Zero oil means zero environmental impact

Seawater lubricated propeller shaft bearings use no oil-based lubricants and can bring 0-EI (zero environmental impact) below the waterline, writes Craig Carter, director of marketing at Thordon Bearings, following the company's presentation to the IMO's DE56 meeting in February.

At February's meeting of the IMO Sub-Committee on Ship Design and Equipment (DE56), a presentation was made relating to the development of a mandatory code for ships operating in polar waters. The presentation entitled, "Eliminating a source of oil pollution on ships operating in polar waters" specifically addressed oil-based propeller shaft lubricants below the waterline during the normal operation of a ship.

After the presentation, a member of the German delegation asked why seawater lubricated bearings were only being considered mandatory for ships operating in polar regions, when it appeared logical to broaden the scope of this proposed regulation to all regions? Indeed, a valid question.

Using oil-based lubricants

Currently, the majority of commercial sea-going vessels use an oil lubricated white metal propeller shaft bearing system. The lubricant used is typically a mineral oil (SAE30) and typical stern tubes contain 1500 litres (396 US Gallons) of oil. Sealed systems have been used since the 1950s. The oil is contained using shaft seals at the forward and aft end of the stern tube below the waterline. The purpose of the seals is to keep oil from leaking out into the seas and into the ship, as well as prohibit the ingress of seawater which may contaminate the oil. However, seals leak oil and some ship owners have paid heavy fines for violating oil pollution laws.

Two types of oil leakage

There are two sources of oil discharges from propeller shaft seals: operational – where oil leaks in order for the seals to work and accidental – where there is damage to the sealing elements, allowing oil to escape into the sea (or allowing seawater to contaminate the oil).

Historically, 'operational discharges' of lubricating oil have been considered normal, and as the discharges have been below the waterline in smaller quantities, in large part ship owners have not been concerned. This has changed over the past decade with better oil detection methods (such as satellite) and increasingly larger oil pollution fines.

Modern seawater bearings have been used for over 10 years without any serious issues arising says Thordon's Craig Carter.

A 142,000dwt tanker equipped with seawater lubricated propeller shaft bearings.

Operational discharges from stern tube leakage have only recently been quantified. The first authoritative study on stern tube oil operational discharges was from Dr. Dagmar Etkin in 2010. Her research was done on port oil discharges from ships, but the author estimates that if the same rates of discharge occur at sea as they do in port, the estimated worldwide annual inputs of lubricants into marine waters both in ports and at sea might amount to four times the port estimate. She estimated that total worldwide use of oil-based lubricants from operational leaks and discharges would then be about 130 million to 244 million litres (34 million to 64 million US gallons.) annually. This would be equivalent to 137 individual oil spills of equal size to the *Exxon Valdez* disaster in 1989.

At the 11th Shafting Symposium of the Society of Naval Architects and Marine Engineers (SNAME), a large shaft seal manufacturer, Kobelco Eagle Marine Engineering Co. Ltd, stated that: "In stern tube bearings, the radial movement of the shaft is considerably larger than that of bearings for general industrial applications. In addition, external disturbances such as rough seas and vibration are considerable. It is practically impossible to seal the stern tube oil perfectly."

In 2005, the European Maritime Safety Agency (EMSA) set up an agency called CleanSeaNet to provide a European wide operational system for oil slick detection based on satellite-sourced synthetic aperture radar (SAR) images. In 2007, an 18-month study by CleanSeaNet reported on ship pollution totally based on space -borne SAR remote sensing. It revealed for the first time the dramatic dimension of shipping pollution in European waters with 4027 oil slicks detected and reported, not as a result of accidents, but from routine unauthorised operational discharges. Aircraft or vessels verified that as much as 80% of the CleanSeaNet detections were mineral oil.

Ships do not operate in a closed environment. The propeller shaft may become entangled in rope, fishing nets or monofilament lines. The propeller may hit the ocean floor or impact with ice or other heavy objects. Accidental oil discharges have been reported in the press over the past several years from seal repair companies. These companies are hired by the ship owner to fix the seals so they do not leak oil (and prevent seawater ingress so the bearing doesn't seize) and the ship can continue to sail. Since 2008, various press articles have reported over 50 ships operating globally that required stern tube seal repair due to a damaged shaft seal (and this is only what was reported).

Sapphire Princess and *Diamond Princess* are both fitted with seawater bearings.

In 2009, Lloyd's Register reported that: "Defect statistics over the last 20 years indicate that the aft stern bush represents 10% of shaft line failures, with the forward stern bush representing 4% of total failures. Interestingly, the aft stern gland (seal) and forward stern gland [seal] represent 43% and 24% of failures respectively."

In 2010, at IMO's Sub-Committee on Ship Design and Equipment (DE54), a DNV report prepared for the Norwegian Maritime Directorate stated that: "As a potentially relatively large source of operational oil discharge, however, still not effectively regulated and of unknown exact magnitude, stern tube leakage should be addressed as a particular environmental aspect in the polar environment as well as in other areas. Of particular importance under ice operation is the potential for especially high leakage rates, and the proximity to ice with regards to deposition of oil."

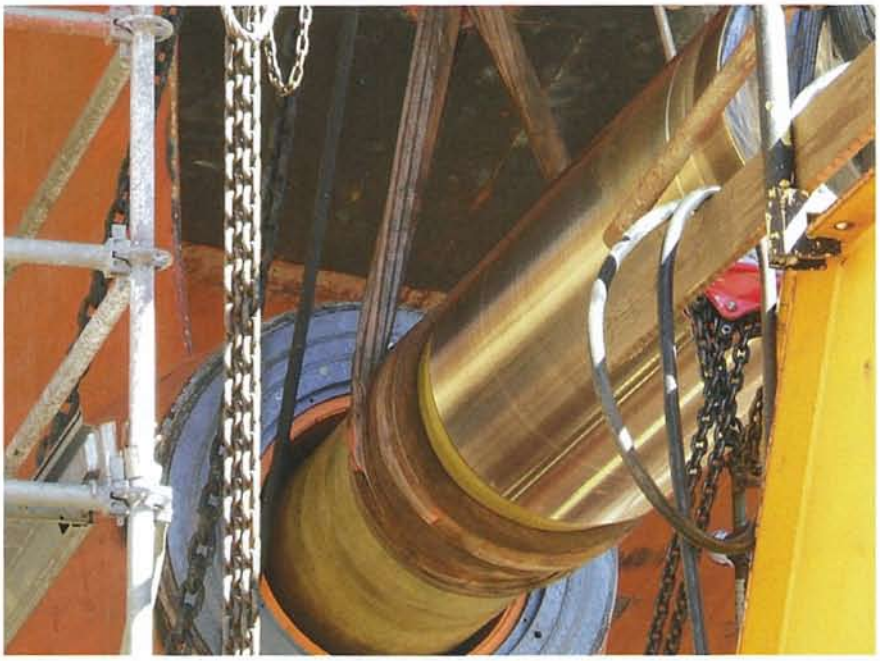
Non-metallic sea water lubricated ropeller shaft bearings.

Alternatives to mineral oil

Two 'conventional' alternatives currently in use claim to reduce the impact of discharges to the environment. Seal manufacturers have developed more sophisticated multi-lip seals which reduce the amount of oil that escapes into the sea, but as the ship does not operate in a perfect environment, shaft seals can still be damaged, and oil can still escape into the sea (or seawater water ingress into the stern tube). Biodegradable oils (both vegetable and synthetic oils) are also becoming more widely used. However, the research on biodegradable oils is varied and limited typically to laboratory tests. According to research, birds do not avoid oil slicks (biodegradable oils typically have a strong smell) and may be fatal if their feathers become matted. In the US, the Clean Water Act defines any substance that leaves a sheen, emulsification, or discoloration, as a pollutant and be subject to appropriate fines and regulations governing pollutants.

Can shaft oil discharges be eliminated?

One alternative that has been overlooked by many ship owners is a return to seawater lubricated propeller shaft bearings. Prior to the 1950s, all ships operated with a seawater lubricated propeller shaft bearing system; seawater was used as the lubricant and wood (*lignum vitae*) was used as the bearing to support the shaft. Bearings



A Seawater-lubricated bearing being installed.

were unreliable – no one knew when they would wear out, as they operated in an uncontrolled environment – wood bearings often had to be changed out after each Atlantic Ocean crossing.

However, there have been significant changes since the 1950s. First of all, the design of a seawater-lubricated system has changed. The seawater is taken from the sea and is pumped through non-metallic bearings before being returned to the sea. The seawater enters the forward section of the stern tube just aft of the seal and then passes through the forward and aft bearing prior to re-entering the sea. Seawater from the sea chest is either filtered or conditioned removing any abrasives in the water. Since the seawater is now cleaner, the non-metallic bearings will last longer.

The bearings used are non-metallic so there is no issue of bearing corrosion. The shaft and inside of the stern tube, however, does require corrosion protection from the seawater. Bronze liners are typically used in way of the bearings and a flexible, anti-corrosion shaft coating is required between the shaft liners. The bronze liners are typically the most expensive part of a ship owner's decision to switch to a seawater lubricated system at the newbuild or conversion stage. New bearing designs and materials currently available have demonstrated long life performance, which has allowed some class societies to inspect the stern tube and not withdraw the shaft. 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, as no oil used.

Seawater-lubricated propeller shaft bearings are still used by most of the world's Navies and Coast Guards for safety reasons and non-catastrophic failure mode. The experience gained from their continuous use has now transferred to commercial ships, as new materials and designs have shown technical equivalence to oil lubricated stern tube systems. One segment of the commercial shipping industry that has adapted seawater lubricated propeller shaft bearings on many of their ships is the cruise industry. For example, Carnival Corporation owns 15 cruise ships using seawater lubricated propeller shaft bearings (all twin screw) with the first ship equipped since 1998 - and that ship is still running with the same bearings. This is quite a contrast to the original water lubricated bearing materials used in the first half of the 20th century where wood bearings lasted only a few years. Currently, there are over 750 commercial ships that use seawater lubricated propeller shaft bearing systems including large tankers, bulk carriers, dry cargo ships and ferries.

Weighing up the issues

Commercial ships have been using new design seawater lubricated propeller shaft bearing systems since the late 1990s with very few issues. Ship owners have saved money as aft seal maintenance costs are eliminated because there is no aft seal. There are no oil storage and oil disposal costs and no emergency seal repair costs. The bearings are acoustically quiet (in use by NOAA and other fisheries research vessels), so there is reduced noise impact on sea life. They pose zero risk to the ocean and sea environment as no oil-based lubricants are used. It also eliminates any risk of criminal or civil penalties and other adverse reactions such as bad public relations for the ship owner that may result from oil-based lubricant discharges into the ocean.

The cons to this type of system are related to the corrosion protection of the shaft and stern tube which may mean a higher upfront cost compared to an oil lubricated white metal bearing.

2020 – Zero ship discharges?

The regulation and elimination of global ship discharges are becoming the norm. Under the EU's directive on "Ship Source Pollution" [EU/2005/35], the OSPAR Commission called to "move towards the target of cessation of discharges, emissions and losses of hazardous substances by the year 2020. In the US, under the Clean Water Act, the EPA now regulates many ship discharges, specifically oil lubrication discharges from stern tubes. The time may be coming when discharges of oil-based lubricants may not be permitted and some ship owners are looking or have implemented other alternatives to using oil-based lubricants.

A seawater-lubricated propeller shaft bearing system offering zero pollution that operates interchangeably in the same space as an oil-lubricated stern tube system can meet the zero discharge requirement. It is not a half step towards eliminating this type of ship pollution but a realistic and existing solution to eliminate oil-based lubricant discharges from the world's oceans and seas today. *NA*