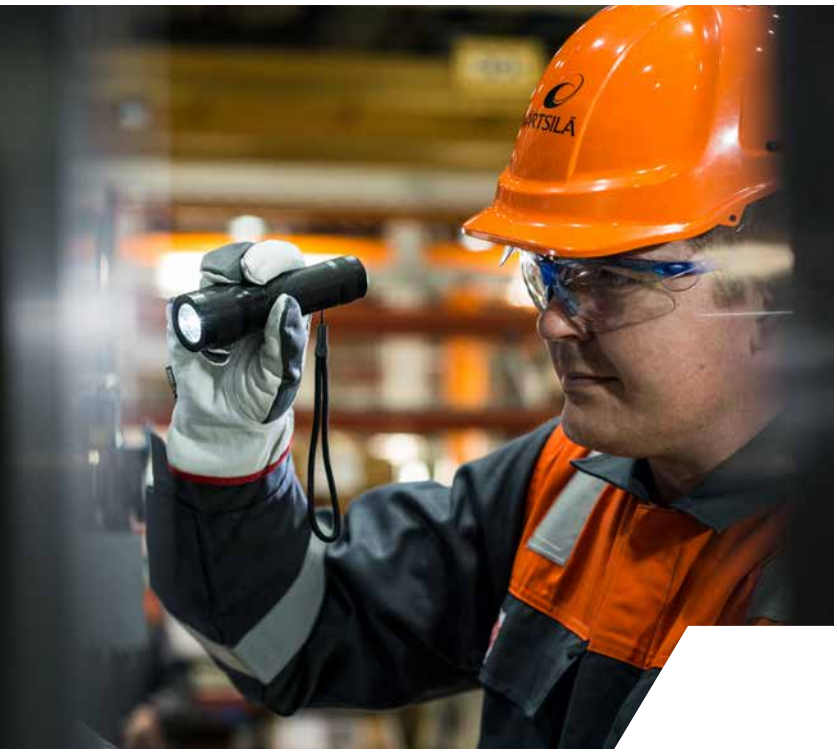
Recovering the shaft line after a grounding

BUSINESS WHITE PAPER



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Introduction

Relatively minor damage could severely hinder future operational performance.

Ships are incredible machines at the mercy of powerful natural forces; sometimes even the best planning and operation cannot prevent them from running into trouble. When that happens, ship operators need partners they can rely on to get them back into normal operation as quickly, smoothly and cost effectively as possible

When major incidents occur, damage to the shaft line connecting the engine to propeller can immobilise a vessel. Even if a vessel can still move under its own power, relatively minor damage could severely hinder future operational performance and lead to costly unplanned maintenance if not identified and repaired rapidly.

Over the decades, Wärtsilä has built up market-leading expertise in shaft line services, from the production of seals and bearings through accurate alignment and measurement to technical surveys and in situ repairs. Now, using experience gained from managing countless complex projects across the world, Wärtsilä has brought these elements together under a new, integrated service offering: Wärtsilä Shaft Line Repair Services.

One of the most damaging, complex and costly major incidents ship owners may encounter is when a vessel runs aground. A case study highlights how Wärtsilä Shaft Line Repair Services can help ship owners and operators to get their vessel up and running again whatever the situation, wherever they are.

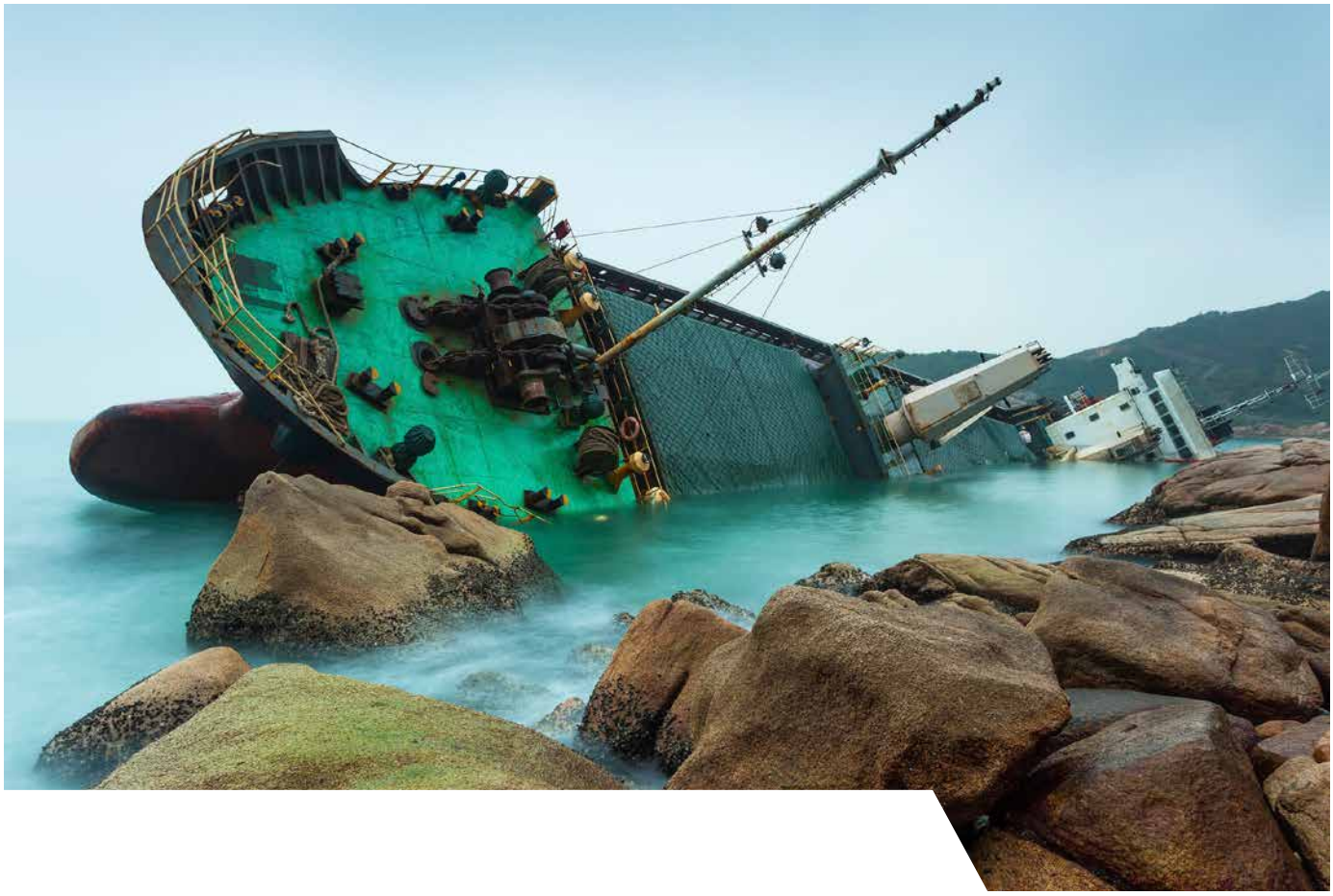
Running aground

Companies are unlikely to recover the full cost of disruption to their business.

From the Torrey Canyon in 1967 to the Costa Concordia in 2012, some of the most infamous shipping calamities have occurred when vessels have run aground. In the worst cases, the human and environmental cost can be tragic, with 110,000 tonnes of crude oil spilled and 32 lives lost in the incidents mentioned above. Even when such losses are avoided, the impact on a vessel can be catastrophic.

Grounding can result in simple stranding, with or without damage to the submerged part of the hull. However, breach of the hull may lead to significant flooding, which unless contained in watertight bulkheads can compromise the vessel's structural integrity, stability, and safety – as well as the safety of marine traffic, human population, wildlife and the surrounding environment.

While ship owners and operators may be insured against the huge costs associated with a grounding, some commercial ramifications are unavoidable. Companies are unlikely to recover the full cost of disruption to their business, for example. Fraught situations like these can strain working relationships and lead to negative, potentially damaging publicity for high-profile cases.



Potential damage

Contact can result in damage to the main engine bearing or a fracture crack in the shaft.

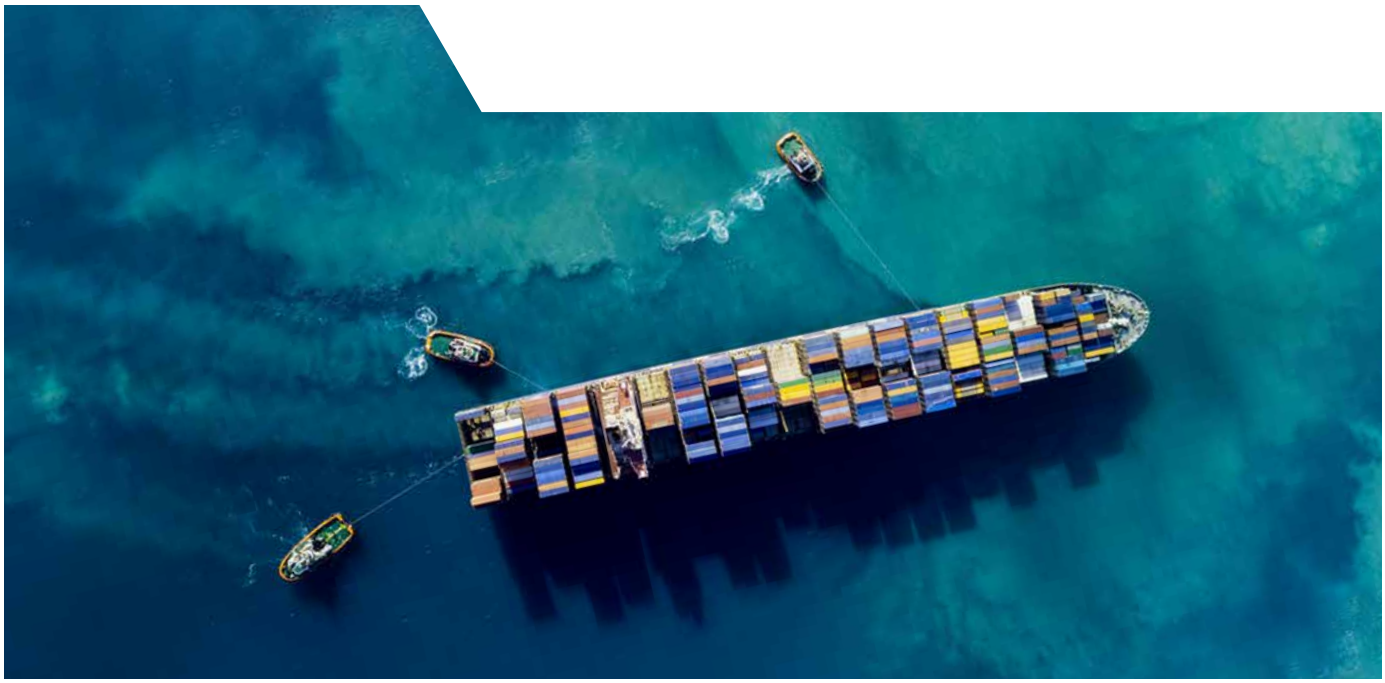
Because of the powerful forces working against a ship, even a minor grounding is likely to have an impact on the shaft line. If, for instance, the propeller comes into contact with submerged rocks there is a significant risk of shaft misalignment as well as damage to the propeller. If the vessel's hull is grounded on soft sediment, it is likely that the hull will have been deformed in the process and that the main engine and/or gearbox will have moved from their original positions. This in turn will impact on the shaft line.

The shaft bearings supporting the propeller shaft, including the intermediate bearings and the line shaft bearing at the stern, are positioned within a very fine tolerance when a ship is built. To ensure that the shaft turns smoothly, the inside of the bearings are covered with a film of mineral oil (or in some cases biodegradable oil or water). If the shaft is knocked out of alignment this oil film is likely to have been damaged and the shaft is at risk of coming into contact with the white metal lining on the inside of bearings.

In critical cases, this contact can result in damage to the main engine bearing or a fracture crack in the shaft. Both require costly repairs and much time out of service. In less severe cases, persistent contact between the shaft and the white metal shaft bearing (unprotected by an oil film) can lead to higher bearing temperatures and shorter intervals between overhauls. In many cases ship owners will continue to replace bearings at short intervals without realising that shaft misalignment is at the root of the problem.

Misaligned rotating equipment or propellers that have been unbalanced can also damage the aft seal, causing oil leaks to occur. For these reasons, it is critical that the alignment of all components of the shaft line are checked following a grounding, including engines, generators, gearboxes and rudders as well as the shaft, seals and bearings.

The service was recently mobilised to deal with a major grounding. Thanks to Wärtsilä's expertise, experience, engineering capabilities and global reach, the vessel was repaired on a very tight schedule and put back into operation well before its expected return to service.



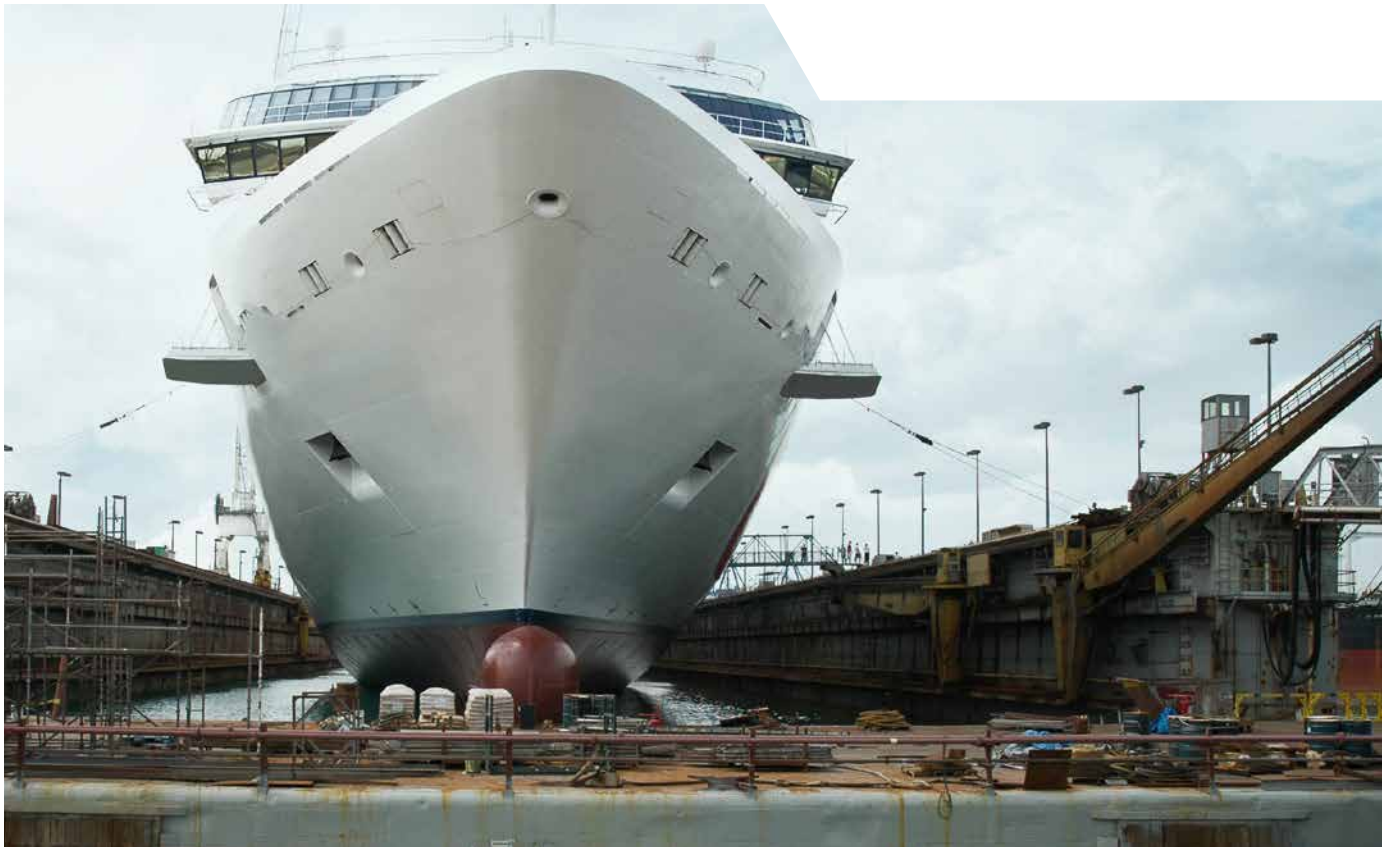
A case study

When these vessels need to be repaired, every day out of service counts.

Expedition cruise ships are designed to carry a small number of passengers to remote or restricted areas. Despite carrying under 100 passengers typically, they are high-value assets; with average cabin prices in excess of US$5,000 for a week, you don't need thousands of passengers to generate big revenues. When these vessels need to be repaired, every day out of service counts.

Wärtsilä was recently involved in the repair of an expedition cruise vessel that had run aground on rocks, leaving its propeller badly damaged and its hull dented. Given the remote location of the vessel, finding a shipyard with the space, manpower and time to handle the repair was the first challenge. Having found an appropriate yard and had the vessel towed there, the next priority was assessing the damage.

Initially Wärtsilä's local office sent specialist engineers. They found the propeller blades bent and in need of replacement. Once they had removed the seals, they observed that the shaft line was also warped. A third party was contacted to evaluate the shaft damage fully. However, assessing the alignment of the shaft proved more complex than usual because the shipyard had already started repairs on the hull. The weight added by welding metal plates to the vessel means that any fixtures to the hull – including engines, gearboxes and shaft bearings – will have moved again having already been shifted during the grounding. This further complicated the correct alignment calculations.



Measuring alignment

The case highlights the importance of having alignment experts on hand before repair work is started.

Wärtsilä Shaft Line Repair Services alignment specialist Thomas Cocks explains: “Because every part of the shaft line had been affected, all alignment calculations had to be started and a new reference line calculated. To do that, every part of the shaft line needed new measurements - main engine to gearbox, gearbox to generator, gearbox to intermediate bearing and intermediate bearing to stern tube.”

After five days of attempting to analyse the results, the shaft repair company handed the task to Wärtsilä Shaft Line Repair Services. Initially the company could not analyse the results because there were no clear reference points indicating where the measurements were taken. An alignment specialist was sent to the shipyard to see how measurements had been taken and to oversee new, correct measurements.

Establishing alignment is not a simple task in a damaged vessel. When a ship is built, a reference line is established for fitting shaft line components in the right alignment. But once a vessel comes for repair that line has been distorted. New measurements are needed to reconfigure the shaft line to the original reference points. Wärtsilä Shaft Line Repair Services establishes the correct alignments by taking measurements from the aft and combining them with rotational centre measurements from the gearbox or main engine. These are then evaluated against the original reference line.

Based on these measurements Wärtsilä Shaft Line Repair Services was able to provide a detailed plan for the repair of the vessel’s shaft line. “The case highlights the importance of having alignment experts on hand before repair work is started”, says Thomas Cocks.

Wärtsilä was able to save valuable time by having experts on site.

“The welding was done early because the shipyard wanted to complete the repair. But you have to be careful when welding not to distort the shaft line further and make repairs more challenging. In the end it would have been more cost efficient if we had been able to advise before they started the process.”

Even coming to the job at a later stage, Wärtsilä was able to save valuable time by having experts on site, with the mathematical knowledge and expertise to ensure that calculations were performed in the right way. For many repair companies it is standard practice for field engineers to rely on oversight from more senior office-based engineers. This can quickly add to the time a vessel spends in drydock. But the depth of experience in Wärtsilä’s shaft alignment team means that its field engineers do not need to rely on extensive remote assistance.

“A vessel’s superintendent will only see one drydocking every few years, and this may not include alignment work,” explains Cocks. “By contrast, each year our team will see close to a hundred shaft line repair jobs and each of our engineers will handle around ten of these.”

Shaft and bearing replacement

In most cases, cold straightening is the preferred option for resuming operation as quickly and as economically as possible.

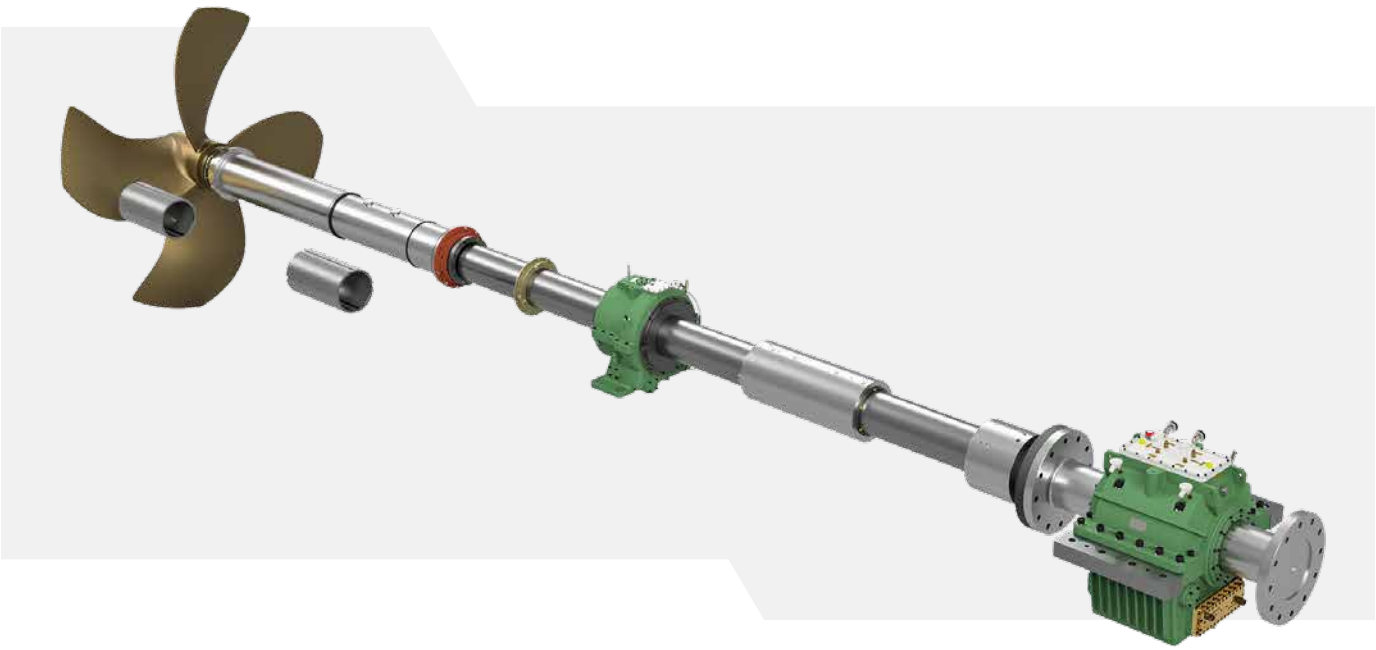
The cruise vessel's bent shaft was sent away for cold straightening, which is performed using a numerically controlled hydraulic press. Compared to the traditional method of shaft repair, which involves applying heat as well as pressure, cold straightening means that the metallurgy of the shaft remains unaffected and any stress from the material can be released. This allows for full recovery of the geometry of the shaft line.

In most cases, cold straightening is the preferred option for resuming operation as quickly and as economically as possible, when compared with fitting a new shaft. Most repairs are completed within 24-48 hours of the shaft reaching the workshop.

The bearings supporting the cruise ship's shaft line were also found to be damaged and new ones were ordered. Wärtsilä supplies bearings from its factory in Vigo, Spain, where it uses cutting-edge technology to make the manufacturing process for engineering higher quality products much faster and more environmentally sound.

To repair damaged bearings or produce new ones, the factory uses a laser application method to bond the white metal lining of the bearings with the outer steel casings. This process creates a more refined metal structure with exceptional bonding strength, compared with more traditional bonding methods, which involve applying heat and acid to both surfaces.

The stronger the bond, the more resilient the product. With traditional methods, the white metal layer is weaker and likely to be ripped if the shaft makes direct contact with the bearing lining, requiring instant replacement. The smooth structure of laser-bonded bearings, however, makes bearing damage much less likely.



— Wartsila Shaft Line Solutions alignment experts analyse your data and present you with the results.

The laser technique makes the repair or production of bearings much faster and many models can be made within three days, meaning that making new bearings can often be more cost effective than sending bearings away for traditional repair by re-metalling, which can also be a much riskier practice. Any reduction of time spent in drydock or off-hire is highly valued by ship owners and operators.

To further minimise the vessel's time out of service, the bearings were ordered before alignment calculations were conducted. This meant that, on this occasion, the bearings had to be finished on site at the shipyard. To allow for machining, the bearings were provided with oversized outside dimensions and an undersized inner circumference. These measurements can only be finalised once the repaired shaft has been returned. They are finished by machinists at the yard, under the supervision of Wärtsilä's alignment engineers.

Here too the experience of Wärtsilä's field team is invaluable. Some repair contractors provide drawings to the yard and let them machine the bearings themselves. But many shipyards lack the specialist knowledge necessary to finish bearings within the small tolerances required to maintain correct shaft-line alignment. To assist in this task, Wärtsilä engineers make drawings on site and supervise the machining, including cross-checking settings and overseeing cutting to provide on-hand quality assurance.

Monitoring alignment

The PCBM is installed onboard vessels to give deeper insight into alignment and condition during operation.

When the shaft has been installed the final measures are taken using a jack up test, measuring how much force the shaft is putting on each bearing. By checking these forces, the engineering team can verify the alignment and make any final adjustments. An experienced alignment engineer will use the time between installation and testing to prepare for these adjustments, making sure that all equipment is in place should changes be needed.

Finally, the repaired vessel underwent sea trials fitted with the Wärtsilä Portable Condition Based Monitoring (PCBM) system, in order to verify the success of the repairs. The PCBM is installed onboard vessels to give deeper insight into alignment and condition during operation – offering a much more detailed analysis of the shaft line than static alignment tests could ever provide. The system measures vibration levels, temperature, runout, whirling, movement, torque, stress and equipment position.

The Wärtsilä Portable Condition Based Monitoring (PCBM) system was used in this case to check alignment during sea trials after repair, but this technology can be installed on vessels permanently, or at any time during their lifecycle, in order to provide early warning of alignment issues. Innovative sensor technology delivers detailed, root cause information on several important indicators - including vibration levels, temperatures, shaft runout, whirling, movement, torque, stress, and equipment positioning - all measured under real-time operating conditions.

Groundings and other major incidents have an instant impact on alignment, but there are several warning signs that point to misalignment during normal operations. These include excessive vibration, high bearing temperatures, leaking seals, extensive wear and contaminated oil. Having the Wärtsilä PCBM system in-situ ensures that investigations into misalignment concerns are based on substantiated facts derived from the entire shaft line assembly. These measurements are all stored in the system's data logger and can be extracted at any time. Reports provide a record of the measurements along with proposals for corrective actions.

Installation can be performed by a service engineer while the ship is in port. Data logging is carried out while the ship is in operation, with no downtime, and the data can be collected for analysis at any port-of-call. Sensor measurements are taken using class-approved methodology, as is analysis by technical specialists.

Conclusion

Wärtsilä's Shaft Line Repair Services brings together project managers, alignment and measurement specialists and field service engineers.

Wärtsilä's Shaft Line Repair Services brings together project managers, alignment and measurement specialists and field service engineers to provide a fully integrated service for ship owners and operators. This cross-disciplinary team of experts can tap into dedicated manufacturing facilities around the world as well as a wide inventory of OEM parts, making sourcing replacements much quicker and project management more streamlined.

Wärtsilä's project management expertise can make the difference between a tightly coordinated, on-schedule repair and one that takes excessive time and cost. With unique insight into all aspects of shaft line repair, Wärtsilä can act as the main point of contact, liaising with owner, shipyard and service teams. In the above instance, for example, on the day that Wärtsilä was contacted spare parts were pre-ordered, the initial project plan was presented to the yard and owner, and a rough pricing was discussed for insurance purposes.

As a result of the fast, integrated coordination by Wärtsilä Shaft Line Repair Services, the vessel was back in operation ahead of schedule. This quick service was only made possible because of Wärtsilä's expertise across specialisms and in all stages of the process, from the assessment of damage through to the manufacturing and sourcing of parts, the supervision of repair work, and the coordination of expert project managers.

Further in-depth technical discussion on several of aspects of Wärtsilä's Shaft Line Repair Services - including alignment measurement, shaft repair and white metal bearings – will be included in a forthcoming series of business white papers.

For more information on Wärtsilä Shaft Line Repair Services please email: **slrs@wartsila.com**

Wärtsilä Shaft Line Solutions in brief

Wärtsilä provides integrated seals and bearings systems, packages and products that offer lifecycle efficiency, reduced risks through reliability and are environmentally sustainable.

As a truly global organisation, Wärtsilä has a broad product and services portfolio covering the whole lifecycle of the vessel. Looking ahead, Wärtsilä's continuing development and technological leadership can ensure customers an environmentally sound solution that always complies with the latest regulations.

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