Availability maximized with class approved PCMS

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Fig. 1 – A Propulsion Condition Monitoring Service system will soon be installed on the eight steerable thrusters of the Songa Eclipse, one of the mobile offshore drilling units owned by Songa Offshore. The Eclipse sails under ABS class society guidelines.

The American Bureau of Shipping (ABS) recently recognized Wärtsilä as a Propulsion Condition Monitoring Service (PCMS) specialist. This service provides the customer with real-time operational feedback and monthly reports on the condition of the machinery. With PCMS, a reliability centred maintenance strategy can be applied to provide insight into the current and future reliability, and to maximize the availability of the installation. This significantly reduces total lifecycle costs.

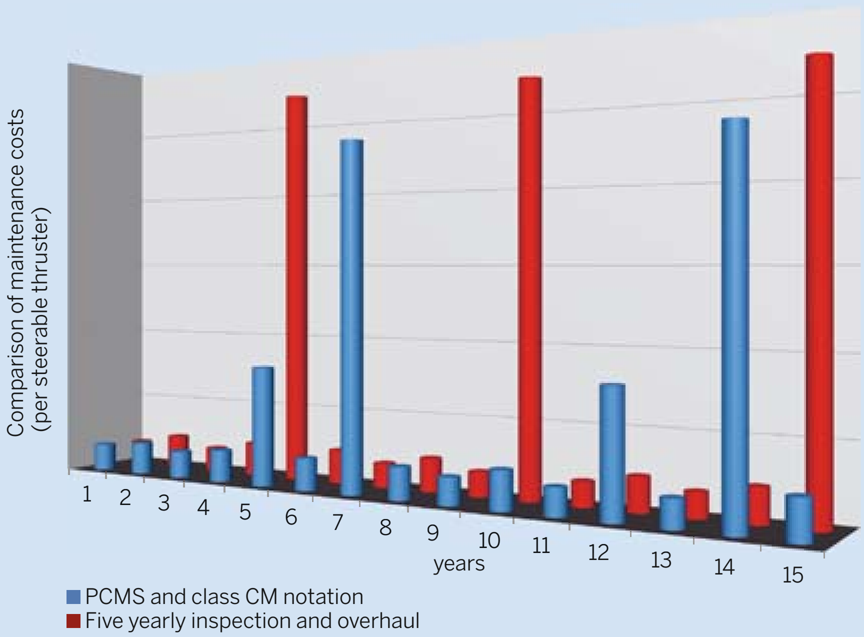
With this approval, ABS acknowledges that Wärtsilä's PCMS is able to determine the health condition of propulsion equipment without visual internal inspection. Therefore, on vessels where an approved condition monitoring system based on PCMS is in effect, the class requirement for a fixed five-yearly internal survey can be waived. Instead, the condition monitoring process is audited on a yearly base.

Maintenance of azimuth thrusters

Azimuth thrusters do not normally require a lot of maintenance during their lifetime, and only the five-year major →

Fig. 2 – Wärtsilä is an ABS recognized specialist in Condition Monitoring.

Fig. 3 – Maintenance costs for a steerable thruster with and without PCMS



This graph shows the maintenance costs per steerable thruster over a period of fifteen years. It compares the costs of a traditional maintenance scheme to one with PCMS and a CM class notation. It is assumed that based on the health condition and operational profile, the maintenance interval can be extended from 5 to 7 years. With PCMS the maintenance costs are around 30% lower in comparison to a traditional maintenance scheme.

In addition to saving maintenance costs, the amount of downtime is greatly reduced. On a semi-submersible modular drilling unit with eight thrusters and two spares for swapping, PCMS will on average require three less thruster-swap operations than with a traditional maintenance scheme. Assuming it would take 10 days (including sailing to sheltered waters, or waiting for good weather on open seas) to exchange a thruster, this gives 30 extra days of operation. When there is only one swap-thruster available the difference will be even greater.

The rate of return for PCMS is typically high in those segments where daily rates are high and downtime is expensive. For semi-submersible modular drilling units, the rate of return can be as high as 4 to 7, depending on the configuration. PCMS also provides an interesting business case for a number of ship types, such as offshore supply vessels, pipe-layers, wind turbine installation vessels, and cruise ships.

overhaul is significant from an economic point of view. During this overhaul, the roller bearings and seals are replaced and the official internal inspection by the class surveyor is carried out. Traditionally this has meant the vessel going into dry-dock, where the thrusters are removed, overhauled, and then reinstalled.

In recent years, a number of attempts have been made to maximize the availability of azimuth thruster installations. We have seen increasing use of spare thrusters, owned by single or sometimes shared by multiple ship owners. The aim of spare thrusters was to reduce the time in dry-dock by quickly replacing the original thruster with the swap-thruster. We have also seen the use of enclosures (habitats) that enable retractable thrusters to be exchanged at keyside, rather than in dry-dock.

On semi-submersible modular drilling units, underwater demountable thrusters have almost completely replaced fixed units. On offshore installations with six or eight thrusters, it is now common for ship owners to own one or two spare thrusters. To maximize the availability of their installations, the thrusters are maintained according to a special continuous survey in which either one or two thrusters are in turn swapped with spares. This swap is performed whilst at sea.

However, in all such survey arrangements thrusters still need to be overhauled at least once during a full period of five years.

The new value proposition of PCMS

Class societies have always required thrusters to be internally inspected every five years. However, few people realise that it is not a class requirement to overhaul a thruster every five years. Instead, a thruster needs to be maintained in accordance with the manufacturer's recommendations. The optimal moment to overhaul an operational thruster depends on its health condition, its design lifetime, and its operational history. Therefore, with the approval of PCMS, major overhauls can now be scheduled when needed instead of at pre-determined intervals.

Azimuth thrusters can now be maintained according to a reliability-centred maintenance strategy in which both the current and the projected reliability are considered. PCMS thus provides ship owners and/or operators with the ability to:

- base operational decisions on the known condition of the equipment,
- assess the risks for upcoming contracts based on the projected reliability of the propulsion equipment,
- maximize the availability of the installation by performing overhauls only when needed, and dramatically reducing the likelihood of unscheduled breakdowns and maintenance induced errors,
- be informed of faults (such as cracks in bearings or gears) well before they lead to breakdowns,
- increase the lifetime of equipment through having real-time feedback on conditions that generate excess wear on the equipment,
- reduce the total cost of ownership and to maximize profitability.

There are third party condition-monitoring systems for propulsion equipment. Most of these systems lack either the accuracy or scope to properly determine the condition of the entire thruster. More importantly, without the class recognition specifically applicable to Wärtsilä equipment, these systems cannot be used to extend ABS' internal survey interval of five years. Therefore, it is not possible to maximize the availability of the installation with such systems.

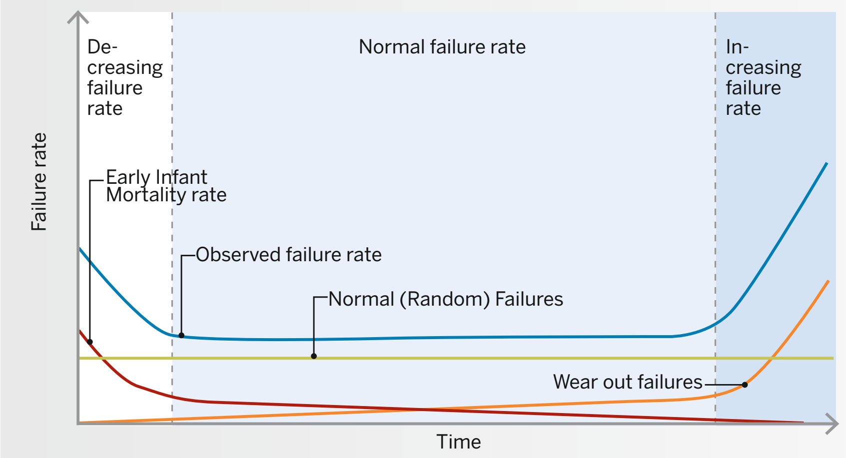


Fig. 4 – Types of fault that occur progressively during the equipment lifetime.

Data analysts

To substantiate these claims, a team of highly skilled PCMS data analysts has been established over the last two years within Wärtsilä Propulsion Services. All data analysts are experts in propulsion and have a degree in engineering. Furthermore, they are ISO-certified in vibration analysis for Condition Monitoring (ISO 18436-2/3) and trained in root cause analysis. These skills enable them to provide solutions rather than merely pointing out problems.

Data that arrives from the vessel is automatically processed by the PCMS central core. The central core informs the data analyst of faults and irregularities. The results of the automated data analysis are always manually checked for validity by the data analyst. Automatic processing ensures that the data analyst has sufficient time to determine the root cause of problems, and to support the customer in resolving issues.

The data analysts are backed up by Wärtsilä's mechanical, hydraulic system, control system, and metallurgical experts.

Other class societies

DNV and Lloyds Register also provide guidelines for condition monitoring. PCMS is designed to be in full accordance with DNV rules for the classification of ships on machinery CM (Condition Monitoring) and classification notes regarding "Thruster CM." According to DNV, condition monitoring on thrusters is intended to replace visual internal inspections of the equipment. For vessels sailing under DNV, a CM notation is granted to ship owners on a vessel by vessel basis. Wärtsilä can provide draft documentation to smooth the application procedure.

Lloyds Register states that the operator is responsible for assessing the suitability and competence of contractors undertaking condition monitoring activities. In its condition monitoring guidelines for ship-owners and managers, Lloyds Register does, however, provide typical assessment criteria for CM. PCMS complies with these criteria. Examples include ISO-18436 certification for data analysts, and sufficient relevant experience. Lloyds Register is currently in the process of defining procedures and requirements for condition monitoring based planned maintenance schemes for thrusters.

Dynamic lifetime prognosis

The remaining lifetime of an azimuth thruster is dependent on its health condition, its design lifetime, and its operational history. Condition monitoring provides an early warning for upcoming failures. Furthermore, if the condition of the thrusters is shown to be deteriorating, it surely indicates that maintenance actions are required. But what if the condition does not deteriorate?

Given enough time without maintenance, drive trains will start to demonstrate signs of wearing out. Such failures give early warnings to the PCMS, just as normal failures do. However operating an azimuth well past its technical lifetime significantly increases the likelihood of initiation of wear out failures. This would decrease the reliability of a thruster to an unacceptable level, and is why class societies state that, even when performing condition monitoring, the equipment should be maintained in accordance with the manufacturer's recommendations.

In order to responsibly extend the maintenance interval of thrusters, it is necessary to re-iterate the thruster design →

lifetime based upon its operational history. The operational history can be presented by the equipment's load distribution, as shown below.

In design calculations, the nominal load and power is used to determine the nominal lifetime in hours. When the lifetime is calculated based on the actual operational profile, it can be several times longer. The ratio between the nominal lifetime and the lifetime based on the average load is, from here on, called the 'dynamic lifetime ratio.' The relationship between this ratio and the operational profile is expressed by formula 1.

$$\lambda_{dyn} = \frac{L_{10h\_dyn}}{L_{10h\_nom}} = \left(\frac{P_{nom}}{P_{avg}}\right)^{(1+2p)/3}$$

Formula 1 dynamic lifetime ratio (p = 10/3 for roller bearings)

This formula is derived from the L10 bearing lifetime formula and elementary propeller characteristics. From the formula it can be concluded that, based on the bearing lifetimes, a thruster that is operated at an average load of 70% has a theoretical lifetime 2.5 times longer than a thruster operated at its nominal load.

These design calculations do not, however, take into account real-life service conditions, such as increased oil contamination levels, oil water ingress, stand still damage, floating debris, windmilling, etc. Each of these phenomena may or may not occur during the lifetime of a thruster. Furthermore, the frequency and the severity with which they occur are also variable.

Whilst PCMS is able to monitor all of these phenomena, it is currently impossible to determine the relationship between these phenomena and the actual lifetime of a thruster. This is because there is no homogenous population with sufficient size to reliably apply statistics. Therefore the dynamic lifetime will be capped at twice the nominal lifetime, and the maximum interval between overhauls is capped at 10 years.

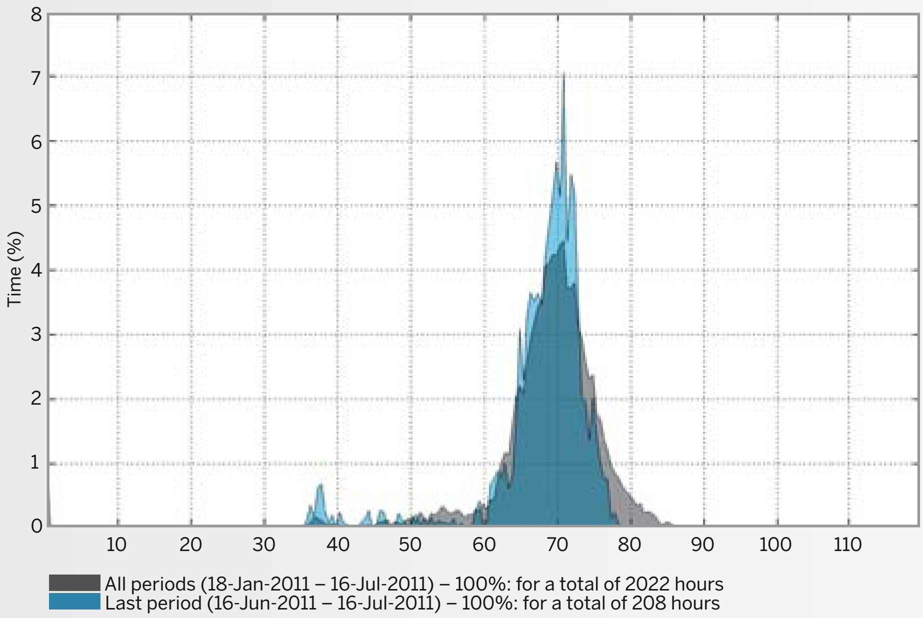
The dynamic lifetime ratio should only be applied under the following constraints:

- The vessel is sailing under a special continuous survey arrangement with a CM notation from ABS, or an equivalent notation from another classification society.
- The equipment has been monitored by PCMS since new-build or the last major overhaul.
- The equipment's health condition shows no signs of faults or degradation.
- The equipment has not been exposed to severe or frequently occurring overloads.
- Lubrication oil contamination levels, oil water saturation levels, and temperatures have not exceeded the recommended limits.
- The calculated lifetime of ageing components, such as seals and o-rings, exceeds the dynamic lifetime.

The PCMS data analyst may decide independently to deviate from these guidelines on an individual case basis.

Most seals currently carry a lifetime specification of five to seven years. These lifetime specifications are under review by Wärtsilä Seals & Bearings. In 2012, development efforts will be focussed on the underwater replacement of seals and seals with a longer lifetime.

Fig. 5 – Example showing the operational profile of a steerable thruster.



CONCLUSION

The ABS recognition of PCMS means that the class requirement for a fixed five-yearly internal survey can be waived, and instead the condition monitoring process is audited on a yearly base. Therefore, azimuth thrusters can now be maintained according to a reliability-centred maintenance strategy in which both the current, as well as the projected, reliability are considered. With PCMS, operators can maximize the availability of their installations whilst reducing their total cost of ownership and increasing their profitability.

The dynamic lifetime prognosis is an effective, generally applicable method to re-iterate the theoretical design lifetime based on the measured operational profile. When this ratio is used under proper constraints, it can be used to responsibly extend the maintenance interval.

PCMS in short

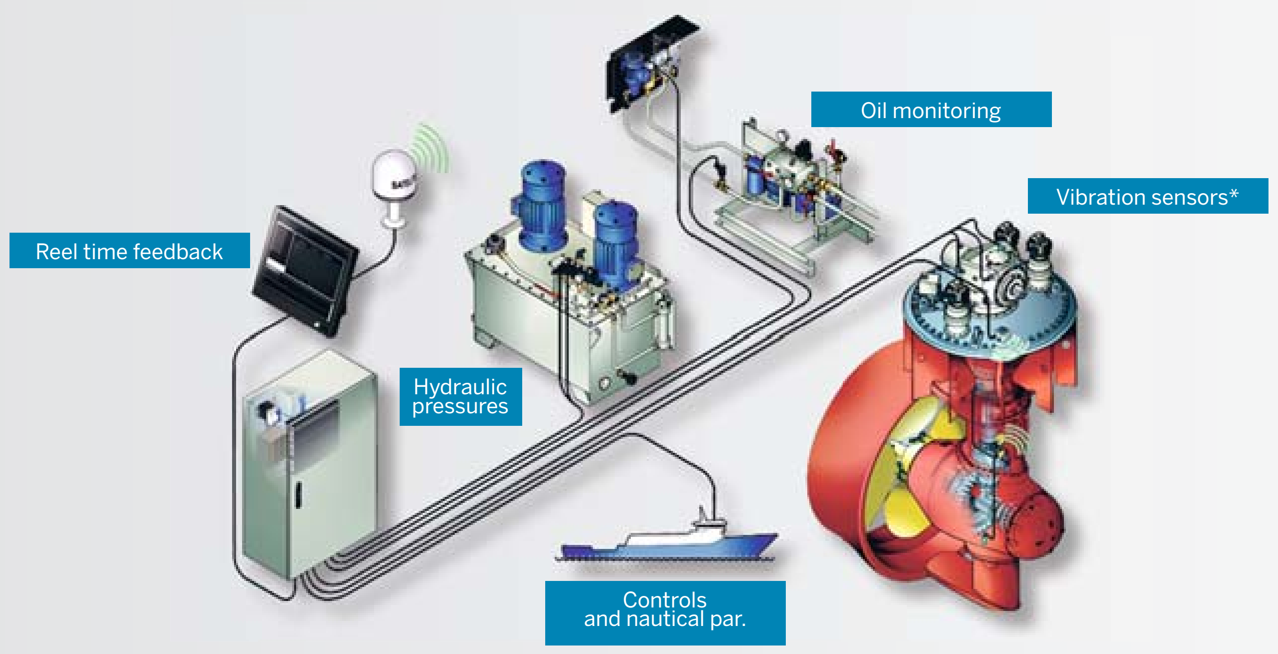
Propulsion Condition Monitoring Service (PCMS) is Wärtsilä's monitoring solution for propulsion equipment. It provides the customer with real-time advice and periodic reports about the condition of the machinery. An overview of a typical PCMS system is shown in figure 6.This has been described in more detail in In Detail issue 2/2010.

Since a thruster is under water, it cannot be visually inspected unless a vessel enters dry-dock. Therefore, an advanced system is required in order to determine the health condition of a thruster. Because of this, the PCMS scope is more extensive than in monitoring products with easily accessible machinery. However, the value proposition is also exponentially greater.

PCMS was released by Wärtsilä on September 6, 2010, and since then the installed base has grown rapidly. Although it is predominantly installed on steerable thrusters, some systems have been delivered also for transverse thrusters and controllable pitch propellers.

PCMS is also used as a tool by which field data is developed into valuable know-how that contributes to improved product quality, thereby increasing customer satisfaction. Data analysis requests by stakeholders, such as R&D departments, are increasingly common and encouraged.

Fig. 6 – Overview of a typical Propulsion Condition Monitoring Service system.



*PCMS vibration sensors are mounted externally, however it is also possible to interface with accelerometers mounted inside the pod.