uptime®

for maintenance reliability and asset management professionals

june/july 14

uptimemagazine.com

UPTIME MAGAZINE

JUNE/JULY 2014

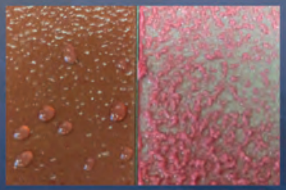
Do More With **LE**ss

ALMAGARD HAS STAYING POWER FOR ULTIMATE LONG-LASTING BEARING PROTECTION

LE offers a wide range of enhanced industrial greases to meet the needs of any challenging application.

When it comes to protecting your expensive equipment, why cut corners? For the past five decades, the go-to grease for extended service and severe duty applications around the world has been LE's high-performance **Almagard® Vari-Purpose Lubricant**, fortified with LE's proprietary Almasol® and Quinplex® additives. Water, heat and high impact won't prevent Almagard from doing its job. Extremely tacky and water-resistant, Almagard also features superior oxidation resistance, mechanical stability and extreme pressure properties. Find out what legions of satisfied customers already know: Almagard is the right choice for ultimate bearing protection.

Very tacky
Almagard clings tenaciously to metal, and will not pound out or sling off, even in extreme conditions.



Highly resistant to water
Almagard (left) stays in place, while the competitor's grease (right) washes away.

Ready to experience **LE**ss downtime and longer lasting equipment? Visit **www.lelubricants.com/industrial-greases.html** to learn more and to request quotes for Almagard® Vari-Purpose Lubricant or any of our other high-performance lubricants and reliability solutions.

www.LElubricants.com • 800-537-7683 • info@LE-inc.com

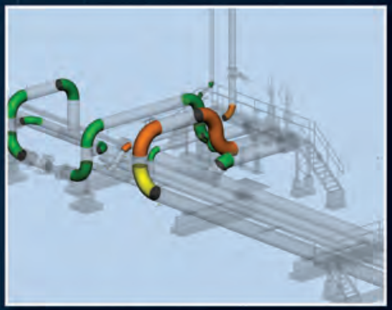
300 Bailey Avenue • Fort Worth, TX 76107 • Fax: 800-228-1142

LE operates under an ISO 9001 Certified Quality System.

Lubrication Engineers, Inc.
The Lubrication Reliability Source™

Roadmap to Operational Readiness and Asset Performance

Assess risk based on failure severity, likelihood scores, and confidence assessment.



Visually navigate assets.

Ensure a safe, reliable and compliant operation.

Achieve business goals with a risk-based approach to asset management. Bentley will help get you there.

Leveraging 30 years in design and visualization innovations, Bentley is at the forefront of engineering software. Combining 2D/3D plant models and point clouds with engineering information and asset performance management, Bentley delivers an enterprise platform to manage assets throughout their entire lifecycle.

The visual workflow supports both greenfield and brownfield operations; bridging the gap between CAPEX and OPEX and enabling a sustainable business strategy for operational excellence and safety.

Enterprise Platform for Asset Integrity, Reliability, and Performance:

- Asset strategy development
- Integrity management
- Risk-based inspections
- Reliability-centered maintenance
- Corrosion management
- System reliability
- Process safety
- Asset health indices and dashboards
- Risk assessment and work prioritization
- ISO 55000 implementation

Learn more at www.bentley.com

Or call 1-800-bentley

Bentley® Sustaining Infrastructure

Contents

june/july 2014

uptime®
for maintenance reliability and asset management professionals

ON THE COVER
National Ignition Facility (NIF) Target Bay showing laser tubes directed towards center of Target Chamber. Each tube contains four laser beams. See page 62 for more on NIF.


36


46

Features

Elements

Editorial

YOUR RECIPE FOR VALUE

Lately I feel like the Johnny Cash song, "I've Been Everywhere (Man)." Since I last checked in with you, I have been to Indianapolis, Bogota Colombia, Las Vegas, Wausau Wisconsin and I am writing this editorial as I travel on plane back to Fort Myers from San Antonio, Texas.

I am lifted and encouraged by the smart and passionate people I meet on the road who all share a goal to make the people and organizations they work with safer and more successful through Uptime Elements – A Reliability System for Asset Performance Management. They share their knowledge and experience freely and they are pushing the boundaries of traditional thinking about asset performance management.

Much of the travel and work we are doing is in support of the Association for Maintenance Professionals' goal of creating 1,000 Certified Reliability Leaders (CRL). We predict that 1,000 CRLs will leverage the Association for Maintenance Professionals' vision of creating triple bottom line of people, profit and planet performance that will be too compelling for other business leaders to ignore.

We owe a debt of gratitude and respect to SMRP Indycon, ACIEM, the Vibration Institute of Wisconsin and Noria Corporation for supporting the Association for Maintenance Professionals and the Certified Reliability Leader exam. I would like to add a big thank you to our own team for their stellar work at Reliability 2.0 Las Vegas and then hitting the ground running to prepare for Solutions 2.0 Innovations in Asset Information Management (July 28-31 in Bonita Springs, FL) and IMC-2014, the 29th International Maintenance Conference featuring the Reliability Centered Maximo Forum and the ISO55000 Asset Management Forum.

Does it sound like we have a lot going on? Yes it does, but we also know that you have a lot going on as you manage and improve reliability on hundreds or thousands of assets. Our focus in this issue and at our learning/networking events is to bring you a customized recipe of strategies, techniques, technology and tools that support you, your work and your organization.

Three key ingredients for you to create this recipe for your own organization are:

1. A framework (like Uptime Elements) for making good evidence-based decisions about delivering value and determining risk. In our world, that typically means making decisions around asset renewal, maintenance strategy and capital replacement with a focus on failure elimination and production output.

2. Software to test, capture and refine your decisions so you can continue to improve your maintenance reliability and asset management strategy.

3. The leadership to take your team on the journey with you. We hope you will consider the Certified Reliability Leader (CRL) program as a way to engage and empower your team to align and focus on that journey. Best practice companies use leadership to engage and empower every stakeholder as a reliability leader.

We worked hard to deliver value in this issue of *Uptime*, however, it depends on you. Thank you for investing your time.

Please consider sharing your own recipe for reliability and delivery of the triple bottom line by writing an article for a future issue of *Uptime,* or as a presentation at one of our learning and networking events. You can send your ideas to me at Terrence@reliabilityweb.com.

Thank you for reading *Uptime* Magazine.

Warmest regards,

Terrence O'Hanlon, CMRP
CEO and Publisher
Uptime Magazine
www.uptimemagazine.com

uptime®

PUBLISHER/EDITOR
Terrence O'Hanlon
terrence@reliabilityweb.com

FOUNDER
Kelly Rigg O'Hanlon

EDITOR
Jenny Brunson

CONTRIBUTING WRITERS
Mark Barnes, Marc Begijn, Leo Faykes, Gary Gardner, Rejesh Gopalan, Carlos Mario Perez Jaramillo, Nick Jize, Mike Johnson, Winston P. Ledet, Doug Plucknette, Jack Rubinger, Fred Schenkelberg, Christopher Shannon, Matt Spurlock, Wayne Tustin, Mohammad Nasser Uddin, Doug Wallace, Cliff Williams, George Williams

VP OF SALES AND PUBLISHING
Bill Partipilo
bill@reliabilityweb.com

ART DIRECTOR
Alexander Canino

DESIGNERS
Andrea Brito, Apple Lemus

PRODUCTION COORDINATOR
Kaitie Sweet

EDITORIAL INFORMATION
Please address submissions of case studies, procedures, practical tips and other correspondence to Terrence O'Hanlon
terrence@reliabilityweb.com

SUBSCRIPTIONS
To subscribe to *Uptime* magazine, log on to
www.uptimemagazine.com
For subscription updates
subscriptions@uptimemagazine.com

Uptime Magazine
PO Box 60075, Ft. Myers, FL 33906
1-888-575-1245 • 239-333-2500 • Fax: 309-423-7234
www.uptimemagazine.com

Uptime Magazine
is a founding member of
AMP

Uptime® (ISSN 1557-0193) is published bimonthly by Reliabilityweb.com, PO Box 60075, Ft. Myers, FL 33906, 888-575-1245. In the U.S., Uptime is a registered trademark of Reliabilityweb.com.

POSTMASTER: Send address changes to:
Uptime Magazine, PO Box 60075, Ft. Myers, FL 33906

Leadership for Reliability

RELIABILITY®

IN THE NEWS

RELIABILITY® is a registered trademark of NetexpressUSA, Inc.

Uptime Magazine App

Look for our app in the iTunes Store

UPDATED: RELIABILITY CENTERED MAINTENANCE PROJECT MANAGER'S GUIDE

In 2005, over 100 individuals in the maintenance reliability community created the RCM Project Manager's Guide, with an update in 2007. The Association for Maintenance Professionals (AMP), along with group facilitator Derek Burley, created a virtual Special Interest Group (vSIG) to revamp and update the document again late last fall. The vSIG worked tirelessly from October 2013 until April of this year to create an effective and well-rounded document. Reliabilityweb.com is happy to announce the release of this updated document, free of charge, on June 11th, 2014 at www.reliabilityweb.com.

IN MEMORY OF MIKE SEITER
A FIGHT FOR MIKE UPDATE

Mike Seiter, (far right)

Just over one year ago in our April/May 2013 issue, we introduced you to Mike Seiter, a contributing author for Uptime Magazine who had been fighting stage 4 brain cancer. Sadly, after almost two years of battling this disease, Mike passed away on April 17, 2014. We would like to send our deepest sympathies to Mike's family and friends, as well as his many colleagues at Honda of America, where he worked for over 20 years. Donations can be made in his name to the James Cancer Research Center or to the Hospice Program at Marion General Hospital in Marion, OH. **#FightForMike**

Congratulations to the newest CERTIFIED RELIABILITY LEADERS!

Ahmed Khalifa, CRL
Sidi-Kerir Petrochemicals Co

Alain Pellegrino, CRL
Laurentide Controls Ltd.

Alan Travierso, CRL
Graymont

Anthony Harris, CRL
Silgan Containers

Dominic Trujillo, CRL
GCC Dacotah

Doug Lambert, CRL
Rock-Tenn

Gail Petersen, CRL
Datamasters

Gary Brown, CRL
Brown & Associates

Glen Huseth, CRL
Peabody Energy

Jack Nicholas, CRL
Self Employed

Jack Lucy, CRL
Process Solutions Assurance

Jeff Kettner, CRL
Kimberly Clark

Joe Erickson, CRL
Advanced Technology Services

John Clow, CRL
Process Solutions Assurance

Jon Schlotthauer, CRL
Peabody Energy

Justin Cowley, CRL
Peabody Energy

Keith Laforga, CRL
Lawrence Berkeley Ntl Lab

Kurt Stowell, CRL
Delta T Engineering

Lisa Ryan, CRL
Lansing BWL

Loyd Hopper, CRL
Herman Miller

Mary Jo Cherney, CRL
Nissan USA Manufacturing

Mike Jang, CRL
Lawrence Berkeley Ntl Lab

Moris Behar, CRL
Monsanto

Paul Fournier, CRL
North Star BlueScope Steel

Paul Crocker, CRL
Board of Public Utilities

Peter Ormond, CRL
NUVOam

Richard Akin, CRL
Smufit Kappa

Robert Bishop, CRL
BMS

Sean Dubois, CRL
Ethicon

Shajeev Puthalath, CRL
Dubai Aluminium

Ted Lazarus, CRL
Peabody Energy

Tom Francisco, CRL
Emerson Process Mgmt

Wayne Hingley, CRL
Graymont

Ziad Hussein, CRL
SIDPEC

CONGRATULATIONS

RELIABILITY 2.0 Las Vegas 2014

Another successful year at the RELIABILITY 2.0 Las Vegas conference. Held April 7-11, the event saw over 500 attendees and solution providers. Complementing the evening events, which included dueling pianos, were two fantastic keynote speakers, Dan Roam and Garrison Wynn. Roam, author of "The Back of the Napkin" and newly released "Show and Tell," provided an interactive keynote session that inspired everyone to change the way they present information to colleagues and the world. Wynn provided humor and a lighthearted look at "The Real Truth About Success."

RELIABILITY 2.0 Las Vegas 2015 will be held April 13-17 at the South Point Resort, Casino and Spa. **www.reliabilityconference.com**

Garrison Wynn

Dan Roam

Certified Reliability Leader Goes Bilingual!

June 4-6 marks the first time the Certified Reliability Leader exam will be given in the Spanish language at the Global Asset Management event in Lima, Peru.

Maintenance, Reliability and Asset Management – What's the

by Cliff Williams

Over the last few years, we have seen a number of changes in our chosen field. For many years, maintenance was the term used for all stewardship of plant and equipment. Then reliability centered maintenance (RCM) started to take off and this saw the advent of reliability, or to be more correct, the term reliability. There was a plethora of job adverts, articles and presentations at conferences that included the term reliability. The strange thing was that in many cases, the content was no different than when it was called maintenance!

What did start to happen was a drift towards the separation of tasks that needed to be performed under plant and equipment stewardship. Whereas for many years it was the responsibility of maintenance to ensure the best availability by using tools, such as failure analysis, root cause analysis and cost analysis, to identify those areas requiring improvement and then enacting solutions, these things started to become the responsibility of the reliability group. To illustrate, there was one organization looking for 70 reliability engineers across their plants and when asked where they thought they would find these people (as there hadn't been an increase in systematic or accredited training programs in reliability), the response was "probably from the maintenance department." When asked what it was they would be doing, it turns out it would be many of those things maintenance manages have been doing for years. So for those of us who had been proactive and forward-thinking, there really wasn't much new, but for those who had been stuck in the reactive mode, reliability was the way out. So to define maintenance in one word, it would be: **FUNCTION**.

Maintenance

The advent of reliability certainly heralded a change in one important respect. Organizations came to realize that there was a better way of doing things than simply reacting. The reliability banner seemed to allow more investment in finding solutions to plant and equipment problems. But one troubling thing at this time was that maintenance was quickly relegated to mean just fixing and doing, and for those of us who had been doing everything, that was now considered reliability. This was a little frustrating, if not insulting.

As with all changes, there were early adopters, some who held the belief that by adopting reliability, they would automatically get better. There was the search for the "silver bullet" and the "one stop solution," but people began to find that reliability didn't come without a great deal of effort. Some organizations started to use statistical modeling to help them with their approach and the term reliability started to become more common in those programs, which, although they helped promote reliability, sometimes they

Maintenance, Reliability and Asset Management – Difference?

took away the need for thought and deep understanding of the issues. Unfortunately, there were still those who did very little different from when they called it maintenance and obviously they saw little improvement.

Those organizations that started to embrace reliability in its truest sense began to understand there was much more to reliability than simply doing maintenance. In fact, they found that maintenance didn't even have the biggest influence on reliability. It came as a shock to find that when they carried out root cause analysis on their disruptions that maintenance was the root cause in a low percentage of cases. They were surprised to find that the inherent design had more influence and when they looked at the consequences of later changes to their process and production, they realized they were, in fact, inducing more failures. This also brought them to the realization that the operation of the equipment was as equally important as the maintenance of the equipment. They discovered that if they ran the equipment out of spec or above rated capability, they were reducing the lifecycle of the plant and equipment. There were organizations that took this to the depth of analysis, where they realized that simple process excursions were reducing the life of the plant and equipment; they understood that after many excursions, although the plant and equipment were returned to service, they were done so with a slightly less capability or life.

Reliability has taken hold of forums, conferences and the marketplace, and has been the focus over the last few years. Yet it still runs the gamut from doing the same as maintenance to having solid cross-functional reliability groups. Those organizations that have come to realize that if we had to define reliability in a word, it would be: **OUTCOME**.

Design, Maintain, Operate

Just when we thought it was safe to go back into the water, that we had an understanding of all things maintenance and reliability, IT happens. The IT being asset management. This is certainly the new kid on the block; for many years, the term asset management was the property of bankers and investment advisors, but sorry that is no longer the case.

In 2004 in the UK, a new standard appeared: PAS55. This standard was born out of several North Sea incidents and some large failures in UK infrastructures – water, hydro, railways – which had been owned and run by the government for many years, but had now been handed back to the private sector. There was concern that the new owners didn't have a systematic way of managing the assets they acquired, so the Institute of Asset Management and the British Standards Institution developed a standard that would serve as a guide and model. This standard was known as Publicly Available Specification 55 or PAS55 for short. The utilities and others in the UK were required to conform to PAS55 and when electric utility companies apply to the government to increase their charged rates, they would have to demonstrate their compliance with PAS55 before it is allowed. This was the start of asset management as we are beginning to understand it today.

PAS55 was revised in 2008, but one year earlier in 2007, even though PAS55 had seen significant adoption by UK, Australian and European infrastructures, it was realized that it was still a British standard. With no global standard available, the seeds of ISO55000

> Reliability has taken hold of forums, conferences and the marketplace, and has been the focus over the last few years.

were sown. So the question becomes, "What is asset management?" The quickest answer received from those working on the ISO standard was, "It's not just managing assets!" In delving deeper, it was found that early adopters seem to be consistent in their belief in what asset management meant, whereas later adopters seemed to have adopted different slants, with some parts suddenly becoming the focus rather than the holistic approach described by the early adopters.

One of the goals of the asset management process is that everyone in the organization will be able to identify the reason and impact of what they do in relation to the strategic objectives.

So what is asset management if it's not just managing assets? Well, if we look at the definition of an asset in this context (ISO55000 definition): An asset is an item that has potential or actual value to a company. These assets may fall into different classes. They may tangible, which are the products you produce and the equipment you use, or intangible, which encompasses your reputation, image, social conscience, etc., or financial concerns, such as costs, investment and performance.

So from this definition, asset may or may not be a piece of equipment or a facility. Having just got our heads around the idea of viewing equipment not as equipment, but as a means of providing a function in RCM, we suddenly find we need to view it as a means of realizing value for the organization. To gain an understanding of what value means, we have to take a step back in the asset management process. At the very top of every organization are groups that will make demands of the organization. They may be customers, investors, shareholders, legislators and even the marketplace that the organization operates in. These demands, current and future, will be used to develop the organization's strategic objectives, or how the organization will operate, where it wants to be in the marketplace and what represents value in this context. The strategic objectives and the defined value drive down though all aspects of the asset management process. In fact, the best definition of asset management may be the one that describes it as the means for enacting the strategic objectives or business plan.

Feeding out of the strategic objectives are the asset management strategy and the asset management policy, with the policy also feeding into the strategy. The policy describes the commitment of the organization to fulfill the strategic objectives and is similar in approach to the safety policy seen in facilities today. The strategy describes what and how it intends to attain based on the policy and strategic objectives, which introduces an important aspect of asset management – line of sight or alignment of purpose.

One of the goals of the asset management process is that everyone in the organization will be able to identify the reason and impact of what they do in relation to the strategic objectives. The only way this is possible is if the thread is maintained through each level of the process. The strategy takes into account current and future demand and the ability of current assets to meet this demand so that any balancing, disposal, or investment of assets can be clearly planned. Coming out of the strategy, there needs to be a strategic plan that describes the framework that will deliver the strategy and include the constraints and criticality of costs, volumes, capabilities, etc.

This leads to the asset management plan, which gets more specific about the activities that will be carried out to meet the strategic plan. The asset management plan specifies how the management of the general infrastructure of physical assets will be carried out, with clear reference to levels of service, desired outcomes and finite time frame. It details any new investments, any disposal of assets, what level of operation and maintenance is expected, any combining of assets, and what training and education initiatives are required to meet the strategic plan.

Parallel to the asset management plan is the development of asset management systems, required to enable the process to flow to achieve strategic objectives. These asset management systems include strategies and systems to manage asset information, general data and knowledge management. These strategies and systems detail what is to be included, in what format, at what level and where it will be stored. This will ensure consistency and appropriateness of information that relates to the achievement of the strategic objectives. It will also guide the way information and knowledge is maintained through to the shop floor, again in demonstration of line of sight or alignment of purpose. This is the area where development of systems to ensure correct competencies, ongoing knowledge retention and behavioral norms takes place. Any changes to the organizational structure due to changes in demand or objectives is controlled through asset management systems, as well as ensuring the correct culture is in place to achieve the strategic objectives. An understanding of how an organization needs to behave to allow everyone to contribute to the strategic objectives is critical and will differ from organization to organization. However, if the line of sight or alignment of purpose is maintained, expectations and communications are clear, and all can believe that they in fact contribute, then they will form a solid foundation to build on.

The last part of the asset management process is risk management and performance review and improvement. Taking place here is ongoing risk analysis and performance management based on many criteria, ranging from environmental to operational to regulatory to sustainability to financial to organizational in the context of strategic objectives. The result and impact of these is fed directly back to all levels of the organization, up to the strategic objective level of the organization and into any specific asset management system that might be impacted, and so the process starts again.

You may notice one important part of the asset management process missing and that's typically known as the useful life or lifecycle phase. That's because there is not a great deal of difference to what was presented in the reliability section. We design, acquire, commission, maintain and operate using the same sort of tools and techniques. It is still important that the rights tools and techniques are used to ensure the reliability of the equipment. What has changed is the context in which these things are done – it's done from the realization of value context. We may not simply keep maintaining and operating equipment to extend the life of an asset. We may decide that it is not really a value proposition and replace or dispose of it. Whatever we do, it is done in the context of providing value to the strategic objectives. We are able to do this because there is a clear line of sight from top to bottom. The other change is one that those who operate in the useful life phase will benefit from, as the design and impact of their efforts will be considered in many more parts of the organization and their influence will be far greater than it's ever been.

This article was not meant to explain all the complexities that come with the change to asset management, rather it was meant to demonstrate that maintenance is not reliability or asset management. Maintenance is only part of reliability and reliability is not asset management, it is only part of asset management and asset management is more than managing assets. So to define asset management in one word is difficult, but a two-word definition is: **OPERATING PHILOSOPHY**.

This article was not meant to explain all the complexities that come with the change to asset management, rather it was meant to demonstrate that maintenance is not reliability or asset management.

__Cliff Williams__ is a thirty year plus veteran of the maintenance field. He has worked in the pulp and paper and steel industries, as well as with food giants, such as Coca Cola, Kraft and Wrigley. He is a Green Belt in Six Sigma and a keen follower of the Lean Manufacturing world.

PLANNING AND SCHEDULING

The Impact of Trends in Shift Management

by Jack Rubinger

Know who has a lot of irons in the fire? Industrial production managers. They are responsible for mistakes, accidents, injuries, theft, security and asset management. This is the person who will have answers to questions like, "Where's the pallet jack?"

The industrial production manager is in charge of day-to-day team performance, making sure it all works together as quickly and cost-effectively as possible, all while turning out a quality product.

They are also responsible for shift management. Their goals:

- Making sure production numbers are hit.
- Maintaining safety.
- Handling absenteeism.

"The shift production manager is responsible for protecting employees and workplace hazards. If the manager identifies safety or health hazards at the work site and cannot eliminate or control them, then the manager has a responsibility to notify upper management and management on other shifts of the hazard," explains Edwin G. Foulke, Jr. He headed the Occupational Safety and Health Administration (OSHA) from 2006 to 2008 and is a partner in the law firm of Fisher & Phillips.

We're seeing a transformation in shifts and managing shifts in industrial facilities. From a worker's perspective, there's a desire for greater leeway. From management's perspective, happier employees equal greater productivity and less costly retraining.

Let's look at some examples. At a veterinary practice, the receptionists are pretty autonomous. The doctors who run the practice just want to know there is a warm body to handle the customers, check animals in and out, and close out billings at the end of the day. The self-ruling approach goes a long way in retaining office employees, often for 20 years and more.

On the industrial side, there's Tim Agee from International Paper, who has been with his group for about seven years. His approach is to keep the mill running until the day shift maintenance crew arrives. Shifts run from 7 a.m. to 7 p.m. and 7 p.m. to 7 a.m.

"Everyone is usually relieved about 30 minutes early to discuss jobs completed or not completed and work orders not started. If it is an emergency, it will be determined if it can wait for day shift maintenance to come in or if extra manpower needs to be called in immediately," says Agee. "This way, we share intelligence and exchange ideas.

"Every shop and control room has whiteboards in them to pass on information. Also, we have labels and warnings on floors, doors and walls, and instructions on how to avoid problems and accidents."

By posting weekly shift schedules in advance, workers have the time and space to accommodate corrections. "A thing as simple as changing a shift start time can feel like a catastrophic event to an unprepared workforce. How will they get their kids to school? Their carpool won't wait for them. They can't take that night class they've been thinking about. People have myriad responsibilities, activities and interests that will be affected by any change in their work schedules. Every possible conflict can be blown up into an unsolvable problem," warns Jim Dillingham of Shiftwork Solutions. He consults with companies on employee involvement, asset utilization and managing overtime.

Types of shifts include:

- Traditional, eight-hour shifts and a separate weekend shift.
- Rotating shifts, where employees work days one week, evenings the next week, the midnight shift the third week and have the fourth week off.
- Off-shifts or night shifts. These shifts are favored by workers who want to save money on childcare. At night, there are no meetings, no politics and more independence.
- Long shifts, such as 12 hours a day for four days, with four days off.
- Overlapping shifts. Overlapping provides double coverage during transitions so some workers can be involved in passing on information, while others continue the safe operation of the facility or equipment. Also, safety and other training can be scheduled during times when shifts overlap so two shifts can be trained at once.


Machine fluid.
So many dirty little secrets.
Spectro Scientific lubrication oil analysis instruments allow you to more quickly and accurately predict and avoid machine failure by seeing what others can't. Maximize uptime with better informed maintenance decisions. To learn more, visit us at SpectroSci.com, formerly Spectro Inc.
Spectro Scientific
Confidence in knowing

"At Manitowoc Ice, we have found it easiest to retain our employees by primarily running a one-shift only operation. When we are creating fewer machines than orders, our operators will work overtime to keep up with demand. We are a union shop and this was all negotiated within our contracts," says Kassie Freckmann, Manufacturing Engineer Technician at Manitowoc, which manufactures ice making machines.

Overlapping shifts may not always make sense, in particular a three shift operation where overlapping shifts mean the overlap is done on overtime. There's also a possibility of overcrowding, with more people in a workspace than the workspace is designed to accommodate.

"Shift overlap is nearly always wasteful," says Dillingham. "Suppose a company has a single, eight-hour shift that grows into three shifts. Each shift, including lunch, is 8.5 hours, which results in a 30-minute overlap between shifts. Since lunch is not paid, the overlap is actually straight time. People have the overlap because they don't know how to get rid of it. They pretend that it adds value when it does not."

Shift management trends are emerging. Among them:

- People are getting away from 24/7 schedules that have rotating or eight-hour shifts. Why? Because eights have to rotate to work well and 12s offer way more days off.
- Companies are staying away from weekend warrior crews. They are easy to put in, but about 60 percent as productive as weekday crews. They cost more and have high turnover, poorer quality and more safety issues.
- Today, more effort is being made to get overtime to the people who want it and less forcing on the people who don't.
- Once upon a time, only companies "born" into 24/7 ran 24/7. Examples include refineries, chemical plants, or other companies that could not afford to easily shut down for the weekend. Today, companies go 24/7 because the cost of their equipment is going up. Automation is not cheap. As capital costs go up, companies want to get more use out of their expensive production equipment.

So what's the future going to look like? It's hard to say. We are living in a 24/7/365 global economy. That's not going to change. Driven by input from production managers and shift supervisors, many companies are accommodating workers' needs and balancing the speed necessary to fulfill customers' demands. The communications piece of the puzzle will need to grow and improve, too.

***Jack Rubinger**, an Industrial Copywriter for Graphic Products, contributes to industrial publications and blogs. Graphic Products is the global leader in workplace labeling and signage. www.GraphicProducts.com*


CERTIFIED RELIABILITY LEADER
CRL
TM
Bring Leadership to your Organization
World-class organizations don't wait for failures and downtime. They prevent and even plan for them. So how can your organization become a world-class program?
The Certified Reliability Leader (CRL) introduces the overall elements needed to move from reactive to proactive. Simply put, Uptime Elements is a map by which to understand the interrelated nature of reliability. As a result, it produces immediate and sustainable results for your organization, including:
· An engaged and empowered workforce;
· Improved financial results;
· Safety and environmental incident reduction;
· Sustainability and energy savings;
· Improved workforce recruitment and retention;
· Reputation and brand enhancement.
LEADER
Get Started....Become a CRL!
AMP
maintenance.org
Learn more: maintenance.org/crl
888-575-1245 • 239-333-2500

TUCSON ELECTRIC POWER

Photos by David Sanders/TEP.

Builds Award-Winning Predictive Maintenance

by Gary Gardner

In 2012, the predictive maintenance team at the Tucson Electric Power Springerville Generating Station (SGS) helped the company avoid more than $1 million in maintenance and replacement costs. In the first three quarters of 2013, predictive maintenance efforts at SGS saved more than $750,000. This documented return on investment is one of the factors that led Emerson Process Management to recognize Tucson Electric Power (TEP) with the Reliability Program of the Year Award for 2013, an honor for which 64 programs around the world were nominated.

What sets our five-member predictive maintenance team apart from other reliability teams is our commitment to customer service. You can see that reflected in our mission: *"to provide condition monitoring services with the goal of early equipment failure detection and a reliability maintenance strategy which will improve safety, planning and scheduling, operation and maintenance cost savings, and equipment availability. This is accomplished through effective application of the latest predictive maintenance technologies, specialized training, and communication with our customers."*

SGS, located in Springerville, Arizona, has four coal-fired generating units. TEP, which operates the plant, currently receives all of the output from Springerville Unit 1 through a 14 percent ownership and leases for the remainder. TEP also owns and receives all of the output from Unit 2. The two units represent slightly over a third of the company's owned generating capacity, approximately 800 megawatts (MW). Springerville Unit 3 is owned by Tri-State Generation and Transmission Association and Unit 4 is owned by Salt River Project.

TEP leadership strongly supports our reliability program and emphasizes good planning and execution to minimize downtime. Good planning requires good prediction and coordination with other departments. We've built a relationship of trust with our work planning department. When our predictive maintenance department gives the planning group advance warning that a motor is starting to deteriorate, they have adequate time to plan for appropriate staff, parts and tools to complete the work.

In fact, the planning group brings our team in to test high cost or critical equipment before it's even shipped to our facility. This way, TEP avoids incurring the expense of shipping and commissioning equipment that isn't working properly.

Keep Asset Criticality Up-To-Date

At SGS, we're responsible for monitoring an incredible, complex variety of equipment – conveyors, gear boxes, pumps, turbines, blowers, compressors, pulverizers, fans and mills. To ensure we're monitoring the most essential assets, we validate equipment criticality on a regular basis. Considerations used to determine criticality include safety, regulatory issues, envi-

***Figure 1:** Members of the TEP predictive maintenance group at the generating station in Springerville. From left; Latigo Pate, Troy Burk, Gary Gardner, and Kevin Lee*

ronmental compliance, load reduction and single point of failure. We use criticality ranking and run-to-failure statistics to inform the frequency of predictive monitoring for every one of our critical assets. We also monitor critical, redundant equipment. Based on trends we identify in our assets, we're continuously revising our maintenance strategy.

Rely on High-Performing Technology

TEP relies on technology with high resolution, accurate data collection and advanced diagnostics capabilities. Our primary tools include vibration analysis, oil analysis, electrical motor testing, infrared thermography, ultrasonic testing and partial discharges testing.

One of the systems we've recently installed is an automated, wired monitoring system used to determine machinery health. One of the most valuable characteristics is its wide range of coverage, specifically its ability to collect high frequency, high resolution vibration data from equipment that rotates at more than 10,000 rotations per minute.

In 2013, TEP also installed wireless vibration transmitters throughout the coal yard. We now have the largest wireless vibration network of any power plant in the world. The transmitters automatically gather vibration data on equipment while it's running and wirelessly send it back for analysis, ensuring safe, accurate data collection. For example, we now receive predictive diagnostic information on the railcar positioner and dumper asset, which pulls an entire trainload of coal, then rotates and dumps out the coal one car at a time. If this equipment shuts down unexpectedly, we don't dump any coal, resulting in additional labor expense and delays in plant operations. With five motors tied to five gearboxes, the asset is expensive. Due to the nature of its function, it's not safe for someone to be on the equipment while it's moving. Now, with wireless vibration monitoring, we can collect data and use predictive maintenance to help us identify deterioration before the asset fails.

Make Training a Priority

To get the full benefit from its technology and maintenance processes, TEP has made training a high priority. Team members participate in up to three training sessions per year. The entire team has minimum certification in all predictive technologies. This use of cross-training enables the group to offer consistent service if a member is absent. With the breadth of training and tools available, the predictive maintenance team can leverage multiple tools for diagnosis. However, each member has additional areas of specialty. For example, if there is a problem with a motor, we can use vibration, infrared thermography and ultrasonic testing to pinpoint the problem. This approach cuts down on time for troubleshooting and yields more robust results.

Provide Clear, Detailed Reporting

At most companies, a problem, such as a motor bearing which needs replacement, is identified and then a maintenance work order is generated. At TEP, after a problem has been identified, we write a work order and then develop a report for our management team. The report describes the problem, adds context with trends and specific data points, and provides recommendations for resolution. In the motor bearing example, we would show the increase in amplitude and provide details about the frequencies that bearing is producing. After repairs are made, we write a follow-up report with an analysis of failed components, including pictures, and an estimate of how much production availability and money we would have lost had there been a failure. This detailed communication gives our leadership the opportunity to experience the demonstrated value of the work we do in real time.

Recently, we identified an issue with a gearbox that had been rebuilt within the last 18 months. Vibration data indicated looseness in the input bearings. The gearbox was removed for repair before functional failure occurred, which prevented unplanned downtime and secondary equipment damage. During our analysis of the components, we identified fretting corrosion due to the loose bearings, as well as abnormal wear on the gear teeth. Based on our findings, we were able to have the $250,000 gearbox replaced without cost as part of our warranty.

Figure 2: *TEP employee Gary Gardner, who is part of the predictive maintenance group, walks throughout the generating station in Springerville, collecting data where he measures ultrasonic, vibration analysis, infrared thermography and electrical motor testing, analyzing equipment to predict when it will need replacing.*

Expand the Program

Within the last several years, our reliability program has expanded to include lubrication. To combat the threat of cross-contamination, TEP has purchased several climate controlled lubrication buildings that will house large containers of oil. When these buildings are put in place, each type of oil will be stored in its own tank, with its own pump. Storage tanks and canisters, as well as the equipment the oil will be used for, will be color-coded and labeled to prevent contamination. And desiccant breathers will be used to prevent dirt from entering the tanks. By eliminating the threat of contamination through proper storage, handling and application, we anticipate extending equipment life.

In addition, we'll continue to focus on building our predictive maintenance capabilities for equipment that is difficult to access, runs intermittently, or varies in load. We'll do this by expanding our wireless vibration network, both inside and outside the coal yard. We'll also be increasing the number of permanently mounted accelerometers on hard to reach equipment. Used in combination with a machinery health analyzer, the accelerometers enable us to safely collect data at higher frequencies.

Our predictive maintenance team is honored to receive international recognition for our program. Just as importantly, we're proud of the work we've done for our internal customers. We're monitoring more critical assets than ever before. We've put documented proof of the value of predictive maintenance in the hands of our leaders. We've made a difference in TEP's ability to prevent unplanned shutdowns and to more effectively plan maintenance work. With the predictive maintenance foundation we have in place, we're excited to contribute to TEP's success.

Gary Gardner *is a Predictive Maintenance Coordinator II for Tucson Electric Power. Gary has more than 12 years of experience in the preventive and predictive maintenance field, with more than 10 of those years spent in the mining industry. He specializes in vibration analysis and holds certifications in a number of other predictive technologies, including machinery lubrication, infrared technology and electrical motor testing.*

TAPPING INTO THE VALUE OF EXPERiENCE

by Winston P. Ledet

A common joke is that there are people who have one year of experience 20 times and others who have 20 years of experience. The distinction between these two levels of experience is how much people have learned from their experience and how receptive their organization is to using that experience.

It is important to keep in mind that all organizations are socio-technical networks, where the people are the socio part and the machinery, including computers, is the technical part. We often hear people say that their most valuable company assets are the people who work in the organization. In essence, they are referring to the fact that people, as compared to machines, have the intelligence to recognize when the organization is realizing the full value that exists in its assets. The role of people working for a company is to realize that value by applying defect elimination to achieve the purpose of the organization.

Motivation is creating something of value for the society at large. Psychiatrist and neurologist Viktor Frankl states that man's primary concern is his "will to meaning," which he defines as the basic striving of man to find and fulfill meaning and purpose in his life. He contrasts this "will to meaning" with two other sources of drives: 1) the "will to power," proposed by philosopher Friedrich Neitzsche and used by Dr. Alfred Adler in his approach to psychiatry, and 2) the "will to pleasure" or pleasure principle proposed by Sigmund Freud in his approach to psychiatry.

Frankl contends that the status drive or will to power and pleasure principle or will to pleasure are mere derivatives of the will to meaning. As people pursue goals that have meaning, they require certain means that can be obtained through various powers and achieving that meaning has the consequence of creating pleasure. Therefore, power is merely a means for seeking meaning and pleasure is a natural consequence that ensues from achieving meaningful goals. He concludes, "Only if one's original concern with meaning fulfillment is frustrated is one either content with power or intent on pleasure."

Accomplishing meaningful goals, according to Frankl, can take place in three ways:

1. By creating something,
2. Through intimate relationships,
3. Through one's attitude in unchangeable circumstances.

Since the manufacturing world has the **primary purpose of creating something of value for the society at large**, it most legitimately contributes meaning through creating something. In order to create something, some work needs to take place. It is through participation in this work that people find meaning in manufacturing organizations. The primary focus of The Manufacturing Game (TMG) workshops is to restore meaning in the participants' work. This is the source of motivation in the workshops and the essential element in creating commitment to making the change to proactivity. These workshops are used to implement organizational change from a reactive to a proactive mode of manufacturing.

To explore the value of the experience within an organization, we need to look at the definition of several words according to Wikipedia. Experience has five different definitions, and according to your own experience, one or more will be meaningful to you.

EXPERIENCE

1. a: Direct observation of, or participation in, events as a basis of knowledge.
b: The fact or state of having been affected by, or gained knowledge through, direct observation or participation.
2. a: Practical knowledge, skill, or practice derived from direct observation of, or participation in, events or in a particular activity.
b: The length of such participation.
3. a: The conscious events that make up an individual life.
b: The events that make up the conscious past of a community, nation, or human kind generally.
4. Something personally encountered, undergone, or lived through.

> Most companies are afraid to give their employees the freedom to make decisions...

MOTIVATION IS MEANINGFUL WORK

> *It is only when people's concern with MEANING fulfillment is frustrated that they are either content with POWER or intent on PLEASURE.*
>
> *—Victor Frankl*

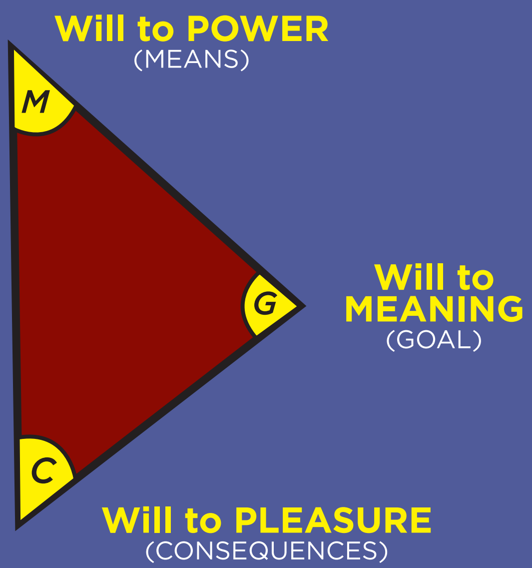


Figure 1

5. The act or process of directly perceiving events or reality.

UNDERSTANDING

a: The power of comprehending; especially the capacity to apprehend general relations of particulars.
b: The power to make experience intelligible by applying concepts and categories.

TACIT KNOWLEDGE

(AS OPPOSED TO FORMAL, CODIFIED, OR EXPLICIT KNOWLEDGE)

Tacit knowledge is the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalizing it. For example, stating to someone that London is in the United Kingdom is a piece of explicit knowledge that can be written down, transmitted and understood by a recipient. However, the ability to speak a language, use algebra, or design and use complex equipment requires all sorts of knowledge that is not always known explicitly, even by expert practitioners, and which is difficult or impossible to explicitly transfer to other users. While tacit knowledge appears to be simple, it has far reaching consequences and is not widely understood. (see *TMG News*, January 15, 2012)

The conclusion from these definitions is that the value of experience resides in the collective understanding by the workers and managers of the value chain they serve. If an organization can tap into the knowledge, skills and tacit knowledge of all employees to create a clear **understanding** of the potential value that can be realized if they collaborate, it can produce far more value for the company and the world than what they are currently achieving. Most companies are afraid to give their employees the **freedom** to make decisions because they don't have a process to ensure the best understanding of the situation is used to make that decision. When an organization cultivates a strong "shadow network," the probability of sharing understanding is vastly increased if that network is very diverse and includes all the functions. In DuPont's worldwide benchmarking of maintenance, the facilities that were visited in Japan were by far the best performing organizations in maintenance throughout the world. The biggest differences the Japanese facilities exhibited were in the action taken in cross-functional teams where they could share their collective intelligence.

Understanding the system we work in is what creates our ability to know what to pay **attention** to, how to make **choices** and why we make certain **decisions** to maximize the value we realize from our assets and effort. These together display our will to maximize our contribution to the world. The principle here seems to be "**waste not, want not**." Defects are elements of waste.

This article was originally published in *TMG News*, October, 2013.

***Winston Ledet** is a leading consultant and internationally known workshop instructor on proactive manufacturing and maintenance. He has 27 years of experience with E.I. du Pont de Nemours, serving in a variety of assignments. He is one of the creators of* The Manufacturing Game® *as part of his work at DuPont. Winston formed his own consulting firm, Ledet Enterprises, Inc., in 1993, using The Manufacturing Game® to help drive improvement efforts in process industries, as well as discrete part manufacturing sites around the world.*

Myths of RCM Implementation

PART 2 of 2

7 questions to ask when analyzing your assets

1. What are the functions and performance associated with the asset's standards in its current operating context?
2. In what ways does it not perform its functions?
3. What is the cause stopping it from performing its function?
4. What happens when each failure occurs?
5. What is the impact of each failure?
6. What can be done to predict or prevent every failure?
7. What should be done if adequate work could not be performed before the failure?

Reliability centered maintenance (RCM) focuses on identifying what should be done to assure the functions of a system or asset in a safe, cost-effective and reliable way. RCM analysis is carried out by a group of experts, called the analysis team, for the equipment, asset, or object of the study. It is their responsibility to answer seven questions (above) about the asset being analyzed. In Part 1 of this series (April/May 2014), Myths 1-10 were discussed. Now we will examine the remaining 12 myths.

by Carlos Mario Perez Jaramillo

MYTH 11: RCM is a project, i.e., an initiative with defined termination or completion.

The application of reliability centered maintenance (RCM) is not temporary; it is a process that has a very clear objective. It is defined as "a process used to determine what should be done to ensure a physical element continues performing the desired functions in its current operational context."

RCM is a dynamic and permanent process because analyses must be validated over time since operational context, functions, failure modes, effects and failure management strategies can be changed by different requirements of the assets, changes in the skills of operators and maintainers, and by environmental modifications.

MYTH 12: RCM must be applied to all assets of the company.

RCM is a process that can be applied to all assets of a company, but not necessarily at the same time in a massive and intensive effort. The most advisable is to implement it step-by-step, selectively to equipment, systems, or assets that facilitators, along with their analysis groups, have identified to reduce high levels of dissatisfaction. In doing so, the results motivate management and the company to continue investing in further asset analysis.

The approach of analyzing all equipment hastily with large amounts of resources and time, but without defined foundation is not recommended because few people share knowledge on a lot of assets and it is physically impossible to be in several analysis groups.

MYTH 13: RCM is only for companies with many assets.

All companies, from all sectors and conditions, want to be more reliable. In fact, the answers to these questions will validate the interest in reliability:

- Can the company sell everything it can produce (i.e., products or services)?
- Does the company want a tolerable and acceptable performance in terms of safety and environmental integrity?
- Does the company have a lot of preventive activity simply because it is a habit?
- Are operating costs high in relation to other, similar businesses?
- Has the company been collecting information for decades to be able to make the best decisions?
- Do user areas believe that shutdowns and breakdowns are only maintenance problems?
- Are priorities and criteria for operators and maintainers different?
- Are shutdowns long and costly?
- Were maintenance plans not made by people close to assets?

MYTH 14: RCM has a poor cost-benefit ratio.

Many maintenance managers do not understand what RCM is and believe they cannot handle costs to do it properly. This is dangerous, since in decision-making schemes, money and production stoppages are no longer the only elements present; now risk shows up too. Therefore, those who say they do not have time and money to implement responsible and defensible methods cannot afford not to do it because there are lives depending on them.

Applying RCM slightly, without a series of indicators that check the progress, makes achievements and the advance of the process useless. The rate of return of a RCM process is 17 to 1. That's why RCM, in addition to its intangible achievements, is still used and enjoys such a good reputation.

If RCM is applied correctly by well-trained people working on projects clearly defined and properly managed, the analyses typically pay for themselves within weeks and months.

MYTH 15: RCM outcomes take time to be seen.

Outcomes from a RCM process are related to the level of dissatisfaction the user has with respect to the asset. So when choosing assets, some kind of indicator showing the opportunity for reliability improvement should be selected. In some cases, the assets have not been operated, maintained and managed in an appropriate manner, therefore, in the stage of analysis implementation, urgent findings are achieved and serve to show the benefits of the process without finishing it. In other cases, analyses must be implemented, as well as the proper application of the results, to achieve the expected improvements.

If there are no urgent findings, especially in assets that currently have "satisfactory levels" in their indicators but offer attractive opportunities for improvement, it is necessary to implement all the recommendations of the analysis to obtain the results.

MYTH 16: RCM is not considered one of the so-called best practices.

Best practices are understood as the consistent application of a certain technique, methodology, tool, process, activity, or action, as the most effective way to deliver a particular outcome. It includes experiences based on learning and continuous improvement; that's how processes and activities are progressively checked and tested. The application of best practices is very useful. Standardization of practices across companies allows optimization of integration and management tools, so many organizations perform similar tasks using the same method.

RCM can be described as a process of high levels of commitment. Constructing new maintenance plans is a great improvement for two reasons: First, experts in operating and maintaining the equipment perform the RCM analysis and second, companies know that maintenance plans are technically justified.

MYTH 17: RCM is a maintenance initiative; therefore its success lies in the maintenance staff.

Although there is a wrong perception that RCM is an initiative that is only within the maintenance area of a company, it is necessary to emphasize that the success of RCM is associated with all units of the company. Only in this way will the company reach the required degree of reliability.

Conviction, support and monitoring of the directors of the company are key factors for achieving the purpose of a RCM process. This manifests itself in a good budget, reporting requirements, results and extension efforts in all areas of the company.

MYTH 18: RCM requires weekly meetings, schemes and work teams.

Companies have time to gather; they do it all the time because they are immersed performing failure analysis, problem analysis, corrective actions, planning and scheduling to handle failures, and using software to attack failures. Modifying their routine to analyze how to solve problems is something that can be linked to the proactive and modern vision of the management.

In addition, creativity to find appropriate times to meet is linked to intelligence, motivation and commitment. There are also alternative models for meeting, such as full weeks of total dedication, which increase efficiency and effectiveness of the process.

MYTH 19: RCM only can be carried out by the maintenance area, or even more, it can be hired.

RCM is not a household word of the "do-it-yourself" style. There is the idea that RCM must be learned and practiced to achieve skill and gain the benefits that can be obtained. Maintenance staff cannot answer all the questions themselves. Many of the answers only can be provided by operators; this applies especially to the questions concerning the desired performance and effects and consequences of failures. For this reason, an analysis of maintenance requirements of any equipment must be performed with work teams that include operators and maintainers.

Seniority of team members is less important than having a broad knowledge of the equipment being considered. Each member of the team also must have been trained in RCM. The team must be multidisciplinary and be able to receive the knowledge from specialists in the subject when required. The use of these teams not only allows managers to gain access in a systematic way to the knowledge and experience of each team member, but it also distributes maintenance problems and their solutions in an extraordinary manner.

MYTH 20: Third parties who use templates to save time in the analysis may be hired.

Third parties are far less informed than maintenance personnel about the operational context of the asset, the desired performance patterns, failure modes, effects and their consequences, and the capabilities of users and maintenance staff. Often, these third parties don't know anything about these issues. As a result, plans achieved with this support are almost always unsatisfactory.

Third parties commit resources from maintenance users, therefore, they have little interest in optimizing them. The mistake made in these cases is committed by the users, for making unreasonable requests to organizations that are not in the best position to meet them.

On the other hand, an analysis performed on a particular procedure or on systems that are technically identical under the "buying an analysis is cheaper" assumption, has to be carried out with the greatest care for several reasons:

- The operational context is different.
- Different competencies of individuals performing maintenance. In one case, they may prefer a proactive technology type, while another team working on another identical asset may be more comfortable using other technology.
- The analysis level may be inappropriate to establish the causes of failures for technically identical resources. This can deliver a result that is too superficial, possibly dangerous, or perhaps useless.
- Performance standards may differ.

All these reasons show that the best thing to do is to take advantage of the accumulated experience of those who operate and maintain assets to define the best strategies to handle failures.

MYTH 21: The RCM process does not require facilitators.

The RCM process requires enthusiasm champions, persevering individuals with the ability to overcome resistance to change and have management support.

The primary function of a RCM facilitator is to enable the application of the RCM methodology by asking questions to a group of people selected for their knowledge on the equipment or asset, ensuring agreement upon answers and registering them. He/she is responsible for:

- Technical quality of the analysis.
- Proper handling of the attitude of the participants.
- Handling of the analysis as a project.
- Time administration during the analysis.
- Application of an appropriate analysis pace.
- Application of RCM logic without tricks, shortcuts and mistakes.

The RCM process requires enthusiasm champions, persevering individuals with the ability to overcome resistance to change and have management support.

- Conducting the meetings.
- Managing the implementation of RCM with a corporate approach as a whole.
- Proper implementations of all tasks, redesigning, training, coaching, inventory policies, and keeping alive and updated the RCM process in the company.

MYTH 22: All methods are equal; after all they are called RCM.

It is true that many systems call themselves RCM, but in most cases, these approaches have been shortened and carry the statement that they can produce the same results as legitimate RCM in one half or a third of the time.

Since the RCM model was implemented, a variety of processes have emerged and are called RCM by their proponents. But they often have little or no resemblance to the original process developed by F. Stanley Nowlan and Howard F. Heap, which is structured and fully tested. As a result, if an organization says it wants assistance to use or learn to use RCM, it may not be sure which process will be offered to it.

The word "abbreviated" suggests that something is being left out and leaving things out inevitably increases the risk. If the worst happens, directors and managers will have to give explanations as to why they chose a non-optimal decision-making process to establish their strategies, instead of using one that meets a standard set by an international organization specialized in establishing such schemes.

Throughout this two-part series, we have discussed myths about RCM methodology implementation that is widespread in organizations. This is intended to provide clarity about the true strengths and forms of RCM application.

Carlos Mario Perez Jaramillo is a RCM2™ Professional of Aladon Network and an endorsed assessor and trainer of the Institute of Asset Management. He earned a master's degree in project/business and physical asset management, and has worked as a Maintenance Management Advisor and Consultant in many industries and served as an Instructor in various aspects of RCM and the PAS 55 standard for optimal management of assets. He has performed training and application of RCM2, maintenance management and asset management for companies worldwide.

UP IN THE Cloud

Predictive Maintenance Becomes Even Easier With Cloud-Based PdM Technologies

by Christopher Shannon

When researchers at Stanford University, the University of California at Los Angeles (UCLA), the University of California at Santa Barbara, the University of Utah, and Bolt, Beranek and Newman linked together the first five nodes of the Advanced Research Projects Agency Network (ARPANET) in 1970, they never dreamed how important their collective innovation would become.

Since its inception 44 years ago, the Internet has grown drastically and now has even become a tool for maintenance teams. Welcome to predictive maintenance in the cloud.

Taking advantage of continuously developing wireless sensing technologies, cloud hosting makes predictive maintenance even more attractive to industry. Limiting capital outlay, it makes the installation and use of those technologies even easier, giving users the biggest bang for their buck. Not only does it create a remotely accessible centralized system for maintenance teams, it also makes sharing with outside experts simpler and more convenient, while making it easier and more affordable than ever to update software.

"Comparing cloud to non-cloud, you have more interfaces to go through in non-cloud, you have more steps to go through to get data to your respective laptop or computer….so, I guess you could say that cloud has a lot less hassles as far as networking goes," says Mike Hoy, a vibration analyst and maintenance professional at a large university in Pennsylvania.

Predictive maintenance using cloud-based technologies eliminates the worry of integrating with mature corporate networks and the complexity of tying into unfamiliar new software. Cloud setup only involves a small machine that connects to the cloud and talks to the sensors. This reduces installation complexity to plugging a server that talks to the cloud into the wall, which, in turn, allows attention to be correctly focused on the more important maintenance effort of installing sensors on critical machinery.

will run on, and pay the system administrators and operational professionals to do everything that is necessary to keep the software running in the customer's own network. That's a lot of responsibility and a lot of expense.

With a cloud-based monitoring system, fees are spread out over time, the cost of maintaining servers is covered and there is no need to buy additional computers or hire additional personnel to manage servers. Service charges for using software in the cloud are less than the cost of ownership and operations of the software if it ran on the customer's own network.

> Since its inception 44 years ago, the Internet has grown drastically and now has even become a tool for maintenance teams.

Cloud systems not only give users their best value, but they limit capital outlay as well, which includes the cost of software and license fees, and the cost of installing and operating software from within a company's own, often highly specialized IT infrastructure. When purchasing software to run on their internal network, many firms insist that the user pay for the software upfront, pay maintenance and support agreements, buy the computer or computers that the software

As far as potential value to your maintenance regimen is concerned, a low-cost, cloud-based system continuously monitors data on asset health. This allows detection of failure signatures at the earliest possible signs of trouble, such as when phenomena linked to degradation first develop, and expensive replacements and profit-robbing unscheduled downtime may still be avoided.

It's more than merely convenient that cloud-based systems can be monitored from a central-

Figure 1: *KCF Technologies' David Shannon installs a collection server at a wastewater treatment plant. The collection server is a key element to KCF's SmartDiagnostics® in the Cloud system*

With a cloud-based monitoring system, fees are spread out over time, the cost of maintaining servers is covered and there is no need to buy additional computers.

ized location. This also means that organizations with multiple buildings and far-flung facilities, but with small maintenance staffs, have the flexibility to monitor data from multiple machines, in multiple facilities, from one decision-making center. In other words, the cloud allows smaller maintenance staffs to provide more predictive monitoring and to keep an eye on "problem children," critical equipment that may be exhibiting the first symptoms of incipient breakdown. Having a centralized monitoring location also means users can focus resources and optimally schedule skilled professionals who can perform maintenance only when maintenance is clearly needed.

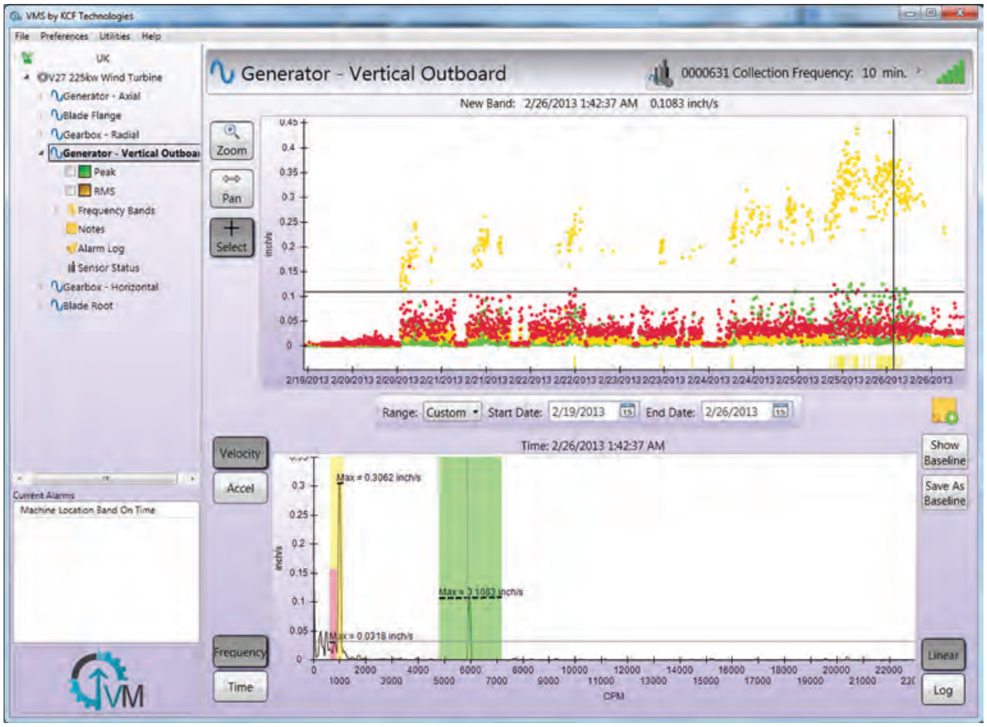
Predictive monitoring in the cloud makes sharing machine health data with outside experts easier. Along with allowing companies to offer a service that differentiates them from their competitors, the cloud also enables them to leverage machine health data on behalf of their clients. From the perspective of customers, this arrangement allows them to only have to hire professionals who specialize in actually maintaining vital machines; they no longer have to hire third-party vibration experts, or similar professional advisors.

The cloud also makes getting software updates easier and cheaper. With software in the cloud, the manager of the cloud system ensures the newest updates will be uploaded to the cloud server. This means users are always getting the latest updates. Because of the cost and complexity of staying up-to-date with new software versions frequently offered by vendors, many companies that install software on their own networks fall behind on updates. When these companies finally bite the bullet and decide to upgrade, mainly because of proliferating problems in the system, the cost of upgrading can become expensive with the costs of modifying databases and training personnel to use the new software. With the cloud, software updates to which customers are entitled happen automatically, little by little, as and when they become available.

To see how the cloud can be an added asset in monitoring industrial machines, look at the different ways that industrial equipment is monitored now, then compare that to monitoring in the cloud.

Figure 2: *A sample high-level illustration of one possible cloud system configuration*

__Figure 3:__ Using the cloud, this data on the health of a wind turbine in England could be directly monitored here in the United States



First, a route-based maintenance strategy where maintenance professionals physically walk around to each asset, place a sensor on the machine and gather data. This method of machine monitoring has many disadvantages that monitoring in the cloud addresses. This route-based scheme only gives maintenance staff brief snapshots of machine health data from which to make recommendations. Also, this method of machine health monitoring has safety issues, as maintenance personnel are required to go into various facilities and climb around sometimes hazardous job sites. Lastly, in some cases, machines need to be taken offline to do testing. Not only can this downtime be costly, but from a practical standpoint, convenient shutdown scheduling is not always easy to arrange.

Second, for continuous monitoring, wired sensors have been a traditional choice. However, wired sensors require not only the installation of the sensors, but also running of cables from the sensor on the machine to a terminal box. This whole process can cost hours of downtime and still requires a good deal of time be spent climbing around job sites. And a wired system is only as strong as its weakest circuit.

> With the cloud, however, wireless sensing technologies become even more powerful.

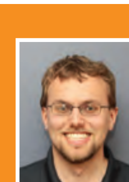
Third and most recently, wireless sensing technologies have garnered the attention of manufacturers. Wireless provides a viable solution to the problems posed by the more traditional machine monitoring methods, such as route-based and wired monitoring. However, using a local network can cause headaches when it comes to obtaining access to a company's network. Furthermore, sensor data only can be viewed from a computer that is on that network.

With the cloud, however, wireless sensing technologies become even more powerful. The issues presented by having to get access to a local network and only being able to view data from a computer on that network are solved when using the cloud because all a maintenance team needs is an Internet connection. Additionally, with data being able to be viewed from the cloud, data can be seen from anywhere, whether it's down the street or across an ocean. As an example, a wind farm in the United Kingdom acquired a wireless vibration monitoring system to monitor some of its wind turbines. Not only could the data showing the health of the turbines be seen off-site in the UK, but it also could be looked at and critically analyzed by the engineering firm in the United States that had sold the system to the wind farm and was helping the farm owners learn to interpret the meaning and significance of the data.

__Figure 4:__ KCF Technologies' Matt Cowen attaches a receiver node to a collection server while installing a wireless vibration monitoring system at a paper mill; the collection server will enable vibration data from sensors in the mill to be sent to the Cloud

For all the benefits of using cloud technology, some potential customers still have their doubts. Some are nervous about the risk of data or about their machines leaving their enterprise. But the reality is that secure, accurate, complete, real-time data is in the best interest of the cloud service provider. For this reason, the service providers invest in technologies to give clients equal, if not superior, control over their data, compared to what they would have in-house. Furthermore, cloud service providers are committed to maintaining their security and that of their clients' IT infrastructures, because, again, it is in their best interest to do so. In addition, data in the cloud gets backed up and is easily retrieved for integration back into an in-house system, if and when desired.

As the cost of manufacturing continues to rise, the Internet continues to grow and data becomes cheaper. This means that—thanks to a few researchers in the late 1960s and early 1970s—condition monitoring of industrial machinery is becoming easier and cheaper. As part of this growing "Internet of Things," cloud technology is able to utilize the Internet and its ready, high-speed flow of inexpensive data to provide industry with an affordable and convenient option for predictive maintenance programs now and into the future.



__Christopher Shannon__ is the Marketing Analyst at KCF Technologies. Christopher's responsibilities include leading the company's media and press relations activities, where he has authored numerous press releases and trade magazine articles.

Macro-Managing Your MRO Inventory

by Doug Wallace

The mission of the maintenance, repair and operations (MRO) warehouse is to have the right parts at the right place at the right time. Too often, that objective is achieved by simply stuffing the storeroom to the gills. Some organizations do a better job of trying to determine realistic stocking plans based on criticality, estimated requirements, supplier lead times and other variables, but then fail to review them periodically to ensure the assumptions used in developing the stocking plans are still valid.

Either way, the end result is the same: inventory gets out of control over time and some difficult decisions have to be made. Often those decisions are made with no strategy or overarching goal other than cutting inventory as quickly as possible, and no real understanding of the impact they cause on production or reliability. The results actually can be counterproductive, leaving operations exposed to critical material shortages and significant production delays.

Whether in steady state or crisis mode, trying to control inventory by micro-managing it at the item level is not the right approach. The need to support maintenance and operations has to be properly balanced with the responsibility to minimize the costs associated with carrying that investment. A top-down approach that starts by macro-managing your inventory produces a more integrated strategy that results in less total costs to the company.

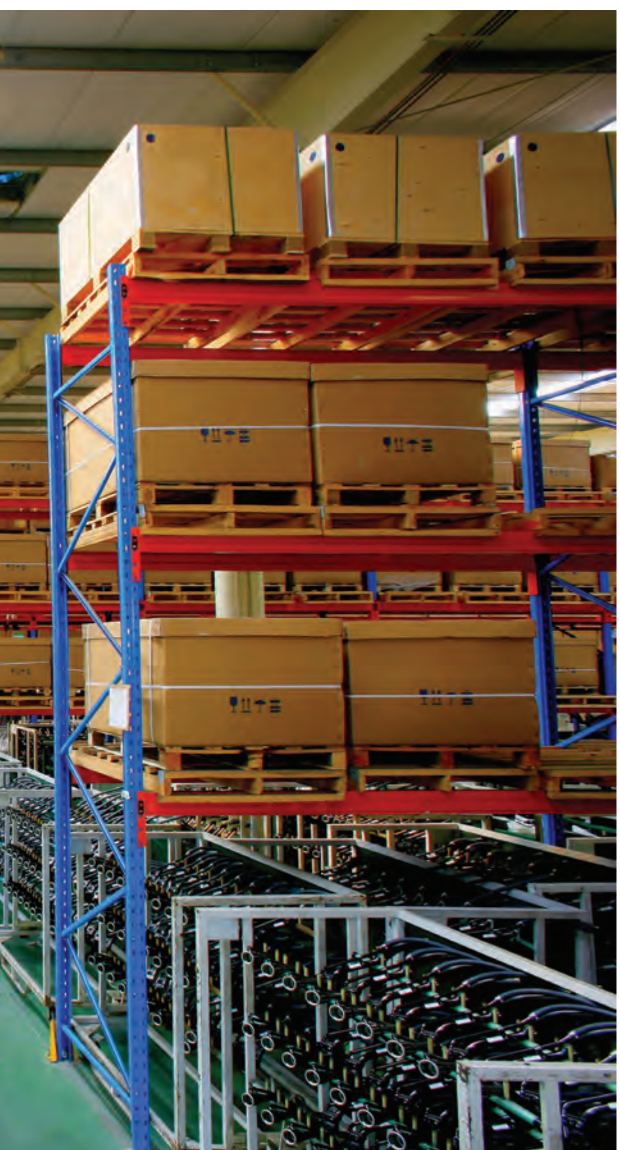
The first question to answer is: "How much inventory do I have?" If you are in a position in the organization where the storeroom reports to, you should know. You are the steward of those resources and it's your responsibility to manage them effectively. If you don't know what you have, that responsibility will be difficult, if not impossible, to carry out.

The next question to answer is: "How much inventory should I have?" This is a tougher question to answer, but it's much better to determine that target yourself than to be told by someone else who has no direct responsibility for the inventory on a day-to-day basis.

There are a couple of ways to estimate how much inventory you should have. The more preferred way is turnover, which is a ratio of dollars issued to dollars of inventory. Turnover directly relates your level of inventory to the level of demand for that inventory. Best-in-class targets for turnover in an MRO environment are between 2.0 to 3.0 turns per year.

Inventory Profile									
Inventory Category	Number of Items	Average Annual Usage	Current Investment	Current Turnover	Turnover Target	Expected Change	Inventory Target	Expected Change ($)	Expected Change (%)
A Items	593	$3,664,088.00	$2,507,450.00	1.46					
B Items	1,328	$687,264.00	$1,696,999.00	0.40					
C Items	21,128	$226,611.00	$6,396,745.00	0.04					
Total	23,049	$4,577,963.00	$10,601,194.00	0.43					
Obsolete Inventory	2,475		$2,051,162.00						
Excess Inventory	3,487		$2,352,252.00						

Figure 1: *Baseline inventory profile*



Turnover is most effectively improved through better management of the storeroom investment, but most organizations will find that even modest improvements in the metric would require eliminating so much inventory that the results could be catastrophic!

Achieving or approaching best-in-class inventory benchmarks almost always requires a number of carefully developed strategies and tactics implemented concurrently over a significant period of time. To help determine which approaches will be most effective for your organization, it is helpful to start with the steps below:

1. Identify Obsolete Material

Almost every MRO storeroom has some parts that are for equipment no longer in service, have been redesigned, or are otherwise unusable. Any items found to be obsolete should be flagged in the system and physically segregated.

2. Identify Excess Inventory

Excess inventory is stock of usable materials that exceeds short-term anticipated requirements. For most items, the highest the inventory should ever go is the sum of the reorder point plus the reorder quantity. Excess is simply the amount of on hand inventory above that highest expected level.

3. Prioritize the Active Inventory

An ABC analysis will determine the items that have the greatest impact on service and investment, thereby identifying the ones that you should spend the most time on. Make sure to exclude anything identified as obsolete.

4. Establish a Baseline

A baseline profile uses the results of the above activities to depict a high-level view of the current state of your inventory. It shows the amount of investment tied up in obsolete and excess material. It also shows how inventory is distributed by activity level and how quickly materials are turning over at an aggregate level. Figure 1 is an example of a baseline profile taken from an actual case study.

Once you understand the makeup of your inventory, you can determine which tactics are most likely to reduce your inventory without adversely affecting service.

Start by eliminating any obsolete materials. They have no impact on service, but depending on your carrying costs, can be expensive to keep. You may need to lessen the impact on bottom-line plant results by establishing a monthly scrap budget and spreading the expense over a period of time, but determine the best way to dispose of it (scrap it, recycle it, sell it, donate it) and get rid of it as soon as possible so it's out of your inventory.

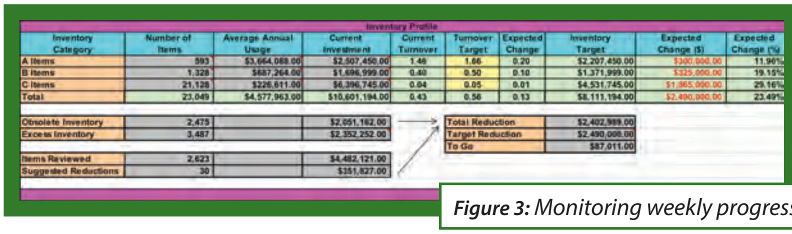
Evaluate excess inventory, starting with the highest values first. Each item needs to be reviewed to determine the cause of the excess and the right course of action. For any item that is overstocked, specific action plans should be developed to scrap, sell, use up, or otherwise eliminate the excess inventory. As these plans are executed, the associated value of the excess material should come out of your inventory.

Next, review your stocking plans, starting with the "A" items that have the greatest investment. By definition, these items are more active and, therefore, can be managed more aggressively. Lowering the reorder point will reduce average inventory, but it also impacts service. Lowering the reorder quantity increases reorder frequency, but also reduces average inventory levels without impacting service. Making changes to stocking plans on "B" and "C" items will help as well, but generally have far less impact.

Look for items that don't need to be in inventory at all. Materials for preventive maintenance (PM), such as lubricants and filters, should be identified on standard PM job plans and demand for these items can be predicted based on the frequency of the PM. Some

Inventory Profile									
Inventory Category	Number of Items	Average Annual Usage	Current Investment	Current Turnover	Turnover Target	Expected Change	Inventory Target	Expected Change ($)	Expected Change (%)
A Items	593	$3,664,088.00	$2,507,450.00	1.46	1.66	0.20	$2,207,450.00	$300,000.00	11.96%
B Items	1,328	$687,264.00	$1,696,999.00	0.40	0.50	0.10	$1,371,999.00	$325,000.00	19.15%
C Items	21,128	$226,611.00	$6,396,745.00	0.04	0.05	0.01	$4,531,745.00	$1,865,000.00	29.16%
Total	23,049	$4,577,963.00	$10,601,194.00	0.43	0.56	0.13	$8,111,194.00	$2,490,000.00	23.49%
Obsolete Inventory	2,475		$2,051,162.00						
Excess Inventory	3,487		$2,352,252.00						

Figure 2: *Estimated impact of inventory management activities*



Inventory Profile									
Inventory Category	Number of Items	Average Annual Usage	Current Investment	Current Turnover	Turnover Target	Expected Change	Inventory Target	Expected Change ($)	Expected Change (%)
A Items	593	$3,664,088.00	$2,507,450.00	1.46	1.66	0.20	$2,207,450.00	$300,000.00	11.96%
B Items	1,328	$687,264.00	$1,696,999.00	0.40	0.50	0.10	$1,371,999.00	$325,000.00	19.15%
C Items	21,128	$226,611.00	$6,396,745.00	0.04	0.05	0.01	$4,531,745.00	$1,865,000.00	29.16%
Total	23,049	$4,577,963.00	$10,601,194.00	0.43	0.56	0.13	$8,111,194.00	$2,490,000.00	23.49%
Obsolete Inventory	2,475		$2,051,162.00						
Excess Inventory	3,487		$2,352,252.00						
Items Reviewed	2,623		$4,482,121.00						
Suggested Reductions	30		$351,827.00						

Total Reduction	$2,402,989.00
Target Reduction	$2,490,000.00
To Go	$87,011.00

***Figure 3:** Monitoring weekly progress*

material requirements can be anticipated based on predictive maintenance (PdM) technologies. Work on non-critical assets can be planned and scheduled and the materials ordered as needed.

A top-down approach that starts by macro-managing your inventory produces a more integrated strategy that results in less total costs to the company.

Try to establish consignment or vendor stocking arrangements to get other items out of inventory, but still assure adequate supply. These arrangements significantly reduce the lead time and also increase turnover since they are issued through the storeroom, but don't get reported in the inventory.

Look for potential free issue materials. These are typically low value/high volume items, such as fasteners, fittings and consumable materials where usage doesn't need to be tracked. They are usually expensed at the time of purchase so the on hand balances don't need to be maintained and, therefore, the value of the material does not show up in the storeroom investment.

With these plans in place, it should be possible to establish target inventory levels, which can be translated into revised turnover goals. The updated inventory profile in Figure 2 shows how the client in the case study estimated the impact of its inventory management activities.

Reducing the investment by almost 1/4 was only expected to improve turnover by about a third, but eliminating nearly $2.5 million of inventory would still be a significant achievement.

As the client reviewed individual items, progress was monitored each week, as shown in Figure 3.

Within three months, the client was able to realize nearly its entire goal by prudently, yet aggressively, following the aforementioned steps. In fact, having achieved its initial target of $2.49 million, the client went on to identify an additional $1 million of material that it believed could be removed over the next 12 months.

By successfully macro-managing inventory, this client was able to meet – and exceed – its inventory reduction target, improve its turnover and significantly reduce its carrying costs with no appreciable impact on service.

***Doug Wallace**, CPIM, is a Senior Consultant and Materials Management Subject Matter Expert for Life Cycle Engineering (LCE). In addition to his materials management expertise, Doug is knowledgeable in planning and scheduling and operator care best practices. He is also certified in Prosci's Change Management methodology. www.lce.com*

RELIABILITY and MAINTAINABILITY MANAGEMENT: A PRIMER

Reliability and maintainability management is the management of failure. By using specific approaches and tools, one can obtain optimized, cost-effective solutions to the design, assembly and use of a product.

by Fred Schenkelberg

Reliability is the probability of a product successfully functioning as expected for a specific duration within a specified environment. Figure 1 shows the four key elements to reliability: function, probability of success, duration and environment. Maintainability is a characteristic of design, assembly and installation that is the probability of restoration to normal operating state of failed equipment or systems within a specific timeframe, using specified repair techniques and procedures. Maintainability is related to reliability because when a product or system fails, there may be a process to restore the product or system to operating condition.

The fundamental expectation from a customer's point of view is for the product to work as promised. However, failure happens. How to anticipate and deal with failure are cornerstones to a successful reliability and maintainability (R&M) management program.

R&M engineering pulls together resources from across many fields, including design, materials, finance, manufacturing, failure analysis and statistics. R&M management requires knowledge of product specifications, apportioning reliability, an understanding of feedback mechanisms and a consideration of maintenance requirements. These aspects will be addressed in turn.

SPECIFICATIONS

Everyone desires products that offer more features, provide higher value, cost less and last longer. These four aspects drive the development of any product. The set of product functions or features defines the operating state and, conversely, what a system failure may include. Although not required, a set of functions is often detailed at the outset of a product development program. During product development, the design is regularly evaluated or tested and compared to the desired set of functions.

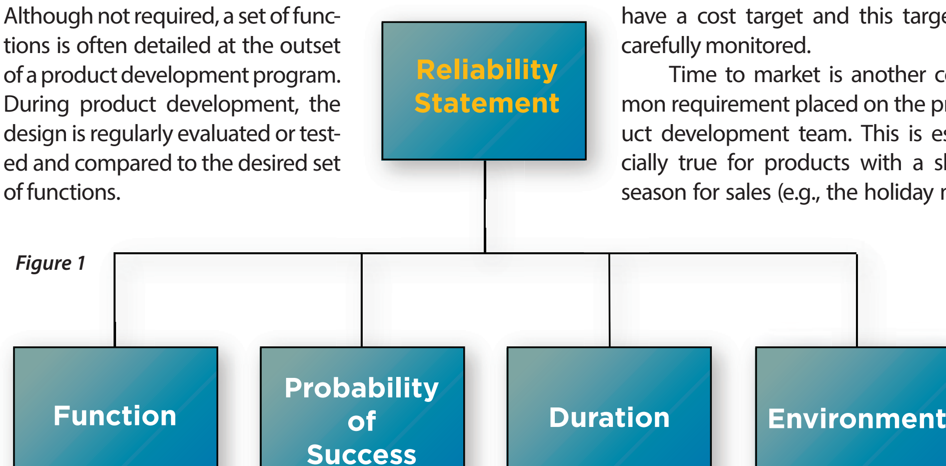


Figure 1

Cost may or may not be the most important consideration over the product lifecycle, yet it is often known and tracked during development and maintained for products during use. Cost includes the cost of goods sold and may include the cost of service and repairs. It often does not directly include the cost of failure to the customer, yet that cost may be known. For example, when a deep-sea oil exploration rig has to retract a drill head because of a part failure, it may cost close to $1 million per day. Many products during design have a cost target and this target is carefully monitored.

Time to market is another common requirement placed on the product development team. This is especially true for products with a short season for sales (e.g., the holiday mar-

ket). Setting milestones and deadlines is a management tool that helps get the product to market in a timely and coordinated manner. Like functions and costs, shipping a product on time is routinely measured.

Clearly stating the complete reliability goal is not difficult to do at the beginning of a design program. Moreover, once stated, the goal provides a common guide for the development decision-making, along with reliability test planning, vendor and supply chain requirements, and warranty accrual. The goal certainly may change over the development process, as may product features, cost targets, or deadlines. The reliability goal is like any other product specification; it just concerns the performance over time after the product is placed into service.

It is important to state the reliability goal so it includes all four elements of the reliability definition (e.g., a wireless router provides 802.1n connectivity with features specified in product requirements document HWR003, in a U.S. factory environment, with a 96 percent probability of still operating after five years of use).

RELIABILITY APPORTIONMENT

An extension of reliability goal setting is to break down the goal to cover the individual elements of the product, thus providing a meaningful reliability objective for each component. In a series system, the probability of failure for each element is lower than that for the overall system. The opposite is true for elements in parallel. For complex systems, the apportionment calculation may become more complex, yet the concept still applies.

Assigning a clear and concise reliability objective to each of your design teams and suppliers provides a means to make reliability-related decisions local to the element under consideration. This may influence design margins, material selection and validation techniques.

Keep in mind that all four elements are part of the apportioned reliability goal. Often, the environment and use profile will be different for different product elements. For example, the power supply may operate full time, but the hard drive may often be idle and partially powered down. The location within the product may alter the temperature the elements experience. One must localize the apportioned goal, or at least provide sufficient information, to fully articulate and act upon an apportioned reliability goal.

The process used to create the apportionment may be simply an equal allocation to each element or a weighting on expected or known reliability performance (e.g., predictions, models, etc.). Rarely is there enough information to provide perfect apportionment from the start. Apportionment will be a work in progress, evolving as the design matures, new information becomes available and the design is evaluated.

FEEDBACK MECHANISMS

For system development, setting a reliability goal or any specification requires measurement of the performance compared to the desired performance. The difference may require changing the design or adjusting the goal.

What will fail is a core question facing nearly any product development or maintenance team. Understanding the expected failure mechanisms plays a crucial role in the steps followed to determine the expected failure mechanisms. In situations with known failure mechanisms and only minor design changes, there is little need to "discover" failure mechanisms. The focus may shift to those areas related to the changes and validation of existing failure mechanisms. Another situation may include many uncertainties related to failure mechanisms. A design change to eliminate a specific mechanism may reveal another, previously hidden, mechanism. A new material may involve exploration of how the material will react over time to its shipping and operating environment.

Discovery includes a range of tools available to R&M professionals. This may include literature searches, failure mode and effects analysis (FMEA), and discussions with suppliers or researchers. Discovery may involve a wide range of tests, including material characterization, step stress to failure testing, and highly accelerated life testing.

The intent is to find the weaknesses within a design and take steps to minimize failures. For example, a team may discover a material color fades quickly in sunlight, but adding a stabilizing agent may ensure color fastness. A highly accelerated life test (HALT) may expose a faulty layout and require a redesign of the printed circuit board. Understanding and characterizing the failure mechanisms enable the designer to avoid surprises in later product testing or during use.

FMEA is a tool used to merge the ideas and knowledge of a team to explore the weaknesses of a product. To some, this may seem like a design review, to others it is an exploration of each designer's knowledge of the boundary to failure. Depending on the team and amount of knowledge already known, FMEA may or may not be a fruitful tool to discover product failures. However, it nearly always has the benefit of effectively communicating the most serious and likely issues across the team.

What will fail is a core question facing nearly any product development or maintenance team.

In the design process, the designer needs to consider access, disassembly, assembly, calibration, alignment and numerous other factors when creating a system that is repairable.

HALT is a discovery tool in which sufficient stress or multiple stresses are applied to a product to cause failure. Starting at nominal stress levels, the HALT approach then steps up increasing amounts of stress until the product no longer functions as expected. Careful failure analysis may reveal design weaknesses, poor material choices, or unexpected behavior. The failures provide knowledge on areas for improvement. A product that has its detected weaknesses resolved is more robust and, thus, able to withstand normal stresses and the occasional abnormal stress load without failure.

FMEA and HALT provide information about product design and materials that, to some extent, rely on previous knowledge about the expected failure mechanisms. Within the FMEA team, this knowledge is shared or a new question may be explored, possibly revealing new information. Because the HALT applies stresses that are expected to cause failure, in each case, a new product design or material may have an unknown response to an unexplored stress. Both tools serve a purpose and have proven very useful in the failure discovery process, yet acquiring more information about possible failure mechanisms may enhance both tools and the product.

Most materials and components undergo development and characterization. Modern products may have hundreds of materials and thousands of components, yet each has some failure mechanism history of exploration and characterization. As a minimum, new materials or components must be researched to understand the known failure mechanisms and how they manifest within the chosen design and environment. Published literature in scientific and engineering journals is a good place to start. Researchers should be engaged in a discussion about how the material may behave in the chosen design. Many component and material suppliers have intimate knowledge of the component or material weaknesses and are willing to share that with their customers.

MAINTENANCE CONSIDERATIONS

Repairing a product presumes the product is repairable. Creating a product that is repairable is part of the design. Some products are not repairable simply because the repair process costs more than the value of the product. Products, such as an escalator or an automobile, have design features that make them economical to repair. The combination of the design, the supply chain for spare parts and tools, and the execution of repairs are all part of maintainability.

There are many metrics related to the time to repair: diagnostic time, spare part acquisition, technician travel time, equipment repair time, etc. Combining mean time to repair (MTTR) and mean time to failure (MTTF) information provides a measure of availability. Availability is related to the concept that the equipment is ready to work when expected. Concepts of throughput, capacity and readiness are related to availability.

In the design process, the designer needs to consider access, disassembly, assembly, calibration, alignment and numerous other factors when creating a system that is repairable. For example, a car's oil filter has standard fittings, permitting the use of existing oil filters as a replacement. The design of the system may involve trade-offs between design features and aspects of maintainability, such as the cost of spare parts and the time needed to actually accomplish a repair.

For the team maintaining equipment, considerations include understanding equipment failure mechanisms, symptoms and MTTF expectations. Stocking of tools and spare parts can be expensive and minimized if the system behavior over time is understood. The team may require specialized training and certifications; these also may increase maintenance costs.

There are a couple of basic approaches to maintenance: time-based or event-based. If you change your car's oil every three months, you are using a time-based approach; if you are changing your oil every 5,000 miles, then you are using an event-based approach. Both require some knowledge about the failure mechanism involved to set the triggering time or event criteria so the maintenance is performed before either significant damage to the system or failure occurs.

Another approach is to monitor indicators of the amount of wear or damage that has occurred and repair the unit just as that unit's specific useful life is about reached. For example, periodically testing an oil sample may reveal when the oil is about to become ineffective as a lubricant. Monitoring and maintenance can be very sophisticated or very simple, such as having a brake wear indicator that causes a squealing sound. Prognostic health management is a relatively new field focused on measurement techniques that, like the wear indicator in brake pads, assist the maintenance team in maximizing the useful life of a product and effecting repairs and maintenance only as needed to prevent failure.

CONCLUSION

The various tasks and activities commonly associated with R&M are not accomplished without purpose. They add value to making decisions, provide direction and feedback, help to prevent expensive mistakes and avoid excessive repairs. The tools and resources of R&M engineering provide a means to efficiently achieve one's R&M goals.

__Fred Schenkelberg__ is a leading authority on reliability engineering. He is the reliability expert at FMS Reliability, a reliability engineering and management consultant firm he founded in 2004. Fred has a Bachelor of Science in Physics from the United States Military Academy and a Master of Science in Statistics from Stanford University. www.fmsreliability.com


OilSafe RED
OilSafe MID GREEN
OilSafe BLUE
OilSafe YELLOW
UL
LISTED
NO. MH47936
PROUDLY MADE IN THE USA

Figure 1: Volvo Cars Gent

Journey to Maintenance Excellence

After 48 years, Volvo Cars Gent received an award from the Belgian Maintenance Association (BEMAS) for the continuous efforts in its maintenance department. As the maintenance manager, I received the title of "Maintenance Manager of the Year 2013." Here is why our maintenance achievements attracted the attention of the non-profit organization for maintenance professionals.

by Marc Begijn

Volvo Cars Gent was founded in Belgium in 1965. Establishing this plant was an excellent way for the Swedish car manufacturer to reap the benefits of the European Economic Community and to evade the heavy import tax. High productivity attracted heavy investments. At this moment, the plant has the highest production volume of all Volvo plants. The following Volvo models are manufactured at Gent: the V40, the S60 and the XC60.

The growth of Volvo Cars Gent was the result of decades of effort. At the end of the 1980s, the first managers visited Japan to understand local production methods. In the 1990s, Volvo started to decisively implement total productive maintenance (TPM) methodology. The approach was translated from the Japanese culture to the European (Belgian) culture in different steps.

Maintenance was fully integrated within production. Early equipment management took care of addressing maintenance in the design phase of the equipment. Extra attention was given to the maintainability and reliability of the equipment. Within production, there were also self-steering teams that were responsible for a number of basic maintenance activities. As a result of our efforts, in 1999, Volvo Cars Gent became the first manufacturing company in Europe to achieve the TPM World Class award. That same year, Volvo Cars Gent was taken over by Ford.

This acquisition required Volvo Cars Gent to align with the Ford Production System (FPS). After thorough analysis and benchmarking different Ford plants, it appeared quite quickly that Volvo Cars Gent had a big lead in different manufacturing techniques. But there was one big problem: the Volvo approach was not uniform within different establishments of Volvo Cars. The Volvo Cars Manufacturing System (VCMS) was created to make the Volvo approach identical throughout Volvo Cars. The responsibility of this initiative was to collect best practices and roll them out uniformly. Mainnovation, which created the Value Driven Maintenance® (VDM) methodology, supported Volvo Cars in shaping VCMS maintenance. VDM was used as a central model to collect all best practices from the different Volvo manufacturing factories and make them uniform. Based on these best practices, a common maintenance process was established, maintenance tools were introduced and training was initiated. Creating added value with maintenance was getting more and more important as time progressed. This model was used continuously to determine whether the dominant value driver should be availability or costs. The processes, IT tools, data and maintenance performance indicators were refined and adjusted to Volvo's needs.

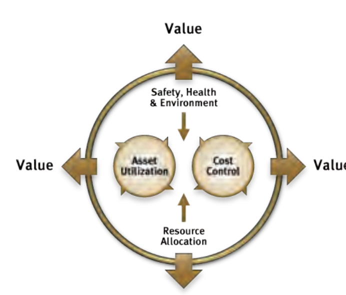


Figure 2: The four value drivers of the VDM model.

A crucial adjustment was made in the maintenance organization. The decentralized maintenance organization was completely integrated into production during the TPM period, but it appeared to be too expensive and the exchange of experience within the overall organization was labor-intensive. Most companies have cy-

Figure 3: Automation will only work if maintenance can manage it

More than 8,000 assets, 828 robots and 9.8 miles of conveyor belts produce a whopping 250,000 cars per year.

cles of centralizing and decentralizing the maintenance organization where they usually embrace either extreme. But Volvo Cars Gent didn't make this mistake and chose a hybrid maintenance organization. The "own maintenance activities" (maintenance executed by production operators) and corrective maintenance stayed within the production organization. All remaining maintenance was centralized into a governing maintenance department. This department is responsible for all preventive maintenance activities, modifications and long-term asset management. I was responsible for leading this department and am a permanent member of the plant management team.

Since 2010, Volvo Cars has been part of the Chinese automotive manufacturing company, Geely. This company has the ambition to grow Volvo Cars into a world player in the premium segment. Geely wishes to target the development of new models and new manufacturing facilities in China. The production volumes will have to double within a couple of years, but this growth plan only can be realized by utilizing the current models and managing the current facilities more efficiently. Maintenance plays a crucial role. It delivers high availability against the lowest possible costs. If this is successful, mass production in Europe gets another chance.

In the elections for Maintenance Manager of the Year 2013, I competed with Stora Enso's maintenance managers, Katrien Bouckaert and Peter Heyndrickx. The election is organized by BEMAS. I won the election and was praised by the jury. Focusing on deriving value through maintenance over a number of years certainly brought success! Of course, I did not achieve this award by myself. A team of more than 300 associates with a strong passion for maintenance helped me realize my goals.

The figures are impressive. More than 8,000 assets, 828 robots and 9.8 miles of conveyor belts produce a whopping 250,000 cars per year. Technical availability is 98.7 percent. This truly makes Volvo Cars Gent a top tier performer in the worldwide car manufacturing industry.

Marc Begijn *graduated as Master in Science in 1983. In that year, he started to work at Volvo Cars Gent. Marc had various positions in production and maintenance. He also supported the Volvo plant in the Netherlands (Born) for several years. From 2007 until 2013, Marc was responsible for the maintenance department in Gent. In August 2013, Marc was promoted to Manager Body Shop. In this role, Marc can apply his production and maintenance experience as the body shop is highly automated with more than 800 robots.*

80:20

Developing a Lubricant Contamination Control Strategy

by Mark Barnes

Most of us have heard of the 80:20 rule: 80 percent of the consequences are caused by 20 percent of the root causes. This rule of thumb is based on a well-known business theory known as the Pareto Principle, reputed to have been hypothesized by an Italian economist back in 1906 who noted that 80 percent of the land in Italy at that time was owned by 20 percent of the population. The Pareto Principle is often cited in various and diverse business practices, such as explaining why 80 percent of sales come from 20 percent of most companies' customer base, or why 80 percent of customer complaints come from 20 percent of customers.

In lubrication, the Pareto Principle also applies. Studies indicate as many as 60 percent to 80 percent of mechanical failures can be attributed directly or indirectly to lubricant contamination. And while this statistic will vary based on application, machine type and industry, what cannot be disputed is that without precision control of the contaminant, machine reliability can be seriously compromised.

It's All About the Small Stuff

For the purpose of this article, consider the two primary contaminants found in most plants: particles and moisture, though other contaminants, such as air, chemicals, fuel and glycol, also can have deleterious effects on equipment. Most companies recognize that dirt and moisture are bad, but fail to recognize how small amounts of contamination can have a very serious effect.

For particle contamination, the primary concern needs to be silt-sized particles in the one to 10 micron size range. While small in nature – less that 1/20th the thickness of a human hair – three micron silt-sized particles that are no bigger than a red blood cell are as much as five to 10 times more likely to induce a failure. The reason for this is twofold: many filters are not designed to remove such small particles and dynamic clearances (the separation between moving parts under operating load, speed and temperature) are typically in the one to five micron size range for most common equipment classes (see Table 1). Controlling contaminants in this range is critical since dynamic-sized particles can easily enter oil-wetted pathways, yet are large enough to cause cutting (abrasive) wear, premature fatigue failure and valve stiction issues.

Table 1

Typical Dynamic Lubricated Components	Clearances in Oil
Ring to cylinder *(engine)*	0.3-7 um
Journal bearing	1-100 um
Rolling element bearing	0.1-5 um
Gears	0.1-2 um
Servo valve *(spool to bore)*	1-4 um
Hydraulic vane pump	0.3-5 um

Particle contamination is usually expressed according to the ISO4406:99 standard. This standard reports particle concentrations in hydraulic fluids in three size ranges: particles > 4 microns, particles > 6 microns and particles > 14 microns. Based on the ISO4406:99 standard, Table 2 shows recommended target cleanliness levels for different types of common plant equipment.

Aside from particle contamination, water is the second most insidious contaminant. Present in most fluids, even in the most pristine environments, water can increase failure rates 10 to 20 fold, depending on the circumstances. Water causes problems in a number of ways. First, any iron or steel surface in contact with water will start to rust. This can induce premature failure due to corrosion, as well as introduce rust particles into the fluid. Second, water performs very

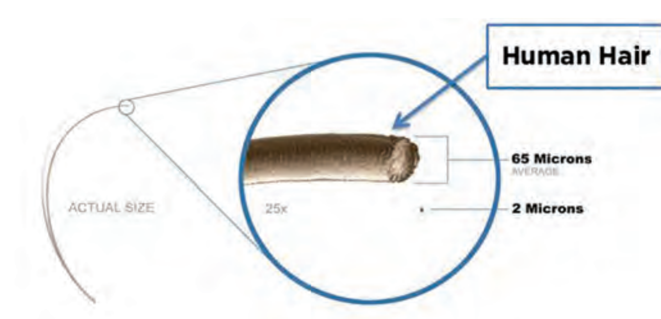


Figure 1: *Silt particles in the one to 10 micron size range are only less than 1/10th the thickness of a human hair, but cause five to 10 times the amount of damage as larger particles*

differently to lubricating oils under operating loads and speeds.

So how much water is too much? To a large extent, the answer depends on the type of equipment, the age of the fluid and the operating temperature. The reason for this pertains to the form that water takes in lubricants. Most fluids will hold a certain amount of water in the dissolved phase. For the most part, as long as the water remains dissolved, most water-induced problems will be minimal. However, as soon as the water comes out of solution and becomes free or emulsified, it becomes a very real concern. While highly temperature dependent, the saturation point of most conventional oils ranges from 100 ppm to 200 ppm for lightly additized oils, such as turbine oils, to as much as 500 ppm to 800 ppm for more heavily additized oils, such as gear oils. As such, water levels should be set accordingly to try to ensure that any moisture present is below the saturation point at all in-service temperatures.

Table 2 - Recommended Cleanliness Levels for Different Equipment Classes

Machine Type		Particle Level Target	Moisture Level Target
Hydraulics 1500-2500 psi	With servo valves	15/13/11	125 ppm
	With proportional valves	16/14/12	150 ppm
	Variable volume piston pump	17/15/12	150 ppm
	With cartridge valves or fixed piston pump	17/16/13	150 ppm
	With vane pump	18/16/14	150 ppm
Gearbox		19/16/13	300 ppm
Paper Machine		18/14/11	200 ppm
Steam Turbine		18/14/11	100 ppm
Pumps		17/14/12	150 ppm

Developing a Contamination Control Strategy

For those who believe in lubrication's own Pareto rule – 80 percent of problems are caused by the 20 percent of contamination issues – developing a plant or corporate-wide contamination policy should be a priority. While more complicated to execute, establishing the policy is very simple.

Step 1:* *Know how clean the oil needs to be

The first step is to know how clean and dry the oil needs to be. This is analogous to setting speed limits on a highway. Depending on ambient conditions and operating context, set target cleanliness and dryness levels that provide a reasonable surety that contamination-induced failures are unlikely to happen. Just like setting lower (tighter) speed targets (limits) in critical traffic zones (e.g., busy highway intersections, school zones, etc.), targets for oil cleanliness need to be adjusted based on the type of equipment, its criticality and the environment in which the machine is functioning. While driving at 5 mph over the limit is unlikely to induce a speed-related accident in a 55 mph zone, the further from the posted limit a car goes, the more likely a failure will occur and, in the case of driving, the greater the likelihood for a speeding ticket! Likewise, the probability of a contamination-induced failure increases dramatically the further away from the optimum target level for particles and moisture.

While Table 2 is a good starting point, targets should be set for each machine class based on the aforementioned factors, with the goal being to not exceed the limits set for particle or moisture contamination.

Step 2:* *Control contamination to levels below the target

Just like having the ability to control speed while driving, having a "brake" to control contamination is vital. To do this takes a two-pronged approach: exclude contamination at the source, then work to remove any contaminants if they get into the machine. To exclude contaminants, look at the total pathway that a lubricant takes from storage to handling and application to the machine. This includes pre-filtration of new oils, lubricant transfers using quick connects to avoid exposure to the ambient plant environment, and tanks and reservoirs that are properly sealed and using appropriate particle and desiccating breathers to prevent contamination ingress from air exchange between the machine head space and the ambient operating environment. Once everything has been done to exclude contaminants, filters and filtration systems need to be evaluated to ensure they are capable of maintaining the contamination control targets established for each machine. In doing so, it is necessary to try to balance filtration needs, making sure vents, breathers and filters are selected to achieve the established targets. Trying to maintain a critical hydraulic system to 15/13/11 or better with a standard original equipment manufacturer vent cap and 10 um filter is never going to happen!

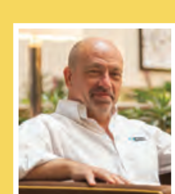
Step 3:* *Monitoring contaminants

Trying to effectively control contaminants without good data from oil analysis is like trying to drive within the speed limit without a speedometer. It's simply guessing (or hoping!) that the contamination control strategy is working. Good data requires taking proper oil samples from the correct location and having the lab perform the correct tests capable of detecting contaminants at low levels. This is particularly true for water contamination since many of the common tests used by labs to look for water are not able to detect water down to the levels identified in Table 2. Care should be taken to ensure that sample results indicate compliance with the target levels set and where no compliance is found, corrective action is taken to determine the root cause of the problem.

Putting It All Together

Based on the above, contamination control is as simple as 1-2-3, but even this simple approach can have a very dramatic effect on equipment reliability. Using a real-world example from a stamping press in an automotive plant, based on a high level of contamination in the stamping presses, the plant set about creating new targets for particle contamination. By installing proper breathers, sealing up reservoirs and installing kidney loop filtration, the plant was able to reduce overall contamination levels by an average of 93 percent to 97 percent within a few days!

Based on failure reporting, analysis and corrective action system (FRACAS) data, the plant was able to track downtime rates for lubrication-related issues before and after filtration with dramatic results. On average, the plant witnessed a 54 percent reduction in annualized downtime in the first six months after deploying new contamination control measures, compared to its average annual lubrication-related downtime for the three previous years. For this plant, the savings exceed $1 million dollars and getting there was as simple as 1-2-3!



__Mark Barnes__, CMRP, is Vice President of the Equipment Reliability Services team at Des-Case Corporation. Mark has been an active consultant and educator in the maintenance and reliability field for over 17 years. Mark holds a PhD in Analytical Chemistry. www.descase.com

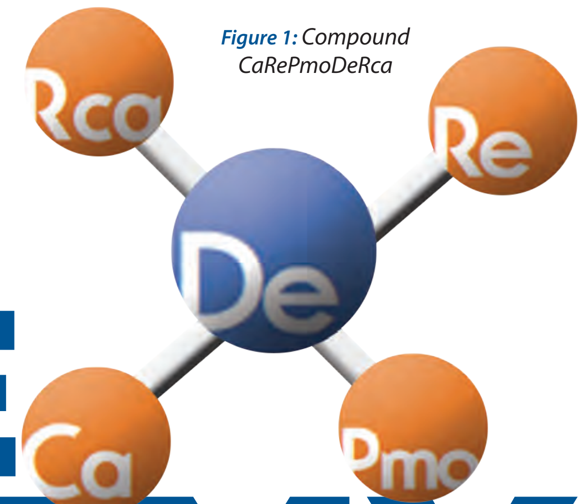
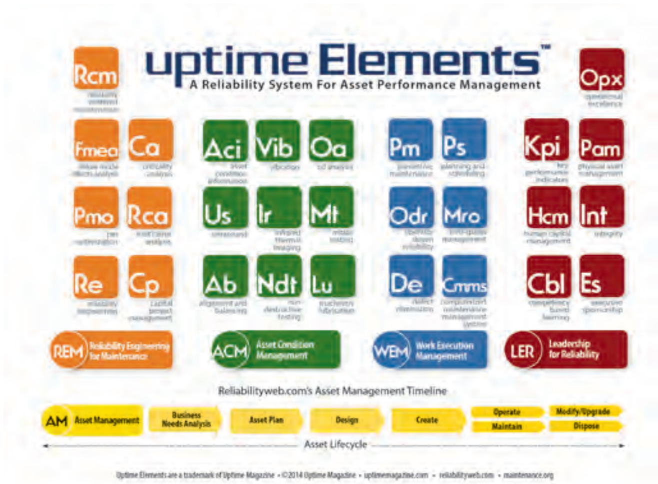


Figure 1: Compound CaRePmoDeRca

UPTIME ALCHEMY



Developing Compounds to Implement Sustainable Change

by George Williams

For many of us, the road to reliability has had many ups and downs. At times, we feel overwhelmed with the enormity of effort required to make a positive impact on our organizations. This is compounded early in our journey when we quickly realize how many tools, approaches and methodologies exist, and how many opportunities for improvement we have at our facilities. Trying to have the biggest impact we, at times, jump right to advanced methods. Many an effort has failed due to an advanced methodology being utilized without laying the basic groundwork required to ensure a sustainable success. We, as reliability professionals, need to understand the relationship and interactions of these approaches and provide a level of understanding throughout our organization. To that end, it is time to major in…cringe…shriek…wait for it…"Chemistry."

In many ways, reliability improvement efforts feel like chemistry to those within the maintenance and operations organizations without formalized training in all the elements that make up the asset management domain. People tend to shy away from unfamiliarity and can tune out if changes seem complicated.

The Uptime Elements (see chart above) and the Association for Maintenance Professionals Certified Reliability Leader (CRL) body of knowledge provide an understanding of each element contained within the asset management domain and serve as a guide to develop leaders within an organization. Encouraging the entire organization to attain the reliability leader certification can provide widespread awareness and empower the organization through knowledge and a common language. The more CRLs that are developed within an organization and the more widespread this awareness is, the more likely changes will be understood, embraced and sustained.

So how does becoming an Uptime alchemist help you achieve your maintenance reliability goals for 2014? As leaders, we can use the Uptime Elements periodic table to evaluate all the necessary elements to create improvement compounds aligned with our business goals. Visually recognizing the related elements and connecting them ensures that the elements necessary for success in our improvement compound are included. In addition, it takes the 29 elements and focuses your organization on the compound comprised of fewer elements, reducing the stress associated with too broad an approach. These compounds give you a visualized grouping of elements to enable a sustainable reaction, as opposed to a short-lived explosion.

To illustrate, let's look at some improvement efforts that typically end up as failed experiments. What happens when you implement precision maintenance without providing competency-based learning? BOOM!! What if you are looking to increase maintenance efficiency by installing a computerized maintenance management system (CMMS) without a planning and scheduling process? BOOM!! How about predictive maintenance program development without removing preventive maintenance (PM) tasks that address duplicate failure modes… BOOM!! Each of the above compounds ends with a not so desirable outcome and is seen as a failed experiment. These failed experiments result in a negative perception of leadership and a lack of enthusiasm for future efforts. This can cripple your reliability improvement efforts.

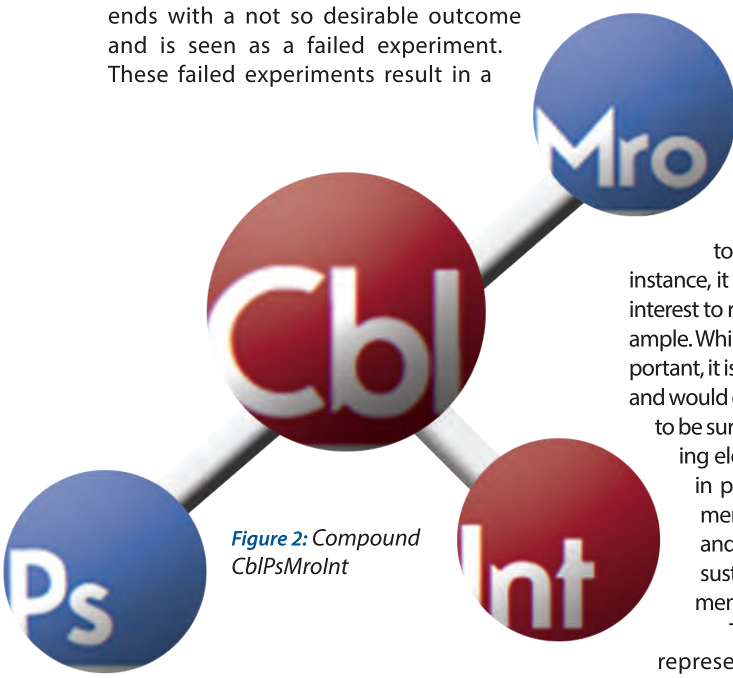


Figure 2: *Compound CblPsMroInt*

Utilizing the visual capabilities of the Uptime Elements periodic table and information contained within the body of knowledge, you can identify the elements necessary to create a successful compound. Let's look at some examples which, of course, can be modified to meet your organization's goals and current state of maturity.

See figure 1

Company Goal = Meet customer demand

2014 Maintenance Goal = Increased uptime on critical assets

Compound = **CaRePmoDeRca**

As each organization is different and on different levels of the reliability continuum, these elements can be modified to suit your needs. If you have already executed a criticality assessment, that element drops out, but perhaps you add operator driven reliability or reliability engineering and create a different compound for your 2014 goals. Let's look at another example.

See figure 2

Company Goal = Reduced cost to produce

2014 Maintenance Goal = Right first time maintenance

Compound = **CblPsMroInt**

Again, if you have a sound maintenance, repair and operations (MRO) process, you can eliminate that element or replace it with another element in alignment with your goals. Avoid elements in your compound that are not directly related to your goals to avoid confusion. For instance, it would probably not be in your best interest to replace Mro with Cp in the above example. While capital project management is important, it is not directly related to the 2014 goal and would distract focus. Additionally, you want to be sure you don't jump to higher functioning elements if the base elements are not in place. The objective is to match elements to your organization's 2014 goals and current maturity status to create a sustainable compound in a compartmentalized view of expectations.

This approach provides a visual representation on a common platform of understanding that empowers leadership throughout the organization through familiarity and knowledge.

Illustration by Anjelica Williams

***George Williams** is the Associate Director of Asset Management at Bristol-Myers Squibb Company. He holds a Masters degree in Reliability Engineering Management from Monash University, is a CMRP, and CRL. George also teaches for the University of Wisconsin's Maintenance Management Certificate program and sits on The Association for Maintenance Professionals advisory board.*

USERS of ENTERPRISE ASSET MANAGEMENT SYSTEMS WHO AND HOW IMPORTANT ARE THEY?

by Rejesh Gopalan

There are many factors contributing to a successful enterprise asset management (EAM) implementation, not the least of which is the strategic relation between IT and the business during an implementation or product development lifecycle. While synergy between IT and business strategies is essential, another core element is the EAM user's participation in the implementation and product development process. In fact, it's one of the most critical elements to a successful EAM system.

The EAM user community is unique compared to their counterparts, such as finance and supply chain management. They're not people who can be spotted behind a computer screen all the time, or those busy on their phones doing some price negotiations. Rather, they are out in the field most of their day. They are not computer savvy and very proud about this fact! Yet, they are the actual users of an EAM system, so it seems ironic that sometimes they get completely left out of the real action. They, to a greater extent, are detached from the IT stuff as opposed to their counterparts who occupy the top slots for any IT implementation decision-making process. When it comes to designing an EAM system of choice, the voice to put forth their ideas is the least.

As a real-life example, during a requirements gathering workshop for a business optimization program, Bob, a person in his mid-40s, turned up with a scribbled sheet of paper. He mentioned his manager insisted that he show up with the process map for the fleet maintenance department. At the time, the workshop was concluding, the clarifications and changes were all done, and sign off on the document was to be secured in the later part of the day. Bob's attendance was surprising, not because the document was in the form of a scribbled piece of paper,

EAM users, to a greater extent, are detached from the IT stuff as opposed to their counterparts who occupy the top slots for any IT implementation decision-making process.

but because of all the sessions he had missed already. When asked about the absence of representatives from the fleet division, Bob's response was, "We guys work!" It was pun intended! For many in the EAM user community, most of their days are spent at far off sites, let alone participating in IT meets. Meeting with the boss often takes place on the weekend, when team meetings would plan work schedules for the coming week. IT didn't work on weekends!

When an EAM software provider conducted a utilities amplifier solution, an application that leverages the inherent capabilities of the software and combines utilities best practices, the solution was well received by the likes of vendor teams, analysts and the business community. The functionalities, especially around efficient usability across multiple EAM roles, were very much appreciated during the demos and presentation. But the critical success factor of the solution was an "end user-input" element. So how did this happen? While being encouraged to critically evaluate core functionalities that would comprise the solution, each attendee was also encouraged to be very particular about having "a free mind" and donning that "user's hat," thinking through important aspects of a day in the life of various maintenance roles and the problems they face, and identifying solutions to optimally address them. The team working on the solution had this free mind when conceptualizing the functionalities and developed a working model out of it. This is something that normally does not happen in a regular EAM implementation or a product development process.

> While upgrades, enhancements, industry add-ons, etc., are emphatically discussed, what really matters is a system designed for a purpose.

It was a good thing that Bob turned up that day. The surprise was a pleasant one because the process maps made a lot of sense and aligned well with the organization's process optimization goals. While upgrades, enhancements, industry add-ons, etc., are emphatically discussed, what really matters is a system designed for a purpose. There needs to be a provision for the actual users to squeeze the system well so their functionality needs are addressed. This can only happen through effective user participation.

We need someone to corroborate jargons like reliability centered maintenance, key performance indicators, etc., with some quantifiable actions. If not, then EAM implementations would just get entangled into mystics of strategies. These users are tactical experts, people who breathe EAM functions day in and day out and who can give life to strategies. Let's give them a chance to participate and let's give them the feeling they are part of the system. Right now, EAM providers are actually missing them in the action and this needs to change!

__Rejesh Gopalan__ has a Bachelor's in Mechanical Engineering with work experience of over 11 years. As a Senior Consultant, Rejesh responsible for providing leadership in multiple Enterprise Asset Management projects involving end-to-end implementation, upgrades and application support. Currently, he's pursuing an MBA program in Engineering Management from Coventry University, UK. www.Infosys.com

Beginner at Project Management?

Here Are Some Learnings of 20/20 Hindsight

by Leo Faykes

In August 2012, our maintenance team made the decision to move forward with upgrading the bolt-on computerized maintenance management system (CMMS) program on our Unix-based legacy system to a more advanced product that offers modern asset management functionality, such as built-in key performance indicators (KPIs), a stand-alone database to reduce integration and data storage issues, and the ability to define assets in a true hierarchy, rather than the flat list of assets stored in the legacy system.

We had been running an earlier version of the bolt-on, but our end users and our business needs had outgrown the capabilities.

We had the functionality of our existing CMMS, which afforded us the luxury to manage the project in-house, thus avoiding the high costs of hiring consultants or a vendor implementation team. Looking back, here are some references to our project charter that may be valuable for those about to undertake a similar project.

Takeaway #1

The value of the project charter is not to be overlooked!

Simply typing "project charter" into a search engine can give you the basis to write one. If you have the knowledge to attain the certified reliability leader (CRL) or the certified maintenance and reliability professional (CMRP) designation, then you have the knowledge and capability to write one. What's important to take to heart is the value of the project charter once it is written. The value increases exponentially as your project moves along. The amount of front-end work that you do will help you and your team remain focused. Experience will teach you the following:

- You will need the support of your stakeholders at times, so be sure they are ALL identified.
- You will need to remind those stakeholders why certain details are important when asking for that support.
- Your communication plan should be detailed to your project scope.
- Identify not only the scope of work, but also the out of scope items that are foreseeable.

Takeaway #2

Identify all stakeholders. These are the people who will want you to succeed and will be resources when you need them.

The numbering system, description and details of your assets affect more than just the maintenance department. Accounting and the supply chain may or may not be affected by certain aspects of your registry, so conferring with them before you start should be considered. It goes without saying that operations should be represented for this process as well; they own the asset, it is maintenance's responsibility to ensure it is available when needed.

Takeaway #3

Develop a skills matrix required for your team members.

Selecting the team is a daunting task that requires careful thought. You are likely surrounded by people whom you've worked alongside and know to have the skills and personalities that you are looking for in team members. While it's convenient to quickly choose from your planners, supervisors and maybe some of your more experienced tradespeople, it's helpful to document the skills criteria required. It's important to know exactly what skills will benefit the project the most.

Developing the skills matrix ahead of time also gives you the opportunity to pinpoint the gaps that may be overcome with training to ensure you get the most from the people you want to include. Each of us can likely relate to the older tradesperson who is close to retirement and wants nothing to do with a computer, yet has all that valuable knowledge and experience locked up inside. As we moved forward through our objectives, we involved different people from respective areas and found that we had some hidden talents in our midst.

Takeaway #4

Involve not only the whole team when discussing the scope, have conversations with all of your stakeholders. They may see things that you've overlooked out of familiarity. Review it multiple times before committing to the scope.

Scope creep will happen! Yes it will, it will happen all over your carefully planned and laid out project, and when it does, it is your project charter that will be there for you to refer to. Not that the items that arise won't be important, in fact, they will likely be unavoidable. The more detailed your original scope is, the better you can plan your work and assign responsibility.

Having a communication plan in place ahead of time will make tasks more manageable as you move along. Considering that some people from your maintenance group may not be well versed in reliability centered maintenance (RCM), include other stakeholders, even if some of your reasons might not make any sense to them. A few PowerPoint slides explaining how the new maintenance software and process will benefit everyone in the end may be of use.

Takeaways #5, 6, & 7

a. Match your communication plan to your scope of work. Different tasks may require different plans.

b. Presentations detailed to the tasks of the project will reduce the 'flooding' of information' at one time.

c. Presentations at new milestones provide opportunity for motivation and review of successes.

Communicating the success of your milestones allows your team to celebrate their achievements and renews motivation for the tasks ahead. It also allows the rest of your maintenance people the opportunity to see the work being done that contributes to the overall acceptance of change.

Takeaway #8

Standardization! As always it is one of the watchwords of our business.

Standardization is one of the most important terms in RCM and with good reason. Each industry may have different terminology and even individual regions will have their own. What we needed to overcome was our own departments and, in some cases, our crews having their own terms. Where possible, we used regulatory standard terminology as it related to electrical and fixed equipment. However, that may differ from country, state or province.

Your asset hierarchy is a simple chain of parent-child relationships and referring to your own family unit will help outline a structure for you to visualize. Choosing your plant as the starting point, it's as simple as following the chain of children that your plant encompasses. Perhaps the most challenging aspect of this process is when you take into consideration that you are not only arranging the assets of a single fixed plant. The multiple examples of water treatment or power generation that can be found are, at first glance, no help when compared to having to include underground crushing/conveying systems, a fleet of mining equipment, milling operations and an underground power distribution system that rivals a small city.

The aha moment for us was when we realized exactly where our separation of hierarchy by physical and functional location began. Dividing assets into surface and underground is the obvious place to start. From there, it's simply a matter of breaking out your physical locations and then proceeding to break down your functional asset hierarchy within those locations.

With the conclusion of the hierarchy and asset criticality ranking stage of the overall CMMS project, we are now nearing the completion of the entire CMMS upgrade. Moving into the last stage of the project, the application of what we learned in the beginning phase about shareholders and detailed communication plans has allowed our efforts to progress much more smoothly. We are blitzing our job plans and BOMs using our existing planning teams and tradespeople and the value of skill assessment, and then tailoring the training has also proven itself for this type of project.

__Leo Faykes__, CMRP, CRL is CMMS Project Lead at Goldcorp Canada's Musselwhite Mine. He has 5+ years of Mobile Maintenance Planning experience prior to being selected to lead the CMMS upgrade project. He and his family live in a small town in Northwestern Ontario where they enjoy the outdoors year round.

OiL ANALYSiS AND ITS ROLE IN EQUIPMENT RELIABILITY

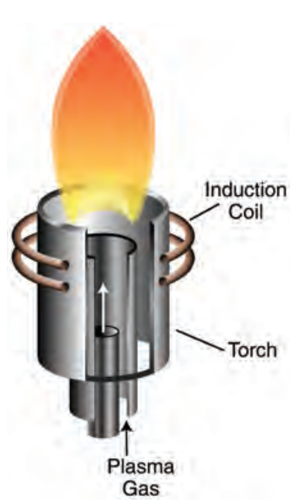
by Mike Johnson & Matt Spurlock

For decades, oil analysis has been considered a cornerstone for predictive maintenance programs in a variety of industries. If something rotates and requires oil to reduce friction between surfaces, then oil analysis is a great tool to diagnose machine condition. Over the past two years, however, focus on oil analysis as a reliability tool has waned. With several reliability trade shows having a noticeable absence of oil analysis related presentations, it begs the question: Why? Both as a topic of discussion in conference presentations and as an actual condition monitoring tool, oil analysis should, at a minimum, be proportionally represented alongside other condition monitoring tools and should be considered the primary tool for low speed and hydromechanical machines.

The condition-based maintenance strategies (e.g., preventive, predictive, proactive) rely upon effective use of technologies to achieve their promise of reduced cost and improved productivity. Vibration, thermography, oil and ultrasonic analysis, and motor current analysis seem to be the predominant analysis methods for electrical and rotating machines, but there is a lack of proportional balance in how these are implemented.

There are a multitude of technical presentations demonstrating the strong reliance on thermography and vibration analysis within the predictive and proactive maintenance strategies for mechanical systems. Again, there are plenty of presentations demonstrating thermography as a universally adopted technology for condition monitoring of electrical systems and components. One can easily find presentations related to ultrasonic assisted regrease methods, a clearly proactive approach to bearing lubrication, and the extensive benefits from this approach particularly for high-speed bearing applications.

Figure 1: Inductively coupled plasma energy source



Machine condition monitoring via sump sampling and oil analysis is represented less and less in conference presentations, yet it is the one technology that operates in multiple maintenance strategies. When utilizing a comprehensive test slate, oil analysis is able to identify the presence of primary root causes of failure before reaching point P on the P-F curve, predominantly from accurate contamination and fluid property monitoring. When the test slate adequately covers the monitoring of machine condition, the predictive strategy is then covered. It is a multifaceted and repeatable technology, but it isn't relied upon as "real" condition monitoring much beyond engine analysis.

We think the explanation is rooted in a lack of knowledge at the plant level. In this and the three upcoming articles in this series, we will present the specific correlation of each condition-based maintenance strategy to oil analysis and discuss the merits of multiple routine test methods as first-line approaches for determining machine and system health.

OIL ANALYSIS AS A PREDICTIVE MAINTENANCE TOOL

With the right test slate and frequency for a given machine/component, oil analysis should be able to readily identify an impending machine health problem. We'll start with the merits and deficiencies of multiple techniques to provide wear debris analysis.

The cornerstone of nearly all routine oil testing is atomic emission spectroscopy (AES), commonly referred to as metals testing. AES is the test that provides data to us, in parts per million (ppm), related to wear metals, lubricant additive metals and contaminant metals.

There are two common types of AES performed in oil analysis laboratories: inductively coupled plasma (ICP), as shown in Figure 1, and rotating disc electrode (RTD), arc spark, rotrode, as shown in Figure 2.

The basic premise of these instruments is the same: apply a high

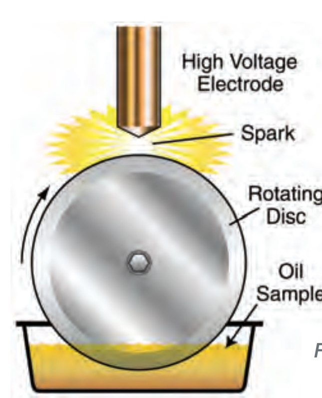


Figure 2: Arc emission energy source

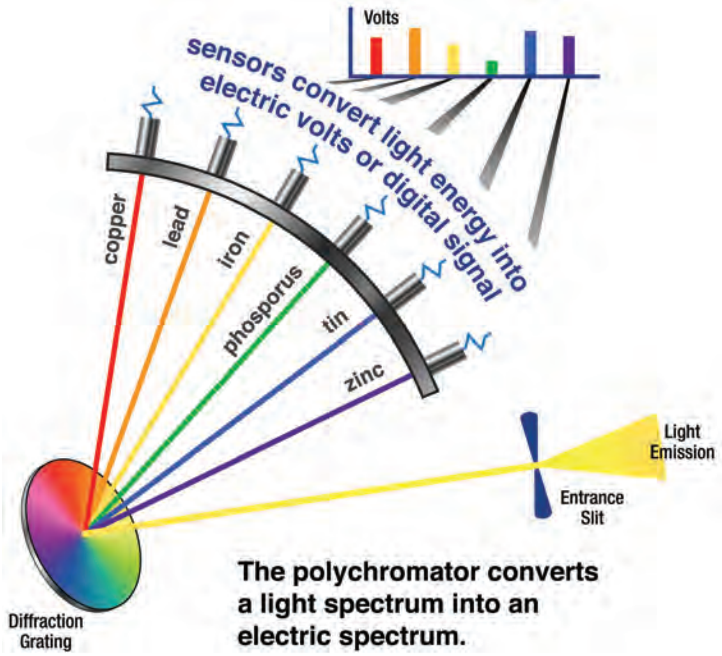


Figure 3: Wear debris analysis instrument function

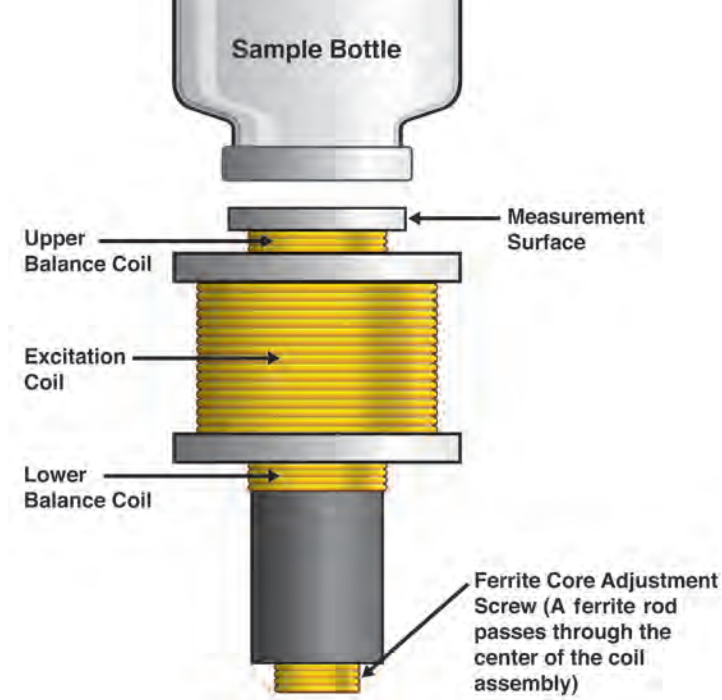


Figure 5: Schematic of the PQ Index Instrument (Courtesy of Jack Poley at Condition Monitoring International)

energy source to excite (vaporize) the atomic particles and measure the amount of light given off by these particles at different wavelengths, as shown in Figure 3. While there are some minor differences in the optics of these instruments, the primary difference is the source of the high energy. With ICP, arguably the most widely used method, the energy source is a plasma flame. With RTD, the energy source is a spark (think lightning bolt) delivered by a carbon electrode over a carbon disc.

Both instruments do a fantastic job at measuring particles that are very small. In fact, ICP has a very good accuracy level with particles up to about five microns in size. Accuracy is lost between five and eight microns, with the instrument being blind to anything above eight microns in size. RTD is accurate to about eight microns, loses accuracy at eight to 10 microns and is blind to anything over 10 microns unless advanced rotrode filter spectroscopy (RFS) is employed. This is important to recognize because as the wear state progresses over time, the particles become larger and larger, eventually becoming large enough to be beyond recognition by the instrument.

Accordingly, AES can provide only a small part of the data needed to fully understand the wear-related condition of equipment, particularly when realizing that normal wear debris is considered to be up to about five microns in size. This suggests that abnormal wear debris is likely to occur well beyond the detection limits of the cornerstone laboratory test instrument. As Figure 4 suggests, AES is good at characterizing changes at the benign wear state, in front of the P on the P-F curve. If changes are made to lubrication and operating conditions based on the low-level wear debris generation, then machine and component lifecycles can be extended, with all of the resulting benefits.

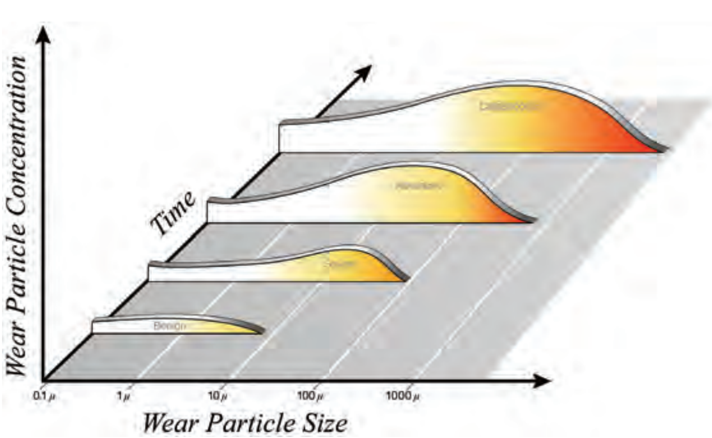


Figure 4: Correlation between time, wear particle size and wear particle correlation. (From "Wear Debris Measurement" by M. Johnson, Tribology and Lubrication Technology, May 2011)

To address the particles that will go undetected through AES metals analysis, other testing must be employed. The most relevant for ferrous (Fe) wear metals is the ferrous index. There are several ferrous index instruments available, but only a couple will be explained in this article as the technology will be similar to those not mentioned.

The first is direct reading (DR) ferrography. It takes the ferrous particles in an oil sample and separates them into two classes: particles <5 microns in size (DS) and particles >5 microns in size (DL). The two values derived from this test are referred to simply as index values. Both are unitless and serve simply as trendable data. It is easy to understand that if either value increases, then the equipment being tested is experiencing a higher degree of wear. The values of DS and DL can be used to calculate an overall wear particle concentration (WPC), as follows:

$$WPC = \frac{D_L + D_S}{\text{Sample Volume}}$$

The downside to DR ferrography is the testing process. Sample prep for this test requires a double dilution with a toxic chemical. Along with a manual data entry procedure, the cost of this test alone is on par with the cost of a particle count test. This has historically resulted in a perception that particle count and ferrous density on the same sample is cost prohibitive.

In order to offer a cost effective approach to ferrous density, many labs will employ the particle quantifier (PQ) index, as shown in Figure 5. The PQ index, like DS and DL, is simply an index value. The higher the value, the more ferrous metal is present in the sample. Unlike DR ferrography, however, PQ only has a single value. PQ is not sensitive to particle size since it is simply measuring a disruption to a referenced magnetic field. The amount of disruption is then calculated as the PQ index. The downside to PQ is that there truly is no separation of particle size. A single, large ferrous particle can offer the same PQ value as many smaller particles that could simply be normal wear debris.

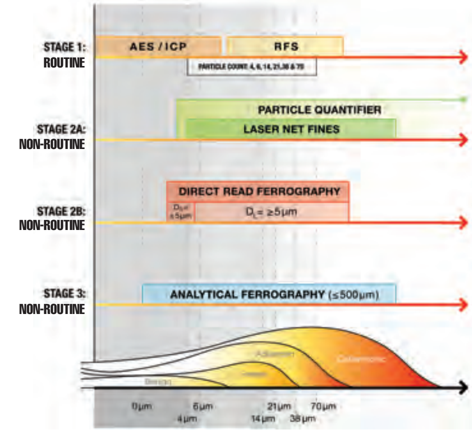


Figure 6: Wear debris analysis

When utilizing the ferrous index values in oil sample data interpretation, it is imperative that trending practices are followed. Trending ferrous index alone provides useful, but limited, insight to machine condition. An example of how ferrous density and metals analysis can be reviewed is seen in Table 1:

Test	ICP Iron	PQ Index
Oct 2013	13	7
Nov 2013	17	7
Dec 2013	24	12
Jan 2014	37	17
Feb 2014	42	22

As ICP-based Fe rises, PQ rises slowly, suggesting that the bulk of the ferrous wear is, indeed, very small in size.

Test	ICP Iron	PQ Index
Oct 2013	23	7
Nov 2013	27	15
Dec 2013	31	32
Jan 2014	35	47
Feb 2014	43	74

As ICP-based Fe rises slowly, PQ rises significantly, suggesting this component is developing large ferrous particles that are not getting detected with ICP.

Even with the increased level of confidence that PQ and AES metals analysis provide, another key test should be used to truly confirm that an impending issue is present.

Particle counting has historically been promoted as a means to measure contamination. While this is certainly the primary use of particle counting, that data also can be used as a confirmation tool of the presence of abnormal wear particles.

The current International Organization for Standardization (ISO) calibration standard for automatic particle counters is ISO11171. When a lab is using this standard for calibration, the reported values should be:

>= 4 microns
>= 6 microns
>= 10 microns
>= 14 microns
>= 21 microns
>= 38 microns
>= 70 microns

While the ISO code (particles ≥4, ≥6, ≥14 microns, respectively) is generally what gets monitored (and even all that is reported by some labs), the particle values at and above the 14 micron size can provide valuable insight to the potential size of ferrous particles being picked up by the PQ. Conversely, reviewing PQ data can help to confirm that a high particle count value at the larger ranges is a cause of abnormal wear, or a potential effect of abnormal wear.

By having all these tests performed on routine samples, early detection of failures high on the P-F curve is probable. Once a high level of confidence to an impending failure is established, then more advanced exception testing can be performed to determine the type of wear and potential location of wear.

One such exception test is visual determination. Visual determination within oil analysis gives meaning to the old adage that "a picture is worth a thousand words" in diagnosing equipment reliability problems. Visual determination is performed either through patch microscopy or analytical ferrography. Both methods result in reviewing the actual particle morphology through a microscope. With analytical ferrography, the focus is primarily on ferrous wear due to the slide preparation process. Some non-ferrous debris can be still observed as particles can fall randomly out on the slide.

With patch microscopy, a small volume of oil is run through a 0.8 micron filter patch. All particles larger than the 0.8 micron pore size are captured for review. This method allows for a visual check of all ferrous and non-ferrous particles in the oil sample, with the only bias being size.

With both methods of visual determination, the size, shape, color and rough estimate of volume of particles can be determined. Visual determination is primarily qualitative in nature. Using visual determination can help to really hone in on where and how a failure is occurring and what the root causes may be. While visual determination is a labor-intensive process, it provides the most detailed and accurate story about the machine from which the sample was drawn.

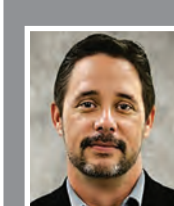
When the test methods are placed within the context of a wear mode and rate of wear, it is possible to see how AES (ICP and RFS/RDT), particle count and ferrography (PQ and DR) methods can present a holistic picture of changing machine health. Figure 6 reveals the strength of each relative to wear particle sizes.

SUMMARY

This is just a review of the primary tools used in oil analysis that allow machine owners to monitor machine condition. With a properly designed test slate that meets the reliability objectives for a machine, coupled with knowledge of alarm development and data evaluation, oil analysis can and should be the go-to tool for machine condition monitoring. Machine metals analysis is a uniformly popular starting point for sample-based testing. There are major strengths and weaknesses to the commonly used techniques. Some instruments are best for reporting the very earliest stages of component damage, while some are best for reporting symptoms of catastrophic, immediate pending and destruction. Once this is understood, a properly designed test slate allows the end-user to look at the machine's risk with a wide-ranging time line, revealing a continuum between immediate and very long-term risk quite effectively. When integrated with a solid vibration program, reliability improvement could be undeniable!

Images courtesy of Spectro, Inc., unless otherwise noted.

***Mike Johnson**, CMRP, CLS, has 22+ years of oil analysis experience including eight years in the United States Marine Corps where he utilized oil analysis for effective troubleshooting on Amphibious Assault Vehicles. Matt has written working procedures for oil sample testing, designed and managed multiple lubrication and oil analysis programs and has consulted in the fields of lubrication and oil analysis to various industries all over the world.*



***Matt Spurlock**, CMRP, CLS, has 22+ years of oil analysis experience including eight years in the United States Marine Corps where he utilized oil analysis for effective troubleshooting on Amphibious Assault Vehicles. Matt has written working procedures for oil sample testing, designed and managed multiple lubrication and oil analysis programs and has consulted in the fields of lubrication and oil analysis to various industries all over the world.*


TS-1X

10 things YOUR EQUIPMENT OPERATORS CAN DO TODAY TO IMPROVE RELIABILITY

by Doug Plucknette

There's no denying that the equipment that makes your products and the operators who operate it are the most valuable assets an organization has. So unless you are actually manufacturing product and putting it out the door, you are overhead. From the janitorial services to the CEO, you are just another additional cost that has to be included in the cost of the product.

So why, then, do our most valuable assets receive so little training, are swapped around like poker chips in Vegas, and are often expected to do little more than push a button and babysit the machine? Given this prevalent management philosophy, we then struggle to understand why our continuous improvement efforts fail to take hold and come to the conclusion that the equipment we purchased is junk and/or our people don't know how to operate it.

Well folks, it's time to wake up. Here are 10 things your operators can do today to improve the reliability of your equipment.

However, the reality is that while we expect our machines to perform precision work, we rarely apply precision techniques to our machines when it comes time to perform a product change.

1. KEEP IT CLEAN: There's a mountain of data that supports the fact that clean machines run significantly better. We need to give our manufacturing equipment operators time to clean their equipment and perform routine operator care tasks during each shift. These tasks need to be clearly identified with qualitative descriptions that give specifics regarding what type of cleaning agent, what type of cloth and what the area should look like when the task is complete. If this sounds a bit excessive, try this on one of your critical assets. In three months, you will definitely see a return on investment in increased productivity and reduced maintenance costs.

2. INSIST ON TRAINING: Trained equipment operators understand how their equipment works, know the performance standards they need to maintain so equipment operates properly, and know how to troubleshoot and address any problem they might encounter with their machine. Those without training fumble through the day; they know where three buttons are on the operator screen: stop, start and reset. They shut their machine down and contact maintenance for simple problems, and they struggle with product changes. If you are an equipment operator, you have to insist on formal training. Watching someone else run a machine for a couple of hours or days IS NOT formal training. Chances are, that person was never formally trained either. Insist for your own safety, because you love your parents, spouse, children, or friends. Operators who are not formally trained are much more likely to suffer a severe injury or fatality on the job.

3. STOP THE MUSICAL CHAIRS: The theory that we need to train all our operators to run every piece of equipment continues to cycle through the manufacturing community every few years. To any manager who believes in this foolish concept, here's a challenge: Put on some work clothes, take a month out of your busy schedule and try this out yourself. See what you can learn in a few days on each machine and decide for yourself if you feel confident in what you are being paid to do. Having your operators change machines on a regular basis makes about as much sense as it would to have NASCAR drivers drive someone else's car in the race each Sunday. It doesn't work well and, once again, it's not safe! As proof, operators should begin taking data regarding how effectively the machines run when we change operators. In the same way that automated equipment doesn't like to stop and start, operators are less effective in their work when they are required to change to a new machine. It's understandable to have a few people who can operate more than one or two machines, but these people are called team or line leaders.

4. LEARN STATISTICAL PROCESS CONTROL (SPC): The next step beyond learning how to operate your machine is learning when to make adjustments based on operating and product parameters. SPC is a very powerful tool used mostly by the folks who work in product quality, but it can be just as powerful, if not more so, when put into the hands of operators who are looking at learning more about the machine or process they operate.

5. GET SERIOUS ABOUT ROOT CAUSE ANALYSIS (RCA): RCA has been getting a bad name lately, with experienced operators using a simple 5 Why process and doing two or three RCAs a week, but nothing ever comes of them. In most cases, RCA is ineffective because the triggers are set way too low or people rush through the process and look for a single solution. Your lead operators or team leaders should be leading your RCAs and if you didn't find the correct solution, it's because you didn't identify all of the causes.

6. BRING PRECISION INTO PRODUCT CHANGE: More than half of organizations report struggling with product changes. Even stranger than this, the companies that do the most product changes tend to struggle the most. One would think if performing product changes was a daily part of your work schedule, you would naturally become good at them. However, the reality is that while we expect our machines to perform precision work, we rarely apply precision techniques to our machines when it comes time to perform a product change. Managers have somehow come to believe that using a permanent marker to make a black mark that is nearly one-fourth inches in width on a piece of sheet metal will result in a tremendously accurate product change. Make six other marks in different colors, don't label any of them and do this in six or eight different stations, then sit back in your office and wonder why your operators struggle at each product change. Operators should be vocal about bringing precision techniques into each product change; the use of jigs and blanks will go a long way in reducing the cycle time for product change and improve the precision to a point of one and done.

7. GET INVOLVED IN THE RELIABILITY TOOLS RCM AND TPM: If you are really interested in how your machine was designed and how it was intended to be operated and maintained, volunteer to become part of a reliability centered maintenance (RCM) or total productive maintenance (TPM) team. Both of these tools take operators to the next level. For example, operators who have participated in RCM analyses for critical machines report having a better understanding about how the equipment was designed to work and why it was critical to inspect and record things like pressures, temperatures and flows on each machine.

8. DRIVE DECISIONS WITH DATA: For some reason, those who work in the operations and maintenance departments believe if they complain long enough and loud enough about the problems their machines are having, then someone in management will finally do something about it. The reality is this thinking could not be further from the truth. If you want to see changes, you need to bring data to the table. In your job, you are surrounded by useful data. Each day you record useful data, but chances are that very little is done with that data. Learn the art of business by driving change through data supported decisions.

9. MAKE SAFETY FIRST: While some believe reliability and safety go hand in hand, the reality is reliability depends on safety. If your equipment is not safe, then it cannot be reliable. On the other hand, at plants where reliability is a big issue, the pressure is on operators to keep equipment up and running. This can result in operators cutting corners with safety to maintain throughput. It is important for everyone to understand that in order to have safe and reliable equipment, everyone has to do the right things when it comes to safety. Cutting corners on safety to keep equipment running doesn't help anyone and puts personal health and safety at risk. If you have been cutting corners on safety at your plant, do the right thing starting today – shut it off and demand that someone make it right.

10. FOLLOW THE CHECKLIST: If your job is to operate a piece of equipment – it doesn't matter if it is a Boeing 747, a chemical reactor, paper machine, steam turbine, or flour mill – you should be using a detailed checklist to start up the machine, shut it down, make sure it is fit for use, or perform a product change. The checklist wasn't created because someone thinks they are smarter than you or that equipment operators are dummies; the checklist was created to ensure we do our jobs in the correct order and sequence to guarantee safety and reliability. If you are still skeptical, think for a moment about how much training the average commercial airline pilot has to go through to become certified to pilot or co-pilot an aircraft. Does anyone doubt their intelligence? Yet each and every flight, the pilots go through a detailed checklist to ensure the aircraft they are operating is fit for use.

The best equipment operators enjoy their work, see the value in what they do and, quite often, have some great ideas on how to improve both processes and equipment. And they do this while working rotating shifts, often scheduled to work while their children and families get on school buses, or play in ballgames and concerts. Yet, when something goes wrong in the middle of the night, while engineers and managers are home sleeping, they are the first people we seek to blame for the upset.

The best equipment operators enjoy their work, see the value in what they do and, quite often, have some great ideas on how to improve both processes and equipment.

These top 10 items for equipment operators will improve the lives of everyone who work at a manufacturing facility. And for those who question the important work of operators and maintenance people, then perhaps they should try working at least three months of back-to-back rotating shifts to truly appreciate the sacrifices these people make to keep things running.

Doug Plucknette is the worldwide RCM Discipline leader for GPAllied, creator of the RCM Blitz Methodology, author of the book, "Reliability Centered Maintenance using the RCM Blitz Method," and Co-Author of the book "Clean, Green & Reliable." Purchase at www.mro-zone.com www.rcmblitz.com

AUTOMATE PERFORMANCE METRICS TO DRIVE PRODUCTIVITY

by Mohammad Naseer Uddin

Massive improvements in data storage and visualization techniques in today's age are changing how companies do business for improved profitability. Applying real-time data handling capability to automate performance metrics improves decision support by making better decisions faster. This article shares some examples of automated equipment performance metrics using real-time process data to make timely decisions for improved asset reliability.

EXAMPLE 1 – Dealing Proactively With Gas Turbine Performance Degradation

The two basic types of performance degradation mechanisms in gas turbines are non-recoverable degradation and recoverable degradation. Non recoverable degradation occurs from physical wear and damage to internal components and only can be recovered with major overhaul and repair maintenance. Most recoverable performance degradation in gas turbines is due to contamination and can be recovered by online/offline washing and air filter replacement/cleaning. Due to varying operating conditions at each installation site, the best practice is to initiate the mitigation action based on its condition instead of time based. Monitoring compressor discharge pressure is the most effective way to keep track of fouling. Utilizing real-time process data from a distributed control system (DSC) and data historian, a simple automated tool can be developed that effectively monitors engine compressor performance and triggers mitigation actions.

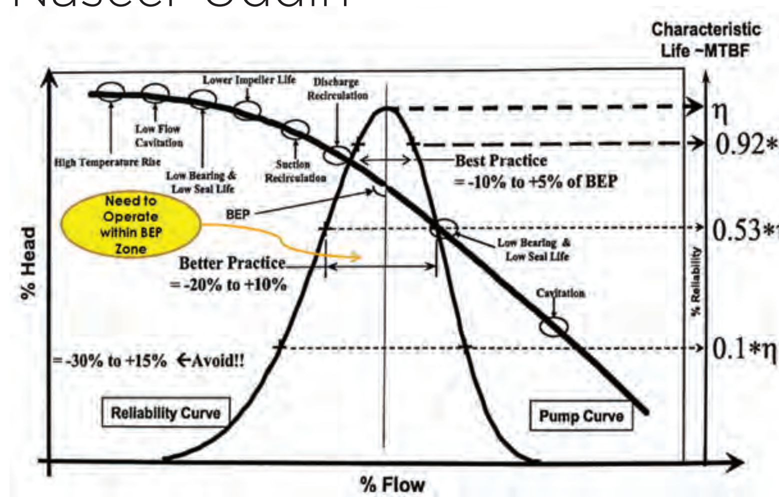


Figure 2: *Pump curve vs. reliability curve*

The automated tool calculates the actual pressure, compressor, discharge (PCD) variation percentage and trends it to monitor performance degradation. Mitigation action can be initiated at the right time, when the threshold of the PCD variation percentage of -5 percent is reached as per original equipment manufacturer (OEM) recommendation, thereby securing recoverable degradation.

EXAMPLE 2 – Pump Performance Monitoring to Maximize Reliability Uptime % Out of BEP Zone

Centrifugal pumps account for the majority of rotating machinery in process plants. It is often observed that the centrifugal pumps are select-

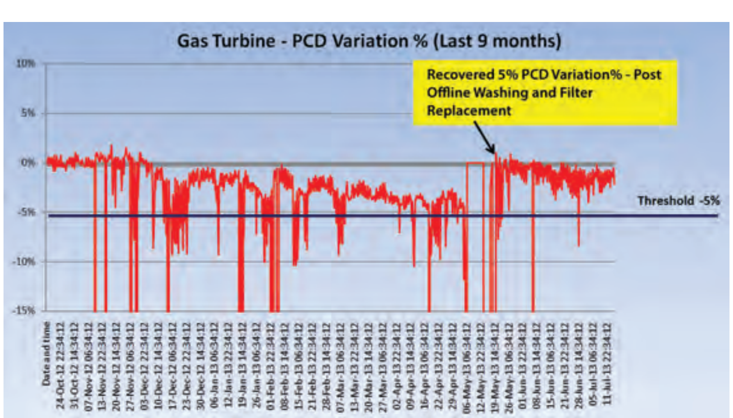


Figure 1: *Snapshot of gas turbine compressor PCD variation percentage trend showing pre- and post-performance improvement after condition-based maintenance activity*

LIFE CYCLE INSTITUTE

CHANGING BEHAVIOR TO PRODUCE RESULTS®

TRAINING SCHEDULE: JUNE 2014 - DECEMBER 2014

REGISTER NOW: 800-556-9589 | education@LCE.com | www.LCE.com

COURSE	WHO SHOULD ATTEND	YOU WILL LEARN HOW TO	DATES & LOCATION	DAYS/CEUs	COST
ISO 55000 for Leaders: Developing the Asset Management Policy	This 4-hour program is designed for senior leaders who are sponsoring an ISO 55000 initiative	Identify the benefits and clauses of the ISO 55000 standard, develop the asset management policy, and define roles and responsibilities for those involved in implementation.	Contact us to schedule a private onsite class.	½-day .4 CEUs	Contact us for pricing
ISO 55000 for Managers: Developing the Strategic Asset Management Plan	Leaders who are implementing an ISO 55000 initiative, including middle managers from across the organization	Identify the benefits and clauses of the ISO 55000 standard, develop the strategic asset management plan, and create a project plan for individual asset management plans.	Contact us to schedule a private onsite class.	2 consecutive days 1.4 CEUs	Contact us for pricing
ISO 55000: Creating an ISO 55000 Implementation Plan	Operations leaders who are implementing an ISO 55000 initiative, including middle managers from across the organization	Develop and draft an asset management policy for your organization, develop the strategic asset management plan, and create a project plan for individual asset management plans.	Jun 10-11, 2014 (CHS)	2 consecutive days 1.4 CEUs	$1,495
Lean Maintenance (Delivered by Joel Levitt)	All levels of maintenance personnel, including Supervisors, Planners, Managers, Engineers and Maintenance Workers	Effectively eliminate waste in maintenance operations and projects, and use tools and processes to create a Lean organization.	Aug 5-7, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Materials Management	Materials Managers, Storeroom Managers, Planner/Schedulers, Maintenance Managers and Operations Managers	Apply sound storeroom operations principles. Manage inventory to optimize investment. Understand the role of purchasing. Implement effective work control processes.	Sep 30-Oct 2, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Maintenance Planning and Scheduling	Planner/Schedulers, Maintenance Supervisors, Maintenance Managers, Operations Coordinators, Storeroom Managers and Purchasing Managers	Apply preventive and predictive maintenance practices. Calculate work measurement. Schedule and coordinate work. Handle common maintenance problems, delays and inefficiencies.	Jul 21-25, 2014 (CHS) Nov 3-7, 2014 (CHS)	5 consecutive days 3.2 CEUs	$2,495
Operator Care (Delivered by Joel Levitt)	Production Supervisors, Operations Managers and Personnel, Maintenance Supervisors and Personnel, Team Leaders, Lean Implementers	Improve production performance and asset reliability with an Operator Care program. Make data-driven decisions to create effective Operator Care tasks and achieve operational stability.	Sept 9-11, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Planning for Shutdowns, Turnarounds and Outages (Delivered by Joel Levitt)	Members of the shutdown or outage teams, planners, plant engineers, maintenance engineers	Save time and money on your next shutdown by learning how to effectively plan for and manage such large projects. Learn processes and strategies for optimal resource allocation.	Oct 28-30, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Predictive Maintenance Technologies (Delivered by Keith Mobley)	Plant engineers and managers, Maintenance, Industrial and Manufacturing Engineers, Maintenance Supervisors and Managers	Collect and analyze data to assess the actual operating condition. Use vibration monitoring, thermography and tribology to optimize plant operations.	Jun 24-26, 2014 (CL) Sep 9-11, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Problem Solving	Front-line Supervision, Quality Personnel, Team and Business Unit Leaders, Area Managers, Support Staff, Process Operators	Select and apply effective problem-solving methodologies and resolve problems that limit performance using five data analysis tools.	Aug 19-21, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Prosci® Change Management Programs	Executives and Senior Leaders; Managers and Supervisors; Project Teams; HR and Training Groups; Employees	Build internal competency in change management. Deploy change management throughout your organization. Become licensed to use Prosci's change management tools.	Contact us to schedule a private onsite class.	Sponsor: ½-day Coaching: 1-day Orientation: 1-day Certification: 3-day	Contact us for pricing
Reliability Engineering Excellence	Reliability Engineers, Maintenance Managers, Reliability Technicians, Plant Managers and Reliability Personnel	Learn how to build and sustain a Reliability Engineering program, investigate reliability tools and problem-solving methods and ways to optimize your reliability program.	Aug 19-21, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Reliability Excellence for Managers	General Managers, Plant Managers, Design Managers, Operations Managers and Maintenance Managers	Build a business case for Reliability Excellence, learn how leadership and culture impact a change initiative and build a plan to strengthen and stabilize the change for reliability.	SESSION 1 DATES: Jun 10-12, 2014 (CHS) Sep 16-18, 2014 (CHS) (Sessions 2-4 dates are available on the website)	12 days total (4, 3-day sessions) 8.4 CEUs	$5,995
Risk-Based Asset Management	Project Engineers, Reliability Engineers, Maintenance Managers, Operations Managers, and Engineering Technicians.	Learn to create a strategy for implementing a successful asset management program. Discover how to reduce risk and achieve the greatest asset utilization at the lowest total cost of ownership.	Sep 23-25, 2014 (CL) Nov 4-6, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Root Cause Analysis	Anyone responsible for problem solving and process improvement	Establish a culture of continuous improvement and create a proactive environment. Manage and be able to effectively use eight RCA tools to eliminate latent roots and stop recurring failures.	Jul 29-31, 2014 (CL)	3 consecutive days 2.1 CEUs	$1,495

*LOCATION CODES: (CHS) = Charleston, SC | (CL) = Clemson University | (UA) = University of Alabama

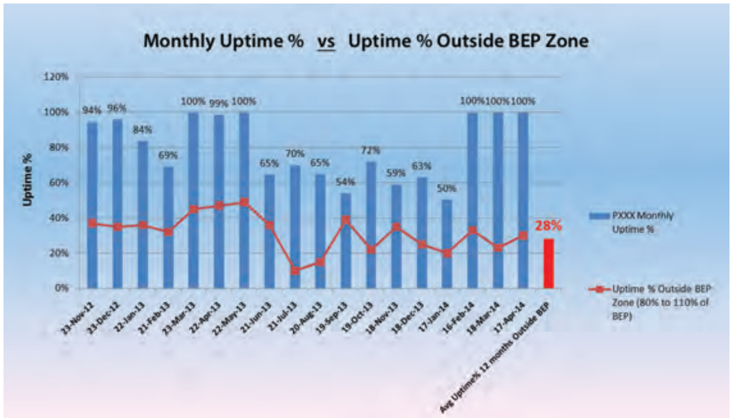


Figure 3: *Snapshot of automated pump uptime percentage vs. uptime percentage outside BEP zone*

ed oversized to accommodate higher capacities. Fixed speed centrifugal pumps have a fixed best efficiency point (BEP) that coincides with delivering highest reliability. Continuous operation of a centrifugal pump far away from BEP affects pump performance and shortens pump life. Running multistage, high energy pumps <3000 kW at 30 percent BEP could reduce pump life by 50 percent.

Utilizing process data from the data historian, a simple, automated tool can be developed that could effectively monitor the pump's uptime percentage out of the BEP zone (i.e., 80 to 110 percent of BEP). If the plot shows the pump operated out of BEP zone most of the time, that would reduce pump life. Accordingly, the reliability engineer can take necessary mitigation action to bring the pump within the BEP zone for long-term reliable operation.

EXAMPLE 3 – Variable Speed Pump Operating Envelope

The real-time information from the data historian can be utilized to monitor the operating performance of variable speed pumps to take timely mitigation action.

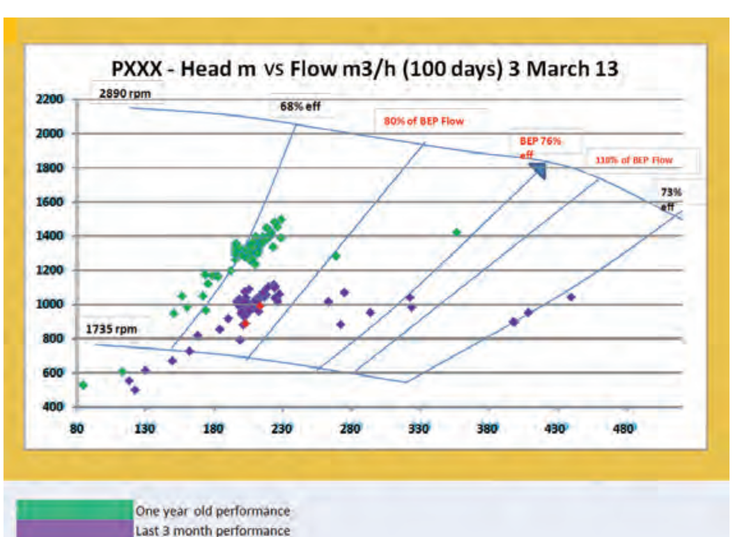


Figure 4: *Snapshot of real-time operating envelope for a variable speed pump*

EXAMPLE 4 – Monthly Uptime % and Uptime % Rolling Trend

Automating the monthly uptime percentage graphically shows the monthly run hours performance of the assets. A lower uptime percentage can be investigated for critical assets for reasons of downtime (e.g., planned, unplanned, standby, etc.) to take necessary actions. Long duration standby machines (more than three months) can be easily picked to follow up on periodic test runs to identify and fix hidden failures.

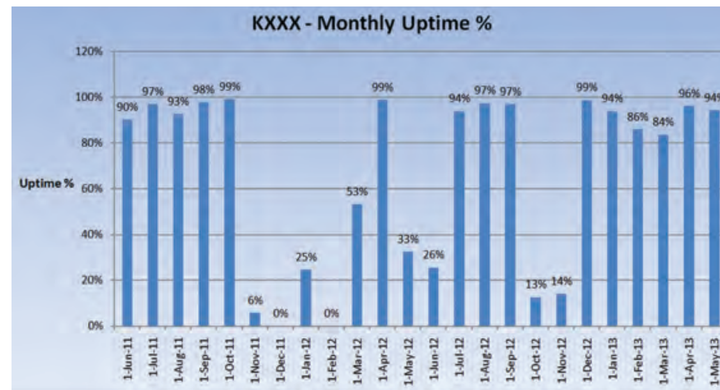


Figure 5: *Snapshot of automated monthly uptime percentage for a compressor*

An uptime percentage rolling trend graph demonstrates the uptime performance trend of the asset, indicating whether it is improving or declining.

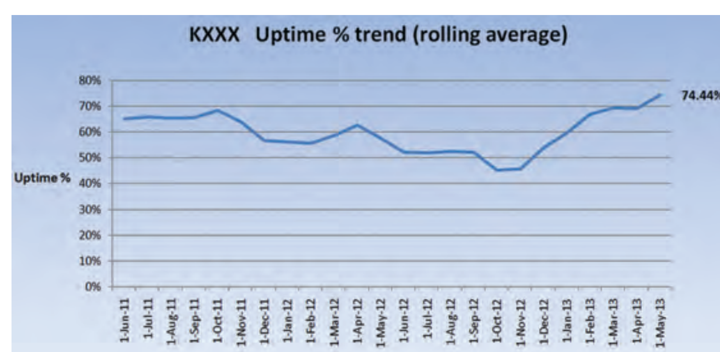


Figure 6: *Snapshot of automated uptime percentage trend for a compressor*

EXAMPLE 5 – Monthly Trip Rate (Number of Restarts/Month) and MTBT Trending

For machines with higher uptime and running within BEP zone most of the time, if they have frequent trips followed by restarts, this also would be a threat to reliable performance. Examples include the risk of increased failure rate of mechanical seals in centrifugal pumps and thermal shock degradation of gas turbines. An increasing trip rate is an early warning sign of deteriorating performance. It's an important metric to be monitored for ensuring long-term reliable operation of critical machines. If equipment stoppages are the main cost drivers for the operation, then mean time between trips (MTBT) trending is better than absolute readings.

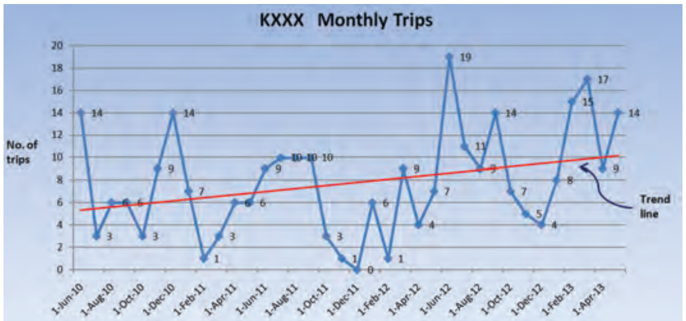


Figure 7: Snapshot of automated monthly trips for a compressor

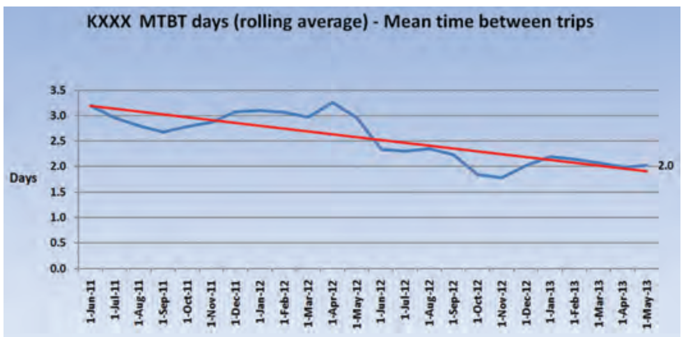


Figure 8: Snapshot of automated MTBT trend for a compressor

Benefits of automated real-time performance metrics

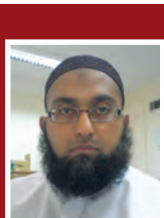
- Automated performance metrics enhance monitoring capability for early detection and mitigation of potential failure modes, allowing efforts to proactively focus on problem areas.
- Real-time performance monitoring helps in optimizing maintenance activities by reducing or eliminating unnecessary maintenance intervention for equipment with good performance history.
- Real-time reporting supports condition-based maintenance by ensuring that maintenance is carried out only when necessary and convenient.
- Analytical visualization of real-time data gives necessary information to take needed mitigation action quickly and at the right time.
- Automated reporting saves manual data collection time to do more productive work and also eliminates the chance of human error in manual data recording.

Conclusion

The nice thing about automating performance metrics is that it doesn't require spending a lot of money to implement it. It just requires utilizing data that already exists and intellectual resources available in your organization to explore many hidden opportunities that drive productivity.

References:

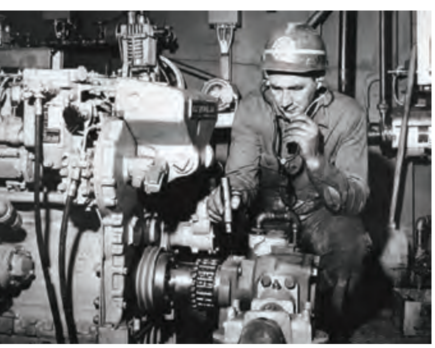
Beebe, Raymond S. *Predictive Maintenance of Pumps Using Condition Monitoring*. Waltham: Elsevier Science, 2004.



***Mohammad Naseer Uddin**, CMRP, MLA-II, is the Senior Reliability Engineer with Petroleum Development Oman. He has more than 19 years of experience in the Oil & Gas industry, has worked with reputable companies in the Middle East (Oman and Qatar) in the field of Maintenance, Reliability and Project Commissioning. He is currently based in Muscat, Oman.*

Machinery HEALTH MONITORING

This is Part 5, the last installment of the five-part series entitled, Machinery Health Monitoring Depends on Accelerometers. Part 1 covered the mechanical aspects of selecting and using accelerometers, while Part 2 presented the electronic aspects of dealing with those small signals. Part 3 addressed calibrating accelerometers to determine their sensitivity. Part 4 started and Part 5 concludes with seeing accelerometers attached to various machines so they can report on machinery health. The goal of the series is to assist newcomers and those considering machinery health monitoring.



by Wayne Tustin

Machinery Health Monitoring (MHM)

"Young Charley" (photo above) in Part 4 (April/May 2014) is gone and now his job is being done with vibration sensors (accelerometers), computers, etc. We call this procedure condition monitoring (CM), condition-based maintenance (CBM), or machinery health monitoring (MHM). The general idea behind CM/CBM/MHM is:

1. Costs are high when no maintenance is done, as shown in the left peak in Figure 1. We run machines until they fail and replace machines as needed.

2. Costs are high when we maintain on schedule (preventive maintenance), whether anything is wrong or not. Too often, disassembly and reassembly create damage. That's the right side peak in Figure 1.

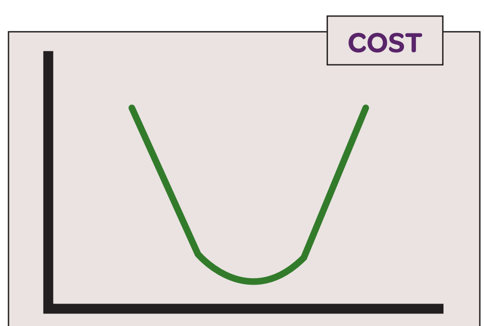
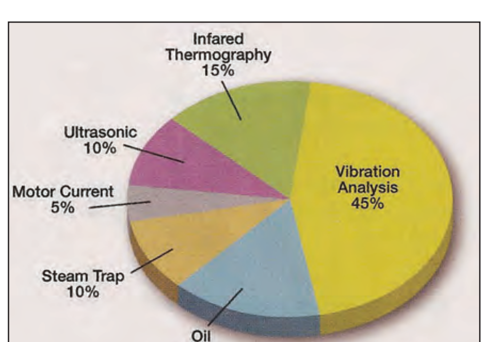


Figure 1: Concept of CBM/MHM



3. Costs are lower when we maintain only when a known need exists, as the dip in Figure 1 reflects.

How do we know when need exists? Lacking "Young Charley," we must use more modern (often computer-based) warnings and diagnoses. Figure 2 mentions some of the techniques. Vibration warning and diagnosis is popular and is our focus here.

In MHM, we basically compare today's vibration spectrum (or "signature") with other spectra obtained using the same instruments at the same locations last week, last month, or last year, or when the machine was first installed or immediately after an overhaul. We try to deduce internal changes (deterioration) from changes in the spectrum.

Figure 2: Predictive maintenance tools (Image courtesy of Lindsay Engineering & Electronic Products magazine)

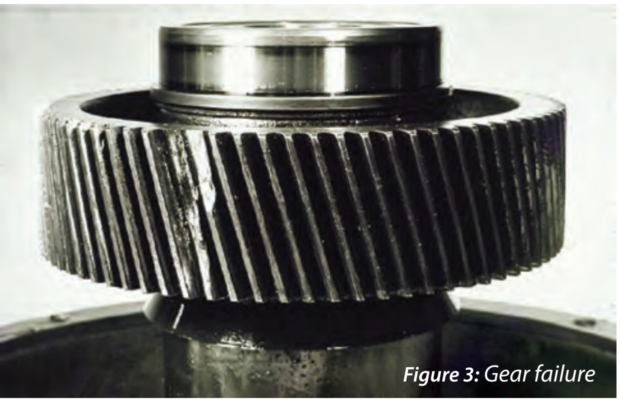


Figure 3: Gear failure

The goal of MHM is predictive maintenance. We want to be warned when overhaul or replacement of worn or damaged parts is becoming necessary.

As tooth condition deteriorated in the gear shown in Figure 3, the machine's vibration signature changed, alerting maintenance that overhaul was necessary on the next weekend shutdown. Replacement gears and other parts were procured by Friday afternoon. That plant was lucky. Had the gear failed, the plant would have had an unscheduled shutdown at a cost of millions of dollars per day.

Digital Recording Useful

Could that change if vibration had been detected by the oversimple readout instrument suggested by Figure 4? No. Nor by the combined sensor and readout of Figure 5.

Overall vibration, as displayed on any meter, would probably not change very much. The signature, the vibration spectrum, is needed to reveal subtle, but significant changes. To whom? To trained personnel, to a highly specialized analyzer, or to a specially programmed computer.

We have replaced "Young Charley" and his stethoscope with more modern data collectors, which usually contain digital recorders cable-connected to an accelerometer. These are carried from machine to machine, perhaps monthly, so each machine's signature is recorded on schedule. Next, all machines' signatures are downloaded into the maintenance department computer's larger memory for storage and later comparison with earlier signatures. Spectral changes alert maintenance personnel to possible problems.

Figure 4: Ordinary voltmeter is of little value for MHM

Figure 5: Indicator containing accelerometer (Photo courtesy of IDCON)

Figure 6 shows Equipment Reliability Institute (ERI) student Kevin White measuring vibration on an idler gear bearing of a Minton dryer at Fletcher Challenge Canada's Crofton Pulp Company. Crofton's predictive maintenance program includes analyzing dryer felt and dryer bearings for faults.

Shafts turn slowly here: 24 RPM to 45 RPM. High temperature (+300° F on dryer bearings) vibration sensors are permanently installed and hardwired to monitor 100+ inaccessible bearings. (Drive gears prevent easy access to bearing locations.) Data is gathered at five junction box locations.

Personnel Safety

Instead of climbing over greasy surfaces 30+ feet above the ground, analysts (see Figure 7) use nine, permanently mounted accelerometers to gather data from important, but inaccessible points. Accelerometers are wired to a junction box. Analysts simply turn a switch at the box to cycle through the sensors. They monitor additional accessible points using magnet-mounted sensors and a handheld data collector. In total, they monitor up to 50 data points on a medium-sized press and up to 80 points on a large press. Stud-mounted sensors are installed on seven of the 14 forge hammers at the Tonawanda Forge, Tonawanda, New York, plant of the American Axle and Manufacturing Company. In Figure 7, a near molten billet is about to be stamped into a net-shaped gear assembly for a major automaker.

Let's eliminate the walk-around job. Rather than carry the data collector and accelerometer from machine to machine throughout a large factory, let's permanently attach accelerometers, and possibly other sensors, to vital machines. And let's permanently install cables between all accelerometers and the central maintenance computer.

Figure 6: Checking paper production machinery (Photo courtesy of Crofton Pulp & Paper, Crofton, BC, Canada and Wilcoxon Research, Gaithersburg, MD. Photo by Douglas Schwartz)

Figure 7: Forging hammer vibrations (Photo courtesy of IMI Sensors, division of PCB Piezotronics, Depew, NY)

Figure 8: Wireless sensor

Figure 9: Concept of a wireless sensor system (Image courtesy SKF)

Is this costly? Yes. Permanent wiring also makes it difficult to move machines to other locations. Or a vehicle may need monitoring. In these situations, go wireless. Consider Figures 8 and 9 using wireless radio links between the machines and the central maintenance computer.

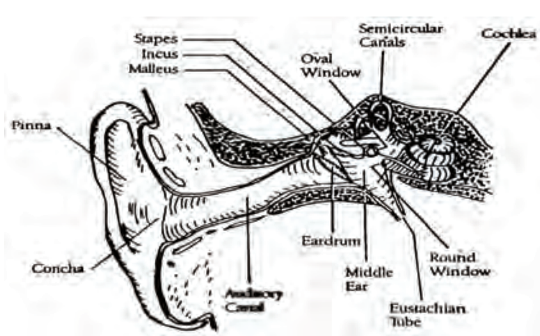


Figure 10: Spectrum analyzer in cochlea

At the left in Figure 9 is a 2.4 GHz transceiver connected to two sensors. Batteries are drained only when the transceiver is interrogated. At right is a base station, which receives signals from up to 32 transceivers. The base station connects into the RS-232 port on the maintenance department's computer.

Energy Harvesting

The frame of an active machine is where sensors are attached to detect motion. At certain locations on that machine, there must be dynamic strain. Development work, mostly piezoelectric, is underway to harvest energy from that strain to keep batteries charged.

Web Access

One expert is able to examine signatures and trends from a remote location, possibly from another continent. This expert can serve several plants, saving much travel time. The machines can alert this person when a problem arises. He or she can interrogate any machine of concern and, if necessary, dispatch parts and skilled labor to arrive within 24 hours.

Spectrum Analysis

MHM provides us with a good reason to learn about spectrum analyzers and spectrum analysis beyond the scope of this series. Over the past 50 years, as machinery speeds and vibration frequencies have increased, early analyzers have become technically obsolete, although many are still in use.

Think for a moment about the two spectrum analyzers each of us carries in his/her head – the cochlea, as shown in Figure 10. Quoting Richard D. Lee's letter to *Electronic Design* magazine, "The inner ear has resonant fibers in the cochlea that stimulate attached nerve endings at a level corresponding to the fiber response amplitude. An array of nerves scans the outputs from these fibers and develops what amounts to a Fourier transform of the received sound. If a single frequency is received, only one fiber has a max response. The array locates it and reports that to the brain."

Consider the similarity of the mechanical spectrum analyzer in Figure 11. Here, the slight vibration of a slightly unbalanced motor shaft running at 1,750 RPM is sensed. One particular reed, having an fn of 1,750 cpm, responds.

Figure 11: Mechanical spectrum analyzer

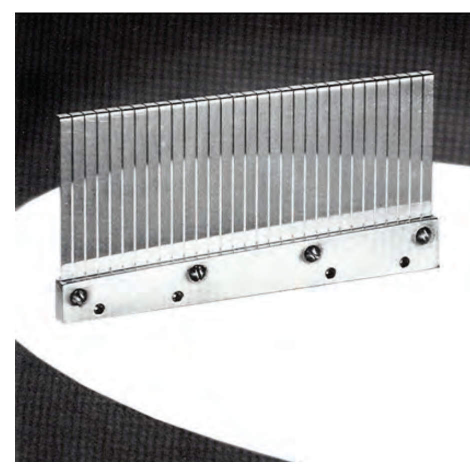


Figure 12: Array of reeds

An array of reeds is seen in Figure 12. Individual reeds are hand-tuned by filing. The multi-reed mechanical spectrum analyzer might be considered a parallel analyzer. Each reed continually monitors a given slice of the mechanical spectrum.

***Wayne Tustin** is founder and president of the Equipment Reliability Institute (ERI) in Santa Barbara, California. ERI operates worldwide, though Wayne, now 91, has cut back on overseas travel. Wayne has authored a 33 iBook series, available at Apple Bookstore's http://goo.gl/xNWC49. Several expand upon the five parts in this Uptime series. Book #1 is free. www.equipment-reliability.com*

Q&A with an Industry Leader

Nick Jize

Recently, *Uptime* caught up with Nick Jize, Facility Operations Maintenance Manager at the National Ignition Facility (NIF) in Livermore, California. NIF is home to the world's largest and highest energy laser, as well as 192 of the most powerful lasers in the world. Nick has more than 20 years experience in RCM and predictive maintenance leadership.

Uptime: As the reliability manager, what are your primary areas of responsibility at NIF?

Nick Jize: I am the facility and operations manager at the NIF. In my role, I ensure all conventional facility equipment and utilities are ready for laser shot operations on a 24/7 basis. NIF uses 192 of the world's most powerful lasers to focus energy on a target the size of a peppercorn in an effort to ignite a fusion reaction.

This facility is a very complex machine with interdependencies between virtually every system. As an example, if the HVAC system temperature varies by more than 0.25 degrees F within a span of 30 minutes, it could cause misalignment of the laser with significant operational delays. In a facility the size of three football fields, holding this temperature specification is one of our daily marvels.

Uptime: With the high tech equipment utilized at the NIF, what type of preventive/predictive practices do you have in place to ensure the equipment all performs reliably?

Nick Jize: We are using vibration analysis to assess the health of our critical pumps and motors in order to mitigate failures and plan for repairs with as much notice as possible. We also use our vibration analyzer to perform precision alignment and balancing whenever we replace motors or fans. We also use oil analysis to monitor the health of our pumps and as a way to confirm any diagnoses from our vibration analysis data.

We use ultrasonic lubrication for all our rotating equipment. This technology alone has doubled the mean time between failures of our bearings. In addition, we plan on using our ultrasonic device for electrical cabinet inspections.

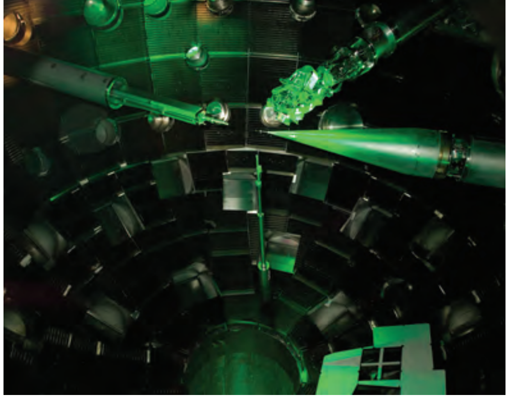
Uptime: What types of root cause analysis and/or reliability centered maintenance (RCM) analysis do you utilize?

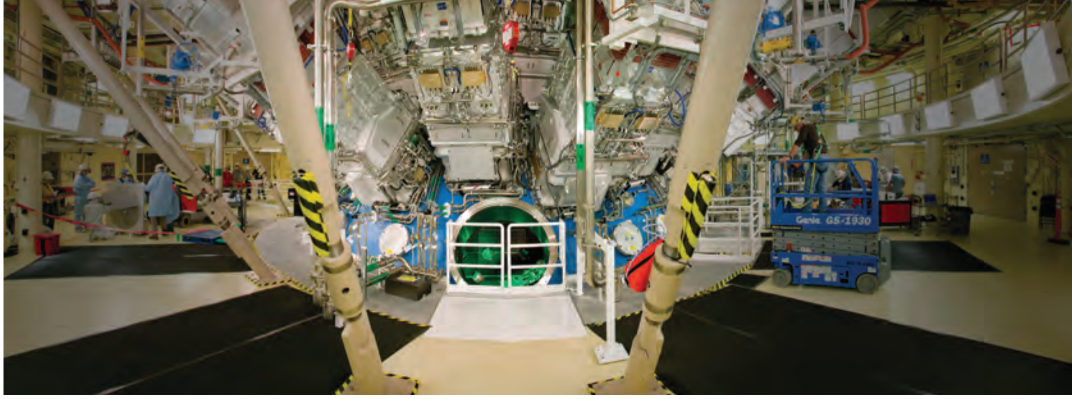
Nick Jize: We use classical RCM for our 80/20 systems; that is any system that is causing the majority of recorded downtime or requiring a majority of our resources to maintain. For the other 20/80 systems, we use either an abbreviated classical approach of experience centered maintenance (ECM).

Our field technicians are a critical part of the analysis process. We have found that their input is a substantial part of our decision process. In addition, it helps them understand the required functions of each asset, the consequences of the failure modes and why they are performing the preventive maintenance that results from the analysis.

Uptime: With NIF being a secure site, do you have problems planning and scheduling maintenance/reliability work and meeting the security requirements?

Nick Jize: Security issues rarely create any scheduling problems for us. Our biggest planning and scheduling challenges are access to the facility between laser shot campaigns. We usually get around this by planning all our work a week ahead of time and coordinating with shot directors to understand where we can fit in our work. In addition, the facility has two days a week that are dedicated to maintenance.





***Clockwise from top left:** Inside of NIF Target Chamber, showing target positioner and several alignment diagnostics; NIF Target Chamber View Port; Exterior of the National Ignition Facility at Lawrence Livermore National Laboratory; NIF Laser Bay 1, showing a portion of the 192 laser tubes heading to the target chamber*

It takes over a year for newly hired individuals to understand the impacts of system shutdowns and failures on the overall facility.

Uptime: With the high tech equipment that you have at the NIF, do you have problems recruiting properly skilled maintenance personnel?

Nick Jize: Although the project is high tech, our conventional facilities, equipment and maintenance needs are fairly standard. The difficulty arises with the interdependencies of all the systems and the exacting specifications that we have to meet. It takes over a year for newly hired individuals to understand the impacts of system shutdowns and failures on the overall facility.

On the other hand, our beam line equipment is not conventional and very unique. Precision maintenance and cleanliness are of critical importance. Laser optics have to be swapped out frequently due to the damage created by the high powered laser. These operations require highly trained technicians.

Uptime: Do you have an internal training program for the maintenance technicians? If so, could you give us an idea of what some of the training involves?

Nick Jize: We have a maintenance "qualification card" that outlines all the skills needed for the various tasks being performed. Technicians need to read and understand a system level maintenance plan before they are qualified to work on a system and they also must be trained by other qualified technicians. Technicians must then demonstrate their proficiency and knowledge to the engineering subject matter expert (SME) responsible for the system.

Uptime: What performance metrics do you use to evaluate your maintenance program?

Nick Jize: Our most important metric is the preventive maintenance (PM) to reactive maintenance (RM) ratio. We try to maintain a ratio of four or better and use that to adjust where our resources are spent. Initially, we had to do significant training so our engineers understood the difference between corrective (planned) maintenance and reactive (unplanned) maintenance.

On time PM performance is another very important metric we have been able to use to justify to management when we need additional resources. We define on time as the work being completed within 10 percent of the periodicity of the PM. For example, a 30 day PM has to be completed within 33 days of the previous PM and a 180 day PM within 198 days, and so on.

Uptime: What is the next development for your maintenance program?

Nick Jize: We are currently working on going mobile with our maintenance procedures. We believe this will allow our technicians to directly enter data into our computerized maintenance management system (CMMS) and alert SMEs about any issues they see in the field in almost real time.

Lawrence Livermore National Laboratory is operated by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy, National Nuclear Security Administration under Contract DE-AC52-07NA27344.


Earn Professional Certification
Increase your value
IMC 2014
The 29th International Maintenance Conference
Save the Date!
December 8-12, 2014
Hilton Daytona Beach Ocean Walk
Daytona, FL
imc-2014.com | 888.575.1245 | 239.333.2500
It's OK to Have Fun!

IF JUST THE IDEA OF
CONTAMINANTS
MAKES YOUR SKIN CRAWL,
IMAGINE WHAT THEY DO TO
YOUR SYSTEM'S
PRODUCTIVITY.
Effective contamination control will keep your industrial equipment operating at peak efficiency. And it all starts with the proven team of lubrication engineers at Des-Case, with more than 75 years of practical experience working for you—with the training, consulting services and local distributor support necessary to keep your equipment up and running.
615.672.8800 | DesCase.com
Count on Des-Case.
DES-CASE™
Keeping Contamination Under Control.®
© 2014 Des-Case Corporation