InTech ISA

Improve reliability with essential asset monitoring

Improvements in plant reliability reduce risk of catastrophic events, lower maintenance cost

By Nikki Bishop

"Reliability" in the control process industries can be defined as the ability of a system to perform and maintain its functions in routine circumstances, as well as in hostile or unexpected circumstances. Unexpected circumstances in an operating facility can easily lead to catastrophic events. Improvements in plant reliability reduce the risk and occurrence of these events and lower maintenance costs. Improving plant reliability means ensuring process equipment is properly maintained and available for continuous operation. According to Solomon Associates, a world-class performer is a company whose maintenance costs are below 1.4 percent plant replacement value, with mechanical availability greater than 96.7 percent. Becoming a world-class performer requires implementation of an effective asset management strategy.

Real-time monitoring (and protection) of critical process equipment, such as large compressors or turbines, is standard practice at most facilities. However, monitoring of second-tier equipment has traditionally been deemed cost-prohibitive or too difficult. Second-tier equipment, also referred to as "essential assets," includes such things as pumps, heat exchangers, blowers, small compressors, pipes/vessels, cooling towers, and air-cooled heat exchangers ("fin fans"). While these unmonitored assets may not have been originally classified as "critical," an outage or failure can cause a serious process disturbance or shutdown, resulting in lost production, injuries, fines, and adverse impact to the environment. The U.S. National Response Center reports an average of almost 9,000 incidents per year, between 2000 and 2010, due to equipment failure (Figure 1). It is possible that many of these incidents could have been prevented with an early warning system in place so issues could be identified and corrected before failure.

According to Doug White, a refining industry expert with more than 30 years of experience, "We have performed a large number of studies for various refineries around the world. Our analysis of this data compiled from multiple industry sources shows that, in a typical refinery, about 25 percent of unplanned outages are related to equipment failure. Our consolidated data is presented in Figure 2, which shows the main root causes of unplanned shutdowns and

FAST FORWARD

- Automated monitoring of essential assets reduces unplanned shutdowns and slowdowns.
- Wireless technology breaks through cost barriers for implementation, making it easy to monitor the condition, or "health," of process equipment.
- Essential Asset Monitoring strategy keeps UT-Austin's Pickle Research Center out of a "pickle."

slowdowns and the unit availability loss associated with each. According to our studies, just seven asset classes account for the majority of the loss: valves, pumps, vessels, compressors, piping, exchangers, and fired equipment."

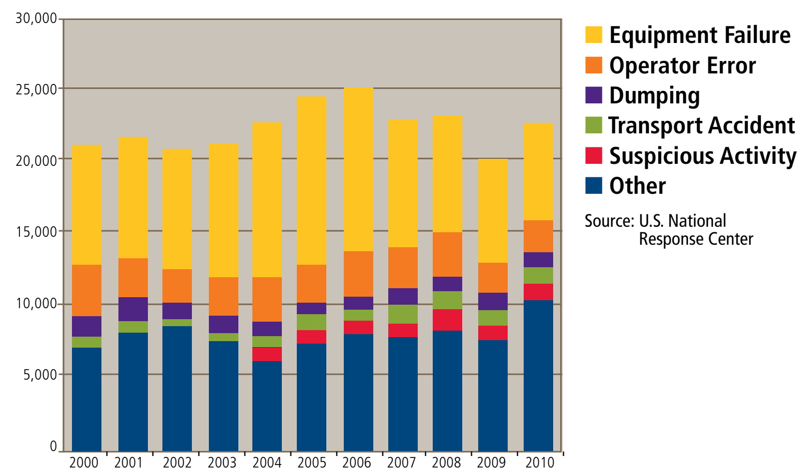
With regards to the maintenance spending on these assets, White adds, "Based on our industry analysis, maintenance of these same seven asset classes consumes about 70 percent of the total maintenance budget at a typical refinery. Figure 3 shows the approximate percentage of the maintenance budget associated with each of the seven asset classes that we have found in our studies. We have found maintenance cost to be closely correlated with the asset management strategy employed. Choosing the right strategy can reduce costs and increase asset reliability and process availability. While it may be tempting to focus only on cutting costs, that practice can lead to reduced reliability over the long run. Maintenance and reliability cannot be decoupled. The focus should be on increasing reliability, which will, in turn, lower the total cost of ownership."

Common Strategies for Reliability

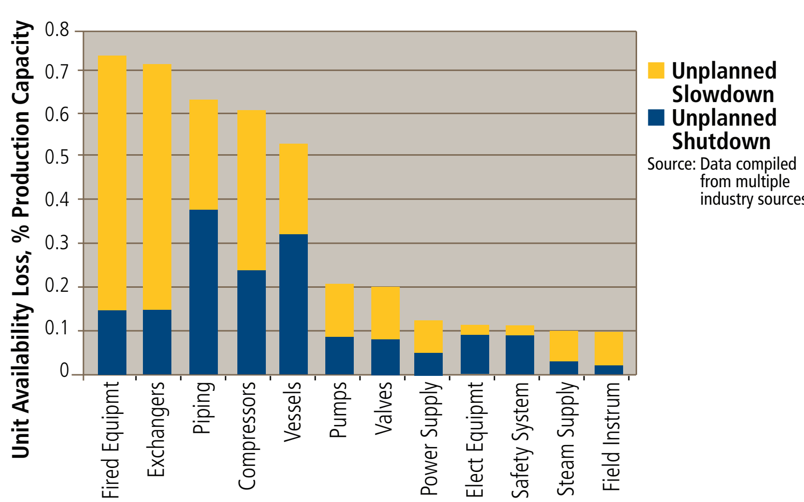
Selecting the right asset management strategy is a balancing act between implementation cost and expected reliability. Reactive maintenance represents the most costly and least reliable maintenance program. For example, some essential assets may have a spare as part of a reactive maintenance program. A common practice is to run equipment to failure and then switch to the spare when needed. But it may not be possible to bring the spare online in time to avoid process disturbances or a shutdown. Even with the spare asset online, maintenance personnel are faced with repairing the failed asset. For equipment without a spare, shutdowns are necessary to repair failed assets. On average, repair cost for a failed asset is typically 50 percent higher than if the problem had been addressed prior to failure.

Alternatively, some sites employ a preventive maintenance program that calls for schedule-based asset servicing, whether maintenance is necessary or not. While this approach may offer greater reliability than a run-to-failure method, it has its own drawbacks. Valuable time and resources are wasted servicing assets that may not require repair. The personnel busy unnecessarily servicing assets could easily be doing other productive work instead. And if the assets being serviced do not have a spare, the process is unnecessarily disrupted, costing valuable production time.

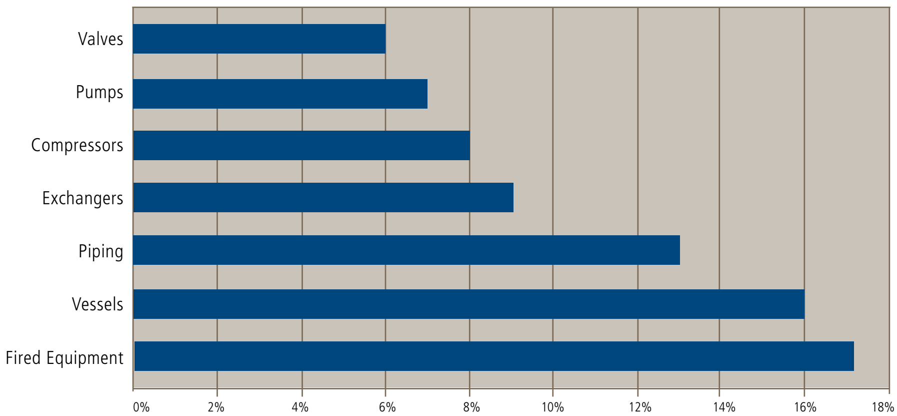
Predictive maintenance is another option as an asset management strategy. In this approach, essential assets may be monitored manually with spot-checks in the field. These "clipboard rounds" may occur once per shift but can occur as infrequently as once per quarter or longer. Periodic handheld vibration or performance audits may be conducted on selected assets on an annual or monthly basis. This method of predictive maintenance based on periodic—possibly infrequent—data acquisition fails to give real-time insight into asset health. Thus, equipment may fail during the interim of data acquisition, causing process disruption and a



As reported by the U.S. National Response Center, equipment failure accounts for the majority of reported incidents. (Figure 1)



Failures of "essential assets" can represent the majority of unplanned slowdowns or shutdowns causes. (Figure 2)



Seventy percent of total maintenance budget can be consumed by only seven asset classes. (Figure 3)

more costly repair than a well-maintained asset. Resources are wasted sending skilled personnel for data collection into the field, which might also be a hazardous environment. Additionally, analysis and interpretation of collected data requires the skills of a trained reliability engineer or equipment specialist. The problem is compounded as experienced personnel retire and take their vast stores of knowledge with them. Periodic monitoring leaves operators and maintenance personnel without sufficient insight into the health of their equipment.

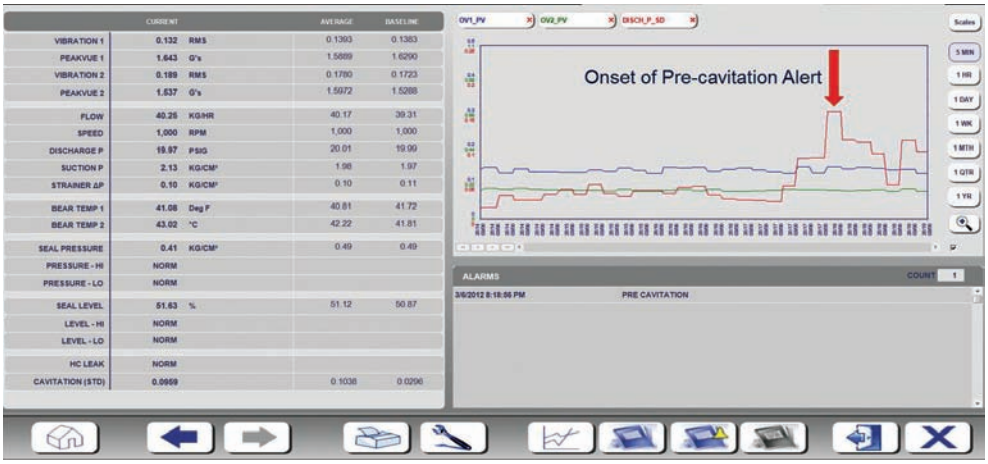
When faced with selecting an asset management strategy, the ideal approach for increased reliability and minimal maintenance costs is an automated monitoring strategy—one that provides online indication of an asset's health. Automated monitoring can detect process conditions that may be unintentionally and unknowingly inducing a fault on equipment. Armed with the knowledge of adverse process conditions, operators can make adjustments so that process-related equipment faults can be avoided altogether. In the event of impending failure, online indication of asset health provides advanced warning of health degradation that allows enough time for spare equipment to be safely brought online, eliminating process upsets, off-spec product, and safety incidents that result from an unexpected trip. Advanced warning gives maintenance staff the information they need to determine when servicing is necessary to prevent a failure, even on assets that do not have spares. An automated monitoring strategy can bring asset management into the control room and eliminate unnecessary trips to the field to collect data. Centralized, online asset monitoring also eliminates the need to send personnel into hazardous areas for data acquisition.

Wireless technology opens the door to online monitoring

The heart of any early warning system is online field signals. Historically, process plants have been built with only the minimum amount of instrumentation necessary to safely operate the unit. This may be due to budgetary constraints, or it may be that the necessary measurement technology was not available at the time of design, such as vibration or acoustic transmitters. An effort to improve reliability and reduce maintenance costs should start with a survey of what measurements currently exist and what measurements are missing. Traditionally, adding missing measurements was a daunting task that was expensive, time consuming, and, at times, impractical due to the location. The advent of wireless technology has considerably lowered cost barriers to implementation, making it easy to monitor the condition or "health" of process equipment—be it a pump, heat exchanger, control valve, steam trap, pressure relief valve, or other essential assets. Wireless devices can be installed in hard-to-reach places and in locations deemed cost-prohibitive by conventional means. Wireless devices typically take two hours to install, compared to two days to install a wired device. Setting up a wireless network allows for easy future expansion by seamlessly adding devices to the existing network, while simultaneously strengthening the network robustness and resilience. Wired devices can also be adapted to communicate wirelessly, allowing stranded local measurements to become part of the wireless network.

While wireless technology provides an easy and cost-effective means of adding measurements, data collection alone will not prevent equipment failure or improve plant reliability. Data aggregation and analysis is necessary to generate meaningful alerts from the information gathered. Combining asset data, process data, and statistical process control techniques creates a powerful trifecta for detecting equipment faults. Monitoring process data, such as pressure, temperature, or flow, along with asset data, such as vibration or bearing temperature, identifies specific process conditions that may cause asset health degradation. Adverse process conditions can be detected and adjustments made to prevent further asset damage. Statistical process control methods applied to aggregated process and asset data provide meaningful alerts to plant staff and eliminate nuisance alarms. Alerts that clearly indicate actionable issues enable problems to be diagnosed and resolved quickly and effectively. Applying smart analysis to generate meaningful alerts also reduces the demand on trained reliability engineers or equipment specialists, as less experienced personnel can respond when meaningful alerts clearly indicate problems.

Furthermore, pre-engineered integrated solutions comprised of application software and the necessary measurement devices provide a convenient and powerful means of asset monitoring. By simply connecting process and asset data, a pre-engineered solution can provide an easy, "plug-and-play" solution to what may seem like a complex task. Pre-



Trends of asset and process data clearly show the onset of pre-cavitation conditions. (Figure 4)

engineered solutions also offer the benefit of easy deployment to multiple assets of the same type. Consistent analytical methods across all assets of a particular type (e.g., pumps or fans) are instrumental for effective decision support.

Pump cavitation is a prime example of a condition that warrants early warning. Cavitation occurs when the liquid pressure falls below its vapor pressure at the pump suction, causing bubbles to form. The bubbles implode on impellers and interior surfaces, damaging the pump internal structure, disrupting flow, and, possibly, leading to seal failures. By examining the process conditions around the pump and pump asset data, such as vibration and bearing temperatures, early cavitation alerts can be issued, allowing plant operations to modify process conditions to minimize cavitation damage (Figure 4).

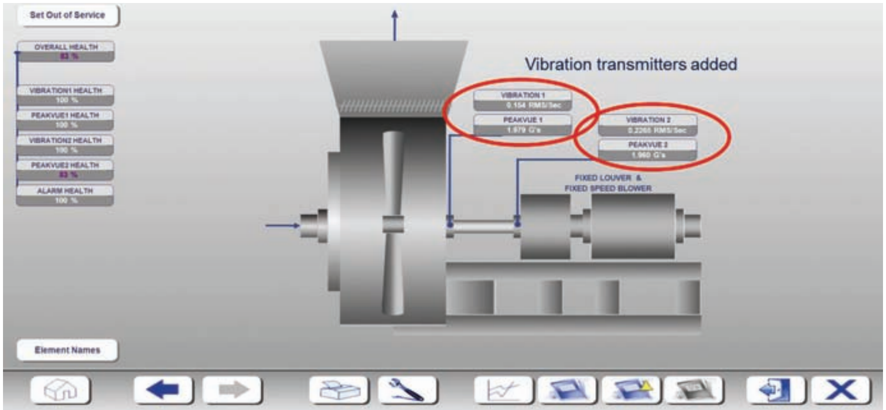
Welded seams from a previous failure serve as a reminder of the value of online monitoring.

Wireless vibration transmitters provide valuable insight into the health of the blower.

Essential asset monitoring solutions in action

Assets sometimes get the reputation as being “bad actors.” These are assets that experience repeated problems and, possibly, even repeated failures. Monitoring these “bad actors” provides early warnings of impending failures. The University of Texas–Austin’s J. J. Pickle Research Center currently uses an essential asset-monitoring strategy to monitor the health of its equipment. One particular asset monitored is the forced-draft air blower, which services a vintage natural gas-fired boiler. The boiler provides steam for the Separations Research Program facility, which is unable to operate without it. The boiler is considered one of their “bad actors.” It is oversized for normal demand and, therefore, cycles on and off about every 20 minutes. This constant cycling puts stress on the blower, which must start and stop to provide combustion air. In the past, catastrophic impeller failure caused the blower to tear apart and become detached from the boiler. Without the necessary combustion air, the boiler tripped, and steam supply to the Separations Research Program was cut off. Replacing the blower was not an option, as parts for the aging boiler were unavailable. Instead, the blower was rebuilt and re-welded to the boiler, but scars from the welding repairs were clearly visible. After the last repair, wireless vibration transmitters were installed on the blower motor, and plant personnel now have insight into the health of the blower. In this case, two accelerometers were installed, each providing two vibration measurements—one for overall vibration and one for PeakVue vibration. The PeakVue vibration is extracted from a very fast sampling rate of 50,000 times per second and is a measure of the peak value of impacts that occur when metal impacts metal. Operators can monitor the health of the blower and make repairs as necessary to prevent another such failure. Figure 5 shows the operator display used to monitor the boiler blower. The overall health of the blower is displayed, as well as the measurements from the wireless vibration transmitter.

In addition to monitoring the blower on the boiler, online monitoring solutions for pumps and heat exchangers are in place at the J. J. Pickle Research Center. The bottoms pump on the CO_2 stripper column is monitored for such faults as cavitation, low pump head, and high or increasing vibration. A heat exchanger on the stripper column is also monitored. Alerts are generated when fouling is detected and



An essential asset monitoring program can translate into significant annual profit improvement. (Figure 5)

cleaning is required. Exchanger duty calculations are performed, and the results are clearly displayed. The overall health of both the pump and the exchanger are also calculated and displayed. The J. J. Pickle Research Center has gone one step further with its asset monitoring system by setting up a remote connection, where experienced subject-matter experts can log in using secure VPN access to help diagnose problems with assets and assist with the appropriate corrective action.

Benefits of essential asset monitoring

Downtime of essential assets causes process slowdowns or shutdowns, which lead to lost production and, ultimately, decreased profit. An automated monitoring program reduces unplanned shutdowns or slowdowns, providing the highest reliability and lowest maintenance costs. Wireless technology, coupled with pre-engineered integrated solutions, breaks through cost barriers to provide an easy and cost-effective means of essential asset monitoring.

Online monitoring of essential assets:

- detects abnormal operation or imminent failure
- provides online information to predict and plan maintenance for normal wear and tear of assets
- provides operators with direct feedback when the process conditons are harmful to plant equipment
- delivers diagnostics, as well as equipment and process health alerts
- enables timely corrective actions to keep a facility online

Improving reliability and lowering maintenance costs means increasing profit. As shown in Figure 6, for a typical 250,000 barrel-per-day refinery, an effective essential asset monitoring program could be worth up to $14.7 million based just on identifying developing faults. Giving operators the tools they need to avoid harmful operating conditions brings further benefit by eliminating the fault entirely. Those savings would be over and above what is illustrated in the chart. The right tools exist in the marketplace today. Wireless technology has simplified the process of addressing missing measurements. Pre-engineered monitoring solutions have removed the engineering design barriers. Pacesetter refineries have begun to move toward automated monitoring—and have already seen early results.

What is this worth to you? (Figure 6)

For a typical 250,000 barrel per day refinery an effective essential asset monitoring program can save up to 14% of your maintenance costs. 1.2% of your production capacity, and 2% of your pre-heat energy costs every year.

INPUT	
Refinery capacity in barrels per day	250,000
Refinery net margin per barrel refined	$5
Refinery total annual maintenance spend excluding turnarounds	$50,000,000
Energy costs per MBTU	$6
Operation days per year	350
OPERATIONAL BENEFITS	
Production capacity lost due to essential equipment	3.5%
Gain back production with predictive diagnostics	30%
Annual Operational Improvement	**$5,512,500**
MAINTENANCE BENEFITS	
EAM covered equipment maintenance cost as percent of total	70%
Annual maintenance of essential assets	35,000,000
Reduction in average cost to repair with predictive diagnostics	20%
Annual Maintenance Cost Reduction	**$7,000,000**
ENERGY BENEFITS	
Gain back energy with improved monitoring	10%
Pre-heat fouling maximum	20%
Fired heater efficiency	80%
If heater limited, % time unit is at maximum capacity	25%
Annual Energy Cost Reduction	**$2,200,000**
TOTAL ANNUAL PROFIT IMPROVEMENT	**$14,712,500**

ABOUT THE AUTHOR

Nikki Bishop, PE, is a Senior Application Consultant at Emerson Process Management. Her experience in the process control industry includes projects in industrial energy, pharmaceuticals, power generation, pulp and paper, and refining. She holds a BSChE degree from Georgia Tech and resides in Atlanta, Ga., with her husband and two young sons.

View the online version at www.isa.org/intech/20120605