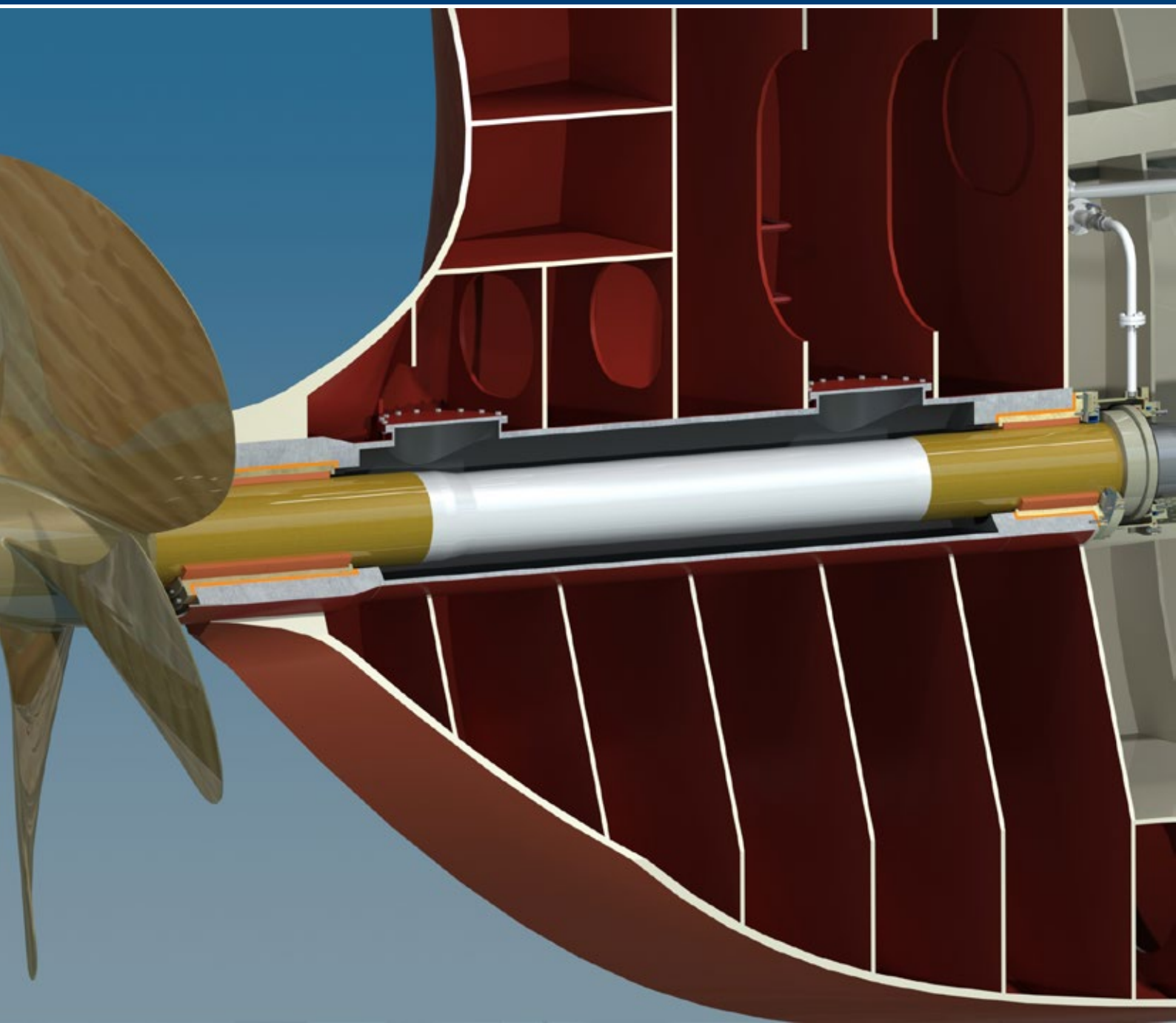


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# Water-lubricated shaft reliability proven in cruising



The cruise vessels *Disney Magic* and *Grand Princess* are equipped with water-lubricated propeller shaft bearings

Canada's Thordon Bearings has equipped 32 ocean-going cruise vessels with its COMPAC water-lubricated propeller shaft bearings, the first ones being Princess Cruises' *Grand Princess* and Disney Cruise Line's *Disney Magic* 20 years ago. The following article gives an insight into why the cruise sector has become a major proponent of this design since the first installations.

The reason for the wider take-up of water-lubricated propeller shaft bearings in the cruise sector is not only based on environmental conscientiousness: system reliability, reduced operational expenditure and maintenance are other key factors influencing the purchasing decision.

"There is a raft of reasons behind the sector's adoption of the technology," said Richard Vie, a former vice president, Technical Development and Quality Assurance, within Carnival Corp's Corporate Shipbuilding division, who was involved in the design of the *Grand Princess* and subsequent Princess cruise ships.

During their years of continuous service, neither *Grand Princess* nor *Disney Magic*, or for that matter, any other cruise ship operating Thordon's water-lubricated propeller shaft bearing systems, have experienced downtime, cancellations or changes to cruise itineraries due to propeller shaft bearing or seal failure.

"Theoretically, a well-designed oil-lubricated shafting system should outlast the operational life of any vessel, but this

depends on the quality and type of lubricating oil used and regular seal maintenance," continued Vie.

"When we built *Grand Princess* the risks we were addressing were unscheduled drydockings (there were not many drydocks that could accommodate a ship of this size at the time) and oil pollution. The cost benefit analysis included, as best we could, the expected lifetime of the bearings and I believe we assumed one replacement throughout the life of the ship. Even with this cost figured in, the benefit was still overwhelming."

Over the course of the past 20 years, Princess Cruises and Disney Cruise Line have closely monitored the bearing wear-down rates on these vessels. Data published shows propeller shaft bearing clearances for both ships within the classification societies' maximum allowable wear-down rates. This is how far the shaft has 'dropped' from its original build alignment condition.

"With water-lubricated systems the issue of how long it will last depends on the water quality and how many shaft revolutions there are in the ship's life," said Vie.

After 18.5 years of continuous service Princess Cruises decided to replace the bearing – again with Thordon COMPAC bearings – during *Grand Princess's* scheduled drydocking, in December 2016.

Andy Wright, Fleet Operations director of Technical Operations at Princess Cruises, said: "During the vessel's scheduled drydocking in 2013, class surveyors found the COMPAC bearings still fit for purpose but recommended changing them at the next drydocking in 2019. We decided to replace all four bearings in 2016 during *Grand Princess's* extensive refit at the Vigor floating dock in Portland, Oregon. Despite our apprehension at working on equipment that had remained untouched and under water for many years it went very smoothly indeed with no issues."

The Disney ship, meanwhile, continues to operate with the original polymer bearing. In September 2015, during the *Disney Magic's* last shaft inspection, surveyors recorded a bearing wear down of 7mm, significantly below Lloyd's Register's 10.5mm maximum allowable clearance. This was 17 years after the system was installed.

“Based on our cruise installations to date, a seawater-lubricated propeller shaft system will typically have a wear life of 18 to 20 years depending on the operational profile. For all the cruise ships where Thordon COMPAC is installed, none has required replacement due to wear, no shafts have been withdrawn and no corrosion issues have occurred,” said Thordon’s director of Marketing & Customer Service, Craig Carter.

As the design of the COMPAC system allows the water-lubricated bearings to be removed, inspected and replaced without shaft withdrawal, the major classification societies have now introduced shaft condition monitoring notations for water-lubricated shaft bearings which, provided certain conditions are met, allows extended shaft withdrawal periods of 18 years or longer depending on the classification society.

While performance of the water-lubricated propeller shaft is undeniably reliable and environmentally sound, Carter admits that these systems can initially cost slightly

more than oil-based alternatives – a possible factor in some shipbuilders’ reluctance to offer the systems as standard.

“But with fewer components and installation simplicity, those shipbuilders that are not offering it as standard are really missing an advantage, especially in these environmentally conscientious times. Seawater-based shaft systems are less time-consuming to install than an oil-lubricated system with complicated air seals. There is only one shaft seal, pipe work and wiring are minimal and there is no header tank to top up, which can reduce installation and operating costs.”

One advantage that should not be undervalued is the elimination of an aft seal, the component most susceptible to damage in an oil-lubricated propeller shaft configuration.

In a 2007 technical paper, Lloyd’s Register said shaft seals for oil-lubricated propeller shafts have always been a problem for shipowners, noting that “defect statistics over the last 20 years indicate that the aft stern gland (seal) and forward stern gland

(seal) represent 43% and 24% of failures respectively”.

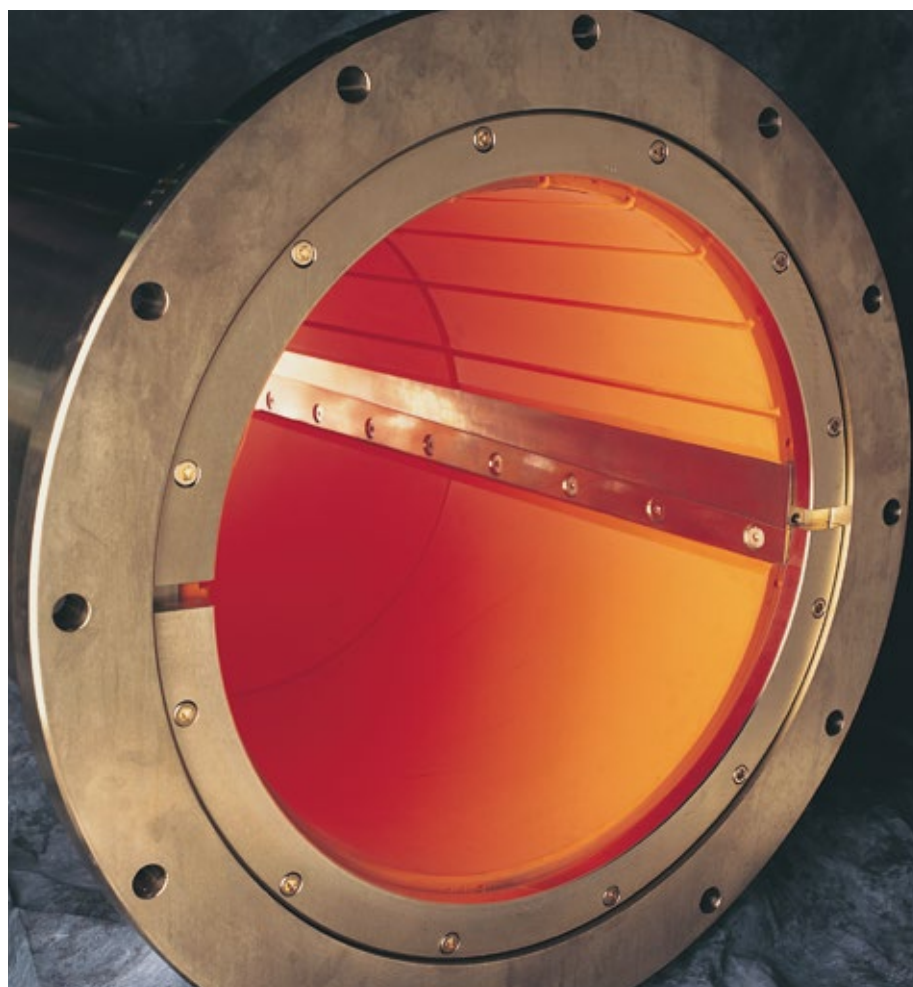
Typically, aft seals require maintenance every three to five years. Even if they are not damaged, the rubber sealing elements wear down as operating hours increase and seals start to leak oil. A typical closed oil-lubricated system contains 1,500 to 3,000 litres of mineral oil. And when they do leak it not only gives rise to environmental concerns, but seawater passing into the closed system can emulsify the oil, leading to shaft bearing failure.

Andy Wright said: “We have experienced seal problems on vessels with oil-lubricated shafts, resulting in one vessel having to emergency drydock as there was water ingress. Compared with the oil-lubricated propeller shafts of other vessels in the Princess fleet, there has been no issues with the Thordon water-lubricated configuration. To me, it’s a no-brainer. A water-lubricated shaft means there is less to worry about.”

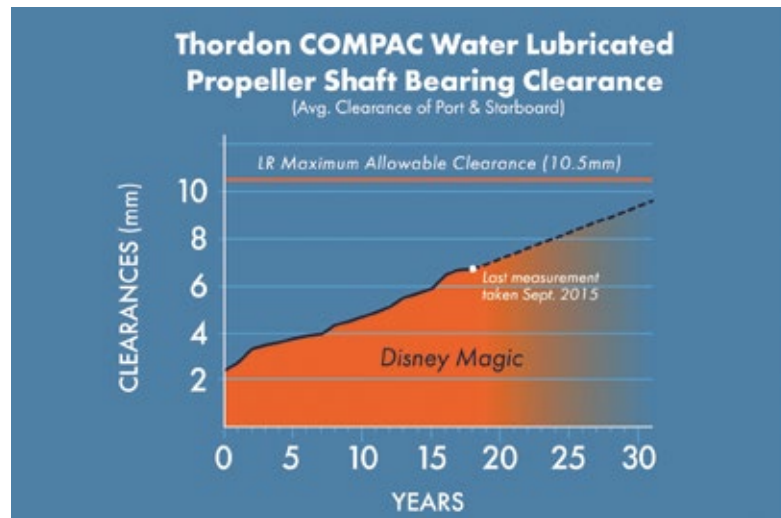
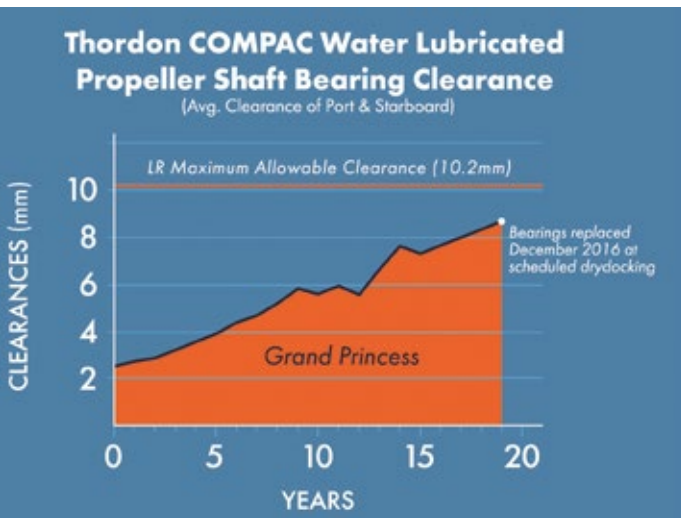
“Aside from the environmental issue of oil leaking out, water ingress can affect the viscosity of the lubricating oil,” Carter added. “This means shipboard crews have to drain down the contaminated oil and top up with fresh, which can be expensive. You don’t have these problems with water-lubricated shafts. A seawater-lubricated system can eliminate this unnecessary expense, negate the regular maintenance or emergency repair of these seals, and mitigate against any off-hire time and unexpected itinerary change.”

Indeed, taking a cruise ship the size of *Grand Princess* out of service for an emergency drydocking can be a considerable cost which can quadruple for podded ships if special tools or replacement parts are required. Therefore water-lubricated shafts could have the edge on a cruise ship propelled by pods, which are no less immune to bearing and seal failures than an oil-lubricated shaft.

In a paper presented to the Royal Institution of Naval Architects (RINA) in 2007, Fincantieri’s Giampiero Lavini and Lorenzo Pedone concluded that a passenger ship with a rounded skeg hull shape, twin six-blade fixed pitch propellers and a seawater-lubricated shaft line, with appendages optimised using computational fluid dynamics, would be comparable with a cruise ship with podded propulsion. Oil leakage is avoided, while the intermediate bracket provides a stiff shaft configuration that reduces bearing mechanical and



Thordon COMPAC bearing with single key design



Bearing wear charts of the two cruise vessels *Grand Princess* and *Disney Magic*

thermal stresses, especially during manoeuvring or crash stops.

Another issue that may prompt more cruise ship owners to consider conventional seawater-lubricated shafts is the steep rise in bearing and seal failures on ships with conventional closed propeller shaft systems

where environmentally acceptable lubricants (EAL) have been used.

This is such a concern that the classification society DNV GL recently established a working group to study performance and compatibility of EALs on conventional metal bearings. The clas-

sification society also suggested that the introduction of new propulsion system designs, such as single stern tube bearing installations and larger and heavier propellers operating at lower RPM, have also had a negative impact on the oil-lubricated propeller shaft bearing.

# 10 REASONS TO USE SEAWATER LUBRICATED PROPELLER SHAFT BEARINGS IN YOUR SHIP

**1** **15 YEAR WARRANTY**  
Long, predictable bearing wear life

**2** **Proven Performance**  
over **2,000 ships** use water lubricated propeller shaft bearings

**3** **Water is an EAL**  
(Environmentally Acceptable Lubricant) and it is **FREE!**

**4** **U.S. EPA recommends**  
that all new build vessel operators endeavor to use **seawater-based** systems for their stern tube lubrication to **eliminate the discharge of oil** from these interfaces to the aquatic environment

**5** **NO** aft seal means **NO** oil leakage from a damaged aft seal. **NO** possibility of pollution & **NO** fines.

**6** **NO** risk of expensive **shaft seal repairs** that could cost over **US\$150,000** per repair

**7** **NO** stern tube oil means **NO** oil discharges, **ZERO** impact on seabirds and aquatic life

– See U.S. Vessel General Permit (Section 2.2.9)

**8** **Survivability**  
Polymer bearings non-catastrophic failure mode allows vessels to get back to port **without being towed**

**9** **Lower Operating Costs:**  
**NO** aft seal maintenance  
**NO** oil  
**NO** disposal of oil

**10** **Water lubricated propeller shaft bearings** **Technically Equivalent** **Oil lubricated propeller shaft bearings**  
Almost all class societies have revised their rules allowing the shaft to remain in place if certain monitoring conditions are met.