

THORDON COMPAC OPEN SEAWATER LUBRICATED PROPELLER SHAFT BEARING SYSTEM OPERATIONAL AND PERFORMANCE BENEFITS FOR CANADIAN NAVY JSS

A. About Thordon Bearings

Thordon Bearings Inc. is a 4th generation, family owned Canadian company, part of the Thomson-Gordon Group established in 1911. We design and manufacture a complete range of oil and grease-free sleeve bearing and seal solutions for marine, clean power generation, pump, offshore oil and other industrial markets. ***Our philosophy is to provide premium quality products and engineered solutions that last the life of the vessel, requiring little maintenance and no spare parts with zero impact on the environment.*** We have a strong, factory-trained distribution network with over 85 Distributors worldwide to support our international marine customers.

B. Benefits of Thordon COMPAC System

1. Reduced Operating Costs

- No Aft seal (water lubricated FWD seal only)
 - no Aft seal maintenance
 - no emergency Aft seal repair from rope/line damage
- No oil/EAL costs
 - no purchase of oil; no storage of oil
 - no sampling of oil; no disposal of oil
 - no labour required to top up header tanks
 - no crew complaints about bad odour
- Maintenance of seawater lubricated propeller shaft bearing system is very low

2. Manufactured in Canada

- Total Canadian content of all system components is 68%
- Products developed, designed and manufactured in Burlington, Ontario

3. Zero Pollution Risk (zero fines)

- Eliminate oil from the stern tube

4. Controlled Bearing Environment

- Thordon Water Quality Package monitors essential parameters, i.e. clean, consistent water flow
- Allows for SCM & T-MON Notation– No shaft withdrawal for 18+ years with monitoring
- Technically equivalent to oil lubricated white metal propeller shaft bearings

5. Long predictable propeller shaft bearing wear life

- Installed on over 2000 vessels to date with first installs in 1980’s
- Canadian Navy - 12 Halifax Class Patrol Frigates: 18-20+ year wear life to date
- Cruise Ships – 18 year wear life to date

6. Low complexity for shipbuilding and crew operation compared to oil system

- Only one forward shaft seal and Water Quality Package operate with ultra-low maintenance
- No header tank; less piping and wiring; less labour to maintain
- No air compressor system compared to complex aft oil seals
- No oil disposal

7. Survivability

- Non catastrophic failure mode with seawater lubrication allows vessel to get back to port

C. Thordon Solution – Made in Canada

Our COMPAC system solution consists of components that are manufactured in Burlington, Ontario with minimal components sourced outside of Canada. Please see below for percentage of Canadian content.

- COMPAC Elastomeric Polymer Propeller Shaft Bearings fitted in bronze carriers (100%)
- Thordon Water Quality Package (25%)
- ThorShield Propeller Shaft Coating (100%)
- SeaThigor Shaft Seal (95%)
- Bronze Shaft Liners (0%)

D. COMPAC Water Lubricated System Has Lower Life Cycle Costs than an Oil Lubricated System

Life Cycle Cost Analysis	Seawater Lubricated COMPAC Propeller Shaft Bearing System	Oil Lubricated White Metal Prop Shaft Bearing System
Bearings and Related Shaft Line Equipment	\$537,200	\$479,700
Cost of Acquisition & Installation	\$537,200	\$479,700
Cost of Ownership (25 Years)	\$190,000	\$1,325,180
TOTAL	\$727,200	\$1,804,880

See actual numbers used in this analysis in Appendix A.

E. Reduced Operating Costs

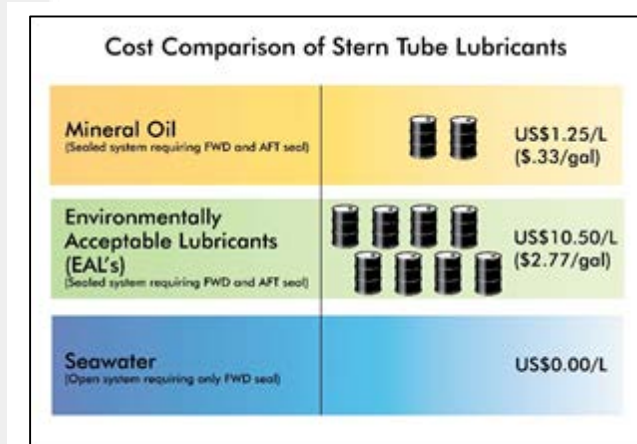
Seawater lubricated propeller shaft bearings are used by many of the world’s Navies and Coast Guards. Today however, commercial ship owners are also using Thordon bearings, shafting materials and system packages to increase bearing wear life and reduce ship maintenance costs.

Corrosion protection may mean higher up-front cost to the seawater lubricated bearing system. However, with the elimination of the aft seal and its maintenance, and without the need of storage, sampling and disposal of oil, the up-front costs are recouped with lower in-service costs along with no aft seal damage worries or oil pollution risk.

When it comes to discharges from a ship’s propeller shaft system, ships operating in US waters must be mindful of the regulations set forth by the U.S. Environmental Protection Agency Vessel General Permit, the environmental consequences, and operating costs when selecting a propeller shaft lubricant. While Environmentally Acceptable Lubricants (EALs) are a viable option, they do have many limitations and do not necessarily avoid the ship from needing an upgrade or replacement of parts.

In DNV GL’s newsletter 12-77, the classification society states that “there are different drawbacks in the way EALs react to the challenges of lubricating machinery. More specifically, biodegradable oils deteriorate when mixed with water, and the inevitable result is that the lubricating capabilities will be adversely affected.”

EALs are approximately 7-10 times more expensive than mineral oils for lubrication (refer to Fig. 4). Given that EALs are highly water absorbent, both maintenance and replacement costs heighten for ship owners. Scant and inadequate lubrication can lead to corrosion and bacteria growth on these parts, prompting a shortened life of lubricated parts, so it cannot be used sparingly.



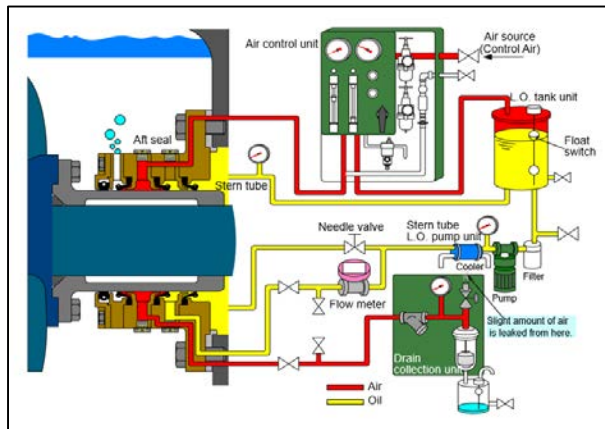
F. Potential Shipbuilding Cost Savings and Less Complexity for Ship's Crew

A Thordon COMPAC system is much less complex than an oil lubricated system. Some of the differences between a current oil lubricated propeller shaft with an aft air seal and a seawater lubricated propeller shaft bearing system with no aft seal are:

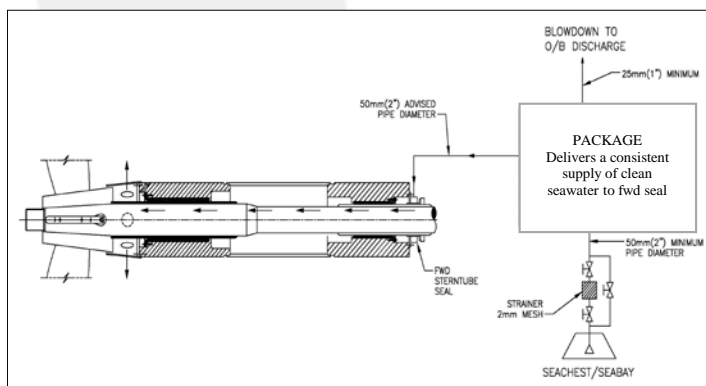
- Only one shaft seal (there is no aft seal) with oil lubrication
- No header tank with water lubrication
- Typically 8-10 less pipe runs for water lubrication than with an air seal
- No controlled air equipment with water lubrication
- Less wiring compared to installing an air seal with water lubrication
- Heat sink surrounding the stern tube is not required on certain ships with water lubrication
- Shaft corrosion protection required with water lubrication

Typical arrangements for each are illustrated below.

Typical oil lubricated system with aft air seal

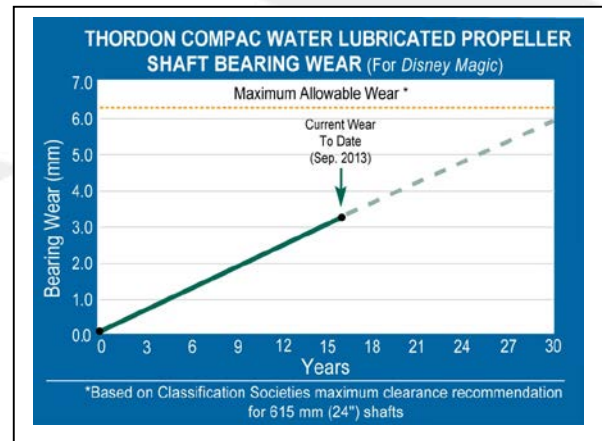
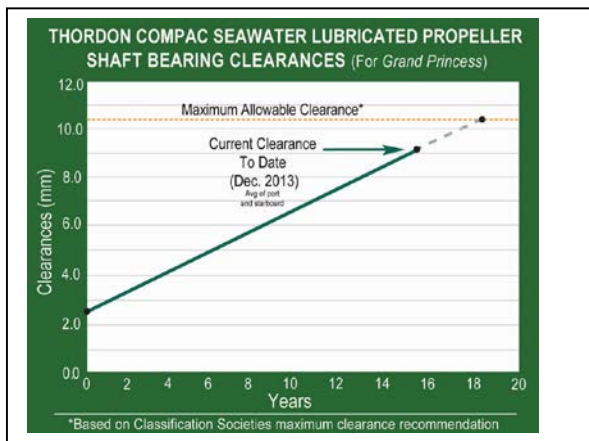


Thordon COMPAC system with Thordon Water Quality Package and no aft seal



G. Exceptional Bearing Wear Performance

Recent bearing wear measurements taken from large ships that were installed with Thordon seawater lubricated propeller shaft bearings in the mid/late 1990's show that bearing life is expected to be 20 years or more. **For example, after 15 years of operation on these twin screw cruise ships, no bearings have been replaced, no shafts have been withdrawn and no corrosion issues have occurred. It is important to note that commercial ship running hours are typically much higher than that of military vessels (6000+ hrs/yr vs. 2000 hrs/yr). See charts below.**



Canadian Navy Halifax Class Frigates

Similar performance has also been experienced with the Canadian Navies 12 *Halifax* Class patrol frigates (CPF's) delivered between 1992 and 1996. The original propeller shaft bearing specification for the CPF's was rubber bearings, but since they did not meet the Navy's acoustic or friction requirements during the first sea trials, the bearings were changed to Thordon COMPAC on the first ship and installed on the remaining 11. To date, no bearings have been replaced due to bearing wear.

Proven Performance

Currently over 40 Navies and Coast Guards use Thordon propeller shaft bearings including German Navy (K-130, F-125), Italian Navy (FREMM), Swedish Navy (Visby), Argentinean Navy (MEKO), New Zealand and Australian Navy (ANZAC), Dutch Navy (Holland), Brazilian Navy (SSK), Hellenic Navy (MEKO), as well as US Coast Guard (POLAR, WLB) and US Navy LCU's (1600) and MSC (T-AKE). Please see Thordon Naval Propeller Shaft Bearing References in Appendix B.

One of the largest ship owners in the world, China's COSCO, has ordered 20 seawater-lubricated propeller shaft bearing systems for a 90,000dwt semi-submersible heavy transport vessel, three 50,000dwt semi-submersibles, four 36,000dwt bulk carriers, three 50,000dwt bulk carriers, two bulk carriers, four AHTS vessels, a 2D seismic vessel, a 28,000dwt heavy-lift ship and a 12,800dwt bitumen tanker.

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Other merchant vessel owners to have opted for the more environmentally acceptable COMPAC solution include Matson Navigation (USA), Erik Thun Group (Sweden), Carisbrooke Shipping (UK), Grimaldi Group (Italy), Flinter Groningen (Netherlands), CSL International (Canada), Atlantska Plovibda (Croatia), BC Ferries (Canada), Tidewater (USA), Palmali Shipping (Turkey), Blue Star Ferries (Greece), NY Dept of Transportation-Staten Island Ferries (USA), ConocoPhillips (USA) and BP Shipping (UK). And of the 30 cruise ships that are currently on order, one-third of them will be equipped with Thordon seawater lubricated propeller shafts.

H. Conclusion

Cost savings are achieved through ease of installation, low to no replacement cycles, lower dry-docking frequency and a shorter dry-docking period. With over 2000 proven installations on Naval and commercial ships, the design has demonstrated its superior performance with no catastrophic failure, zero pollution, ease of installation, low coefficient of friction and reduced wear rates resulting in significant reductions in dry-docking frequency and period. Today, a seawater-lubricated propeller shaft bearing and seal system offers considerable advantages to ship owners, not only in bearing wear life predictability and reliability, but they are also cheaper to maintain, easier to install, have absolutely zero risk of pollution and are future compliant.