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ANY OTHER BUSINESS

Use of seawater lubricated tube bearings to eliminate stern tube oil pollution from ships

Submitted by Canada

SUMMARY

Executive summary:	This document provides information on stern tube oil pollution from ships and examines a proven and available technology to eliminate it using seawater lubricated stern tube bearings
Strategic Direction:	7.1
High-level Action:	7.1.1
Planned output:	–
Action to be taken:	Paragraph 21
Related documents:	None

Introduction

1 Currently, most of ocean-going ships use a propeller shaft typically supported by oil lubricated metal bearings, with forward and aft shaft seals confining the oil within the stern tube. Seal manufacturers indicate the seal must leak at the shaft/seal interface (aft-to-sea, forward-to-bilges) in order for the seal to function properly. As well, debris such as rope caught on a ship's rotating shaft can also damage the aft seal, allowing stern tube oil to flow into the sea. This can be frequent. Typical ocean-going ship stern tubes contain 1500 litres (L) of oil and even at a conservative leakage rate of 6 L/day (from Lloyd's Registry Class Society Seal Type Approvals), stern tube oil pollution from normal operations can be estimated to be over 80 million litres annually. Oil pollution from the **Exxon Valdez** oil tanker spill was 41.6 million litres.

2 Using a proven, available technology, there is an alternative to an oil-lubricated sealed system that completely eliminates stern tube oil pollution. A seawater-lubricated open system uses seawater as the lubrication medium in place of oil. The seawater is pumped from the sea through non-metallic shaft bearings and returned to the sea. No stern tube oil is needed. Proven materials and new designs of non-metallic bearings now offer performance similar to metal shaft bearings. One difference is that the mild steel propeller shaft requires corrosion protection from

seawater. This may mean a higher initial cost for the stern tube bearing system. However, with the elimination of aft seal maintenance, the initial costs are recovered by lower service costs, no aft seal damage and reduced oil pollution risks.

Historical overview of propeller shaft bearings

3 Over fifty years ago, propeller shafts were supported by *lignum vitae* bearings made typically from a dense wood from South America and lubricated with seawater in what was called an "open system". The constant flow of water from the sea lubricated the stern tube bearings and then flowed back into the sea. There was only one shaft seal in an "open system", which prevented seawater from entering the ship.

4 In that era, seawater lubricated bearings generally were not reliable beyond five years, requiring the expensive task of withdrawing the shaft and replacing the bearings. In addition, most shaft seals of the day were packed stuffing boxes that tended to score the bronze shaft liner in the way of the packing. That meant skimming or replacing the packing liner at the same time, which was another additional cost.

5 Improvements in sealing technology in the 1950s encouraged the move to an oil lubricated propeller shaft. White metal bearings then offered a new technology, which, in a sealed oil system, provided for predictable and controlled wear life and reduced maintenance of stern tube bearings. There were some issues with this oil system. Although stern tube bearing maintenance was reduced, the two shaft seals required frequent maintenance or oil would leak into the sea or into the ship. Stern tube propeller shaft seals were the only barrier between the oil and the sea and over time, the seals can become damaged or worn, often resulting in oil leaking into the sea, into an onboard containment system, or into the engine room bilge. Some stern tube seal oil leakage into the sea was accepted as "normal operational consumption". Oil in larger quantities also leaked to the sea if the seal was accidentally damaged due to a rope or fishing net caught on the ships rotating shaft or with propeller impact.

6 A propeller shaft sealing system is designed to prevent the ingress of water into the stern tube where it could damage the bearings. The seal is also designed to prevent the leakage of stern tube oil into the sea or into the engine room bilge. These sealing systems are costly to maintain because they are normally designed to withstand extreme conditions such as axial and radial shaft displacement, ship vibrations and operating periods of up to five years. The presence of sea water coming into the stern tube may also strongly indicate that there is a good chance that oil is escaping out to pollute the seas.

Extent of stern tube oil pollution

7 In 2001, the European Commission DG Joint Research Centre reported on the extent of ship pollution based on space-borne SAR remote sensing. It revealed for the first time the dramatic dimension of shipping pollution in the Mediterranean Sea, not as a result of accidents, but from routine unauthorized operational discharges. Canadian research in 2002 estimated annual seabird mortality from chronic oil pollution to be 300,000 birds on Canada's Atlantic coast. The industry also noted stern tube oil leaks could be a substantial source of oil pollution.

8 At the 2003 RINA International Conference for the Design and Operation of Container Ships, one of the largest shaft seal manufacturers, Wartsila Propulsion (Bearings & Seals) UK, stated that, *"Oil consumption is always lost direct to the sea so contaminating the environment. The best estimates that can be made can only be based on seals in a lab condition running in clean and controlled environments but even this indicates an excess of 10,000,000 litres/year of oil is lost. Many organizations predict far higher in reality but it is difficult to prove with facts."*.

9 At the 11th Shafting Symposium of the Society of Naval Architects and Marine Engineers in 2006, another large shaft seal manufacturer, Kobelco Eagle Marine Engineering Co. Ltd., Japan, stated that, "*In stern tube bearings, the radial movement of the shaft is considerably larger than that of bearings for general industrial application. In addition, external disturbances such as rough seas and vibration are considerable. It is practically impossible to seal the stern tube oil perfectly. Therefore, one of the serious environmental issues in medium and large commercial vessels is stern tube oil leakage."*.

10 In 2007, a major stern tube seal repairer, Simplex Americas LLC, repaired a large tanker stern tube seal that was damaged due to fishing line. This was the twenty-first stern tube seal repair job completed afloat by Simplex Americas LLC during 2007, allowing ship owners to renew their stern tube seals quickly on the spot. The various customer vessels included bulkers, tankers, and containerships. This statistic represented one seal repair company in North America, but it certainly gives an idea of the scope of problems that occur with stern tube seals.

11 Based on these leakage rates of ships trading in international waters, the amount of oil pollution from stern tubes may have a large impact on the marine environment, assuming:

45,000 commercial ships (>1000 DWT) in operation worldwide,[1]
90% of these ships operate with oil lubricated stern tubes,
average oil leakage = 6 litres/day,[2]
330 working days/year (according to IMO),

a conservative estimate of stern tube oil from operational discharge would be:

45,000 ships x .90 x 6 litres/day x 330 days = 80.19 million litres/year.

12 This estimate of annual stern tube oil loss from the commercial shipping fleet of approximately 80 million litres per year does not include oil lost from *damaged* stern tube seals. By comparison, the oil spilled from the Exxon Valdez off Alaska in 1989 was approximately 41.6 million litres.

Using water-lubricated bearings to eliminate stern tube oil pollution

13 While seal manufacturers have developed more sophisticated multi-lip seals, which reduce the amount of oil that escapes, shaft seals can still be damaged and oil can still escape into the sea. Biodegradable oils are also available, but they can still present pollution risks.

14 The simplest way completely to eliminate oil from the stern tube is to use seawater as the lubrication medium and proven non-metallic bearings in place of oil and white metal bearings. The seawater is pumped from the sea through the bearings and returned to the sea. Water enters

1 *Lloyd's Register -Fairplay PC Register.*
2 *Lloyd's Register Type Approvals for stern tube seals.*

the forward section of the stern tube just aft of the seal and passes through the forward and then aft bearing prior to re-entering the sea. The quality of the seawater supplied to the bearing is critical in ensuring long wear life. To ensure that abrasives are removed from the seawater supply, a water quality package is used. This package uses centrifugal forces to remove particulate from the sea water stream, then collects it and discharges it through a blow down line. Use of seawater lubricated bearings eliminates the aft seal, as well as the storage, sampling and disposal of oil. The potential impact of stern tube oil pollution is zero. Thus, using a proven, available technology, stern tube oil pollution can be eliminated from the world's oceans and seas.

15 Research presented at the 2007 RINA (Royal Institute of Naval Architects) Design and Operation of Passenger Ships conference, noted the benefits of water lubricated propeller shaft bearings. The Italian shipyard Fincantieri stated, *"Traditionally, the shaft line is oil lubricated, and located inside the tube case with a diameter larger than the shaft itself. An alternative solution is presented with water lubrication, which offers some consequent benefits. First of all, the inflow water meets a smaller diameter and so the wake peaks on the propeller plane are reduced. Furthermore, the water through frictional effect is trailed in rotation towards the propeller with a significant benefit for propulsion efficiency (about 2%). The water lubricated shaft line is also practically maintenance free and represents a 'green' solution as the risk of oil leakage is avoided."*.

16 An additional design consideration with water-lubricated bearings is that the mild steel propeller shaft requires corrosion protection from the seawater which typically may mean a higher up-front cost to the bearing system. However, with the elimination of aft seal maintenance, the up-front costs are recouped with lower in-service costs along with no aft seal damage worries or oil pollution risk.

17 Thordon Bearings Inc. (www.thordonbearings.com) is a Canadian firm that installs seawater bearings. Currently, there are over 500 commercial ships operating with Thordon seawater lubricated propeller shaft bearings since its first commercial installation in 1983.

Expected bearing wear life performance

18 Figures 1 and 2 show actual and expected wear life for water lubricated Thordon COMPAC propeller shaft bearings indicating an expected life of 15 to 20 years.

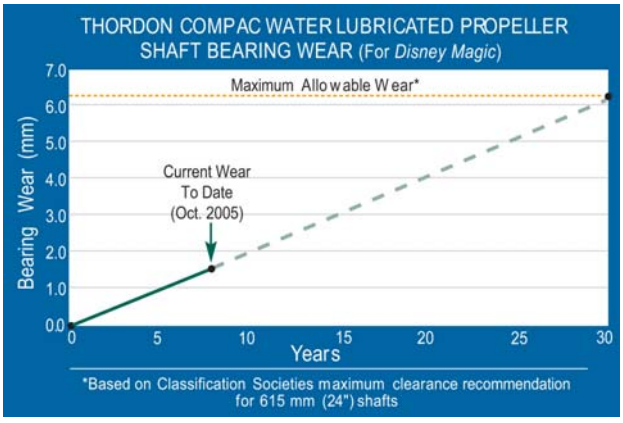

Figure 1. COMPAC Seawater Lubricated Bearing Wear for the *Disney Magic* after eight years

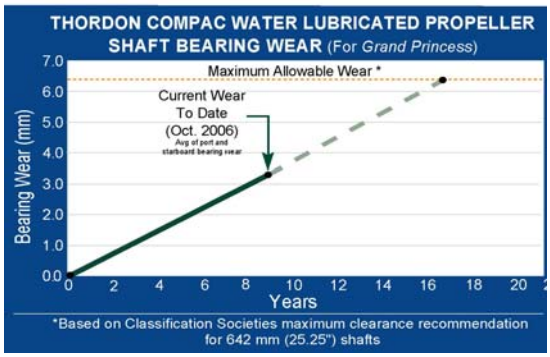

Figure 2. COMPAC Seawater Lubricated Bearing Wear for the *Grand Princess* after nine years

19 Thordon COMPAC stern tube bearings have been designed to reduce running friction and improve low speed hydrodynamic film development. The lower (loaded) portion of the

COMPAC bearing is smooth and the upper half is designed with water grooves for lubrication and cooling. Although start-up friction is initially higher, at rated shaft speeds drag on the rotating shaft resulting from the viscosity of the lubricating fluid is lower with water than with oil (see Figure 3), resulting in potential fuel savings.

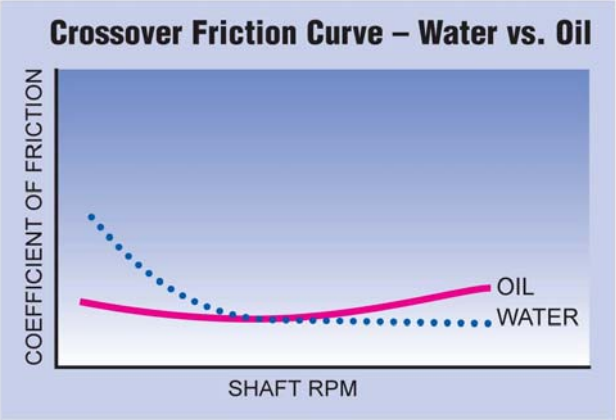

Figure 3. COMPAC Seawater Lubricated Bearing Friction Curve

Conclusion

20 Using new bearing designs and technologies ships trading in the world's oceans and seas can now eliminate both operational and accidental stern tube oil pollution. The improvements from using seawater lubricated Thordon COMPAC bearings also offer:

- reduced operating costs (no aft seal)
- proven performance and reliability
- fitting and monitoring methods to meet Class Society approvals
- reduced legal and business risks from oil pollution

Action requested of the Committee

21 The Committee is invited to note the above information.

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