Assessing Water Pump Health

More effective than traditional vibration monitoring

Whether your plant is hydroelectric, fossil-fueled, or nuclear, water is essential to the power generation process. And to move water you need pumps in good operating condition. Without timely, accurate information about the condition of the pumps in a power plant, a utility cannot operate efficiently. But effectively monitoring the condition of operating pumps has been difficult or impossible for the following reasons.

Traditional condition monitoring methods do not work reliably on this type of equipment, particularly if it is large or operating at lower speeds.

Periodic monitoring with handheld devices produces an inaccurate or misleading assessment of machinery health.

This document analyzes the problems with monitoring water pumps and recommends an approach that works. It is based upon real-world data developed through work with leading North American utilities and pump manufacturers.

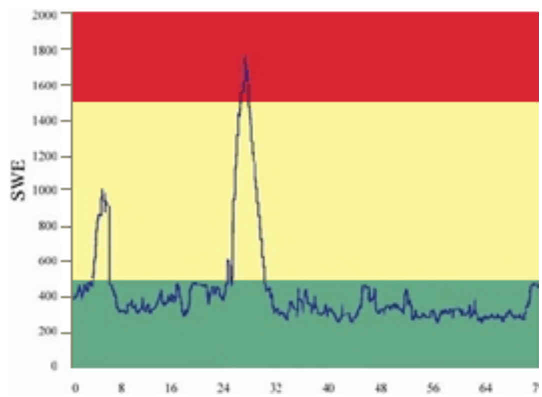
Sound vs. Motion

Traditional condition monitoring is based on vibration analysis, but vibration analysis is ineffective on large water pumps. Vertical pumps, like those shown in the photograph to the right, operate at relatively slow speeds and can be eight to ten feet in diameter. The bearings that need to be monitored are in the center of these large devices. At normal operating speeds, these bearings do not transmit sufficient energy to be detectable by motion sensors on the out-side of a machine's housing. Stress Wave Analysis (SWAN™) techniques do not suffer from the inherent limitations of vibration analysis. Stress Wave Energy is an excellent indicator of the overall health of a pump because it provides direct measurement and comparison of the amount of friction and impacts occurring on moving surfaces. Healthy pumps produce relatively low-energy stress waves, as compared to damaged machines where energy levels are consistently elevated in accordance with damage levels. A key characteristic of SWAN technology is that friction levels between like machines operating in healthy condition are similar. Thus, a unique baseline does not have to be established on every pump; instead, one properly established baseline can be used to immediately verify the health of all similar pumps, significantly reducing the time, resources, and data compilation required by conventional monitoring methods.

A Look at Operating History

The first tool for assessing the health of a pump is the Stress Wave Energy Operating History Chart, which captures the level of stress wave energy produced over time. Sensors are placed at key points, such as the top and bottom bearings of the main shaft. The amount of Stress Wave Energy detected by each sensor is then plotted on a chart broken into three color bands: green indicates healthy operating condition, yellow indicates the beginning of adverse operating conditions, and red indicates maintenance should be scheduled in order to prevent machine failure or significant secondary damage.

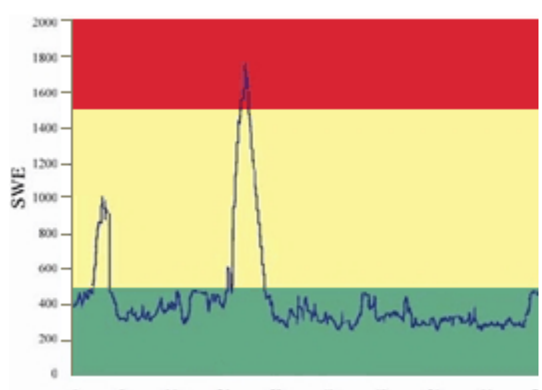
The figure to the above right shows a comparison of the performance of four circulating pumps with data taken over several hours. Pumps B and C are performing at consistent, low stress levels. Pump A, while still in the green zone, shows elevated SWE and an erratic trending pattern. Pump D has exceeded the yellow threshold, an early indication of an adverse operating condition. Subsequent analysis on Pumps A and D showed that the shaft and sub-surface bearings were being adversely loaded and that tapered roller bearing damage was present on the outer race.



Continuous monitoring provides greater accuracy-periodic monitoring might have missed the shock events around 6 hours and 28 hours, incorrectly causing this pump appear healthy.

Some companies periodically dispatch maintenance personnel with handheld devices for pump condition monitoring. Unfortunately, occasional sampling can produce a misleading view of equipment health. For example, the plot to the immediate right shows a 72-hour operating history, recording the stress wave energy detected by a sensor mounted at the bottom of a circulating pump motor. The energy spikes around hours 6 and 28 show major transient shock and friction events; however, if periodic sampling were done between hours 8 and 24, or 32 through 72, these events would be missed, and the pump would incorrectly appear to be in good condition. Continuous monitoring avoids the possibility that sample data will create either a false positive or false negative assessment of a pump's operating condition.

Regardless of when failures occur during a pump's life cycle, they start as small discrepancies and progress to larger ones that result in secondary damage, unacceptable operating conditions, or catastrophic failure. Traditional diagnostic techniques do not provide a clear indication of problems until late in the failure process, if at all. Stress Wave Energy measurements; however, provide a quantitative measure of internally generated shock and friction energy during the entire life cycle, as illustrated below.



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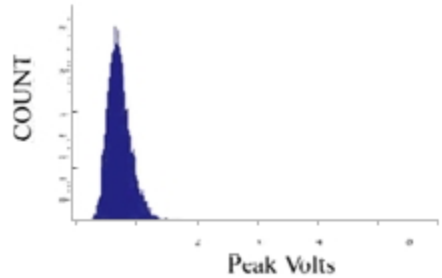
The quantitative nature and predictive accuracy of SWE, as a measure of machine condition, allows the time between overhauls to be safely extended to the time when wear out begins. The benefits of this service life extension are not only economic, but operational as well. The trend of SWE measurements from normal levels through caution and danger zones provides the information necessary for advance scheduling of corrective action and true predictive maintenance.



A normal condensate pump - low voltage stress wave energy in a bellshaped curve shows a healthy, consistent, well-lubricated machine.

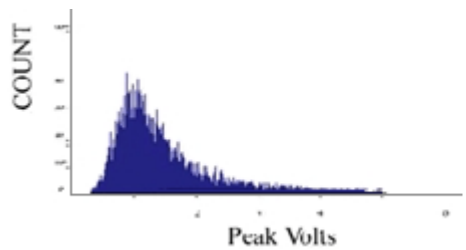
Stress Wave Analysis Histogram The Operating History provides an intuitive method for quickly assessing pump health. If a sensor records unusually high levels of stress wave energy or an erratic trend, a Stress Wave Analysis Histogram provides insight into the cause of the problem.

The figure to the extreme right of the page shows data taken from a condensate pump. All of the stress wave energy is at low voltages in a tightly distributed bell-shaped curve. This indicates a healthy, well-lubricated, consistent machine.

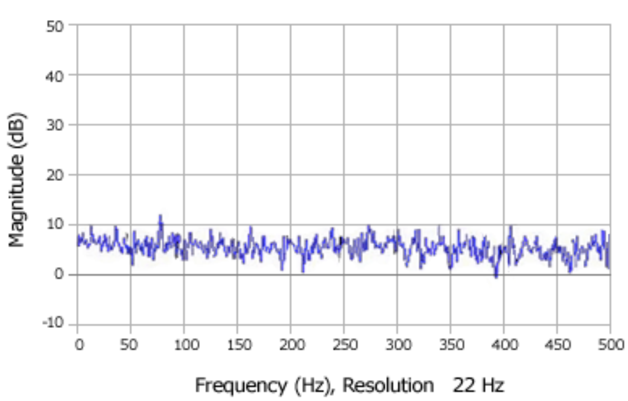
The Stress Wave Analysis Histogram below shows a broad-based distribution with excessive tailing to the right on the x-axis, as compared with the normal, healthy pump. This indicates poor lubrication effectiveness, which could be caused by particulate or fluid contamination, skidding events, sliding contact, or by random shock or friction events.

Stress Wave Spectral Analysis

A third tool, Stress Wave Spectral Analysis, is ideal for isolating damage to dynamic components, thus pinpointing the damage location. A flat spectrum (see figure below) verifies that no repetitive shock events typical of bearing or gear damage are occurring. A spectrum with a significant spectral line or lines (a spike in the vertical direction) at least 10 dB above background levels indicates a repetitive friction or shock event at the indicated frequency. Readily available bearing and gear data will assist in identifying the machine components that could potentially cause a shock event at that frequency, thus identifying the damaged component.



Broad distribution of stress wave energy with excessive tailing to the right on the x-axis indicates poor lubrication effectiveness.



The Spectral Analysis at the left is based on data taken from the top bearing on a condensate pump. The analysis shows moderate to heavy spectral content at 20 Hz (the other spikes are harmonics of the 20 Hz signal). Synchronous events this prevalent are generally undesirable and caused by shaft misalignment, imbalance, rubbing, and so on. Efforts to reduce these events can result in the extension of the useful life of a machine. The figure at the bottom contains data taken from the top bearing of an inlet cooling water pump.

The Spectral Analysis exhibits non-synchronous impacting at 97 Hz with harmonics. These events match the calculated defect frequency for the upper bearing's outer race and confirm that it is damaged. However, the Stress Wave Energy from this location is still low and consistent. As the damage zone increases in size, stress wave energy will correspondingly increase. The unit will not need to be taken out of service until the sensor consistently trends in the red zone. At that point, the bearing will have significant damage.

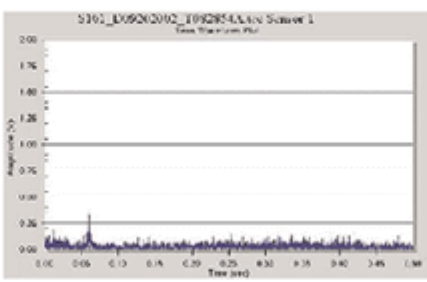
Conclusions

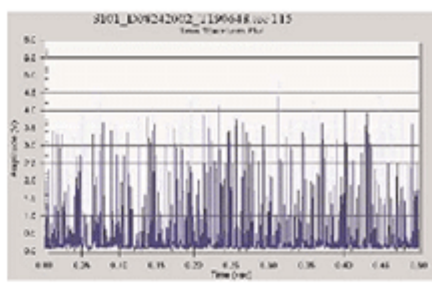
SWAN prevents the unexpected failure of a pump. When the red zone is reached, the pump should be pulled from service to prevent secondary damage or catastrophic failure. SWAN also eliminates false alarms. At least a 500% growth in signal strength is required to reach the red zone threshold. When this occurs, without question an undesirable condition has developed in the pump. When it is pulled from service, it will show clear signs of wear or physical damage.

SWAN technology provides power utilities with timely, accurate assessment of the health of mission-critical operating equipment. Unlike vibration analysis, SWAN tools can accurately detect even slight shock and friction events at the heart of the largest pumps and in all locations even those that are submerged under thirty feet of water.

SWAN tools are powerful and sophisticated in their diagnostic capabilities; however, they are simple enough even for the most junior-level operator to use. As little as one or two days training is all that is required, as opposed to the weeks and months of initial and recurring training that are required by other condition monitoring technologies.

SWAN technology is available in several different product packages, depending upon a company's individual needs. The examples in this document were developed using the SWANview system.





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