SPECIAL FOCUS: PREDICTIVE MAINTENANCE

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Special Focus: Predictive Maintenance

Contents

What is Your Equipment Trying to Tell You? p. 4
Click here

All in This Together p. 10
Click here

Alcoa Warrick Commits to Reliability p. 13
Click here

Reliability and the Bottom Line p. 16
Click here

Department of Equipment Health p. 18
Click here

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It’s easy to regard vibration analysis and ultrasound as competing technologies. As these technologies grow and mature, however, the experts in both fields are coming to agree that, for many applications, vibration analysis and ultrasound are at their best when they are used together. Vibration analysis and ultrasound are often viewed as complementary parts of a complete condition monitoring toolkit. Sophisticated users select their technologies on a very individual basis. The choice takes into consideration equipment criticality, typical failure modes, the cost of failures, the cost of monitoring, the practicality of redundancy, and other characteristics of the business, the site, and the individual assets within it.

“We use both vibration analysis and ultrasound to monitor bearing condition and trends over time to predict bearing failure,” says Paul Berberian, vice president of predictive technology at GTI Predictive (www.gtipredictive.com). “While we are using our vibration tools to determine root cause analysis for unbalance, misalignment, bearing defects, and looseness, ultrasound is a very good tool for...
determining when and how much to lubricate. This prevents over lubrication which is one of the main causes of bearing failure. Financially, if you correct the root cause and you lubricate it properly, a bearing should easily operate throughout its expected life.

Traditionally, vibration and ultrasound inspections have been most popular in bearing monitoring, explains Alan Bandes, vice president of marketing at UE Systems (www.uesystems.com). “Since ultrasound senses friction, it has gained popularity in lubrication programs where users can identify bearings in need of lubrication quickly, and, by incorporating equipment such as the grease caddy, lube techs can apply just the right amount of grease to prevent over lubrication,” he says. “Another use of the two technologies is basic bearing route inspection. Since ultrasound relies on just one test point, the time of inspection is cut by at least a third. Yet another application in which ultrasound has assisted vibration programs is inspection of slow-speed bearings. Ultrasound will detect the slightest signs of increased friction or early stages of spalling in a relatively short time.”

Combined use of vibration analysis and ultrasound also improves equipment availability and wrench time (Figure 1). “Ultrasound and vibration analysis have unique capabilities,” says Trent Phillips, condition monitoring manager at Ludeca (www.ludeca.com). “However, they’re companion technologies, as well. Using both together can provide very early detection and confirmation of bearing faults, lubrication issues, and more. Additionally, the combination of these tools can deliver optimal use of manpower through more efficient condition monitoring coverage of important assets. All of this leads to increased time to plan and schedule activities that will keep equipment running upon demand. The result is reduced downtime, reduced costs, reduced risk, reduced spare parts usage, improved safety, increased capacity, increased uptime, and increased profits.”

The evolution of condition monitoring tools has proceeded against the backdrop of changes to statutory and technical issues in the businesses themselves. New motor technology, notably the spread of variable frequency drives (VFDs), has created new failure modes that must be monitored. New extraction techniques have pushed mining and drilling equipment in new directions, creating unprecedented environmental and mechanical challenges. Arc flash prevention has prompted changes to OSHA, NFPA, and NEC standards. With all these changes come new monitoring requirements.

Change calls for fresh thinking regarding the use of vibration analysis and ultrasound, as well as other condition monitoring tools. Use these tools, individually and in
condition and report if that equipment will have continued availability and reliability. I prefer the extra benefits of a walk-around vibration program. The person that collects the vibration data should also use natural senses — vision, sound, smell, and feel. Using the human senses can provide valuable information to consider when analyzing. A complete program, using all the available technologies and human senses, increases plant and rotating equipment reliability.

Given all the vibration technology and analytical skills of the analyst, it will be worth nothing if the identification and explanation of found faults can’t be presented in an understandable report. But, on the other hand, even though vibration technologies have been around for more than 40 years, you can still find some people who are still skeptical of the information from the vibration guy. To some, it’s like the diagnosis of the fault came from a crystal ball. A vibration analyst has the tools that, when used properly, can see faults developing at a very early stage. Care must be taken to know your personnel and when a report should be provided. Too early of a call for repairs and no discernable faults may be seen with the naked eye; the analyst will be questioned on an alleged bad call. Too late of a call for repair and secondary damage will begin, which decreases the life of the coupled equipment.

I’ve provided predictive services to several different groups of maintenance and operations personnel at several different sites over my almost 30 years in plants. Each has differences on their approaches to the faults or how and when they want a report. To some, if the noise changes, a squeak develops, or the tone changes, they’re on top of it wanting answers. Others have to feel the floor shake before questions are asked and repairs are scheduled. Responding too early to developing faults can waste money and resources. However, if vibration gets to a point that you’re feeling it in the floor, it most likely has generated secondary damage. Reporting can be a balancing act. As in any plant, the scheduling of a repair has to be made so production doesn’t suffer and you want to get the most life from the rotating equipment without generating secondary damage. Finally, buy-in from supervision and management is imperative for any predictive maintenance program to be successful and have longevity.

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Combination, to meet the evolving monitoring needs of equipment and the environments in which it operates.

ARC FLASH IN THE BOX

Ultrasound can be used to keep arc flash danger away from employees, explains T.J. Garten, electrical and energy subject matter expert at Allied Reliability Group (www.alliedreliabilitygroup.com). “During routine infrared electrical surveys, we have utilized acoustical ultrasound to assist with failing part identification, as well as severity determinations,” he says. “Listening for chattering contacts, intermittent auxiliary contact operation, starter coil assembly chatter, and coil winding electrical hum assists the analyst in providing corrective work orders. This information changes the work from a search-and-find mission to a planned repair that eliminates hot-spot chasing.”

Electrical inspection is a fairly new application for ultrasound technology, says Adrian Messer, operations manager at UE Systems, but its use hasn’t increased much in the past few years. “The main driver of this application is safety because we can typically inspect energized electrical equipment without having to open the panels and doors on the equipment,” explains Messer. “So, there’s little fear of creating an arc flash because we aren’t changing the environment.
inside of the equipment and we aren’t exposing ourselves
to the energized electrical connections. Additionally, when
ultrasound is used in conjunction with traditional infrared
inspection, the user can scan with ultrasound prior to open-
ning up the electrical equipment for the infrared inspection.”

VARIABLE FREQUENCY DRIVES
Applying both vibration and acoustical ultrasound for
assessing the health of bearings hits the largest range of
potential lifecycle anomalies, says Allied’s Garten. “Beyond
just the routine bearing failure modes associated with lubri-
cation and wear, effects of electrical transients and VFD-re-
lated anomalies have been identified with both technologies,
leading to corrective action to the power circuit. This solved
root causes rather than allowing repeat failures. There are
slight differences in the data collected via vibration and
ultrasound. This supports not just varying failure detection
for trending and mitigation, but also the addition of varying
alarm banding for anomalies beyond the normal mechanici-

dal focus. These anomalies are becoming more prevalent in
the field.”

Allied has found value in applying acoustical ultrasound
for assessment of several of the internal components for
VFDs, as well, says Garten. “Utilizing acoustical ultrasound
on these components has added value in assessing failures of
these components prior to their normal end of lifecycle. Fail-
ures of iGBT assemblies, internal and external fans, and DC
buss chargers all result in audible and spectral changes that
trigger additional testing such as power quality assessment,
motor current signature analysis, and field technical checks,
to isolate and identify failures.”

A LITTLE VIBRATION
Tom Hoenig, president of GTI Spindle Technology (www.
gtispindle.com), describes an unusual shale processing ap-
lication. “In most cases with vibration analysis we are look-
ing to minimize vibration of machinery to prevent failures,”
he says. “As the vibration increases at certain frequencies, we
start planning for failures. In one case we were approached
by a company who services shale shakers in the oil and gas
industry. These are giant machines that sift large amounts
of earth as their daily function. They only work well when
they vibrate enough in the correct direction, frequency,
and amplitude. So in other words less vibration means poor
performance.”

The shale processor asked GTI to write an app that could
run on GTI’s iPad vibration analyzer to inspect the peak
performance of the vibration for its machines (Figure 2).
The company needed to know how many Gs of vibration
acceleration occurred at each mapped point on the machine,
along with the frequency of that vibration. “They also need-
ted to measure in two axes and show the vibration in an orbit
plot,” explains Hoenig. “This way they could see the shake of
the machine with two axis points of measure at each corner.
The screen shots and reports generated by the iPad show the
machine and all the points needed to be measured.”

Through the project, GTI learned not all equipment
and assets are designed to minimize vibration, continues
Hoenig. “Some equipment is made to vibrate to get the job
done,” he explains. “Either way, vibration analysis again
gives us the visual window to see the vibration and tell us if
it is too much or not enough.”

GET THE SIGNAL
Getting to equipment to take readings can be a major chal-


enge. “Critical equipment can be located on a train, ship, or
a remote site that is difficult or dangerous to access by em-

ployees,” says Ludeca’s Phillips. “Unfortunately, in the past
it was very difficult or impossible to apply vibration analysis
on equipment under these circumstances. We have done a
lot of work to make vibration analysis in these environments
possible, and the process has been very exciting. The condi-
tion monitoring system continually monitors the health of
the equipment under normal operating conditions. Operators, mechanics, and management can be actively alerted via email or text message when conditional changes occur on a monitored machine. The data is automatically transferred back to a centralized location for routine analysis so that corrective action can be taken before unwanted consequences occur. In addition, capabilities such as wireless vibration monitoring, cloud computing, remote monitoring capabilities, and services are now available. In the past two years we have released new multichannel real time vibration monitoring systems. Routine access to cranes and other types of equipment can be very difficult or impossible for routine condition monitoring. We have also installed wireless monitoring systems in these applications to overcome access and safety concerns and ensure that equipment health monitoring is provided.”

The interest in using ultrasound for monitoring critical assets remotely and continuously is on the increase, says UE’s Messer (Figure 3). “Junction boxes can now be used in conjunction with the handheld ultrasound instrument and remote-mounted ultrasound sensors to collect data on multiple points from one central location,” he says. “Other sensors are available that can be connected to PLCs and other online data monitoring systems to monitor both mechanical and electrical equipment. Examples of assets that can be monitored remotely with ultrasound include overhead cranes, enclosed electrical switchgear, robots, and remote pumping stations.”

Impact demodulation is a new wrinkle for vibration analysis installations. “By applying impact demodulation to vibration data, we are able to identify impact vibrations, which decay or ring down very rapidly, and lift them out of the steady background vibration for analysis,” says Steven Hudson, senior analyst at Azima DLI (www.azimadli.com). “Picture separating cymbal crashes from a steady drum beat. The impact sounds typically begin to be emitted long before actual failures in elements like bearings. Adjustments to sample durations and sampling rates may be required to support precise analysis and avoid aliasing or shadow data, but the payoff is better long-term forecasting. This new capability is particularly useful for slower turning equipment that used to make impact data difficult to obtain.” A white paper on impact demodulation is available at www.plantservices.com/white-papers/2014/impact-demodulation-identification/.

To introduce and grow vibration monitoring and ultrasound technologies in an organization, a starter application can help to break into an industrial setting. “Even though it has become common knowledge that ultrasound can be used for compressed air or gas leak detection, it never gets old to see someone who finds a compressed air or gas leak with ultrasound for the first time,” says Messer. “It’s even more satisfying when a facility begins to use ultrasound to find and then repair the leaks and the savings and benefits that are then associated with those efforts. Being able to quantify compressed air and gas leaks using ultrasound is always exciting and is typically a good start for someone who is implementing the technology into a reliability program. Being able to document savings associated with compressed air or gas leak detection with ultrasound typically leads to investments in additional training and other predictive technologies. Benefits also include reduced compressor demand, increased capacity on the overall compressed air system, and a reduction in the facility’s carbon footprint by reducing the greenhouse gas emissions.”
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The North American Maintenance Excellence (NAME) Award is a program of the Foundation for Industrial Maintenance Excellence, a nonprofit, volunteer organization. The award is presented to individual plants on the basis of their maintenance departments’ abilities to provide “capacity assurance for operational excellence” in the areas of organization, work processes, and materials management. In 2011, the Frito-Lay plant in Fayetteville, Tennessee, received the award. Richard S. Cole, Sr., the plant’s director of engineering/maintenance, spoke with Plant Services about maintenance, OEE, training, and the NAME Award.

PS: Is OEE a component of your corporate measuring stick for equipment performance? Who gets the equipment availability (uptime), throughput rate and quality data that determine OEE? How does it affect the way maintenance people do their jobs?

RC: “Scorecarding” is a way of life at Frito-Lay. The site tracks uptime daily and posts the results where everyone will see as they enter into the production area. Performance is monitored by operators and mechanics on each shift. Downtime is tracked by category. There are five main categories: total, changeover, equipment, operations, and other, which are acts of God. Each category has a point person who leads a focus team to reduce downtime in their respective areas as they collaboratively work with others to reduce total downtime. Equipment reliability is important to achieving key metrics in quality, service, and cost. The results by site are compiled by the national reliability team and shared each period to all supply chain managers and their teams. Recognition and bragging rights are awarded to the top performers in absolute performance and percent improvement. Total downtime is one of only 11 KPMs used for the national awards and is also part of the bonus plan.

PS: Does Frito-Lay’s modern, high-speed minimum changeover equipment place any special demands on the maintenance organization?

RC: There have been a rising number of changeovers in the snack food business to meet consumer needs regionally and locally. There are more brands in the Frito-Lay portfolio than ever before, and each brand has its regional flavor, or seasoning, which creates a large number of changeovers. Changeovers are a maintenance team’s nightmare, because every time you take a line down and break it apart to clean and then put it back together is a chance for failure. Instead of seeing the recent trend of more changeovers as a curse, the site and Frito-Lay saw it as a challenge. The team embraced the challenge and looked for ways to simplify the changeover, such as plug-and-play technology or swapping out components — redundancy — and cleaning the used components off-line after the line was back up and running. In addition, the operation team used a pit-stop mentality to changing over the lines by pre-kitting the line prior to the changeover. The site also has goals and tracks its performance against the changeover goals and reports on performance each week. Leveraging these techniques, as well as others, ensures that capacity is maximized and downtime is minimized. Due to more changeovers, the amount of planned downtime for maintenance each week has decreased. Thus, the maintenance team had to figure out how to get PMs and corrective work done in less time. One approach was to see which activities or checks in the static PM could be converted over to the running PM. Leveraging ultrasound predictive maintenance while doing running PMs was one solution. Converting 80 hours/week of static
PM actions into the current running PMs enabled the site to maintain its 92% PM completion which led to 99.4% equipment uptime.

**PS:** What is the educational background that you look for in a new maintenance person? Is there special training that Frito-Lay requires?

**RC:** The team at Frito-Lay is looking for a mechanic that has a multi-crafted skill set along with a teamwork approach to getting work completed. It’s desired that the mechanic have a two-year degree from a technical school as a minimum. Frito-Lay, like most companies, is constantly improving the production lines with new technology. Mechanics have to show that they have the ability and desire to learn to keep up with the ever-changing technology. To reinforce this behavior, the site has partnered with various community colleges and junior colleges in the surrounding area to source future mechanics. Frito-Lay has created an internship program with technical students from these schools. In addition, the maintenance department creates a development action plan for each mechanic that’s based on leveraging strengths and addressing opportunities. More than 36 different technical training classes are offered each year, which allows team leaders to match training classes to mechanics, based on needs. Some of the classes are provided through MRO partners, and others take advantage of online programs.

**PS:** How did preparing your organization for the NAME Award process and then winning the NAME Award help you to become a more productive and profitable plant?

**RC:** The preparation for the NAME Award was not a means to an end, but, rather, for the Frito-Lay team, it was a benchmark to evaluate the progress of the company, not just the Fayetteville site. Frito-Lay was using the Fayetteville site as its”bell cow,” and how well the Fayetteville site did indicated the success of the company as a whole. The NAME assessment is very thorough, and, hence during the preparation, the Frito-Lay team identified some opportunities through documentation and addressed them between the date of the application and the date of the field assessment. But, for the most part, the preparation was more or less an explanation of the engineering department’s business plan to include its overall philosophy, three-year strategic plan, department staffing and crewing requirements, training and development approach, processes and systems used, along with tracking, reporting, and improving results. Once on site, the NAME Assessment Team offered a wealth of knowledge with more than 100 years of combined maintenance management and leadership. The assessors were outgoing and willing to share best practices during the process. They took a good thing and made it better where possible. The assessment provided documentation with a scored rating that identified strengths and opportunities. The site then put together a plan that would leverage its strengths to address the weaker areas. There is always room for improvement, but the “excellent” rating was confirmation that Frito-Lay was implementing a national reliability plan that was on track.

**PS:** What would you recommend to an individual or organization that’s thinking about submitting an entry for the North American Maintenance Excellence Award?

**RC:** No matter where you are with the journey to achieve maintenance excellence, the NAME Award will provide a meaningful insight on what one does well and what one should do differently to achieve world-class results. The NAME leaders have taken steps to make the process smooth and simple to ensure one maximizes its efforts. There is a new, fast, and easy way to check your progress to maintenance excellence. The NAME Award Quick Check is a one-page application focused on results of key department indicators. Upon submitting this form, one will receive a free, personalized response. The feedback will be one of two things: the basics are in place to move forward with a full assessment; or some foundational blocks, maintenance processes, and systems, need to be shored up prior to proceeding. In either case, recommendations are provided for improvement by a professional NAME board member. This is the case throughout the process. The best part is that everyone is in it together.
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In 2003, the Alcoa Warrick Smelter was 43 years old, and it had the second-highest maintenance costs in the corporation’s global smelting system. Asset reliability in the plant continued to suffer, and equipment instability prevented success in fully implementing lean manufacturing tools. A formal assessment of the smelter’s repair and maintenance (R&M) efforts determined a mostly reactive approach with a focus on trying to be really good at response to emergency breakdowns.

That year, the location’s top management provided support to embark on a Reliability Excellence (REX) journey, which created a significant transformation. Ten years later in 2013, Alcoa Warrick Smelter’s R&M costs are 29% below its 2003 pre-REX base (44% lower adjusting for inflation), and OEE performance improvement gains have matched R&M savings dollar-for-dollar annually.

A formal asset integrity audit performed in 2010 by corporate-level resources confirmed that these cost savings were real — in other words, they weren’t gained by simply deferring R&M. In fact, the Warrick Smelter had the lowest percent of corrective actions needing attention in the next five years of all the corporation’s global smelters.

Building a high-performance engineering team contributed to the success of reliability excellence now in use for the smelting business at Alcoa Warrick Operations.

**IMPORTANCE OF RELIABILITY ENGINEERS**
Reliability engineering is different from a traditional engineering role in manufacturing. These are not engineers who provide the routine, day-to-day support for production centers. Instead, reliability engineers are in a strategic role — focused on failure prevention and, most importantly, helping to determine how to improve reliability and operate the plant’s assets at the lowest cost.

Do you have reliability engineers at your plant? If so, what types of tasks are they doing? Are they managing capital projects? Are they firefighting? Are they in tactical roles? If so, they’re not reliability engineers.
If a problem isn’t solved to root cause, it may keep recurring. If a plant doesn’t know which assets are the most critical, then the plant may be focusing on the wrong things. If a facility isn’t using equipment failure data to direct its resources on the true equipment bad actors, then there is most likely a lot of money being left on the table.

Reliability engineers help with all of that and lots more.

**BUT WE LIKE FIREFIGHTING**

How many times have you experienced a major equipment failure at your plant and felt relieved when it was over? We all have praised our firefighters; these are the individuals who excel in a crisis and, in many cases, thrive during every minute of it.

We need them. There is no doubt that when a production center is interrupted we need resources to respond. And when a major downtime event occurs we need people with strong troubleshooting skills and those who can get our equipment back up and running again. These are the ones who are working hard to reduce mean time to repair (MTTR). They could be engineers, technicians, craftsmen, or others. And when they get the equipment running again, we thank them and feel the weight lifted off our shoulders. How many of us have given lavish praise to these “knights in shining armor” when they swoop in to save the day? We probably all have, and that is not a bad thing, but what we sometimes forget in the heat of the moment is to step back and ask, “How did we get into this mess in the first place? Why did this failure occur?” And most importantly, “What are we going to do to prevent it from happening again?”

This is where the reliability engineers steps in. They are not focused on MTTR, but instead mean time between failures (MTBF). While others are on the scene, working to do whatever it takes to restore immediate production flow, the reliability engineers should be there investigating what happened. They will talk with the operators, review operational data and trends, take photographs of the scene, pull up past history of similar incidents, review camera footage, if available, and try to piece together all the available evidence. This is the detective work that will enable them to lead a root cause analysis (RCA) to determine why the failure occurred.

And speaking of RCA, it may seem obvious, but you need to have proper follow-up mechanisms to ensure the RCA action items are getting completed. Have your reliability engineers keep these corrective and preventive action items in front of your teams so that these tasks get done. Archive your RCA files to be easily accessible later on. And if the failure returns, retrieve the previous RCA and review it to try to understand what may have been missed and why the failure recurred.

**FREE-TIME RELIABILITY ENGINEERING**

Focus. That is one of the most important parts of our success. If you have a reliability engineer in a hybrid role — doing some maintenance engineering or some project engineering — then you don’t have a true reliability engineer. In a hybrid role, the crisis of the day or a production manager’s pet project can take precedence over working on long-term objectives. If you expect reliability engineers to work on reliability when they can find the time, you aren’t going to make the gains you’re seeking. They must be focused.

Yes, we all are busier than ever these days. We all wear multiple hats. But the reliability engineering role is one where we must discipline ourselves to focus them solely on failure elimination and prevention. When you pull a reliability engineer off a proactive task to work on a reactive task, you are losing ground in your reliability efforts. Set yourself up with a maintenance engineer or maintenance professional to handle the tactical production needs while the reliability engineer is allowed to focus on the strategic efforts.

And you may ask, “How many reliability engineers do I need?” Well, it depends on several factors, such as the size of your plant or how reactive you are. A guideline is, if you have 100 craftsmen at your plant, then two dedicated reliability engineers would be about right.

**WHAT ABOUT PDM?**

How does predictive maintenance (PdM) or condition-based monitoring fit in to all of this? PdM is an important part of REX, no doubt about it. But if you only do PdM without going after root cause, your equipment failures will return. PdM lets you know about problems early. It buys you the time to plan and schedule the repair vs. letting the equipment run to final failure. And we estimate that letting the equipment run to failure is on average seven to 10 times more expensive than repairing it proactively. So on one hand it’s good to know about your equipment anomalies early. But, on the other hand, you need to ask yourself why the defect occurred in the first place. Root cause efforts can help with this.

**EQUIPMENT AUTOPSIES**

We do equipment autopsies at Alcoa. In our case, it is the death of a piece of equipment. It could also be on a near-death piece of equipment, one where the root cause for trouble remains undiagnosed. We want to understand why failures occur, so we can take steps toward preventing future failures. The root cause aspect of REX cannot be stressed enough. Let’s use our motor team as an example.

We have hundreds of motors at our plant — some small and small huge. As part of REX, we created a cross-functional team to focus on motors. The team’s mission is to improve reliability and reduce costs. The team is made up of representatives from management, engineering, and supervision, as well as PdM/reliability technicians. When we first started, we had many motor run-to-failures (RTFs). We started conducting motor autopsies to understand what was causing the failures; these are discussed as a team at our motor meetings. Initially, we found some common failure modes and developed corrective/preventive actions to go after those. Our motor team also
implements best-practice maintenance strategies for motors — everything from proper motor greasing and storage practices to PdM. Our team sets aggressive, yearly objectives, and we track all motor costs meticulously. What are the results? What used to be several motors a week running to failure is now less than one motor that has run to failure. Our motor costs have decreased by more than 90% since we started, not to mention the significant improvement in production up-time. This is another example of how solving problems to root cause reduces costs and increases equipment reliability.

METRICS, MORE METRICS
It’s true that there are literally hundreds of methods to measure success and their progress on reliability. Deciding which ones can seem like a daunting task. We tried to keep it simple. R&M costs are a key metric for us. If you are doing the reliability work and your costs are not coming down, then there is something wrong. However, measuring maintenance costs alone is not a good way to measure success. Many of us have examples of plants where maintenance was deferred and R&M costs decreased for a short time — that is, until the equipment starts to fall apart and then R&M costs skyrocket. Therefore, in addition to R&M costs, you need to somehow measure your plant’s reliability.

You could choose overall equipment effectiveness (OEE). If your OEE is increasing and your maintenance costs are decreasing, then that is generally a good sign. The percentage of emergency work is another useful metric. Think of emergency work as the killer of reliability. Pretty much everything about emergency work is bad. It’s costly and less efficient, and it can have a higher safety risk. So, if both your percent of emergency work and R&M costs are decreasing, that is good news. Regardless of which metrics you choose, our recommendation is to keep it simple. Don’t get bogged down in too many metrics, and remember that metrics are there to help you improve. So if the number is ugly, it is what it is. Measure it accurately and honestly. Then use it as a springboard to track progress and drive improvement.

WHAT IS THAT RELIABILITY GROUP DOING FOR ME AGAIN?
Sometimes the firefighters tend to get the praise, and those preventing the failures are forgotten because they are behind the scenes. As part of REX, we need to constantly educate and reinforce the value of the various members of our reliability programs. This includes the reliability engineers and the PdM technicians.

Take the PdM technicians, for example. They are performing routes using various PdM technologies, such as vibration analysis, ultrasonic examination, and infrared thermography. They are our scouts, finding equipment defects high up on the P-F curve. From there, corrective work orders should be generated to fix or repair the piece of equipment in a planned and scheduled fashion, before final failure occurs. Sometimes their efforts go unnoticed. As leaders and managers of REX, we need to make sure they are not taken for granted. We must broadcast the successes frequently and in ways that are easily understood by all, especially high-level management.

As an example, let’s say one of your PdM technicians finds an anomaly on a high criticality piece of equipment using ultrasound. This defect gets repaired through your work control process proactively and the equipment never reaches final failure. Then you go through a root cause exercise and determine ways to prevent this defect from recurring. This is a total success. But it may go completely unnoticed without intentional methods to recognize this achievement.

Your method of broadcasting these types of successes is up to you. Perhaps you prefer sending out a spreadsheet that lists the various cost savings/avoidances. Or maybe you have a single PowerPoint slide that describes what happened, what was done, and the benefit. Or you may post “Equipment Bad Actors Eliminated” on a bulletin board. Or you may even choose to have your reliability engineer give some success presentations to your plant lead team. Whatever methods you choose, make sure you know your audience and keep it simple. And don’t forget to tie your successes to financial impact.

THE RIGHT SEAT ON THE BUS
In order to be successful at REX, it’s important to have the right systems and processes in place. But it’s also important to have the right people in the right roles. Individuals should have passion for what they do. They should feel supported and understand why their jobs are important and what their direct impact is on the business. And all employees at the facility should understand their own roles and everyone else’s, too. REX is not just another program of the month. Instead, it’s a permanent change to the way you do things. It should be ingrained into your plant’s culture. It is truly a long-term journey, one that really never ends.

READY TO BEGIN
“But we must get everything just right before starting.” No, you don’t. One key point to remember: don’t allow perfection to get in the way of good. Start simple. Build your momentum one experience at a time. You’ll be amazed at how successes feed upon each other. Always make sure you broadcast your successes. And the successes you broadcast should be that of the team. •

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Jack Nicholas has 50 years of experience in industrial maintenance and reliability. A Navy veteran, Nicholas will be one of the keynote speakers at Reliable Asset World (www.reliableassetworld.com) and Ultrasound World (www.ultrasoundworld.com), co-located conferences being held in May in Clearwater Beach, Florida. He took a few minutes to speak with Plant Services Chief Editor Mike Bacidore about the financial impact of reliability-centered maintenance.

**PS: How do you measure the financial impact of reliability practices in a plant or in an organization?**

**JN:** Reliability practices affect not just the immediate organization or a local plant, but many other constituents. Examples include investors, customers, suppliers, neighboring plants, communities, and retirees. So the measure of financial impact may be measured better by the cost of not being reliable. For example, if a customer can’t count on you for a quality product or an on-time delivery, the customer is going to look for an alternative supplier, and it’s going to cost you that revenue and maybe your whole livelihood. If a plant has an environmental accident that affects nearby residents and businesses, the penalties may be quite severe, reducing the bottom-line profits that benefit stakeholders, to say nothing of the ill feeling of those affected. This can be quite widespread. Consider for example the British Petroleum Deepwater Horizon disaster just about four years ago with financial ramifications that still linger today. If an investor senses an unreliable operation, that investor is going to sell the applicable stock, even at a loss, which may in turn lower value of the overall enterprise as viewed by the market and all who are counting on that value to remain constant and provide income in the form of dividends or growth in capital worth.

**PS: Because of their different functions, should maintenance reliability departments be separate?**

**JN:** The most cooperative arrangement is to have the reliability group reporting to the senior-most maintenance manager, especially in organizations where maintenance and operations, and engineering and stores departments, are co-equal with all reporting to the same senior manager. The maintenance department makes the greatest contribution of time and labor to reliability issues and their resolution — RCM analysis, root cause analysis, reliability reviews of new designs for application of PdM, lubrication best practices, or oversight or actual installations of modifications that improve designs for increased reliability. The senior manager in maintenance can best decide where those personnel in the department should spend their time. Obviously, if they’re constantly in crisis mode, finding time for reliability-improvement initiatives is hard, but the sooner the organization can get ahead of the failure curves and allocate personnel to concentrate on improving reliability, the better life in that organization is going to be. Once on that path, most organizations never want to go back. That said, no RCM study, root cause analysis, or other important process affecting reliability should proceed without an operator who understands the system being analyzed. If needed, the maintenance manager can intercede with the operations manager to make operator personnel available for participation in reliability-related activities. The operations manager is more likely to cooperate if it’s clear that maintenance is committing personnel to the effort. Should there be a reluctance to cooperate, their superior can arbitrate the matter.

**PS: How does a plant manager get operations personnel to work with maintenance and reliability workers toward increased productivity?**

**JN:** First, the plant manager must keep everyone’s eyes on the prize — maximizing designed-in reliability. That in turn means that all work processes must be reliable. Work processes are the high to medium level step-by-step, input-output diagrams that outline how personnel work. Procedures are derived from processes to provide the detail and capture the knowledge of those most closely involved with performing the work. Plant managers must ensure that everyone understands the processes and provides resources to ensure that procedures are derived from processes to provide the detail and capture the knowledge of those most closely involved with performing the work.

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By Joel Levitt, Life Cycle Engineering

Department of Equipment Health

Why does everyone hate maintenance activity?

There’s a common perception in many organizations that everyone hates maintenance activity. Is it possible that this stems from conversations about maintenance work that we and others in our business community hear and repeat to ourselves? Perhaps the reason we look at maintenance the way we do is because there are disempowering conversations traveling around the organization.

There are all kinds of conversations within organizations. Most obvious are the public conversations on everyone’s lips. These might be about the industry or
profit levels or performance. These public conversations are all the things about the company that people say out loud to each other.

There also are behind-the-scenes conversations. These are just as powerful as the public ones, and sometimes more so. These private conversations can include corporate-wide assessments — “Maintenance is wasteful” — and are significantly harder to change. These behind-the-scenes conversations have tremendous impact on the conduct of maintenance activity and how personnel who do maintenance, either operations or maintenance people, are treated.

One example of a conversation statement is that “maintenance activity is a necessary evil.” Let’s deconstruct this. What affect does such a conversation have? How do you act if you’re a necessary evil? Is this kind of conversation the basis for a healthy attitude? How do you contribute if what you’re doing is a necessary evil? Indeed, why would you even want to?

The necessary-evil conversation comes from the simple fact that maintenance activity doesn’t contribute directly to the manufacture or delivery of anything. In modern parlance, maintenance doesn’t add value to the product. But modern organizations also agree that maintenance is necessary. So the necessary-evil statement is born. If maintenance work is an expense only, how does an expense contribute to the success of the enterprise? A good expense is a dead, or zero, expense. Do you see the uphill battle implicit in changing that conversation?

When we look at other businesses, we can see this idea at work. It would be pretty crazy to look at your 40-man football team and tell the defensive players that they don’t add value to the product — value in this case being the points on the scoreboard. The owner could save some real money on salaries without all those defensive linemen, not to mention the reduction in catering costs if you don’t have to feed them.

OK, let’s admit it would be crazy to run a football team without defense. If we translate the way companies view maintenance to the way football is managed, we would want as few defensemen as possible, pay them as little as possible, maybe even be creative and make one defensive squad play for two different teams. By the way, if the team loses, we would downsize the defense. Also, as they moved to the top of the salary range, we would scheme to get rid of them through buyouts or outright dismissal.

Plays would be handled differently because we wouldn’t try to design defensive strategies. If there were any defensive design, it would be done by the defenders themselves without resources or support from management. From a management point of view, when the ball is snapped, the whole squad should run howling toward the ball.

For training and recruiting; just hire bodies. Especially forget respect. These folks don’t contribute toward the score on the scoreboard. If times get tough, get rid of them altogether. It seems pretty silly in football. It’s not silly in companies; unfortunately it’s a way of life.

The all-too-frequent conversation of being a necessary evil greatly limits the contribution of maintenance activity to the success of the enterprise. We have to think up new conversations to take the place of the old. We have to think up new conversations that make more sense.

What if the conversation went something like this: “We have different activities that support production, and each contributes its specific expertise. The only issues are whether each activity’s specialized contribution adds more to the bottom line than the cost and whether the expertise is essential to the long-term success and enhanced profitability of the organization.”

Let’s look at a few of the players in a typical corporation. Lawyers contribute legal expertise. Accountants contribute accounting expertise. This seems pretty simple. If you have an accounting question, you ask one of the experts. Likewise, if you have a process question, an environmental question, or even a question about trash, you go to the person who covers that area. The trend today is to get rid of the expertise and use outside consultants. The outcome is the same; you want the specialist’s advice to be more valuable than what you pay.

Of course, as organizations’ sizes vary, different expertise becomes important. In the 1980s, I worked on a project to computerize the fleet maintenance operation of Federal Express. At the time, FedEx operated 47,000 light trucks. They bought the most advanced software available. Yet FedEx spent the money and time to continue tweaking the package to wring out a few more percent of benefits. After all, a small increase in the savings for 47,000 vehicles was quite a bit of money. In the case of a large company, the specialized knowledge was worth it since the potential savings was so large.

We have to answer the question, “What does maintenance activity contribute to the success of the organization?” Once we identify the contribution, are we positioned to make a maximal contribution based on our present skills, knowledge, and attitudes? We also return to the question, “Do the specialized knowledge and skills contribute more to the bottom line than the cost?”

**UNIQUE EXPERTISE**

What is your maintenance department’s real expertise? Some departments are experts in repairing breakdowns. This is the historical role of maintenance personnel. They can fix just about anything. They have deep and subtle expertise in broken things, how things break, and how to put them back together. And they know how to do that in the shortest time and with the least cost. There is no dishonor in contributing this expertise to the success of the organization. Fixing breakdowns is a real, valuable, and essential expertise that is duplicated nowhere else in the company.
Consider this: Most doctors also are experts in breakdowns. They troubleshoot problems and, if it’s possible, propose fixes. They’re done with their work when the disease is gone from your system and you’re discharged. In truth, very little of a doctor’s training or practice is concerned with health. Mostly, they wrestle with and hope to cure disease. Often, that’s enough. Believe me, when you’re sick you don’t want a lecture on preventive maintenance telling you that you should have given up smoking 10 years ago. You want action now.

Yet, medicine is changing, as is maintenance.

The new, improved conversation might revolve around the idea that the contribution of the maintenance department to company success is its expertise in asset, machine, and unit health. We know how fast and how long to run the equipment to maximize profit. We’re the folks who know what should be done for maximum equipment life, minimizing long-term cost. In short, we’re the high priests of the balance between production and equipment integrity.

In fact, part of this is already happening. In maintenance there is a burgeoning subfield in machinery health. Machine health subfields include TPM, PM, PdM, and RCM. Conference sessions are full when the focus of the talk is on detecting failure before it happens and how to extend the life of the asset. Advanced maintenance departments are becoming experts in machinery health.

EQUIPMENT HEALTH

Imagine that over the maintenance department’s door is a sign that reads, “Department of Equipment Health.” To expand into this role, we need to work on three things:

1. We must continue to build expertise in machine health and push to change the focus from reactive to proactive maintenance. We need to get really good at predicting what will occur based on historic data. Almost all maintenance departments already are either working on this or saying they’re working on this.

2. We need to master the operating modes and conditions of the equipment. We know what happens in the operation and how it’s likely to impact the life of the equipment. We must be able to answer the question, “What will happen if we double the capacity of the feeder” or “What if we speed up the conveyor?” This requires deep knowledge of process, additional knowledge about engineering, and some knowledge of the market.

3. We need to understand accounting and economic modeling. We may need to become experts in economic models that include run-to-failure, run-with-shutdown, run-with-PM or run-with-whatever scenarios. Right now the decision to run-to-failure is made in most organizations by default without data and without expert input from the Department of Equipment Health. We have to be able to answer questions like these:
   • “Given the facts of the value of the production, the impact on the customers of missed or late shipments, and the costs of the additional deterioration, what direction should we take?”
   • “Should we run all-out or stop for maintenance?”

We have to be able to look at the lifecycle cost per part made or gallon shipped. What would be the impact of increasing production with the existing equipment? If we do this, what additional maintenance will be needed and when will it be needed? We want to be at the table when there’s a discussion of which is the better business decision.

The million dollar question: How would you start up this new conversation? If that is the conversation we want to create, how do we do it? Why is it so hard to change a company’s culture and conversations? The reason it’s difficult is that the fundamental conversations have not been understood and dealt with. These old stories and assumptions still run the show and any new cultural changes are merely smeared on top.

To permanently change the status of maintenance, we have to begin by noticing the existing conversations. The old culture is anchored in place by structures, incentives, memory, and custom. As such, it takes no extra energy to keep the old culture in place. The next thing is to disassemble the structures that hold those conversations in place while at the same time creating new ones.

What conversations are going on in your company about maintenance? Look below the surface, turn over rocks, and listen without getting mad. The next step is to see which reports, customs, and incentives hold the old conversations in place. Once the field is cleared out, we’re free to invent new conversations. The final step is to begin building new reports, incentives, and customs to support these newer, healthier, more successful conversations. Then, let’s order the Department of Equipment Health signs.

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Keysight Technologies' Resolution Enhancement Paper
The technology used to enhance the resolution of a digital image is known as super resolution. A thermal imaging system assimilates the resolution enhancement technology used in digital imaging system to improve on its resolution. This paper discusses the high-level concept of this technology.

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