

LNG Carrier Seawater Pump Condition Monitoring

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Artesis has recently completed a successful installation trial of its Motor Condition Monitor (MCM®/ AnomAlert* Motor Anomaly Detector¹ technology for the global shipping organization of an important GE customer – one of the world's largest energy companies. The goal of this installation was to validate the effectiveness of the Artesis condition monitoring technology in a variety of applications. This case history describes the results of AnomAlert units that

were fitted to two seawater pumps aboard a Liquefied Natural Gas (LNG) carrier.

The shipping organization has more than 50 ships in its worldwide fleet, and is already very much aware of the benefits of Condition Monitoring (CM) – running a successful global initiative to adopt CM technologies and programs throughout the fleet. AnomAlert provides the opportunity to monitor equipment that is currently outside of the existing CM program, where the equipment may be

inaccessible or in a location that is hazardous to personnel.

For its wide range of ships – including crude and product carriers, shuttle tankers, Liquefied Petroleum Gas (LPG), LNG and hydrocarbon carriers, lubricant oil barges and offshore support vessels – the shipping organization applies an assortment of tools for identifying, prioritizing, benchmarking, quantifying, mapping and controlling risks – which include the risk of asset failure and costly downtime.

¹Motor Condition Monitor (MCM) and AnomAlert are both names for the same monitor. For simplicity, we will use the term "AnomAlert" throughout this article.

The Project

The Engineering Superintendent for the shipping organization was first introduced to Artesis through an internal recommendation. Then, following his subsequent reading of articles in the engineering press and meeting the team at an industry event, he became interested in exploring the capabilities of the AnomAlert system for himself.

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“As with all new technology in the marketplace, there is a degree of skepticism when embarking on an initial R&D and trial period,” he said. “To prove a useful and worthwhile tool we needed to determine whether the AnomAlert unit could accurately detect a fault prior to catastrophic failure and ultimately, provide us with a non-intrusive monitoring process with cost saving benefits.”

“Having met with Artesis, it was agreed that our validation trial would run up to the point where a specific failure was predicted and maintenance recommended, so that the prediction could be compared with the subsequent maintenance report. The units were then installed by the ship power specialist,” he continued. “Over the next few months the Artesis team provided excellent support, particularly during the commissioning phase where various software communication issues were encountered.”

The two motor-driven seawater pumps that were selected for monitoring are vertical, double-suction centrifugal pumps in the Main Cooling system (Figure 1).

Machine Condition Assessment

Artesis carried out initial assessments with early reports indicating that both monitored seawater pumps were experiencing rubs, misalignment, a vane pass anomaly, and a reduction in pumping efficiency that suggested that early misalignment had contributed to impeller damage. Successive reports increased the indications of progressive erosion or corrosion of the pump internals, with a gradual decrease in power consumption as the pump was able to do less useful work. The monitoring specialists predicted that pump performance would continue to decrease as erosion advanced. This analysis process also allowed the team to use power factor and electrical load (kW) as a simple indicator of the pumping performance and the condition of the parts that are susceptible to erosion.

The initial information presented by the software is in the form of “traffic lights” (red, yellow and green colors) in a diagnostic window (Figure 2). Red lights indicate a problem that needs attention, and simple guidance is provided on the urgency associated with the problem, and the work that is required to address it.

Additional information on these problems is available through trend curves that show how monitored parameters have changed over time (Figure 3).

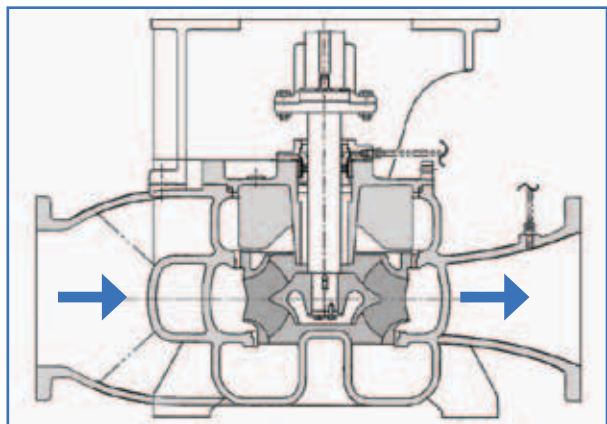


Figure 1: Cross-sectional view of seawater pump, showing the shrouded double-suction, six-vane impeller. The directly-coupled drive motor is not shown in this drawing.

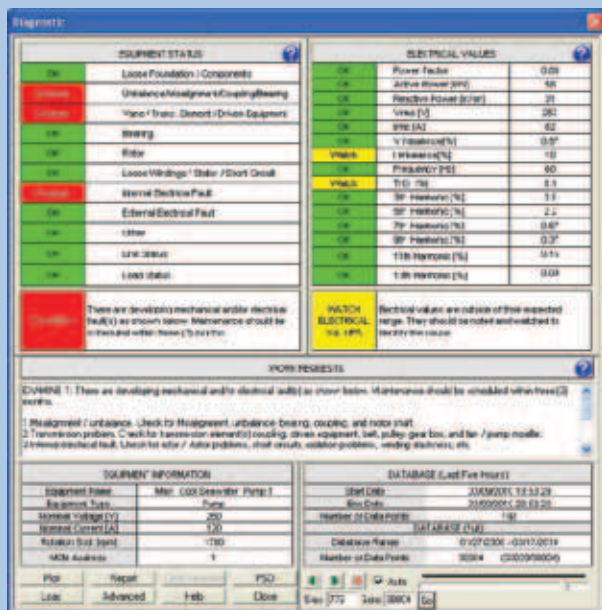


Figure 2: This diagnostic window shows the situation that existed about 6 months into the monitoring process, with level 1 alarms for Misalignment and Rotor Problems, as well as internal and external electrical faults that may be indicating stator deterioration as a result of misalignment. Current imbalance alarms have shown that this has increased to more than 10%, tending to confirm stator damage.



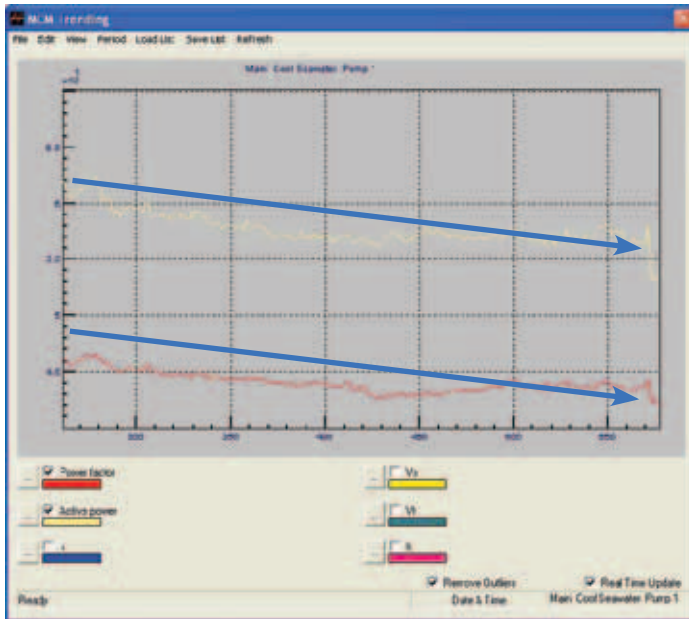


Figure 3: Trend plot showing a gradual progressive decrease in both active power and power factor parameters for Main Cooling Seawater Pump Number 1.



Figure 4: Pump internals after removal for inspection. Observe the significant loss of metal from the tips of the casing flow vanes (fins). Approximately 19 mm of metal was lost in two places. Fin thickness was also reduced from the original dimension of 7 mm to 4.5 mm. It turned out that the Vane Pass anomaly was produced by this damage, rather than by deterioration of the impeller.

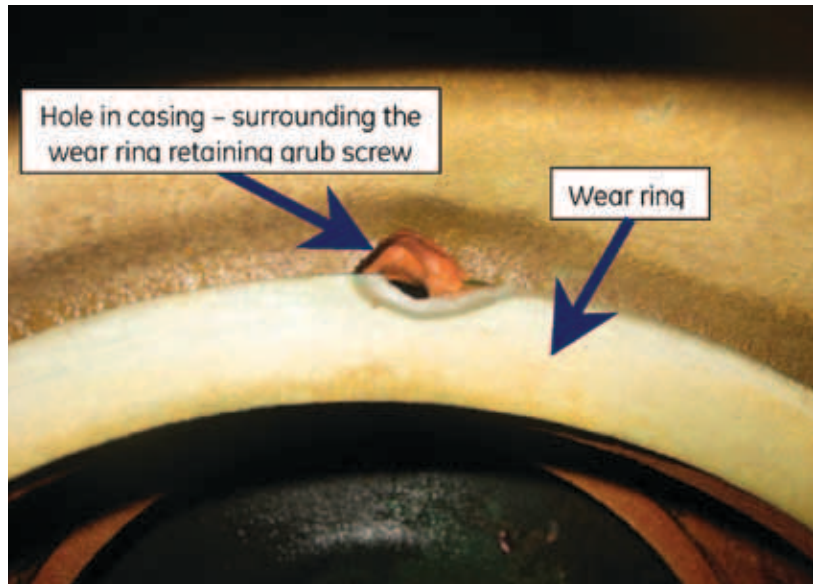


Figure 5: Upon disassembly, it was discovered that erosion had produced a hole in the pump casing, at the point where a wear ring retaining screw caused a localized flow disturbance.

Trend curves can be displayed for all the measured and derived parameters. In most cases, the trend curves are automatically labeled with the parameter causing them. However, in some cases, an unusual problem may not be automatically classified by the equipment, and requires expert interpretation. The expert can analyze the power spectral density (PSD) curve and other parameters – that are beyond the scope of this article – to identify the nature of the underlying problem. In this case it was possible to identify that there was an anomaly corresponding to the vane pass frequency, confirming the diagnosis that something inside the pump was interfering with the normal smooth flow of water.

Interestingly, as time progressed, the power continued to decrease, but some of the indications of rubs and motor stator issues decreased, consistent with internal misalignment loads decreasing as internal wear took place inside the pump. This was followed by a decrease in the intensity of the vane pass frequency signals, indicating a loss of effectiveness of the impeller suggesting it been strongly impacted by erosion or other damage.

Inspection Results

Once the power factor fell below a pre-determined threshold, maintenance was scheduled to disassemble the motor and pump to compare the as-found conditions with

the assessments provided by the AnomAlert unit. When the upper casing cover was removed, it was very apparent that the flow vanes (fins) had suffered significant metal loss due to erosion (Figure 4). The impeller had light fouling, and the wear rings had eroded, causing a reduction in performance by allowing recirculation flow. A small hole had also eroded in the pump casing where a flow disturbance was produced by a wear ring retaining screw (Figure 5).

Pump Repairs

- The impeller was in good condition, so it was simply cleaned and reused (Figures 6 & 7).
- The eroded wear rings were replaced, restoring normal clearances and pump efficiency.
- The hole in the pump casing was repaired using cold resin techniques, preventing further deterioration of the casing at that location.
- Although the casing fins were heavily eroded, they were not significantly impacting performance, so the casing cover was reused without repairing the fins.
- Cost of repairs was approximately 10% of the “normal” cost of pump replacement associated with the previous Run-To-Failure (RTF) regime.



Figure 6: Impeller after cleaning. Axial view into one of the impeller eyes (suction).



Figure 7: Impeller after cleaning. Radial view of the impeller vane tips (discharge).

Summary

Delivering a succinct and informative maintenance report at the end of the trial, Artesis stated that there were signs of wear ring damage and a loss of performance consistent with a hole in the pump casing (Figure 8). The subsequent replacement of wear rings and repair of the casing hole helped return the efficiency of the pump to normal. It was also reported that fixing the hole in the casing where the retaining grub screw for the wear ring is located saved the pump casing from further deterioration. Although the pump casing fins suffered a heavy loss of material during the trial, and it was advised that these should be repaired, this was not essential for pump operation. No damage was recorded to either the rotor or stator of the drive motor and none was suggested from the trial data

At the successful completion of the trial, the Engineering Superintendent concluded: “The online system monitoring was the most beneficial part of the trial process. Using a simple traffic light system to identify that a fault exists, when and where appropriate, allowed for intrusive investigations and repair before failure. This remote on-line indication has enabled a reduction in maintenance man-hours and downtime. The AnomAlert units have the potential to save on spares and we are continuing to evaluate the functionality of Artesis in various applications within our fleet.”

The application of AnomAlert technology facilitated the implementation of a proactive approach to pump maintenance, which resulted in a 90% cost saving over the older method of replacing the entire pump after it failed. ■

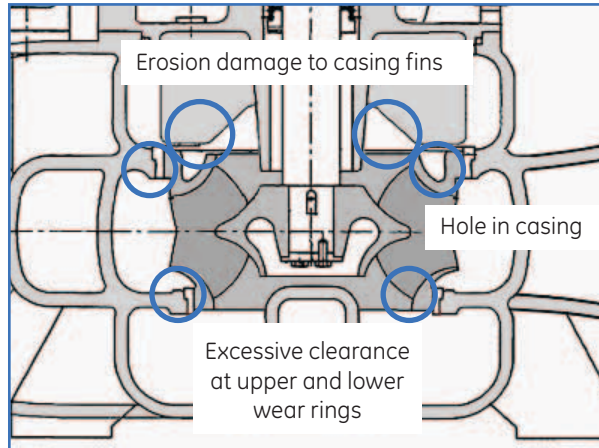


Figure 8: Identified sites of pump condition degradation.