upper staves to obtain a positive setting.
- Tighten all bolts in the compression ring
- Lower the shaft.

WARNING: Do not use oil grease as a lubricant.

Keep each set of bearing as a set, do not mix. Install the set in sequence as indicated in end of staves

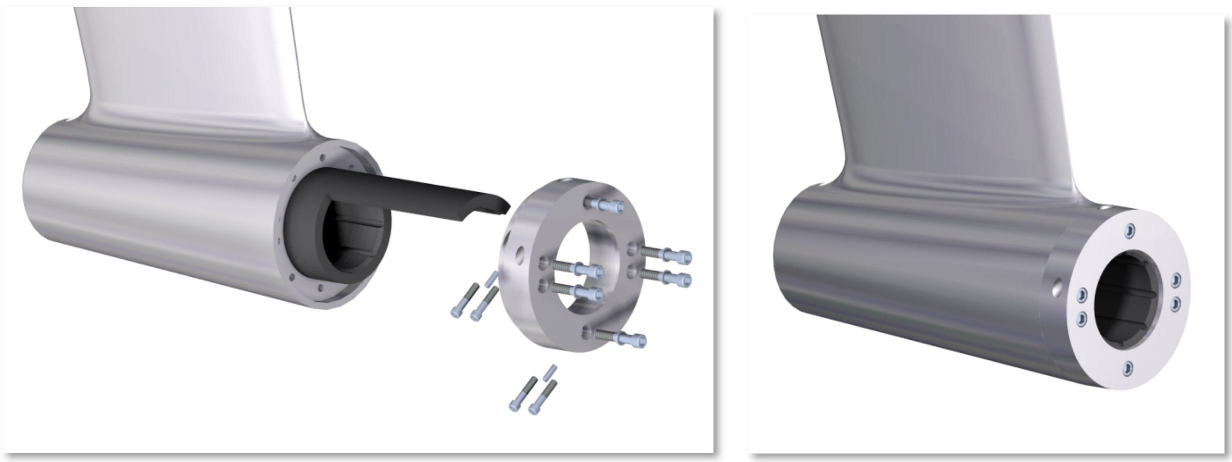


Fig.5-24 The figure shows the bearing staves and the compression ring.

5.5.14.2 Non-metallic shell bearing

When installing a new bearing in the support, do **NOT** lubricate inside the support or outside the bearing. To get an easy installation it is possible to cool the bearing by using a freezer or ordinary ice. This cooling process has to be carried out slowly and must not be lower than minus 15 degree Celsius. The bearing should fit with a light press fit.
Do not pound or shock the cooled bearing as it can cause separation between rubber and shell.
After bearing is pressed into the shaft support, prepare the bearing shell for setscrew by drilling a pit in the bearing shell through setscrew hole in the support. Do not drill into the rubber.

Do not tighten the setscrew to hard as it can deform the liner.

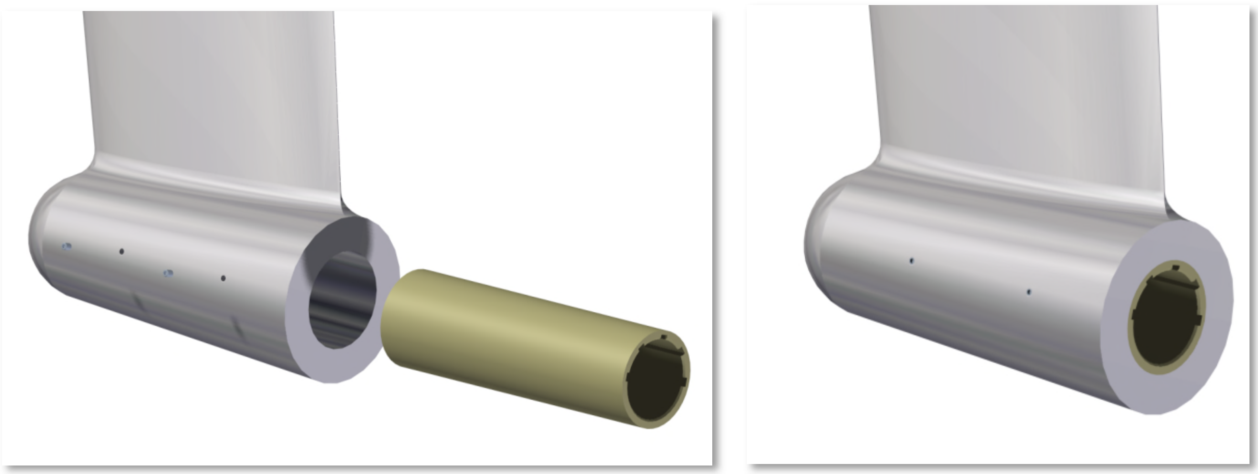


Fig.5-25 The figure shows installing of a feroform bearing

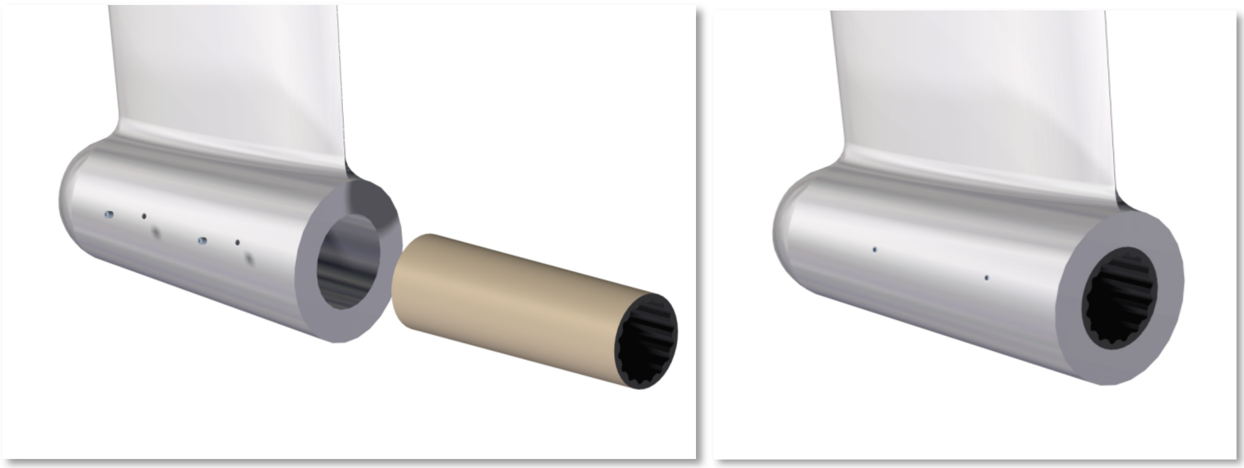


Fig.5-26 The figure shows installing of a nonmetallic rubber bearing.

Contact us

Should you need further information or do you have any questions, comments or suggestions about any of our products and/or services, please contact us.

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