Know the health of your machinery

By Renard Klubnik and Ron Sullivan

Routine checkups, a healthy diet, and regular exercise are the prescription for a healthy life. The same is true for your rotating equipment. Your machines' "diet and exercise" is a function of how you operate them. If the temperature, pressure, or power quality are not within specifications, then their "diet" is not optimum. If they are operating outside of a manufacturer's specifications, then you are "over exercising" them. Just like you, they may experience an "injury" or failure if they are running misaligned or are being over worked. Think how you would feel if one heel of your running shoes was an inch shorter than the other as you tried to run a 10K. By the end of the race your body would be aching, perhaps with some serious back issues.

Machinery health monitoring

Just like you, your rotating equipment – such as pumps, mixers, motors, and compressors – benefit from regular "check-ups" to ensure there are no underlying problems. Diagnostics give us an indication of the health of the machine, such as, "Is this asset suitable for continued operation?" Or, "Will this machine be available for service when needed?"

Some plants (and equipment manufacturers) still promote rigid schedules for equipment teardowns. However, seasoned professionals often contend that regularly scheduled teardowns or rebuilds of machinery are not necessarily a prescription for reliability. Far from it, they anecdotally cite that approximately 25%-30% of the time after a rebuild there is a new problem that was not present when the rebuild was started. It is not hard to understand that opening, inspecting, and rebuilding some machinery can actually introduce a problem!

Scheduled teardowns were mandatory in the past because there were no non-invasive tools to determine the condition of internal components while the machine was in operation. Over the years, sensor technology, of all kinds, has advanced. Today there are infrared imagers, on-line lube analysis, pressure transducers, and flow meters among the growing arsenal of diagnostic instruments. One of the most reliable indicators of mechanical machinery health is vibration. Thanks to advancements in diagnostic techniques, vibration analysis has become a widely accepted tool for condition monitoring.

24/7 continuous spectral monitoring of your equipment's "vitals"

This offers the best defense against unscheduled downtime. It is probably a safe bet that there are a few select pieces of equipment in your plant that are considered to be critical assets. It is also highly likely that these lucky few pieces of equipment have a protection system that includes spectral based continuous monitoring with shut down capability if something extraordinary is detected. These pieces of machinery benefit from this advanced spectral monitoring. As a potential fault develops, these systems have the ability to notify plant personnel well in advance of failure. However, this is a very costly health monitoring program usually reserved for critical equipment deemed worthy of constant monitoring.

Walk-around ("route-based") vibration programs

These programs have gained widespread acceptance and provide a way of trending your machinery health. Over time, the data collected from a route-based program can be beneficial in early detection of adverse operating conditions, such as imbalance or misalignment, as well as early detection of specific machinery defects, such as bearing damage or gear problems.

The shortcoming of this approach is the possibility of a machine failure happening between time intervals of the check-ups. Add to this the cost of completing a full physical check-up on a month to month basis and you can see the rapidly expanding health monitoring cost. In this case, instead of focusing on what is good for the "patient," a decision to include or exclude a machine is often made based upon the cost of adding another machine to the monitoring program.

With both spectral based and route-based monitoring, vibration analysis requires a skilled operator. Vibration experts are educated about the complex analytical monitoring equipment and undergo significant education and on-going training so that their analysis is trustworthy.

An economical continuous monitoring option

Vibration analysis, like an advanced medical test, comes at a price. Just like your insurance company, you have to weigh the benefits against the costs. Not every muscle ache should dictate a full blown MRI. You would quickly go broke from the co-pays alone! Likewise, not all of your machinery needs a full blown vibration analysis every month and the company could not justify the expense.

The most practical means of watching your equipment's health continuously is to utilize 4-20 mA loop powered vibration sensors. These economical vibration sensors, when connected to a monitoring system, such as a plant PLC, DCS or SCADA system, continuously observe the health of your plant equipment. When the overall vibration level (a number between 4 and 20) is observed with the rest of the machine's performance indicators, the output of loop powered vibration sensors will indicate when a change in the operating condition has occurred. Much like monitoring your own heart rate, a change in the vibration level indicates something in the machinery has changed. The exact cause of the

problem cannot be determined at this point but it has at least alerted you to a problem. With this knowledge, it is now advisable to take a closer look at the machine to find the problem. A maintenance professional can sometimes locate the cause of the change by inspecting the machine. One might find a minor problem that arose in day to day operations or the machine may require immediate repair.

Loop powered sensors for many types of physical parameters have been around for a long time. Loop powered sensors for vibration are relatively new but are gaining widespread acceptance because they provide simple data at a fraction of the cost. As with all technology, refinements are constantly being made. While the early vibration sensors output a 4-20 mA signal proportional to peak velocity, a steady stream of improvements led to vibration sensors that output a signal proportional to root-mean-square (rms) velocity, true peak velocity, rms acceleration, peak acceleration, and true peak acceleration. The latest addition is a loop powered sensor that outputs a 4-20 mA signal proportional to the peak-to-peak displacement of the monitored machine. This is equivalent to monitoring your blood pressure in millimeters of mercury or pounds per square inch. The units may be different, but the interpretation of them is the same. A higher or lower trend is an indication that further investigation is in order.

When you implement vibration monitoring with loop powered sensors, you immediately improve the condition of your plant by providing vital information that previously has been overlooked. With this additional knowledge, you now have 24/7 access to instantaneous operating information that is easy to understand, trend, and alarm. By expanding your knowledge base to include machinery health as determined by vibration levels, you are one step closer to a more comprehensive health assessment and closer to maintaining a healthy 'lifestyle' for all your plant equipment.

You already check many machinery characteristics like motor amperage, flow rates, temperatures and even machine speeds. You also probably chart these. At a minimum, operating and maintenance personnel know what the normal ranges for these are and instinctively look for excursions outside normal ranges. Vibration is also a key indicator which can now be easily monitored in the same manner– even if you aren't a vibration expert. By using cost-effective loop powered vibration sensors, a plant's existing process control system can continuously "check-up" on equipment and alert maintenance and reliability professionals that a machine is operating outside of normal vibration levels notifying them of the need to take the necessary corrective actions.

Table 1 ISO 10816 Velocity		Machinery groups 2 and 4		Machinery groups 1 and 3	
		Rated power			
		Group 2: 20 hp - 400 hp motors 6.2" ≤ H ≤ 12"		Group 1: 400 hp - 67,000 hp motors 12" ≤ H	
in/sec peak	mm/sec rms	Group 4: pumps ≥ 20 hp integrated driver		Group 3: pumps ≥ 20 hp external driver	
0.61	11		Damage occurs		
0.39	7.1				
0.25	4.5		Restricted operation		
0.19	3.5		Unrestricted operation		
0.16	2.8				
0.13	2.3				
0.08	1.4				
0.04	0.7	Newly commissioned machinery			
0.00	0.0				
Foundation		Rigid	Flexible	Rigid	Flexible