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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.	Oct 22-24, 2013 (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.	Aug 5-9, 2013 (CHS) Sep 23-27, 2013 (HOU) Nov 4-8, 2013 (CHS)	5 consecutive days 3.2 CEUs	$2,495
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 1-3, 2013 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Predictive Maintenance Technologies	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.	Oct 8-10, 2013 (CHS)	3 consecutive days 2.1 CEUs	$1,495
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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.	Sep 24-26, 2013 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Reliability Excellence Fundamentals	Personnel involved in applying or are impacted by Reliability Excellence, and people who influence business process improvement.	Experience the fundamental concepts of Reliability Excellence in order to drive performance improvement efforts within your organization.	Sep 10-12, 2013 (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: Aug 13-15, 2013 (CHS) Oct 8-10, 2013 (CHS)	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.	Aug 13-15 2013 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Root Cause Analysis	Anyone responsible for problem solving and process improvement	Eliminate latent roots and stop recurring failures once and for all. Learn a process to establish a culture of continuous improvement and create a proactive environment. Manage and be able to effectively use eight RCA tools.	Oct 22-24, 2013 (CHS)	3 consecutive days 2.1 CEUs	$1,495

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Elements

New Uptime App available
see page 50

Editorial

Function, Performance and Value

Of course the recipient always determines value, but I hope you will agree that the team at *Uptime* magazine has raised the bar once again and created another valuable issue. They are not a team of magazine publishers; they are a team of mission-focused people who are committed to making you safer and more successful. Producing *Uptime* is simply a vehicle they use to accomplish that goal.

The current issue was awaiting me as I returned to the Fort Myers office, winding down from six months of travel where I dedicated much of my effort to listening and learning, two areas where I have lots of potential for improvement.

In an attempt to find pockets of new thinking, I spent considerable time outside the traditional maintenance reliability community to see if there were unique concepts that *Uptime* magazine might bring to our members.

During my travels, I met and listened to many inspiring people. I learned fantastic new technical and business processes from architects, asset portfolio managers, city managers, financial experts, accountants, auditors, standards experts, quality managers, project engineers, construction companies, 3D design firms, songwriters, musicians, artists, students, code writers, leadership gurus and a small group of Fortune 500 chief information officers.

Read on and you will see how that influence is reflected in the current issue of *Uptime* magazine, including an operational excellence work we specifically recruited to reinforce the *Uptime* Elements point of view on value versus function and performance.

In this special cover article, maintenance outsider, Joseph Paris defines operational excellence as: "Each and every employee being able to see the flow of value to the customer and fix that flow before it breaks down." This is an exciting new way to look at a complex business goal in such a simple way. As maintenance reliability professionals, we tend to focus on function and performance often without much focus on value. As Mr. Paris aptly points out, "What good is an efficient factory if the customer no longer needs our product?"

This Operational Excellence "value" thinking is not only how the Uptime team works, it is perfectly aligned with the new ISO 55001 Asset Management – Management Systems – Requirements standard. In the new standard, "assets" are defined as something that delivers value to an organization. Having just returned from the ISO PC 251 meeting in Calgary, the global advisory groups approved the final draft of the ISO 55001 Asset Management standard that will be published in November 2013. If you are looking for a way to get up to speed on asset management best practices, consider attending the special Asset Management Forum at IMC- 2013, the 28th International Maintenance Conference being held December 9-13, 2013. The event will feature leading asset management practitioners and subject matter experts from around the world.

As you will also read inside, the teams at *Uptime* and Reliabilityweb.com are also diving into new technology paradigms around asset condition management, including wireless sensing. Please consider attending CBM-2013 if predictive maintenance and condition monitoring are of interest to you.

It would not be right for us to promote change initiatives for your organizations without looking at them for our own operation. We have committed to a long-term path of improvement that we hope enhances the ways you might interact with us online, in-person and in print. Watch your inbox for news.

My thanks and appreciation extend to the excellent team that creates *Uptime* and allows me to lead them, to the incredible and generous authors who contribute knowledge and experience, and of course to you, the reader.

By comparison, I am humbled by how much I have yet to learn at age 54 and the world of knowledge that is available to me. Thank you for allowing me to learn in front of you.

Warmest regards,

Terrence O'Hanlon, CMRP
About.me/reliability

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IN THE NEWS

Best-Selling Author Teaches Leadership at RELIABILITY 2.0 Las Vegas

Author Dave Logan gave the keynote address and taught a short course focusing on leadership and improving team performance during the RELIABILITY 2.0 conference in Las Vegas, March 8-13. Logan, co-author of *Tribal Leadership* and *Three Laws of Performance*, said an organization is composed of tribes—naturally occurring groups of 20 to 150 people. Only a few leaders, however, can identify and develop their tribes, and those rare individuals are rewarded with loyalty, productivity, and industry-changing innovation. Maintenance reliability leaders were taught how to assess, identify, and upgrade their organizations, while at the same time, learn what motivates their teams. The result is an organization that can thrive in any economy.

Do You Have a Story to Share?

Is there a news story you or your company would like to share? Are you interested in providing a case study or an article for Uptime? Email Jenny at jenny@reliabilityweb.com with your news story or for more information on how to provide an article for a future issue of Uptime magazine.
(All material is subject to review and approval)

ISO55000 Asset Management Standard Update

29 April to 3 May 2013, Calgary, Canada

ISO/PC 251 had held its fifth meeting in May 2013 at the Delta Bow Hotel in Calgary, Canada hosted by the Standards Council of Canada and the City of Calgary. Uptime publisher Terrence O'Hanlon participated as a member of the US Technical Advisory Group to ISO/PC 251. He also served as an Asset Management expert through ANSI for the development of ISO-17021-5. The primary purpose of the 5th meeting was to revise the standard drafts and to improve the texts to a point where they would be ready for ballot as Final Draft International Standards (FDISs).

Updates included (partial list):

- A consistent treatment of 'risk'
- Asset Management versus Asset Management System – resulting in definitions being slightly revised
- The use of diagrams – three diagrams had been developed, two for ISO 55000 and one for ISO 55002
- The terms "Asset Life" versus "Life Cycle" – with their definitions being revised

All 3 standards have been prepared as Final Drafts for ISO balloting and if passed may be published as easily as November 2013. More details are available at **www.iso.org.**
NEW: Asset Management Forum at IMC-2013 December 9-13, 2013 Bonita Springs Florida. More details at **www.maintenanceconference.com.**

Fight for Mike Follow up….

In the April/May 2013 issue of Uptime, we introduced you to Mike Seiter. Mike was diagnosed with stage 4 brain cancer one year ago. A charity was established for the James Cancer Hospital in Mike's name through the money raised in the sales of grey cancer bracelets. $800 was raised through Uptime magazine and RELIABILITY 2.0 in Las Vegas!! Your generosity continues to help the fight of cancer. A big THANK YOU to everyone who donated! **FightForMike.org.**

RELIABILITY 2.0 Las Vegas Lhoist Plant Tour

Thank you to Lhoist North America, Apex Plant, with a special shout-out to Sean O'Leary C.A.P.M., Maintenance Manager, Michael Reeves, Maintenance Supervisor and Ted Martinez, Maintenance Mechanic for hosting an incredible plant tour at RELIABILITY 2.0 Las Vegas. The group was treated to a visit of the Lhoist Apex mine and lime processing facility where they had the opportunity see the reliability improvement resulting from defect elimination, teamwork and leadership.

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Planning and Scheduling of Maintenance	June 17-19, 2013	Raleigh, NC
Root Cause Problem Elimination Training™	October 8-10, 2013	Raleigh, NC
Reliability & Maintenance Management *(Processes & Precision Skill Sets)*	November 4-8, 2013	Raleigh, NC

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Operational Excellence

See the Flow of Value

Joseph F Paris, Jr.

Definition:

"Operational Excellence is when the efforts throughout the organization are in a state of alignment for achieving its strategies and where the corporate culture is committed to the continuous and deliberate improvement of company performance AND the circumstances of those who work there – to pursue 'Operational Excellence by Design' and not by coincidence."

– Joseph F Paris Jr., Chairman, XONITEK Group of Companies

Over the past few years, I have increasingly seen a great many organizations (companies and academia) and professionals (practitioners and consultants) attempt to hijack ***Operational Excellence*** in an effort to "rebrand" the disciplines of *Lean Six Sigma* or *continuous improvement*. Admittedly, some do try to build a differentiator by sprinkling some "soft skills," such as *leadership* or *culture change,* on their programs. **But this is a wholly inadequate determination** and merely a subset of what Operational Excellence is all about today and how it was initially conceived some several years ago.

Take for instance a past advertisement I received for the 2012 Operational Excellence Lean Sigma conference which was held in Berlin last November (which is just one of hundreds of examples I can offer; it just happens to be the most recent). While the conference appeared to offer considerable value for those interested in the tools and techniques related to Lean Six Sigma, it fell very short of anything resembling Operational Excellence. If you take a look at the abstracts for the presentations, each had an emphasis on some aspect of Lean Six Sigma, but none spoke to a company's efforts outside of production, supply chain and delivery. Where are the talks that involve finance, marketing, sales and other aspects of a company and their respective roles in pursuing Operational Excellence?

MANY ATTEMPT TO HIJACK OPERATIONAL EXCELLENCE IN AN EFFORT TO "REBRAND" THE DISCIPLINES OF LEAN SIX SIGMA OR CONTINUOUS IMPROVEMENT.

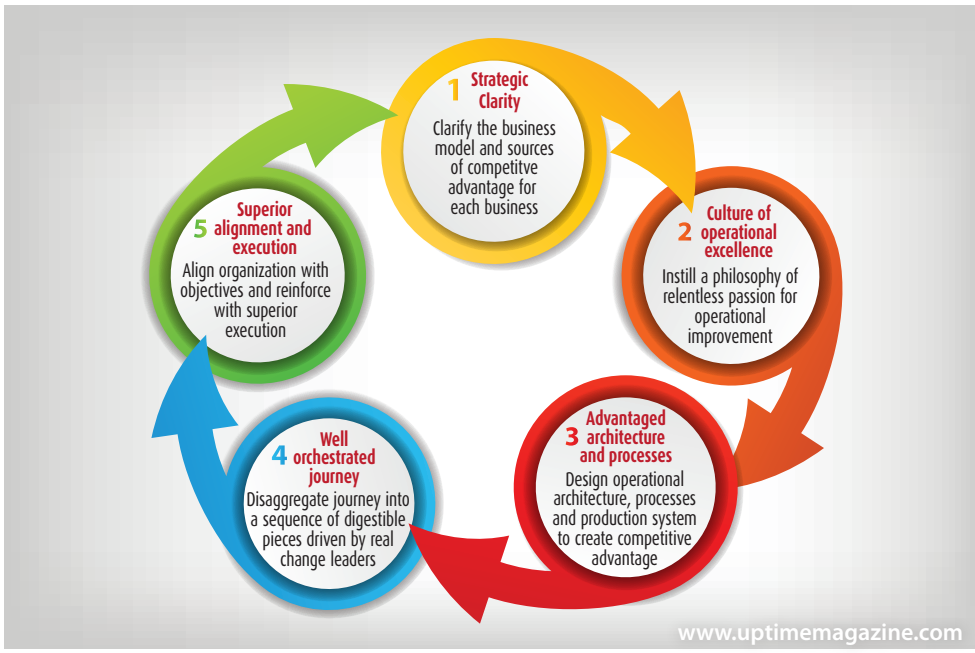


Figure 1: Operational Excellence as defined by a major chemical company

Why not just call the conference "*Lean Sigma*" [sic]? Would anyone notice the difference?

HISTORY OF OPERATIONAL EXCELLENCE

If we look into the past (using a Google Search for "*Operational Excellence YYYY*"), there is a dearth of significant detail with regards to Operational Excellence prior to 2002 and what is available is very thin.

In 2002, the American Society for Quality (ASQ) advertised an article entitled, "How to Achieve Operational Excellence" and the keywords included: *business plans, commitment, communication, continuous quality improvement (CQI), performance objectives, cost management, goals and quality management (QM).* There was no mention of Lean Six Sigma and none of the associated buzzwords.

In 2003, the United States Coast Guard (USCG) initiated an Operational Excellence program in which the criteria was to *"…provide Coast Guard Auxiliary boat crews with a challenging opportunity to highlight their proficiency and skills, foster teamwork and encourage fellowship among operational members."* To the USCG, Operational Excellence was all about performing as a team with an exceptional level of proficiency in completing the tasks necessary to achieve mission successes. In my opinion, this program embraces the spirit of Operational Excellence.

In November of 2003, the Economist Intelligence Unit (a division of *The Economist* magazine), published a report sponsored by Celerant Consulting entitled, "Strategy execution: Achieving operational excellence." It surveyed 276 executives in North America with 50 percent of the respondents being from the "C-Suite" across various industries. The interesting thing about this analysis is that it's a survey whose intent is to measure the importance and impact of Operational Excellence, but nowhere does it state what Operational Excellence might be.

Figure 2: Sample Operational Excellence Elements

TO THE U.S. COAST GUARD, OPERATIONAL EXCELLENCE WAS ALL ABOUT PERFORMING AS A TEAM WITH AN EXCEPTIONAL LEVEL OF PROFICIENCY IN COMPLETING THE TASKS NECESSARY TO ACHIEVE MISSION SUCCESSES.

It's obvious from reading the survey questions that there is a spin for leveraging technology as some means for achieving Operational Excellence. However, the only thing one really seems to gain from reviewing the responses is that top performing companies have *"… more committed management, make better and more frequent use of performance data and management mechanisms, and have stronger communication channels to link senior management with frontline employees."* I read that and couldn't help but think, "*Duh – no kidding.*" But again, no direct connec-

tions or correlations between Operational Excellence and Lean Six Sigma are made.

By far, one of the more interesting position papers I came across was from a major chemical producer. It's a fairly detailed document, but after reading it a few times, I came away feeling that it was disconnected and/or incomplete.

- Athough the document spoke to Operational Excellence and its achievement, it never defines it anywhere. How can one know if one has achieved Operational Excellence (or even on the right path) if one does not know what it looks like?
- There seemed to be a conflict in messaging where the philosophies were presented graphically and never addressed, but what was addressed were the details of the approach and no reference to the philosophies. This left me feeling that the graphics were created and presented by strategists, but the verbiage describing the program was created by the tacticians who implemented, as demonstrated by the following graphic and associated text: a) *"Taking the journey toward Operational Excellence typically begins with making an initial step change improvement, followed by a continuum of incremental enhancement. Installing a culture of Operational Excellence results in a significant and sustained competitive advantage."* And b) *"A study by the Board on Manufacturing and Engineering (formerly the Manufacturing Studies Board) of the U.S. National Research Council showed that the companies that effectively implemented world-class manufacturing systems achieved improvements in asset productivity performance."*

While I thought the graphic (Figure 1) went a long way in illustrating the concepts of Operational Excellence, the content spoke more to continuous improvement and, in fact, specifically mentioned "world-class manufacturing systems." This seems to be a conflicting message; certainly it makes it unclear and confusing.

However, this company did demonstrate that it felt Operational Excellence had three aspects: asset productivity, capital effectiveness and operational risk management, as shown in Figure 2. But again, there is no mention made of Lean Six Sigma being a component of the program.

Another model for Operational Excellence used by a finance and insurance company (see Figure 3) is very nearly identical to the chemical company's Operational Excellence Integrated Management System. It is interesting to note that the major difference between the two models is that the finance and insurance company lists the customer first and the other does not list the customer at all.

There is very little mention of Lean Six Sigma (except for "Lean Project") and it is very apparent that Storebrand differentiates Operational Excellence from Leans Six Sigma.

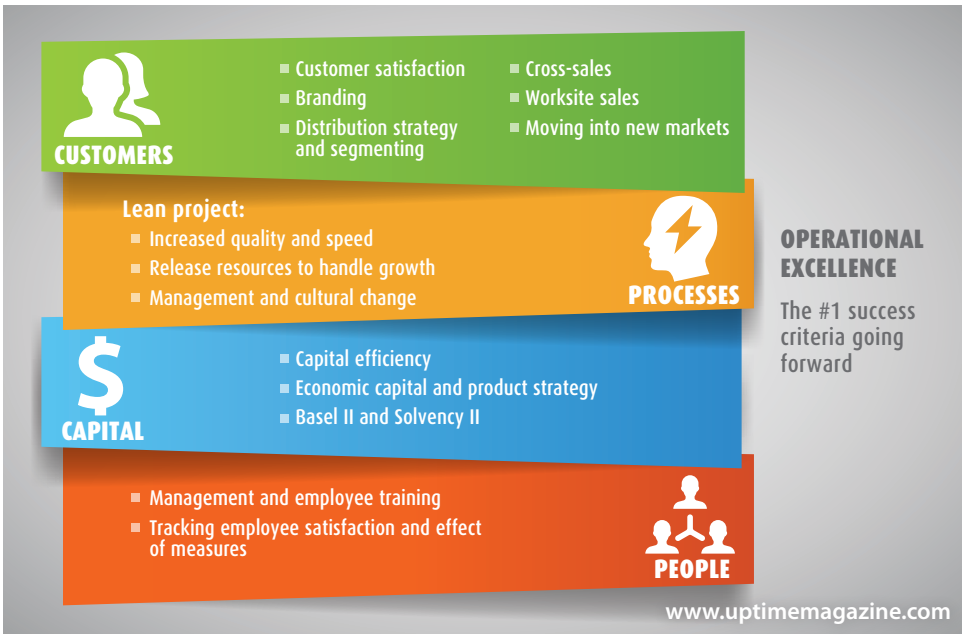


Figure 3

I appreciated the approaches used earlier by ASQ and I especially enjoyed the definition used by the U.S. Coast Guard in their Operational Excellence program. But it still would appear that the definitions used are inconsistent across the companies that embrace Operational Excellence – with most of these individual definitions also being incomplete.

Even one of the most renowned names in Operational Excellence, "The Shingo Prize for Operational Excellence," does a very poor job of offering a definition. From their website:

"MISSION: *The mission of The Shingo Prize is to create excellence in organizations through the application of universally accepted principles of operational excellence, alignment of management systems, and the wise application of improvement techniques across the entire organizational enterprise. We do this by teaching correct principles and new paradigms that accelerate the flow of value, align and empower people, and transform organizational culture."*

IF OPERATIONAL EXCELLENCE ISN'T JUST ABOUT CUSTOMERS, CAPITAL/ASSETS, PROCESSES/OPERATIONS, PEOPLE, OR EVEN FLOW, THEN WHAT IS OPERATIONAL EXCELLENCE ALL ABOUT AND WHAT PART OF THE ORGANIZATION IS INVOLVED (OR EVEN SHOULD BE INVOLVED)?

Nowhere in its definition (or even in the rest of the website or as a link to somewhere else) can I find what these "universally accepted principles of Operational Excellence" might be. So how does one know if they have done the needful to achieve the recognition?

Defining Operational Excellence as Lean Six Sigma is like defining a vehicle as an automobile – the latter of each being a subset of the former, but not the same. Why not just call it Lean Six Sigma?

And I swear, if I read one more definition of Operational Excellence being about "flow," I am going to retch. What good is flow if you have no orders for the product? Or you have no way of collecting the information to build/provide? Or you have no business? A definition for Operational Excellence has to embrace the entirety of the organization.

ORGANIZATIONAL CONSIDERATIONS FOR OPERATIONAL EXCELLENCE

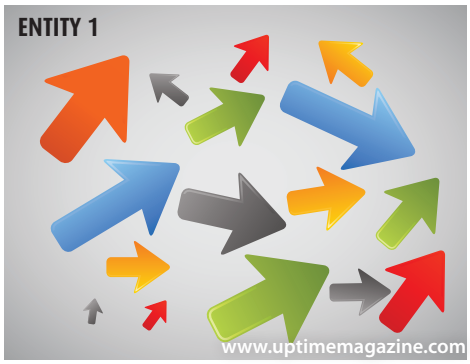
So if Operational Excellence isn't ***just*** about customers, capital/assets, processes/operations, people, or even flow, then **what IS Operational Excellence all about** and what part of the organization is involved (or even should be involved)?

For your consideration, here is an extensive (if incomplete) list of business requirements and functions that must be embraced and integrated into any true Operational Excellence program:

Entity: What is the best type (sole proprietorship, limited liability company, partnership, or corporation) and structure for the entity (investor terms and conditions)? Where is the best place (state where company holds office or some other) for the entity to be formed?

Professional Services: Finance and accounting, who are the "legal eagles," accountants and financial advisors for the company and their respective expertise? Is their expertise in alignment with the requirements of the company?

Finance: What is the best capital finance structure for the organization? Are the investors strategic and what is their exit strategy? How much equity versus debt? What is the collateralization of the debt and what are the covenants associated with the loans?



OR

Figure 4

Development (Design Engineering): Who is the principal designer of the service or product offerings? What do they need to come to market and then perpetuate the value?

Facilities and Production Assets: Where are the production facilities to be located and what characteristics are required for the facility site (existing talent pool, roads, Internet, airport, utilities, taxes, etc.)? What is needed to produce the product or service?

People Resources: I dislike "human resources" and prefer "people resources," but in any case, what talent is required to produce, deliver and service the offerings? How do you find them and how do you effectively get them on board?

Marketing: Let's assume you have a great offering that people will want – how do people know? Who is your customer, how do you reach them and what's your messaging? Are you sure that is the message they want to hear?

Sales: Hurray! They like your messaging! Now, how do you get them to turn that attraction into a transaction – to monetize your offering? You do realize that without this transaction occurring, there is no need to worry about pull or flow, right?

Front Office Operations: We need to make sure the business entity is running smoothly and that the transactions (and all related details) are moving through the entity with as much accuracy and velocity, but with as little friction as possible. Is that happening?

Supply Chain: Do your suppliers know what you need (products and/or services), to what specifications, in the quantities that you need it and when you need it by? How do they know all this? How do YOU know all this?

Production (whether a product or service): How do you generate the products or services in the most efficient and effective manner?

WHERE ARE THE PRODUCTION FACILITIES TO BE LOCATED AND WHAT CHARACTERISTICS ARE REQUIRED FOR THE FACILITY SITE (EXISTING TALENT POOL, ROADS, INTERNET, AIRPORT, UTILITIES, TAXES, ETC.)? WHAT IS NEEDED TO PRODUCE THE PRODUCT OR SERVICE?

Logistics & Delivery: How do you efficiently and effectively convey the ownership of your products or services from you to the customer?

Post-Sale Service: Once you convey your products or services to the customer, how do you keep them happy after they have placed their trust in you?

Since all of these various dimensions must be considered if an organization were to have a hope in achieving any reasonable level of Operational Excellence, how can such a discussion only involve the disciplines associated with Lean Six Sigma? Or even if you toss in leadership and/or culture change?

SO, WHAT EXACTLY IS OPERATIONAL EXCELLENCE?

Which of the organizations in Figure 4 do you believe is more likely to achieve Operational Excellence?

Is it the one that is more aligned and committed? Or the one that is less? Which one are you?

DEFINITION OF OPERATIONAL EXCELLENCE

So, what exactly is Operational Excellence? Where is there an adequate definition that transcends the strategic, through the tactical and logistical, and all the way to execution and does so in a manner that embraces the entirety of the organization and its collective efforts?

Through my studies, analysis and work over the past several years – work that cuts across all industries, geographies and cultures – and by my own experiences and observations in owning the Operational Excellence Group on LinkedIn and in my founding of the Operational Excellence Society, I propose the following definition for Operational Excellence (also found at the beginning of this article):

*"Operational Excellence is when the efforts throughout the organization are in a state of alignment for achieving its strategies and where the corporate culture is committed to the continuous and deliberate improvement of company performance AND the circumstances of those who work there – to pursue **'Operational Excellence by Design'** and not by coincidence."* – Joseph F Paris Jr., Chairman, XONITEK Group of Companies

So let's break down this definition. ***"Operational Excellence is…***

… when the efforts throughout the organization… – all efforts in any capacity, every calorie or cash expended throughout the entirety of the organization and its value chain;

… are in a state of alignment… – there exists communication and transparency such that unity of purpose and of being is realized;

… for achieving its strategies… – the goals of the organization have been effectively conveyed and all assets, resources and efforts are focused on attaining those goals;

… and where the corporate culture is committed to… – there exists an ethos throughout the organization that it is unreservedly devoted to the effort. This is a function of effective lead-

ership, stewardship, mentorship and followership all existing;

… the continuous and deliberate… – not just always moving forward, but moving forward in an intentional and calculated manner, with not only a sense of purpose, but purpose itself;

…improvement of company performance… – This simply means to improve ***profit***, a.k.a., the bottom line, EBIDTA, shareholder value, or whatever other euphemism that can be conjured up in the name of political correctness. There are many ways to facilitate the realization of increased profits, but make no mistake, businesses exist to make profits and their improvement efforts must yield greater profits.

The efforts to improve company performance should ensure the company is always innovative and competitively positioned in its value proposition to its present and future customers and to drive both short-term and long-term value. These efforts include (but by no means should be considered an exhaustive list): aligning the development of the offerings of the company to the desires of the marketplace and ensuring the messaging and sales efforts are effective in positioning these offerings; making sure the finance and equity structure are optimal to support the strategies of the company; validating the efficiency and effectiveness of the supply chain; and all other considerations including those that involve operations, such as Lean Six Sigma, theory of constraints, Total Quality Management, enterprise resource planning and the entire alphabet soup of other management methodologies, are embraced in the definition – and yes, even flow.

"… AND the circumstances of those who work there…" – in addition to improvements in company performance, improvements in the circumstances of those who make the company successful also must be equally considered. I specifically do not specify "pay" or "compensation" because it's been my experience that what is important to each individual varies by the person (or group of people). Most people will not leave a company for five percent (or 10 percent or even more) in pay. They will leave if they feel disenchanted, disrespected, detached or undervalued. They want a sense of pride and ownership. They want their lives to be more joyous and they want to look at their job as a means to that joy. Company leaders who get this will reap great rewards both professionally and personally.

It is a colossal mistake for companies to believe that they can improve company performance just by heaping more and more on the backs of their employees. It's unsustainable and there is a breaking point that will eventually be reached. The company needs to set its pace for a marathon, not a sprint. There needs to be enough energy in reserve for a "kick" when needed.

"…to pursue… – this is a never-ending quest and will not ever be achieved;

… Operational Excellence by Design… – that this quest must be conducted with a sense of purpose and in an engineered fashion with: clearly defined goals; clear and concise plans communicated effectively and transparently; proper commitment, support and alignment throughout the organization; and strong leadership (and followership) during execution;

… and not by coincidence." – Operational Excellence cannot be achieved by accident.

It has taken me a very long time to develop this definition (with many revisions over time and with even one made during the writing of this article) and I am sure there will be many of you who disagree with me. However, discourse and debate are fair and welcomed. After all, even the definition of Operational Excellence should be subject to the mantra that is Operational Excellence – without the opportunity to improve upon it would be hypocritical.

OPERATIONAL EXCELLENCE CANNOT BE ACHIEVED BY ACCIDENT.

This definition, applied throughout an organization and its value chain – from its vendor's vendor to its customer's customer – is the ***"Manifesto of Operational Excellence"*** and, if pursued with vigilance, will result in your becoming a ***high performance organization.***

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Joseph F Paris Jr., is the Founder and Chairman of the XONITEK Group of Companies, an international management consultancy firm specializing in all disciplines related to Operational Excellence, the continuous and deliberate improvement of company performance AND the circumstances of those who work there to pursue "Operational Excellence by Design" and not by coincidence. He is also the Founder of the Operational Excellence Society, with hundreds of members and several Chapters located around the world, as well as the Owner of the Operational Excellence Group on LinkedIn, with over 25,000 members. http://de.linkedin.com/in/josephparis

Non-Intrusive Continuous Asset Monitoring

Is Here and It's Easier Than You Think

Allan Wilson

ASSET FAILURE IS NOT AN OPTION

In oil and gas operations, nothing is more important than ensuring assets operate at their peak performance all day, all night, every day of the year.

These systems are often geographically located in some of the world's furthest corners and toughest environmental conditions. Downtime is measured in minutes and the cost of system failure for even a single day is calculated in the millions of dollars. Under these challenging, and often dangerous conditions, failure is simply not an option.

It is now possible to use electric waveform analysis to root out the cause of electrical and mechanical failures well before they happen. Unlike previous generations of vibration analysis, today's software is completely non-intrusive and monitors the condition of an electrically-driven motor or motor-driven asset 24/7. It checks performance in real-time against established baselines.

NON-INTRUSIVE CONDITION-BASED MONITORING (CBM)

With the software, nothing is installed on the machines being monitored. Instead, predictive intelligence monitors (PIMs) continuously acquire electrical waveforms at the motor switches at high sampling rates. Data is transferred wirelessly to the software, which analyzes these waveforms, identifying impending faults and assessing energy efficiency. The software then produces predictive and actionable intelligence from each asset that operators want to monitor, detecting both electric and mechanical faults.

The software identifies and distinguishes the sources of waveform distortion, whether it is caused by changes in incoming grid power, driven process, or asset conditions. Empirically developing and tracking system impedance models are used to detect electric problems. Further, classification and isolation of faults is accomplished by a combination of machine learning methods based on classifiers and specific spectral fingerprints of faults.

IT IS NOW POSSIBLE TO USE ELECTRIC WAVEFORM ANALYSIS TO ROOT OUT THE CAUSE OF ELECTRICAL AND MECHANICAL FAILURES WELL BEFORE THEY HAPPEN.

In addition, the electrical waveform analysis software learns the specific fingerprint signatures of monitored power trains, sets condition alarm thresholds and then automatically enters the assessment mode to continually check for issues. Because it detects abrupt changes to the preexisting conditions of the monitored assets, the electrical waveform analysis evaluates assets by comparing their actual, observed behavior to previous levels. This helps engineers identify failures before they happen, rather than depending upon manual inspections to uncover potential (or already existing) problems.

SAP EAM MEETS ELECTRICALLY-DRIVEN ASSETS

The SAP enterprise asset management (EAM) interface is a key component for establishing a comprehensive and holistic maintenance and reliability solution where the breadth of SAP tools extends beyond the core modules.

With real-time continuous monitoring, SAP EAM users are able to complete their EAM strategies and specific workflows all the way to the motors themselves. SAP already delivers a comprehensive end-to-end solution for enterprise asset management. However, operators can now take it one step further and enable complete workflow automation and pass specific information for failing parts to initiate workflows right from the source and months ahead of traditional solutions.

OPERATORS CAN NOW TAKE IT ONE STEP FURTHER AND ENABLE COMPLETE WORKFLOW AUTOMATION AND PASS SPECIFIC INFORMATION FOR FAILING PARTS TO INITIATE WORKFLOWS

POINTS OF POSITIVE IMPACT

Asset Operations & Maintenance

Detects developing problems and provides engineers detailed electrical and mechanical fault data directly from the motor. Integration with SAP MII passes asset watch lists, which trigger work orders and enables condition-based monitoring strategies to include asset prioritization and risk modeling.

Asset Planning & Scheduling

Delivers fault warnings and energy efficiency information from several months to up to a year ahead of potential failure. Integration with visual enterprise provides historical details and KPIs available on-demand for detailed 3D visualization.

Service Procurement

Starts the procurement workflow as soon as an upcoming fault is detected and provides operational fault details to the service team months in advance of the expected failure.

Spare Parts Management

Identifies specific issues with related parts, such as bearings and rotors, for mechanical faults and stator for electrical faults. Includes mobility with SAP Syclo to supply to-do lists to field teams on their mobile devices.

SAP HANA & Business Intelligence

Builds "large data" repositories for asset condition and energy effectiveness, and empowers intelligent asset analytics on maintenance and energy efficiency.

AVAILABILITY OF EXPERT CBM TO SAP INTEGRATION SERVICES

As the new asset monitoring tools are coming to market, quality integration services will be needed to support operations and bring asset data captured in the process control network through to SAP in the business network.

CONCLUSION

Any number of factors can cause asset failure, but bringing EAM all the way down to the asset level and implementing a complete CBM solution can produce a major impact by reducing risk of downtime and improving energy efficiency as a result of pro-active maintenance and high reliability.

Continuous monitoring using non-intrusive electric waveform analysis does a great deal in assisting oil and gas operators with reducing downtime in electrical and mechanical systems by eliminating many of the manual processes associated with asset monitoring. This, in turn, closes the gaps in an organization's EAM strategy.

Starting on the path towards true real-time continuous monitoring begins with a pilot program to measure the financial benefits of reducing unexpected failures in power trains, avoiding unrecoverable lost production, emergency maintenance costs and excess energy consumption from inefficiently operating machines.

Innovative oil and gas operators are leading the entire industry in implementing affordable asset performance monitoring tools capable of providing actionable information not only on critical assets, but also across their entire asset. Instead of only monitoring the effect of damaged assets on production, electric waveform analysis detects the root cause, enabling true predictive maintenance and improved asset reliability.

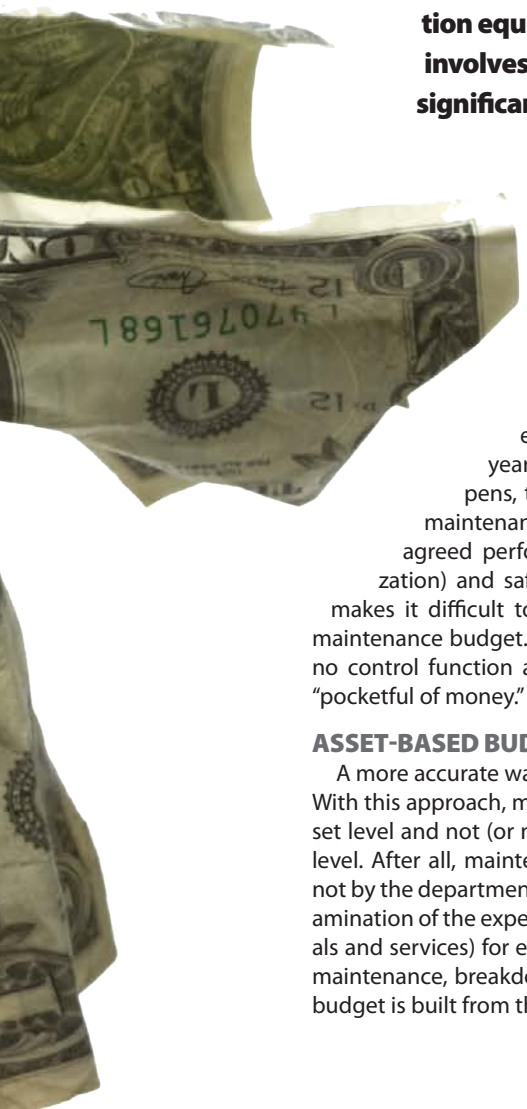
Allan Wilson is President & CEO of Veros Systems. He has over 25 years of experience bringing innovative software solutions to meet the complex demands of the manufacturing, aerospace and defense industries. Today, Mr. Wilson is leveraging his extensive experience with enterprise software to improve asset reliability and energy efficiency in the Oil & Gas and Utilities sectors. www.verossystems.com

Getting a

Grip on Maintenance Costs with Asset-Based Budgeting

Remco Jonker

Maintenance adds value by providing available, reliable, safe and eco-friendly production equipment. Yet, fulfilling this task involves costs that can account for a significant part of a company's overall expenditure. Nevertheless, few maintenance organizations truly have a grip on their maintenance costs.



The maintenance budget, in particular, is not always arranged intelligently. All too often, maintenance budgets are drawn up as an extrapolation of the budgets of previous years (historical budgeting). When this happens, there is no relationship with the planned maintenance activities necessary to achieve the agreed performance in terms of uptime (asset utilization) and safety, health and environment (SHE). This makes it difficult to predict and rectify variances from the maintenance budget. As a result, the maintenance budget has no control function and is used purely as a readily available "pocketful of money."

ASSET-BASED BUDGETING

A more accurate way of budgeting is asset-based budgeting. With this approach, maintenance costs are controlled at the asset level and not (or not only) at the maintenance department level. After all, maintenance costs are generated by the asset, not by the department. For each part of the asset, there is an examination of the expected types of costs (worked hours, materials and services) for each kind of work (inspections, preventive maintenance, breakdowns, etc.). In this methodology, the cost budget is built from the bottom-up.

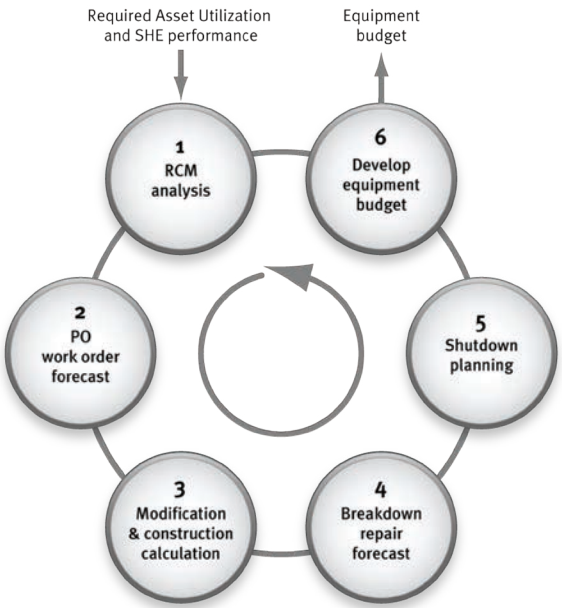


Figure 1: The process of asset-based budgeting

There are six steps in producing an asset-based budget (see Figure 1).

The first step is to determine whether the required performance levels for asset utilization (uptime) and SHE are attainable using the present preventive maintenance program. This step is particularly important if performance requirements change from year to year, or if it proved impossible the year before to fulfill the promised performance requirements. A reliability centered maintenance (RCM) analysis is performed to evaluate the maintenance program and modify it where necessary[1]. Subsequently, it is possible to extract the individual maintenance activities from the maintenance program that need to be carried out in the coming year. Besides the proactive and preventive tasks (periodic overhauls, component replacements and inspections), there are also default actions (modifications, complete replacements and breakdown repairs). In the steps that follow,

these activities are budgeted according to type. Each type of activity is allocated a separate budget code.

Step two of the budgeting process consists of budgeting preventive maintenance activities according to the preventive maintenance (PM) work order forecast. The forecast simulates all preventive maintenance work orders (PM work orders) that will be carried out on the asset in the coming budget year. The basis for doing this is the (forecast) counter readings and stated values at January 1 of the budget year and the defined maintenance intervals (for calendar-driven maintenance) or expected maintenance intervals (for counter and condition-driven maintenance). As the RCM analysis determines for each PM activity which assets (engineers, spares and contractors) will be necessary for its performance, it is simple to turn the forecast into a financial budget. If the preventive maintenance program has been entered into a modern enterprise asset management (EAM) system, this step can be carried out automatically to a large extent.

A MORE ACCURATE WAY OF BUDGETING IS ASSET-BASED BUDGETING. WITH THIS APPROACH, MAINTENANCE COSTS ARE CONTROLLED AT THE ASSET LEVEL AND NOT (OR NOT ONLY) AT THE MAINTENANCE DEPARTMENT LEVEL.

Step three involves drawing up a budget for the project-driven default actions, such as modifications and complete replacements. The budgets for these activities stem from the related project calculations. If calculations are not yet available, the costs will have to be estimated. Note that the RCM analysis only yields modifications that influence maintenance behavior. Modifications for adjusting or expanding the asset's functionality are usually reported directly by the production department. These modifications also must be budgeted based on a project calculation, but they are assigned a different budget code. This is because these costs must remain visible separately, as they do not form part of the maintenance costs and frequently have to be capitalized financially. The same applies to complete replacements of assets.

In step four are breakdown repairs, the final activities requiring budgeting. While the RCM analysis provides a good picture of the likelihood of a breakdown occurring, it is obviously impossible to schedule breakdown repairs at the start of the year. So there is no point in forecasting for breakdowns with work orders. The budget will be based on a forecast of the expected costs of repair[2]. This often takes place using an extrapolation of the historical cost level, possibly adjusted if the preventive maintenance program has been modified.

Before the asset-based budget can be drawn up, there first must be a clear picture of which maintenance costs will be incurred during the shutdown. This takes place in step five. In various industries, a large proportion of maintenance is clustered and carried out in a short period of time. A good example is the turnarounds (outage, shutdown) in the chemical industry. Others are the multi-year shipyard repairs in the marine sector and depot maintenance in the aircraft industry. It is important to make these costs visible separately because of the often large scale of these shutdowns (typically amounting in the chemical industry to 80 percent of total maintenance costs in a year) and the shutdowns may not occur every year. Both preventive and corrective maintenances are carried out during the shutdown, as are modifications and replacements. These activities will already have been budgeted in the previous steps, but will be assigned an extra budget code. Another advantage of making the total shutdown costs visible separately is it avoids unnecessary internal wrangling about sudden increases in the maintenance budget.

The final step in the budgeting process is preparation of the asset budget. All items from the previous steps are gathered together and consolidated. Besides the subdivision into types of activities, the budget is broken down according to cost types (hours, materials, services). It also is wise to itemize the labor costs according to specialist group (e.g., mechanical, electrical, instrumentation and civil) to obtain insight for each specialist group into the expected workload for each asset. In the case of autonomous maintenance, production is also regarded as a specialist group.

As soon as all order information has been collected from the previous five steps for each asset, the asset-based budget can be drawn up and entered into the EAM system. This complete forecast for each asset must be established at the start of the budget period in order to carefully monitor its achievement during the period. An example of an asset-based budget is shown in Figure 2.

Asset Breakdown Structure

Cost / Resource Types

Installation / Asset	Labor				Material	Services	Total equipment budget
	Mech	Elec	Civ	Prod			
Inspections	10.400	10.400					20.800
Work from inspections	1.300	1.300			650		3.250
Periodical service			3.200	3.900	5.300		12.400
Breakdowns & repairs	1.040	2.080			1.560		4.680
Modifications (maintenance)							-
Modifications (production)						50.000	50.000
Engineering projects							-
Total	**12.740**	**13.780**	**3.200**	**3.900**	**7.510**	**50.000**	**91.130**

CMMS/EAM
WO Activity Types

Figure 2: Example of an asset-based budget

DEPTH OF AN ASSET-BASED BUDGET

The depth of an asset-based budget is often the subject of debate, particularly when a computerized preventive maintenance work order forecast is used. With such a forecast, it is possible to prepare budgets at a low asset level. But there are two reasons why this is not wise. First, the budget is used as a financial translation of the wishes of the production department. These wishes are formulated in service level agreements (SLA) at the level of the plant, production line, or critical function within the production line. In negotiations regarding the SLA, the production department will be interested only in the asset level at which asset utilization arrangements will be agreed. While budgets can be drawn up at lower asset levels, they should be used only for internal control purposes.

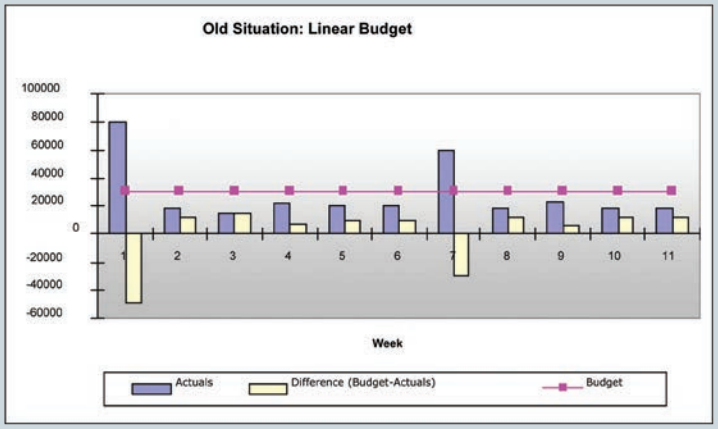
The second reason is controllability. Each year, the budgeting process passes through several cycles in which various changes must be made to the budgets. These will be difficult to maintain if budgeting occurs at an asset level that is too low. A rule of thumb is to keep the asset budget at the level of the SLA, possibly supplemented by sub-budgets at the level directly below (for internal control purposes). These sub-budgets are often prepared only for the cost drivers within the asset family.

The Smurfit Kappa Attica Case:
ASSET-BASED BUDGETING FOR EACH PERIOD

Smurfit Kappa Attica is a subsidiary of the international corporation, Smurfit Kappa Group (SKG). Smurfit Kappa Attica produces approximately 120,000 tons of high-quality solid board each year for the packaging industry in more than 60 countries.

The company has two production sites, each with a board machine. Out of approximately 200 employees, 25 work in the engineering department. The department is responsible for the upkeep of the entire machine family, all buildings and the factory site. The paper and cardboard industry has been under huge pressure in recent years, so cost control is an important issue industry-wide. It is also a key issue for the engineering department.

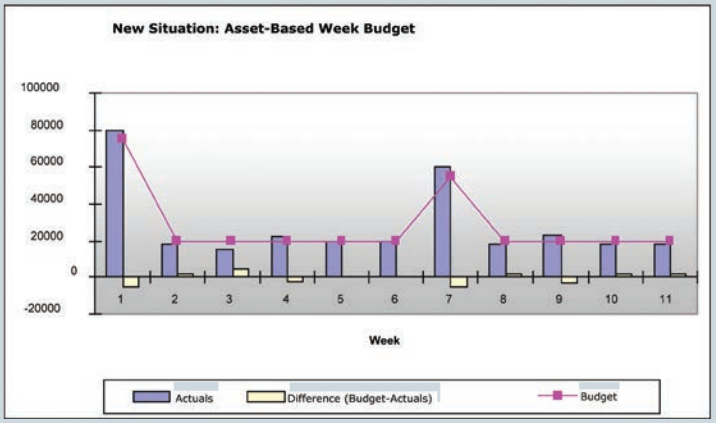
Henry Van Koolwijk, Engineering Manager at Smurfit Kappa Attica, explains why he started using asset-based budgeting. "It was difficult for the engineering department to control the budget properly and get a grip on maintenance costs. One of the reasons for this situation was the budget was drawn up each year based on the past. The budget was linked to each top location in the plant (like board machine, energy supplies, etc.) and divided linearly over the year. Each week, we had a fixed budget to spend, while our maintenance costs exhibited absolutely no fixed or linear progression. For example, we have a production shutdown seven or eight times a year. During these stops, the maintenance costs are many times higher than in normal weeks. Also, many maintenance contracts are signed at the beginning of the year. Invoicing often runs behind contracts, so we were regularly confronted by big peaks in our costs. Time and again, it required a big effort to obtain some degree of insight.



"By introducing asset-based budgeting, we recognized we had a good tool for solving these problems. Each week, a budget is prepared for each type of work for each asset group. This allows us to include separate budgets for every shutdown and make allowances for the payment terms stipulated in the contracts. So the budget for the normal weeks is a lot lower than it used to be. We also have introduced a separate work type called exceptional maintenance (EM). This has made it possible to separately monitor the major non-recurring maintenance activities that are usually carried out during a shutdown."

CHALLENGES

"One of the challenges was the initial preparation of the asset-based budget. Determining the regular maintenance costs of preventive and corrective work orders required a lot of work. We ran through virtually all the previous year's work orders to filter out the larger jobs, like special maintenance and shutdown-related work orders. But it's going to be a lot easier in the coming budget year because the costs have now been entered accurately for each work order and each type of work. Another challenge is dealing with commitments that have been entered into. From a maintenance point of view, these costs only surface in the budget after the activities have been carried out. But financially (in the ledger), the date of the purchase order is the time the commitments were entered into. So it's important to ensure the maintenance budget report and financial ledger reports are properly aligned with each other."



GREATER GRIP

"The biggest advantage of our new working method is both the budget and its fulfillment can be entered and monitored in our CMMS. At the end of each week, we check what kind of maintenance has been planned and we compare it per work type with the available budget. This way, we can now make targeted and validated decisions with regards to activities we will or will not carry out, or perhaps carry out later. In short, we have a grip on the costs."

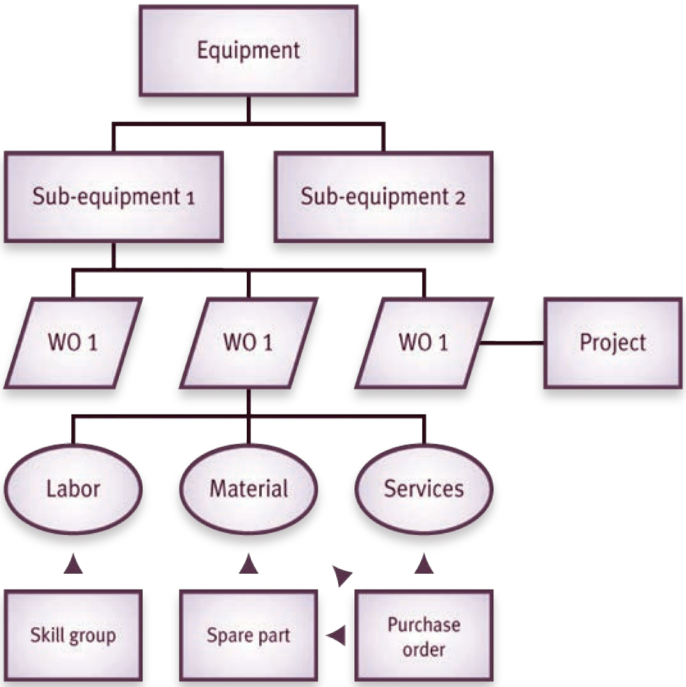


Figure 3: Relationship between work orders, cost types, projects and assets (equipments)

ENTERING ALL TYPES OF COSTS

The asset budget is divided into sub-budgets for each type of cost, e.g., hours, materials and services. To monitor the budget, all these cost types must be entered on the work order (see Figure 3). So it is necessary not only to state hours on the work order, but also for an hourly rate for each craft to be located in the EAM system. Otherwise, the wage costs will not be visible. The same applies to spares, which must be entered on the work order after being used for a job.

Spares and services purchased directly for a work order (the "direct charge items") also must be entered on the work order as costs. It must be possible to link a work order to the purchase order and, in some cases, also to the invoice of the purchase order. This will be the case, for example, when outsourcing maintenance on an as-needed basis, where the true costs become known only when the invoice is received.

USE OF WORK ORDER TYPE

Besides the subdivisions in cost types, the asset budget also can be broken down into sub-budgets for each type of activity. For that purpose, the work order costs must be identified by means of an activity type code. In EAM systems, this has been solved by means of the "work order type" (e.g., inspection, breakdown, etc.). A work order is for one work order type only, so logically, it can concern only one type of activity.

SUPPORT BY EAM SYSTEMS

Obviously, some preconditions are also attached to the introduction of asset-based budgeting. For example, the information about the maintenance history of the assets will need to be reliable to a certain extent. Another precondition is the availability of properly completed preventive maintenance work orders, including costs. Furthermore, the EAM or computerized maintenance management system (CMMS) must provide the right kind of basic functionality. This means hours, materials and services must be bookable against the assets via work orders and a budget must be allocated to the assets concerned. This functionality is provided in almost all EAM systems or CMMSs.

Adequate support in setting up budgeting is a different story. It might involve simulating the total preventive maintenance plan, showing the breakdown history of each asset in terms of problem causes, distribution of budgets over periods and assets/sub-assets, recording of several budget versions and the handling of approvals. By no means are all EAM systems or CMMSs able to provide good support for these functionalities. Some provide a standard module to support it, but oftentimes these solutions are very labor intensive.

GETTING A GRIP ON COSTS THROUGH SOLID MONITORING

To get a real grip on the actual costs, a good reporting function is essential. By correctly using the basic functionality, the maintenance costs can be entered on work orders, making it possible to actively monitor the asset based budget (and its sub-budgets). In practical terms, this means insight exists in the current (cumulative) costs in each period of time (Figure 4, left) and for each period of time, insight is provided in the actual costs per asset and how those costs are divided over the different types of work (Figure 4, right).

This can become even more proactive if you include the outstanding costs of already planned work orders, materials reservations and purchase orders (commitments). At an early stage, this enables you to identify impending budget overshoots and respond accordingly. We know from experience that this makes it easier to control maintenance costs and the "pocketful of money" changes into a tool for exercising control.

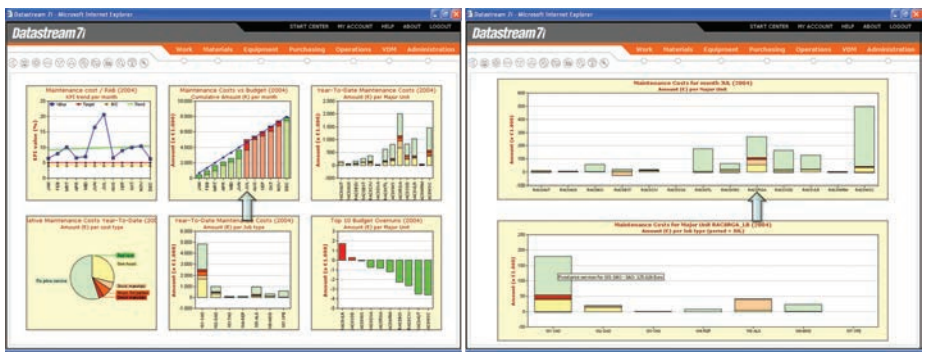


Figure 4: Monitoring an asset-based budget in Datastream 7i with the VDM control panel

References:

1. According to the VDM philosophy, the RCM analysis will be performed only for assets with value potential. It is assumed that the current maintenance program will suffice for the other assets. After all, analyses will already have shown that modifying the maintenance program will not generate any significant value.
2. The repair costs also include the costs of repairs identified through inspections. In some cases, it may be useful to create a separate budget code for this to enable these costs to be reported separately.

Remco Jonker, MSc is Partner in Mainnovation, the company he joined right after the start up. In the course of his career, Mr. Jonker has become a maintenance and reliability expert with a wide array of expertise, helping customers globally develop "World Class" maintenance and reliability policies and practices. He is a former chairman of the Dutch CMMS section of the Maintenance Association (NVDO) and co-writer of the book entitled "Value Driven Maintenance, New Faith in Maintenance". www.mainnovation.com/en

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spectrum OIL CONTAINERS

Certification & Job Performance

Heinz P. Bloch

Soon after the BP offshore oil spill in April 2010, quite a bit of soul-searching was done by industry. As you may recall, 11 people lost their lives in the fiery explosion that preceded the release of millions of gallons of crude oil into the U.S. portion of the Gulf coastline. Some sources called it the greatest spill ever and, if nothing else, we can agree that it changed many lives.

Risk taking was then reexamined and job functions and accountabilities were being scrutinized at some corporations. In line with these commendable endeavors, a major oil producer's corporate maintenance reliability (CMR) team asked me to respond to some interesting questions. They expressed the hope that I might provide some insight.

To recap the main issue, a few team members were given the title "reliability engineer" while working in an *upstream (exploration and production)* segment of the corporation. Upon being reassigned to certain corporate *downstream (refining and manufacturing)* segments, they found out that downstream management considered reliability assurance as simply a function of any discipline of engineering and not a stand-alone or recognizable discipline. That caused puzzlement and some frustration with several team members.

As the CMR team of course knew, a few engineering schools offer reliability engineering curricula. However, in the downstream sectors of industry, discipline engineers---also called subject matter experts later in their careers---are generally focused on projects. They are only occasionally called on to provide assistance in their particular area of expertise. This usually happens when there are serious breakdowns or when in-depth troubleshooting is needed. The point: Except where titled positions exist in a particular industry segment, reliability is rarely a focus (except tracking production losses as a lagging indicator). And even production or operations engineers often do a large amount of small project work.

That then led to the first of two direct questions posed by the CMR team: Is reliability engineer a titled position in the exploration and production (E&P) side of other major petroleum producers/refiners, or is this job function similarly buried in what a discipline engineer or subject matter expert "might" do on a part-time basis in his or her specific area of expertise?

The second question was only vaguely related, but the team asked if many of the other petroleum producers/refiners recommend or require certification, such as Certified Maintenance and Reliability Professional (CMRP).

RELIABILITY ENGINEERS WHO ARE ALLOWED TO BE FULLY ABSORBED IN A MAINTENANCE DEPARTMENT END UP COMPROMISING UNDER THE PRESSURES OF MAINTENANCE.

ANSWERS START WITH DEFINITIONS

I tried to be brief in my "summary of a short summary" of answers to the two questions. Answers, I believe, must start with definitions:

- The definition of maintenance is to maintain equipment in the as-designed and as-built state.
- The definition of reliability engineering is to:
  a. specify equipment and systems so as to design-out maintenance;
  b. define if failure avoidance through upgrading is feasible;
  c. if "yes" on the above, define if upgrading is cost justified;
  d. if "yes" on the cost justification, take charge of implementation planning;
  e. at all times inculcate a mindset that will not tolerate repeat failures because repeat failures are indicative of not having found the root cause of a problem. Not knowing the root cause will set one up for the next surprise. The next incident could be fatal.

Keeping in mind these definitions, one would find subject matter experts in piping & vessels, machinery, instrumentation and controls, welding technology, metallurgy, etc., within major best-in-class petrochemical companies. Sometimes, these subject matter experts reside at the headquarters of an organization. In other instances, the machinery specialist may reside at and get paid by affiliate "A," but spends time on issues that affect all affiliates. The piping & vessel specialist may reside at and get paid by affiliate "B," but spends time on and communicates issues that affect all affiliates, etc.

At best-in-class companies, a subject matter expert spends a huge percentage of time

(usually 60%-80%) on failure analysis and prevention. Failure prevention implies intelligent development and application of specifications, authoritative determination of weak links, and systematic upgrading whenever a cost justification exists or a safety hazard must be removed.

Best-in-class companies consider their subject matter experts so valuable that they cannot be burdened with maintenance involvement. By inference, the involvement of others in maintenance tasks is rather repetitive and routine; it is therefore given to others.

As long as one accepts the above and implements job functions and assignments along those lines, there is no need to use the title, "reliability engineer." However, it would be implied that each of these subject matter experts is performing exactly as we would expect from a reliability engineer. Their role statement will say so.

In my experience, reliability engineers who are allowed to be fully absorbed in a maintenance department end up compromising under the pressures of maintenance. More often than not, the mandate of maintenance is to fix things quickly. There is little probability the reliability engineer immersed in maintenance tasks will be shielded from the fix it quick pressures. In contrast, reliability professionals with a clear role statement, a clear training plan and a firm resolve to know early in the morning how they will add value to the organization, will not allow themselves to be drowned by maintenance demands. Corporate management will support the reliability professionals' stance on the entire issue. These successful professionals will have made it known that one cannot solve 20 different major machinery problems in a 40-hour week. Many of the million-dollar issues that beg resolution deserve the expenditure of hundreds of hours of dedicated effort.

ADDRESSING ORGANIZATIONAL MATTERS

This brings us to organizational issues. In an operating plant, the machinery expert would get involved and become the "owner" of, say, process pumps that have failed more than twice in a 24-month calendar period. The assumption would be that performing conventional maintenance has neither uncovered nor cured the underlying root cause of failure. A highly motivated subject matter expert understands the fallacy of encouraging procurement from the lowest bidder on the one hand and expecting to receive equipment designed for high uptime on the other hand.

It is further assumed that the role of the subject matter (reliability improvement) expert has been clearly defined in a solid role statement and the expert's training plan is like an iron-clad contract. Both the role statement and the training plan represent a shared commitment. As to the training plan, both management and the employee will invest valuable time in targeted and results-oriented training. The full implication of this commitment precludes the standard management reaction of canceling training whenever the economy goes into a downturn.

It follows that the type of subject matter expert discussed here is an individual being groomed and nurtured as a professional by management. That's where targeted training takes on real significance. In any event, we are clearly referring to "people assets" that are far more valuable than physical assets. The very notion that one could hire such an individual from a contractor is deeply flawed and can be refuted by plain logic and existing facts in the marketplace.

I felt the need to commend this CMR team on the crispness of their two questions and the astuteness of their own observations. In my experience, the designations subject matter experts, discipline engineers and reliability engineers describe the very same individuals. There was, however, a huge difference in the questioners intimating that their experts devoted most of their time to project work. It is my experience-based position that, to be worthy of contributing to a project, a subject matter expert must have plant-related knowledge. Therefore, the

importance of actually stationing this professional at facility "A," "B," etc., cannot be overstated. A close substitute for in-plant involvement would be frequent and intense exposure to overseas startup assignments. That, of course, is a luxury that few petrochemical companies can offer or afford today.

Finally, a few comments on certification as a CMRP, or membership in the Society for Maintenance & Reliability Professionals (SMRP). I see these and similar certification pursuits as evidence of an individual reaching out and investing time to gain a measure of recognition. Chances are one's sense of self-worth increases after passing a one-day examination for a professional engineer's license. Going for certification is quite commendable. However, certification alone is not worthy of reward in and of itself. Regrettably, I do not believe that many of these membership entities are successfully (nor are they intent on) imparting the in-depth reliability improvement knowledge that is sorely needed. Case in point: The home facilities of most CMRPs have repeat pump failures and entire facilities are making few inroads towards eradicating repeat failures. What does this tell us?

In summary and from the above, it follows that the answer to Question 1 is essentially "no," but the reliability job function at best-in-class companies is clearly and effectively covered in other ways.

Regarding Question 2, an individual should be rewarded on the basis of performance and tangible contributions. These should be discussed during periodic performance appraisals and the person whose performance is being evaluated should list them on a piece of paper. During the yearly performance evaluation session, it will become clear that a CMRP with certification but no motivation is worth much less than a motivated self-starter who reads, networks, implements and applies, but is not a member of SMRP nor holds a state-issued professional engineers license.

Decades ago, one best-in-class company reimbursed its engineers every year for two professional membership fees. In return, the company expected these professionals to share their knowledge by communicating and networking. It was not mandatory to be a member of anything, but it soon became evident that, on average, the knowledge accumulated by those who attended the local meetings of certain selected engineering societies was enhanced. Attendance at some meetings and conferences led to networking in the truest sense of the word. It allowed the member to call fellow members elsewhere for advice. Much of this networking yielded immense returns on the investment.

Finally, at some best-in-class organizations, depending on only the educational backgrounds of employees was deliberately and clearly discontinued as time went on. In one organization, when an engineer with a master's or doctoral degree was hired, initial advancement was based on salary curves for people with those degrees. However, after seven years with this organization, all salary curves merged and progress was based on nothing but performance rankings. I believe that's how it should be done throughout the hydrocarbon processing industry. Perhaps it would be one more step towards disaster avoidance.

Heinz P. Bloch is a practicing engineer and ASME Life Fellow with over 50 years of engineering experience. He advises process plants on maintenance cost reduction and reliability upgrade issues. Of his 18 textbooks on reliability improvement subjects, 12 are still in print and are being updated periodically. His most recent books on "Pump Wisdom" and "Compressors: How to Achieve High Reliability and Availability" were released in 2011 and 2012, respectively.

Life as a Maintenance Evangelist

Joel Leonard

Below is a journal entry from Joel Leonard, the "maintenance evangelist." If we are going to pass the baton to future generations of workers the skills needed to advance our society, we need more people to evangelize the benefits of maintenance reliability programs.

Just cried upon hearing the latest news from U.S. Marine Taylor King. When he was in high school, he used to mow my lawn. Due to a freak football injury, he could not enter the Marines immediately after graduation. He didn't want to commit to a four-year debt load, so he was looking for options. I gave him all my maintenance books and manuals and told him about some choices, career paths and available opportunities - like I do with anyone who has ears.

As opposed to most people who just humor me and then scamper away and scoff at my suggestions about a "maintenance profession," Taylor, who has great parents that reinforced my suggestions, encouraged him to take some electrical and mechanical classes. He also mended his foot and trained rigorously to meet the requirements to become a Marine. So now he is assigned to be a mechanic on jet fighters and tomorrow morning he is going to mow my lawn. I can now give him a beer along with another load of books and magazines to read to sharpen the saw. Also, I am going to get him connected with my contacts at the National Defense Industrial Association (NDIA.org). He already has interest from companies who want to hire him as soon as he completes his service to his country.

See why my tear ducts are empty? Many in my family still criticize my chosen self-developed career path because it has not been as financially lucrative as others. But when you get feedback like this, who cares?

I can die a happy man knowing that my legacy may not be measured by my personal income, but by the new generation of caretakers capable of handling the latest technology and advancements that protect and propel our society forward. OOOAAAAH!

We hope you can join Joel Leonard and preach the maintenance gospel. Help us build the next generation of technical workers who will be much needed since baby boomers are now retiring in the U.S. at a reported rate of 1,000 per day.

Are you visiting your schools? Are you supporting robotics, remote control hobbyist competitions, etc.? Are you mentoring talent? If so, pass on your tear-jerking moments to Joel@skilltv.net.

Further stories that support Joel's mission:

1. *Student confident will find job:* http://www.digtriad.com/news/local/story.aspx?storyid=252677
2. *Courier Tribune explains why Machinists are in demand:* http://courier-tribune.com/sections/news/business/program-seeks-machinists-technicians.html
3. *Fox 8 WGHP- shares why companies use stealth hiring to locate quality workers:* http://myfox8.com/2012/09/19/piedmont-companies-and-stealth-hiring
4. *Produce to Prosper - Manufacturing Revival Radio:* http://madeintheusa.dreamlandinteractive.com/joel-leonard-if-we-are-going-to-prosper-we-have-to-produce

WHERE THERE'S CONDENSATION, THERE'S PROBABLY WATER

Brian Thorp

Generally when collecting an oil sample, a quick once-over is completed on the equipment using the look, feel, listen and smell approach. Too often, people forget the common sense approach to analysis and tend to rely too much on test instruments.

While collecting oil samples on a 1,200 HP oiled, sleeve bearing motor, I noted an unusual amount of condensation on the inside of the outboard bearing reservoir slinger ring sight glass. For those unfamiliar with oiled electric motors, they generally get oil to the bearings via an oil ring or slinger ring that rotates on the shaft. The slinger ring is larger than the shaft and hangs down into an oil reservoir that is .750" to 1.5" below the level of the shaft and bearing contact area (see Figure 1). Generally, there is a larger sized sight glass located on the top half of the bearing cavity which allows a visual inspection of the slinger ring as it carries oil to the shaft and lubricates the bearing (see Figure 3).

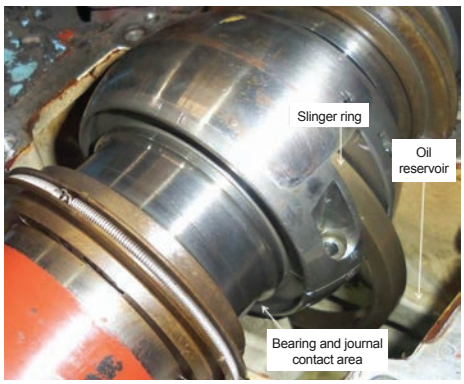


Figure 1: Motor bearing reservoir with top cap removed

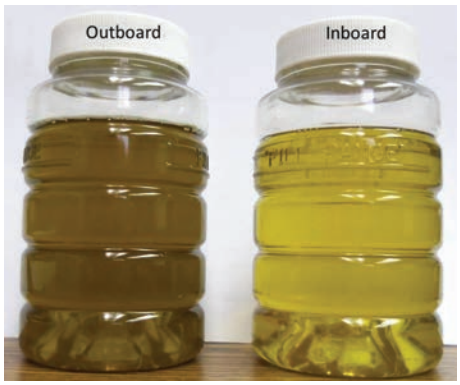


Figure 2: Oil samples from inboard and outboard bearing reservoirs

When oil samples were pulled from the inboard and outboard bearing cavities, the outboard sample was not emulsified, but it was not bright and clear like the inboard sample (see Figure 2).

One of the positive advantages of industrial oils is their ability to demulsify water. Since this reservoir is not aggressively circulated to emulsify the oil, a small volume of free water above the saturation point will separate under normal running conditions. The outboard reservoir drain valve was opened, which yielded about two tablespoons of free water before pure oil started flowing out. The original design of these motors had a drain plug directly in the bottom of the bearing reservoir. During the years before condition-based oil changes were implemented, the drain plug was replaced with a sec-

tion of pipe, a valve and a cap or plug. This made yearly oil changes much easier and less messy than the previous plug removal. Currently, this set up serves as a low leg for water coming out of the reservoir area to collect in (see Figure 3).

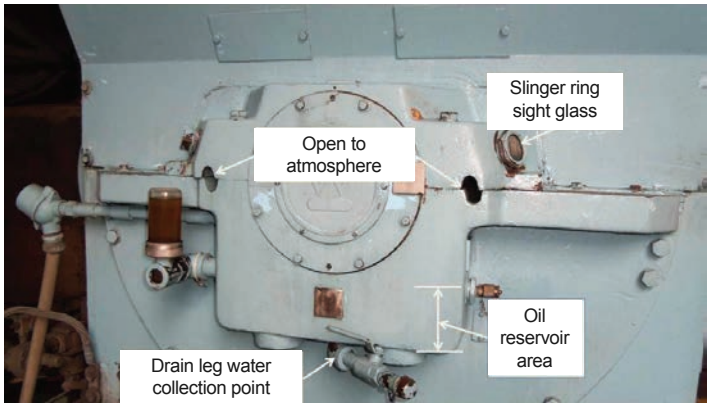


Figure 3: Outboard end of motor

Neither sample crackle tested positive in-house or at the lab. A Karl Fischer water test was requested even when crackle was negative to see what the water ppm was in the samples. The inboard tested at 25.3 ppm and the outboard at 32.3 ppm. Since the inboard bearing reservoir did not have visible condensation in the sight glass or free water from the drain when it was checked as the outboard did, this illustrates the close range of saturation to free water in this oil type. Another interesting note is once the free water had been drained from the outboard bearing reservoir, the condensation in the slinger ring sight glass was gone by the next day.

WHEN WE THINK ABOUT WATER CONTAMINATION, WE GENERALLY THINK ABOUT GROSS WATER CONTAMINATION, NOT NECESSARILY THE DAMAGE THAT CAN OCCUR FROM LOW LEVELS OF WATER CONTAMINATION.

Most people are aware that water can be a very detrimental contaminant. When we think about water contamination, we generally think about gross water contamination, not necessarily the damage that can occur from low levels of water contamination. Water not only reduces the load carrying ability of a lubricant that can increase wear, but also promotes oxidation and corrosion and can cause additives to precipitate or drop out, thus degrading the lubricant's properties. Another serious problem with water in bearings, sleeve, or anti-friction is hydrogen embrittlement. If the water is forced into micro cracks of the babbitt or steel, it releases hydrogen under extreme force or loading and heat, which can create mini explosions that make larger cracks. These cracks sometimes loosen the bond between the babbitt and underlay, or can lead to spalling in anti-friction bearings. With a weakened bond or spalling, it is only a matter of time before the bearing fails.

The next obvious question would be, Where did the water come from? There are a couple of possibilities here. The wash down and cleaning frequency has been increased recently. The two holes shown in Figure 3 are open to atmosphere and come into an area in the middle of the labyrinth seal on the inboard of the bearing housing. A misdirected water spray could possibly get into the bearing cavity, thus causing water to enter the oil reservoir. In case this was the cause, some educational material with internal pictures of these reservoirs showing the possible path of ingress for water was passed along to those responsible for wash downs. A picture of the slinger ring sight glass was included with condensation on the inside and a comment to check the drain for free water and to contact PdM for oil analysis. In the future, a rag will be placed in the holes or a piece of tape over the openings during wash downs.

The other possibility is condensation while passing through dew points when the equipment is shut down based on reduced load requirements. Load reductions are more frequent during spring and fall with moderate temperatures and reduced electricity consumption. The easy fix for condensation would be a desiccant breather on the reservoir. The problem with this is when the reservoir has more than one opening to the atmosphere, as evident in Figure 3. The desiccant would remove moisture from the headspace in the reservoir, but with the housing open to the atmosphere, the path for exchange air would not be exclusively through the breather, thus causing the desiccant to rapidly deplete in high humidity areas.

In conclusion, whatever the cause for the water intrusion, two of the best defenses are training and education. An observant operator should be able to identify gross water contamination by the coloration of the oil in the sight glass, or recognize slight water contamination by condensation in a sight glass above the oil level. When the problem is identified and dealt with in a timely manner, the possibility of damage can be greatly reduced.

Brian Thorp has been involved with mechanics and maintenance for over 35 years. His range of knowledge includes automobiles, trucks, heavy equipment and power plants. His current position is as a Predictive Maintenance Technician with Seminole Electric Cooperative Inc., where he is responsible for the lubrication and analysis for a combined total 1300 MW coal-fired power generation plant.

Roll Alignment Now Faster and More Precise

Christian M. Reidler

In many machines of the paper, metal, converting and printing industries, rolls are the carriers of the material web. However, the parallel alignment of these rolls makes it challenging to measure each roll as the machine geometry very often makes it hard to use optical or mechanical alignment systems like theodolites or telescope bars.

In the paper industry, for example, enclosures, such as the drying hood, represent an optical barrier for the theodolite bar. Large distances between rolls in galvanization lines make the usage of telescope bars impossible. However, roll alignment is absolutely necessary. Figure 1 shows the effects of a nonparallel roll on the material web.

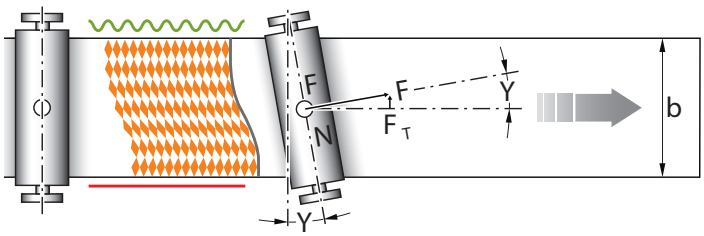


Figure 1: Effect of a nonparallel roll on the material web where a transversal force orthogonal to the production direction occurs. Whatever this force may do to the web, the consequences are negative for production output and quality. They may reach from small folds to web breaks and increased web movement. Furthermore, the web extension is nonsymmetrical (illustrated by the red line for higher tension and the green waves for lower tension), which leads to a nonsymmetrical winding of the web. Last but not least, the material itself is deformed, as shown by the orange rhombuses.

The transversal force caused by the misaligned roll stretches the web nonsymmetrically, deforms it and makes it move up, which results in the production of folds and web breaks. To prevent such a scenario, the rolls have to be aligned orthogonally to the machine's reference line and parallel to each other. As previously noted, this can be a challenging task.

But let's take a look at how this task can be performed using optical systems.

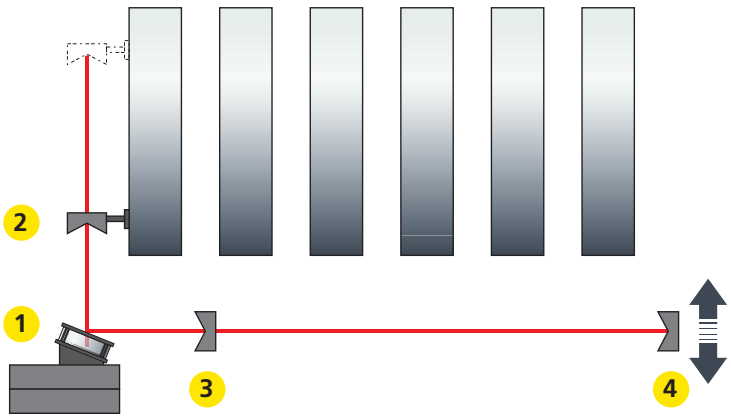


Figure 2: Determination of roll parallelism using traditional technology. A laser beam is set up alongside the machine axis and then deflected into the rolls to be measured. If the rolls are to be checked on separate levels or in housed areas, this measurement procedure is time consuming and the use of additional optical equipment in order to reach each roll represents a loss in accuracy.

In theory, after the machine's axis has been picked up from reference marks 3 and 4 shown in Figure 2, the laser beam is deflected into the machine to measure the position of a roll. Therefore, a detector must first be placed on the operator's side and then on the machine's side. This process has to be repeated for every single roll, which makes it very time consuming.

In real life, machines can reach from the basement of a factory over several floors to the very top. In most cases, no optical access is available. In such cases, telescope bars can help align one roll to the next. Circumference measurements are also a possibility, but only if the distance between the rolls is not too high.

The bottom line is:

- Roll alignment is an absolute requirement to reach a high machine output while keeping the mandatory quality standards.
- The technologies available for roll alignment are limited in one way or another by the machine geometry.

It would be nice to have a system that makes it possible to accurately measure every single roll in the machine independent from the machine geometry and all rolls are measured very quickly to save production time.

The good news is: It is possible!

The key relies on a technology used for almost 100 years in aircrafts and later on in spacecrafts -- the gyroscope as part of the navigation system. Such gyroscopes keep their rotation axes unchanged due to mass inertia, even if their base is shifted. Figure 3 shows this physical phenomenon.

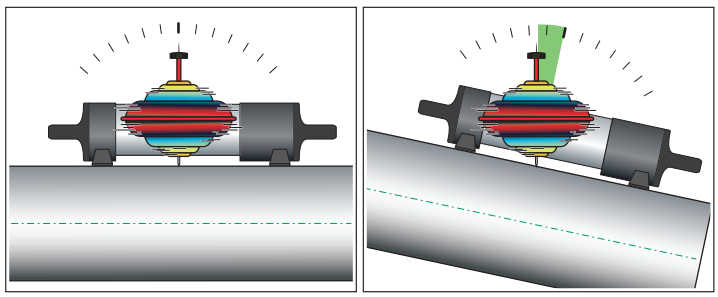


Figure 3: The gyroscope stays in the same axis while its base is being moved. This way an angular measurement along the rotation axis is possible, as shown on the right.

Three gyroscopes arranged along three dimensions in space (x, y, z) result in a measurement unit that can identify its relative position in space at any time. Using this so-called inertial measurement unit (IMU), aircrafts and spacecrafts can determine their flight attitude. The three roll, pitch and yaw angles give the pilot exact values about the aircraft's position in space.

But where is the link between such navigational technology and the challenges of precise roll alignment? A detailed look at the rolls' degrees of freedom in space will give us a hint. Figure 4 shows a roll and its positioning properties. Conclusion: The position of a roll in space is not so different from the one of an aircraft. The roll, pitch and yaw angles also can be used as an indicator of the roll's position, just like the flight attitude.

ROLL ALIGNMENT IS AN ABSOLUTE REQUIREMENT TO REACH A HIGH MACHINE OUTPUT WHILE KEEPING THE MANDATORY QUALITY STANDARDS.

Because it would make no sense to equip every roll in a machine with an IMU, a way to develop a measuring device with an integrated IMU that can be used on the roll's surface to determine its position is needed. The solution is as ingenious as simple. By using the three orthogonally arranged gyroscopes in a frame with two parallel feet, a link between any surface and the IMU itself is created. The device is now ready to be moved along any surface and to record the angular changes during the movement. If the device is moved along a circle around the roll, its position can be calculated. It is not even necessary to move it along the full circle. A movement of 20 degrees around the roll angle is enough; a mathematical algorithm does the rest.

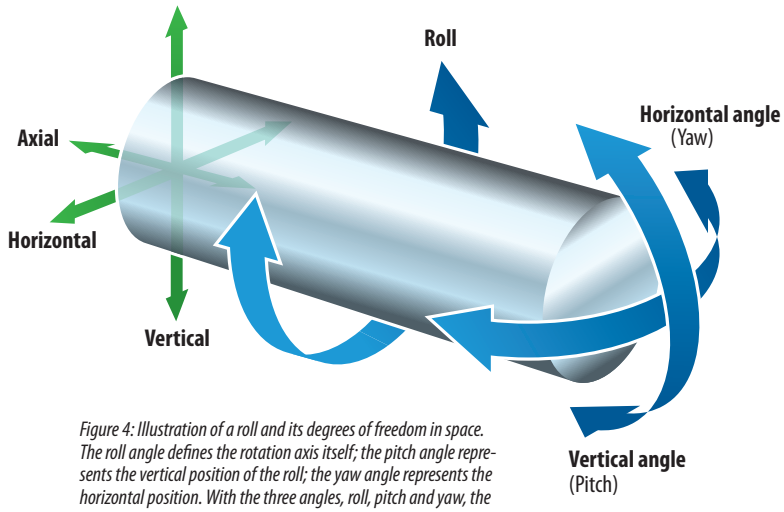
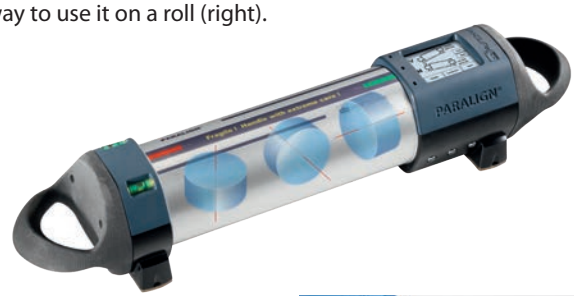


Figure 4: Illustration of a roll and its degrees of freedom in space. The roll angle defines the rotation axis itself; the pitch angle represents the vertical position of the roll; the yaw angle represents the horizontal position. With the three angles, roll, pitch and yaw, the roll's position is determined in the same way as the flight attitude.

Figure 5 shows the IMU within its frame and the two feet (left) and the way to use it on a roll (right).



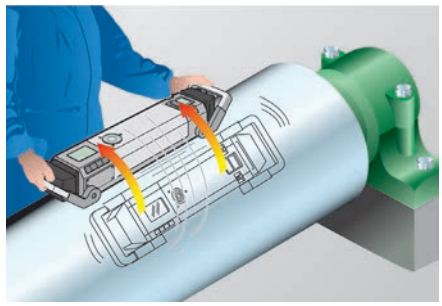


Figure 5: The image on the top shows the IMU and its gyroscopes in blue. Each gyroscope measures around its rotation axis shown in red. The image on the right shows the measurement process of a roll. The inertial measurement unit is placed on the roll's surface. By moving the device along a circle on the roll, the geometrical position of the roll is measured. Unlike traditional systems, the IMU does not need any line of sight to or between the rolls.

The benefits of such a system used for roll alignment are huge: No line of sight is required. Measurements over several layers and high distances in enclosed machine parts are no longer challenging. All restrictions from optical or mechanical systems are removed and the requirements to measure all rolls in the machine with the same accuracy and within an appropriate time are fulfilled.

Using this technology, it is possible to measure and align complete machines during a regular maintenance shutdown. The returns include higher production output and increased product quality by preventing the negative effects of misaligned rolls.

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Recent Impact of E-Procurement on the MRO Industry

Anup Varghese

Market research and procurement intelligence finds that billion dollar consumer packaged goods (CPG) companies with maintenance, repair and operations (MRO) constituting around five percent of their annual revenue have high and undesirable inventory levels and maverick buys. Low spend visibility for their low-value, high-volume indirect goods and services is one of their major issues. This is a key challenge for most mature businesses as they strive toward reducing their total cost of ownership.

There has always been a pressing need to increase spend under management and have better control over maverick spending in order to reduce the amount of associated paperwork and time in procuring these products.

Over the last four years, MRO providers have been increasingly focusing on enabling their customers to purchase goods through their online e-procurement platforms. This allows for quick and paperless transactions, saving time and capital for both the buyer and the supplier. This trend has skyrocketed post-2009 among major global MRO providers, mainly distributors who provide multiple brands and categories, thus enabling MRO buyers to consolidate their current suppliers. Large distributors now make as much as $2 billion annually through their e-procurement platforms. This article will explore the current impact e-procurement has on the global MRO industry, along with key developments in this area based on recent procurement analysis.

UNDERSTANDING E-PROCUREMENT IN THE MRO ARENA

The aim of e-procurement is to be able to purchase the right product or inventory in a timely and cost-effective manner. Reducing maverick spends and maintaining optimum or lean inventory levels can help achieve overall cost savings of around five to 10 percent. Furthermore, paperless communication and invoicing saves 50 to 70 percent of the time required through conventional transactions. Depicted in Figure 1 is the role e-procurement plays for buyer and supplier.

RECENT GLOBAL DEVELOPMENTS IN E-PROCUREMENT

- With the availability of more than 500,000 MRO items across 14 categories, AmazonSupply now provides free one year returns and quick shipment, which increases its attractiveness to the B2B market. AmazonSupply is not expected to have an impact on large global MRO distributors since it does not provide the essential expertise and onsite support that is of high importance to a large MRO buyer. Thus, distributors are still the preferred partners for global MRO buyers.
- In-depth information about the product and other customer-centered details, such as product/brand comparison, is becoming the focus of providers in order to improve the attractiveness of their e-procurement services to their customers. E-procurement solution providers now provide their clients with eRequisition, eCatalogs, supplier integration, implementation services and product visibility.
- The MRO segments of industrial MRO, power transmission and fluid power have seen maximum development in the e-procurement area in the last two years in the B2B market.

GLOBAL ADOPTION LEVELS OF E-PROCUREMENT AMONG MRO PROVIDERS (DISTRIBUTORS/INTEGRATORS)

The largest geographical MRO demand markets are Asia, Europe and North America. Though Asia holds the largest MRO market share, and is the fastest growing emerging region, it has lower levels of penetration for MRO integrators when compared to mature regions such as North America[1].

The adoption of e-procurement depends on the geographic maturity of the MRO industry and the availability of MRO service providers capable of offering such services in the region. The United States, Canada and Western European countries witness the maximum penetration of e-procurement due to their large supplier base and high levels of integrator and distributor penetration. Depicted in Figure 2 are the estimated global e-procurement adoption levels in the MRO industry.

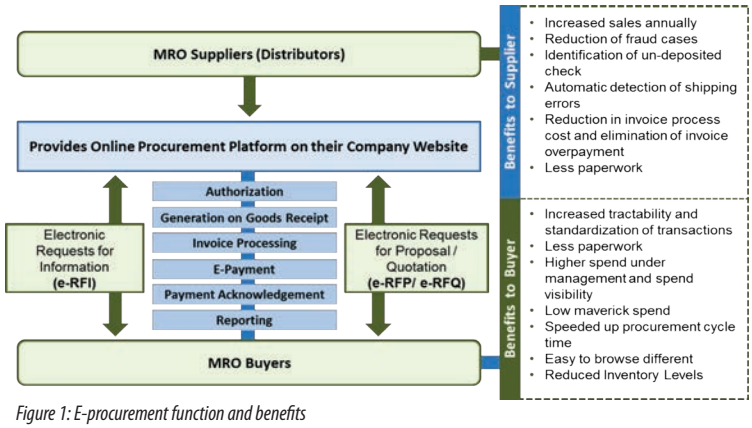

Figure 1: E-procurement function and benefits

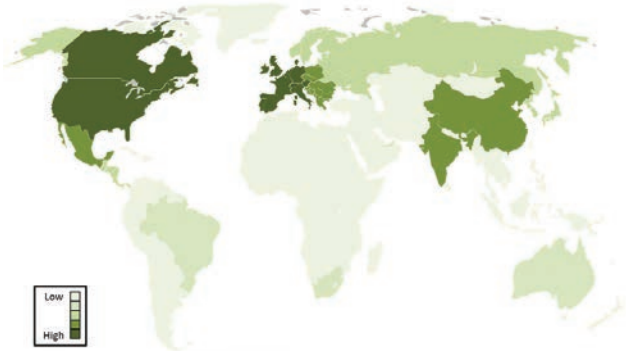

Figure 2: Adoption of e-procurement by MRO distributors globally

The global e-procurement solutions provider market is currently fragmented, however, increases in mergers and acquisitions among large providers are slowly inclining the industry toward consolidation. The e-procurement market is expected to reach $1.5 billion by 2014, with a compounded annual growth rate (CAGR) of five percent over the last four years. E-procurement service providers are now moving toward a cloud-based delivery model (where software and associated data are centrally hosted on the cloud), which increases software flexibility without additional investment in infrastructure. Outsourcing and providing on-premise solutions are other models of e-procurement deployment/installation used by global providers.

RECENT E-PROCUREMENT STRATEGIES ENABLE MRO BUYERS TO:

Bundle Spend and Unbundle MRO Items: In order to achieve better cost savings and spend visibility, e-procurement must be leveraged in such a manner that the organization can track spend on particular MRO items, enabling MRO categorization and category-wise spend levels.

Improve Supplier Relationship Management: Buyers aim at shifting into being their supplier's key clients by increasing the attractiveness of their current account. This can be done by consolidating spend in various categories to a few particular suppliers. This will help buyers implement complex strategies, such as supplier integration or long-term contracts, with lower margins demanded by suppliers.

Link MRO Inventory to the Provider: Organizations can now maintain lean inventory by linking inventory levels and usage to the ordering system of the supplier. This enables timely procurement and gives suppliers a heads-up on predicting demand. This approach, however, is possible only when buyers are willing to disclose and share their inventory information with a selected key supplier.

CHALLENGES FACED WHILE IMPLEMENTING E-PROCUREMENT AT AN ORGANIZATIONAL LEVEL

Large MRO buyers require maintenance and after-sales service from their distributors/integrators, and hence engage in e-procurement only with MRO providers that are able to provide these services. Small- to medium-sized companies face higher initial investment costs due to the need for better infrastructure to facilitate e-procurement from their end. A few major challenges are listed in Figure 3.

Challenge	Remark	Impact on Capital Invested
Lack of IT Infrastructure	Smaller companies would need to boost their IT systems or infrastructure in order to faciliate and ensure secure transactions, which would be a costly affair.	◕
Company Culture	Resistance to change is one of the most dealt with challenges in an organization. Conversion from conventional methods to usage of electronic platforms may require investments in training.	◑
Diminishing Inventory	Afer successful implementation of e-procurement, inventory at every stage will set to reduce, which increases the dependency on quick responses at each link. This increases risk of disruption in production/supply.	◔

Figure 3

○ Low ● High

SUMMARY

E-procurement has enabled MRO distributors who have invested in an e-procurement infrastructure to increase global sales and has ensured paperless and transparent procurement processes to buyers who leverage this facility. This trend is set to be increasingly adopted by MRO providers globally and will pave the way to better spend visibility and tractability by buyers in the future.

References:

1. W.W Grainger's Factbook http://invest.grainger.com/phoenix.zhtml?c=76754&p=irol-irFactBook_pf (2012 Factbook, page 5)

Anup Varghese is a research analyst at Beroe-Inc, a procurement intelligence company. Anup focuses on understanding the procurement trends and best practices across industries. Anup is a graduate from one of India's top 10 engineering colleges (College of Engineering Guindy, Anna University) in the discipline of Manufacturing Engineering.

CASE STUDY

A global provider of valve solutions used in the power and oil and gas industry, headquartered in the U.S. with 50 years in service and represented in more than 60 countries, was looking to adopt e-procurement platforms for their offices worldwide.

Business Challenge: The company had disparate information management systems across its outlets. Although the need to consolidate and standardize all systems on a worldwide basis is being addressed by company executives, efforts in this regard is taking time. Managing indirect spend had reached critical levels, which hindered the company to move to the next level. There was little chance in implementing consistent authorization controls and regulatory compliances.

Solution and Result: The company adopted an e-procurement platform for its worldwide purchase-to-pay system, which was tailored to its needs by an external e-procurement service provider. It allows end users to order commodities online instead of through their purchasing department, manage workflow, and ensure compliance with company policies and local regulations while providing multi-language and tax handling capabilities. The system was installed in less than three months at the headquarter's location and the project was completed worldwide in nine months.

The system has helped managers assess the number of suppliers in each spend category and provides access to transaction details to identify each product procured from their suppliers. This will help improve their global purchasing power and rationalize their supplier base.


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Why We Need Quality Management in Maintenance

Bill Keeter

During recent presentations, I asked the audiences how many of their organizations had quality management systems in place within their maintenance departments. On average, about two percent of the attendees raised their hands. I asked the same audiences how many of their organizations had quality management systems for their manufacturing processes. The response was somewhere in the 95 percent range.

That is a very interesting comparison when we consider that between 50 percent and 70 percent of equipment failures are likely due to infant failures resulting from either maintenance or commissioning errors.

An April 1999 study of misalignment versus bearing life by the University of Tennessee's Maintenance and Reliability Center showed that as little as 5 mils/inch of misalignment when using a grid coupling could reduce bearing life by as much as 50 percent.

It could be said that the most important periods in any asset's life are the installation and commissioning phases. Equipment will achieve 100 percent of its design capability if the job is done well. Conversely, equipment will start life in a degraded state if the job is done poorly.

THE PURPOSE OF QUALITY MANAGEMENT

A quality management system (QMS) consists of two types of activities. Quality assurance (QA) is activities designed to ensure that quality is built into the process. Quality control (QC) is activities designed to ensure that desired quality levels are actually achieved by the process. It takes both types of activities to reach desirable quality goals. It is unreasonable to expect that quality assurance will be 100 percent effective in preventing maintenance and commissioning errors. The activities are a human endeavor, which means mistakes will be made regardless of how rigorous the procedures are. It is also uneconomical to inspect every defect using quality control methods.

	Aircraft		Naval Vessels		Manufacturing
Failure Curve	1968 UAL	1973 Broberg	1993 Surface**	2001 Submarine*	2005 Plucknette
A - Bathtub	4%	3%	3%	2%	3%
B - Wearout	2%	1%	17%	10%	3.5%
C - Fatigue	5%	4%	3%	17%	6.5%
D - Break-In	7%	11%	6%	9%	7%
E - Random	14%	15%	42%	56%	13%
F - Infant	68%	66%	29%	6%	67%

Table 1: Results of Reliability vs. Age Studies (Nowlan and Heap, Nicholas, Pau, Allen, et al.)

*The data was gathered after over 30 years of implementing the SUBSAFE Program

**The data was gathered approximately 15 years after the naval surface force adopted maintenance strategies similar to those used in submarines.

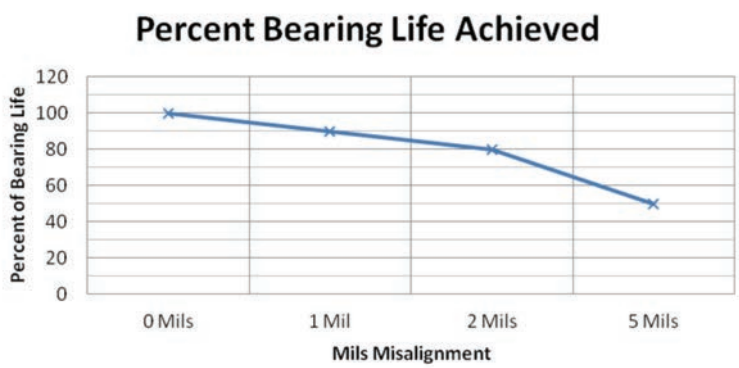


Figure 1: Percent Bearing Life Achieved

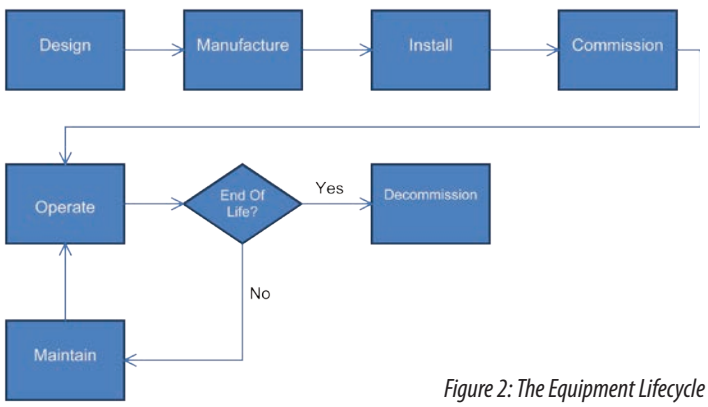


Figure 2: The Equipment Lifecycle

PRECISION MAINTENANCE AND QUALITY ASSURANCE

Precision maintenance is achieved by well-trained people using precision methods and well-written procedures. Quality assurance is achieved by inserting steps in the procedures that require the person doing the work to record a number and the person supervising the work to approve the number. This is not an easy assignment. It will probably make jobs last a bit longer, which nobody likes, but if it makes the installation (I) to potential failure (P) interval longer, it will be well worth it.

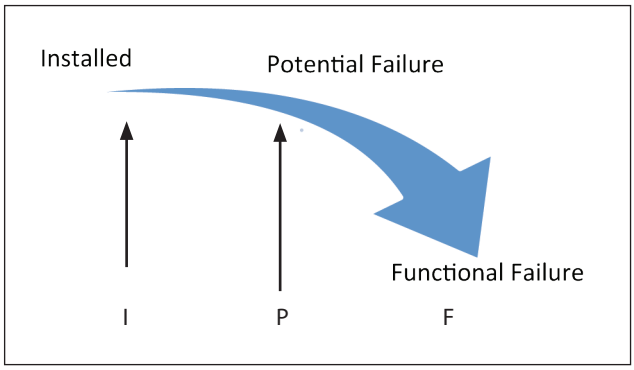


Figure 3: I-P-F curve from Doug Plucknette

QUALITY CONTROL IN MAINTENANCE

Quality control means having the discipline to come back at the completion of the job to take what have been referred to over the years as baseline readings for condition monitoring. Admittedly, this is an important step for the condition monitoring program, but changing the focus from just getting baseline readings to quality control of the work done will result in a greater return on those condition monitoring tools. The use of vibration analysis, thermography and ultrasonic tools will enhance your organization's ability to find misalignment, close couplings, leaking fittings, missing insulation, loose electrical connections and other installation faults after maintenance work.

WHERE TO START

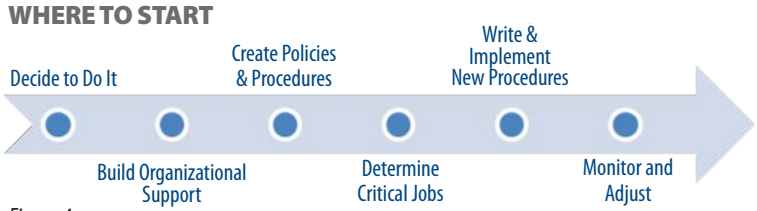


Figure 4

Decide to Do It

The first step in making any change is to decide to make the change. Nothing happens without this critical step.

Build Organizational Support

Support from all levels of the organization is crucial to the success of this program. Management has to be shown the potential value, and the rank and file has to be shown what is in it for them. Evidence from a 1986 Electric Power Research Institute study suggests that a precision maintenance program has significantly lower costs than either preventive or predictive maintenance alone (see Figure 5).

Create Policies & Procedures

Policies and procedures are an important way of institutionalizing any new program. They establish what will be done, how it will be done and

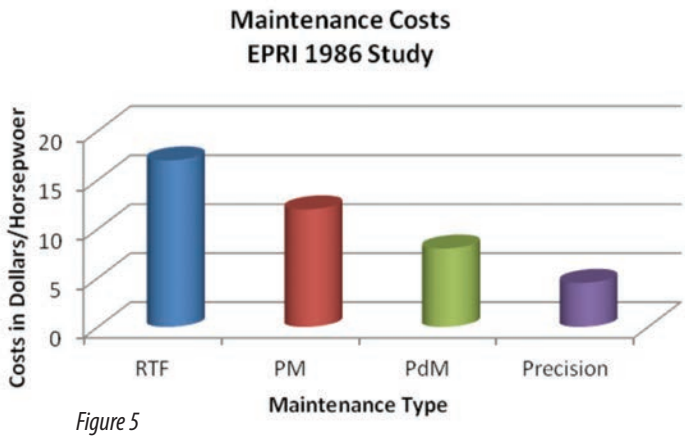


Figure 5

who will do it. Everyone's roles, goals and responsibilities will flow from these, so they should include a RAS/CI table to summarize responsibilities. The RAS/CI table is a quick visual summary of the responsibility level of different organizational roles for a given process.

Determine Critical Jobs

Jobs, like equipment, have some level of criticality. Criticality is a function of probability of occurrence and business impact. High impact jobs that are performed frequently would pop to the top of your list and should be examined for improvement using QA and QC methods to ensure reliable performance.

Write and Implement New Procedures

Pick a procedure and begin working on it. The procedure writing process should be an inclusive, facilitated process that includes the people who will actually have to perform the work. The beginning of this process is a visual breakdown of the job called a job map. A job map is similar to a work breakdown structure for the job, but it has steps that identify dangers to people and equipment, job impediments, resources and job performance standards. The actual writing of the procedure can take place once the team agrees that the map is complete.

Monitor and Adjust

Quality management is a continuous improvement process. It is important to monitor both the process and the work product to ensure the new program is working. Establish key performance indicators (KPIs) to measure progress in creating and implementing the new procedures and to measure whether or not the procedures are effective.

CONCLUSION

There is a lot of evidence showing that the quality of maintenance and commissioning of equipment needs to improve in almost every industry. Hardly any manufacturing or service organizations create their products and services without some sort of QMS in place to ensure the customers get a quality product at a reasonable price. The maintenance department is a service organization whose goal is to deliver uptime at a reasonable price. A well-designed QMS will enable them to do that.

Bill Keeter is the owner of BK Reliability in Titusville, Florida. Bill is an experienced maintenance professional who provides reliability training and consulting services around the world. He is passionate about helping organizations understand and eliminate system failures so they can achieve better safety, environmental, operational and financial performance.

How Good Are We? Just Ask the V-Belt

George Mahoney

"I really don't understand what we are doing here. We are maintenance people; when something breaks, we fix it. You management guys are really making this a lot harder than it needs to be."

These are the words spoken by one of our lead mechanics during a Kaizen event for defect elimination. As each word comes out of his mouth, I feel more and more crushed. Not only have I failed at making it clear why we want to eliminate defects, I also utterly confused everyone involved in the process.

After some soul-searching, I determined that the only way I can bring this message home is to use a tangible example to which they can relate. Instead of talking about process maps, standard operating procedures, and key performance indicators, I decide to talk about something they touch every day - **v-belts.**

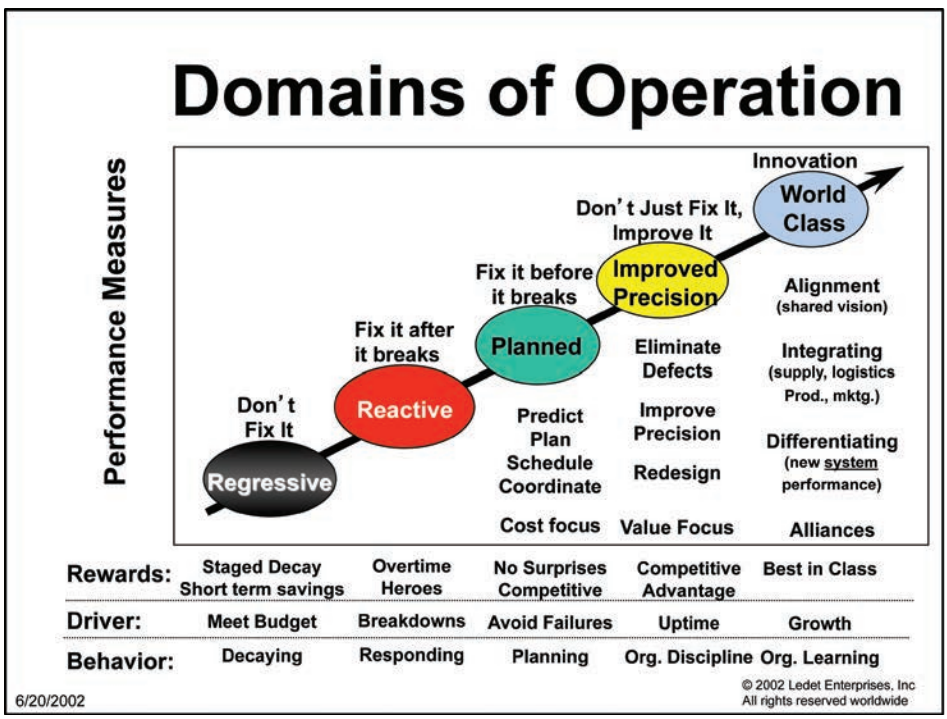
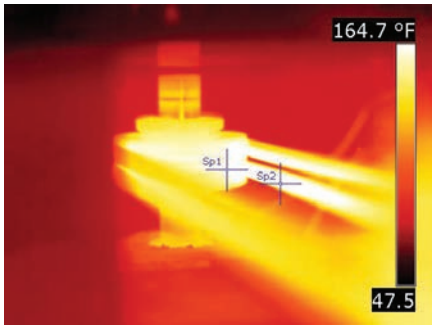


Figure 1: Domains of Operation

From top left, clockwise:
Mounting bolts for motor
Neglected air handling unit
175°F V-Belt
V-Belt broken in half



To keep it as simple as possible, I decided to talk about how we would treat a v-belt in each step of the defect elimination journey. In the process, I linked each step of the journey to the stable domains identified by Winston Ledet. Winston is a key mentor of mine who first introduced me to the concept of defect elimination in his book, *Don't Just Fix It, Improve It!*

Each of the five domains is listed in Figure 1.

Challenge to the reader: As you read the remainder of this article, determine which domain currently applies to your plant. If I am successful at not "making it harder than it needs to be," it should be as easy as looking at how you handle v-belts.

REGRESSIVE DOMAIN: DON'T FIX IT

In the regressive domain, no one really cares about the v-belt. Things are allowed to deteriorate, regardless of the impact to the business.

You know you are in the regressive domain if you hear something like this:

Site Manager: "Who cares if the people in Building 32B have no air conditioning because a v-belt ripped in half. We need to save money and we need to save it now. Fixing this is not in my budget."

REACTIVE DOMAIN: FIX IT AFTER IT BREAKS

In the reactive domain, we only care about the v-belt after it breaks. We don't monitor it on a routine basis to keep track of its condition, nor do we make any effort to ensure it is installed properly in the first place. Nevertheless, when the belt does break, we all run around like maniacs trying to get a new one installed.

You know you are in the reactive domain if you hear something like this:

Site Manager: "Johnson, the people in Building 32B are sweating. Make sure we get a new v-belt installed immediately. Work as much overtime as you need, just make sure this gets done before they get back to work tomorrow."

It's a good thing for Johnson he has an unlimited overtime budget and an army of mechanics just sitting around waiting for things to break. (Insert sarcastic tone here.) It's also a good thing for Johnson that he has a stash of belts hidden in his shop. Who could blame him? No one ever really knows when something is going to break in this plant and even less than no one really trusts the store to have what you need when you need it.

(*Side Note: It would be interesting to see how Johnson has the spare belts stored in his shop. What are the odds the new belt they installed is already defective?)*

Site Manager (the next morning): "Johnson, great job getting that v-belt installed and the air conditioning back in operation last night. You saved the day. Here is a $25 gift card for you and a voucher for a pizza party for the boys in the shop. Keep up the great work."

PLANNED DOMAIN: FIX IT BEFORE IT BREAKS

In the planned domain, we really care about when the belt is going to break and how efficiently we utilize our resources to replace it before it actually does.

Why do I say we care about when it is going to break? Because we pay PdM technicians to monitor the belt condition with infrared and vibration analysis on a three month frequency. At the first sign of belt wear, we instruct these same PdM technicians to create a work request to have the belt replaced before it has a chance to significantly impact equipment functionality.

Why do I say we care about how efficiently we utilize our resources? Because we pay a planner to develop a job plan and obtain the new v-belt a few weeks prior to the installation. We also pay a scheduler to coordinate a system shutdown with mechanic availability. The better we plan and schedule the work, the more efficiently our resources can execute the repair and the less time the equipment will have to be offline.

In the planned domain, you will most likely hear something like this:

Site Manager: "Reducing unexpected v-belt breakdowns is the best way for us to improve our schedule adherence metrics. These items should be on the schedule and executed before the equipment is negatively impacted."

I am sure some of you reading this right now are feeling that the planned domain is a nice place to be. Who wouldn't be in favor of reducing maintenance costs and increasing equipment uptime?

From a distance, this sounds both simple and terrific. But if it is so simple, why is it so hard to live in the planned domain?

It's probably because we never did anything to address the source of the defect. Sure, we knew when the belt was going to break and determined the most cost-effective way to replace it, but we never addressed why it began to wear in the first place.

Enter the precision domain.

PRECISION DOMAIN: DON'T JUST FIX IT, IMPROVE IT

In the precision domain, we care about WHY the belt is breaking and begin to take efforts to eliminate the source of the defect so it does not happen again. We don't just want to fix things, we want to improve them. (In case this is not abundantly clear, this mantra comes directly from Ledet's book.)

In the precision domain, you will most likely hear something like this:

Mechanic: "I am tired of changing these v-belts every six months. We need to figure out why they are breaking so I don't have to keep climbing into this air handler."

(Side Note: Notice it is the mechanic and not the site manager speaking. The only way to truly eliminate defects is to empower the workforce to take action on the things impacting their day-to-day lives.)

In this domain, we take a close look at the predictive maintenance reports to determine if there are signs of misalignment or improper belt tensioning. We form a cross-functional team of engineers, mechanics and operators to inspect the wear patterns on the belt and the sheave's condition.

The investigation may indicate that the sources of the defect were a combination of both workmanship and design. As an example, let's assume the belt was not tensioned properly because the mechanics had to pry the belts on the sheave. Let's also assume the mechanics had to pry the belt on the sheave because there was no space for them to loosen the mounting bolts on the motor so it could be moved closer to the fan.

With the WHY identified, the team can now take action to Eliminate the source of the defect. They can work together to redesign the air handler's housing to enable access to the mounting bolts on the motor. If they want to take it a step further, they can place a label on the housing indicating the correct belt tension and provide the mechanics with a tension tester to ensure the belt is tensioned properly.

WORLD-CLASS DOMAIN: DEFECT ELIMINATION AS A HABIT

In the world-class domain, we care about preventing defects from ever being added to our belt in the first place.

Every time a mechanic installs a v-belt, it is done perfectly. The mechanic does it so many times that it actually becomes a habit. This same type of habit extends to the engineers, who now ensure every air handler they design provides access to the mounting bolts on the motors. This culture of defect-free habits quickly extends around the plant.

After you have been on a few cross-functional action teams, you no longer want to be the one responsible for adding a new defect into the system.

WRAP UP

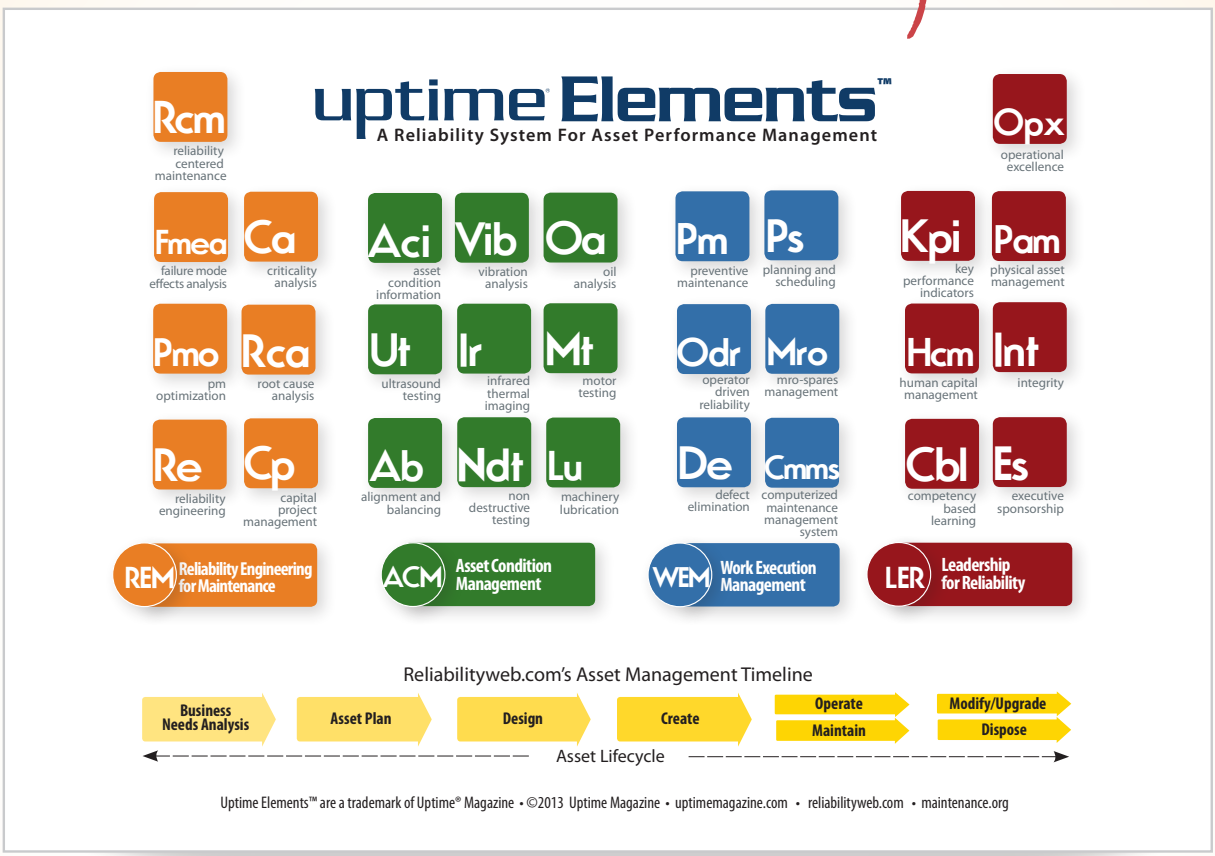
After having read this article, you should be able to easily determine in which domain your plant resides. Now that you have this information, what are you going to do with it?

I recommend you share this article with your maintenance team within the next week and develop a game plan to start eliminating defects. The more defects you eliminate, the less you have to chase them around all day.

Don't Just Fix It, Improve It! www.mro-zone.com

George Mahoney currently acts as a Mentor, Sponsor and Instructor for Lean Six Sigma. He has worked in almost every facet of maintenance and engineering over the past 10 years. He served as an HVAC technician, a Design Engineer, a Maintenance Planner, a Maintenance Scheduler, a CMMS administrator and a Reliability Engineer. George is a certified Six Sigma Black Belt, who has made lean methodologies, root cause analysis and continuous improvement a part of his everyday life. George has a B.S. in Chemical Engineering from Columbia's School of Engineering and Applied Science and a B.A. in Mathematics from Columbia College.

A reliability system for asset performance management



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Top 10 Misperceptions about Oil Analysis

Mark Barnes

Studies show that 60 to 70 percent of all mechanical problems can be detected using oil analysis, yet some people still struggle to realize the value a well-engineered oil analysis program can provide. The reasons are many and varied, but are often related to a fundamental misunderstanding of how oil analysis works. The following Top 10 list identifies some of the more commonly held misconceptions and fallacies about oil analysis.

1 ELEMENTAL ANALYSIS IS A SUREFIRE WAY TO FIND ACTIVE MACHINE WEAR

One of the most common tests used in oil analysis is the elemental – sometimes called spectrometric – analysis test. Depending on which lab you use, this test provides concentrations in parts per million of up to 25 elements, including metals indicative of machine wear, such as iron, lead, tin, or copper; additive elements, such as zinc, phosphorus and calcium; and contaminants, such as silicon and sodium.

Most people rely on the elemental analysis test to determine when a machine is starting to wear so they can take corrective action. However, depending on wear mode, this test can lead to a false sense of security. The issue lies in the fundamental test methodology used to determine wear debris, known as inductively coupled plasma (ICP). Specifically, ICP instruments lack sensitivity to particles below three microns, so depending on wear mode, this test can be misleading. While elemental analysis can be an excellent test for revealing slow incipient wear or wear modes that create small particles (<3 um in size), such as corrosive wear, it can completely miss wear modes that generate larger particles greater than 5um, such as adhesive wear in gearboxes or fatigue wear in rolling contacts. Instead, ICP should be complemented by large particle detection tests, such as particle counting, particle quantifier (PQ) or ferrous density.

2 DON'T SAMPLE THE SMALL STUFF

Another commonly held fallacy is that oil analysis holds no value if the oil volume is so small that the cost of the analysis outweighs the cost to change the oil. And while it's true it may not be cost-effective to use oil analysis to optimize oil drain intervals, there is more to oil analysis than just timing an oil change. Simply changing the oil doesn't guarantee an active wear problem or contamination issue has been resolved. The reality is any machine that is production, safety, or environmentally critical should be sampled, particularly if oil analysis is the only predictive tool capable of providing an early warning. Probably the biggest disservice ever given to oil analysis was calling it "oil analysis." Oil analysis also measures the health of the machine and the degree of contamination, not just the health of the lubricant.

3 MEASURING WATER CONTENT IS IMPORTANT

While this is definitely not a false statement, when it comes to paying a lab to determine water content, it is buyer beware. There are several methods used to detect water in oil, from basic screening tests, such as the crackle test, to instrument-based tests, such as Fourier transform infrared (FTIR) and Karl Fischer moisture. While cut-price oil analyses may appear to give you everything you need, these programs tend to over rely on fast, cheap methods like basic FTIR (absent of chemometrics) or crackle, which lack the sensitivity of more sophisticated tests.

Your response might be, "I've got this one covered, we do Karl Fischer moisture." But not so fast! Karl Fischer refers to the test reagent used, not the test method. In fact, according to the ASTM test standards book, there are several different methodologies that fall under the category of Karl Fischer moisture. The problem lies in false positives that can occur due to creation additives, such as phosphorus containing AW additives, as well as some wear metals, such as ferric salts, particularly with volumetric test methods. Where low water level accuracy is required (<100-200 ppm), ASTM D6304, including co-distillation, is the preferred method.

4 OIL ANALYSIS IS A COMMODITY THAT SHOULD BE BOUGHT FROM THE LOWEST BIDDER

Having cut my teeth in the world of lubrication and oil analysis selling and supporting oil analysis services, I can attest that some users will think nothing of switching oil analysis vendors for a 50 cents or $1 price differential per sample. And while I'm certainly not a proponent of overpaying for oil analysis, consider the cost of missing a failure on a critical gear drive because you weren't willing to pay an extra few dollars to get a PQ or ferrous wear test. The best oil analysis practitioners build test matrices around specific ASTM or ISO test methods (e.g., ASTM D6304 vs. simply requesting "test for water") and mandate that their lab follow the method as closely as practical. In oil analysis, like many walks of life, you get what you pay for.

IN OIL ANALYSIS, LIKE MANY WALKS OF LIFE, YOU GET WHAT YOU PAY FOR.

5 RPVOT IS A GOOD INDICATOR OF OXIDATIVE POTENTIAL

Historically, the rotating pressure vessel oxidation test (RPVOT), formerly known as RBOT, has been used to measure an oil's re-

maining oxidative life. However, because the test is an accelerated oxidation test involving very high temperatures (150 C) and high concentrations of pro-oxidants, like water, copper and oxygen, the RPVOT test alone can be misleading, particularly with modern turbine oil formulations. Where the RPVOT is performed, the results should be considered in concert with other tests, such as varnish potential (QSA and/or MPC) and direct measurement of phenolic and amine-based oxidation inhibitors (RULER instrument), to truly gauge the remaining life and health of the lubricant.

6 SILICON ALWAYS MEANS DIRT

One of the most useful elements to trend is silicon. Common dirt contains high concentrations of the mineral silica (sand) so an increasing silicon trend can be a good indicator of dirt ingression. However, silicon also can be present in other forms. For example, new equipment that has been cast in sand (e.g., new engine blocks) often contains trace silica (silicon) embedded in its walls that sloughs off during the first few hundred hours of operation. Likewise, silicone-based sealants can leach silicon into the oil, while some gear and engine oils contain methyl silicone as an anti-foam agent, often ranging from 10 to 20 ppm in new oil.

PRECISION OIL ANALYSIS IS NOT ABOUT FILLING A SAMPLE BOTTLE WITH OIL, EXPECTING THE LAB TO TELL YOU WHICH COMPONENT IS ABOUT TO FAIL.

The easiest way to determine silicon from dirt versus other sources is to look for secondary elements, particularly aluminum, which is often present from the mineral alumina. Depending on the geology of your local area or the process, silicon to aluminum levels in used oil range from 5 to 10:1, silicon: aluminum.

7 OIL ANALYSIS IS ONLY GOOD FOR OILS

The term oil analysis, of course, refers to chemically analyzing lubricating oils. But did you know you can also analyze grease? While getting a representative sample can be a challenge, grease can be analyzed for the degree of degradation, presence of contaminants, or other incompatible grease, as well as for wear particles that can be evaluated for their morphological properties (e.g., size, shape, color, etc.).

8 OIL ANALYSIS IS NOT NECESSARY WHERE VIBRATION ANALYSIS IS DEPLOYED

Several studies have attempted to evaluate the relative effectiveness of oil analysis versus vibration analysis. But whatever side of that fence you sit on, it's true that in some cases, such as misalignment or imbalance, vibration will always win the day, while in other cases, oil analysis in a better indicator. The reality is that oil analysis is often an earlier indicator of a problem, while vibration analysis is a much better way to localize the source of incipient machine failure. When it comes to predictive maintenance, both oil analysis and vibration analysis are required for an effective program, a true case of one plus one equals three!

9 LOW ACID NUMBER MEANS NO OXIDATION

Acid number testing uses a classic acid-base titration to detect the formation of acidic by-products in oil formed by incipient oil oxidation. However, since the test effectively measures the concentration of these acids in the oil, dilution effects, particularly in large volume systems like turbine oils and paper machine oils, often negate the effectiveness of acid number testing. Similarly, some oils containing antiwear (AW) or extreme pressure (EP) additives that are mildly acidic can also provide falsely high or low readings (due to additive depletion), so caution always should be used when reviewing acid number data. Like most oil analysis tests, acid number values should be considered in concert with other test properties, like additive health, water content and new oil baseline values.

10 ANNUAL OIL ANALYSIS IS A GOOD WAY TO PLAN FOR SHUTDOWN OIL CHANGES

The cost of oil – both the raw cost and disposal costs – always seems to be increasing. Yet, many companies looking to maximize their investment while minimizing their environmental footprint are using oil analysis to time oil changes. But oil analysis, and particularly lubricant health, is about trend analysis, looking at slow changes over time rather than a one-off snapshot. At a minimum, quarterly oil analysis is required for effective monitoring. For higher speed machinery or higher oil temperatures, monthly analysis is really the only surefire way to get good, trendable data in a timely fashion to make sound maintenance decisions.

So there you have it, the Top 10 oil analysis misperceptions. How many can you identify with? Don't let yourself be lulled into a false sense of security. Precision oil analysis is not about filling a sample bottle with oil, expecting the lab to tell you which component is about to fail, how long it has left and how to fix the problem. Oil analysis is like any other tool; it has to be used in the right way and at the right time by a skilled craftsperson who understands how to maximize the leverage of the tool in hand.

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

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BEST CONDITION MONITORING PROGRAM

Luminant's Condition Monitoring Program Achieves Notable Successes

Keith Lawson

The true success of Luminant's condition monitoring program is a direct result of the commitment from company leadership to entry-level employees and the processes and procedures put in place to protect employees and equipment. It's that dedication to excellence and safety that will ensure its success.

Picture collage curtesy of Luminant

Luminant is the largest power producer in Texas and the company's mining division is the state's leading producer of lignite coal, producing roughly 33 million tons per year to meet the fuel needs of our lignite plants. Mine Maintenance Support Services (MMS) is responsible for providing support for 15 draglines, 10 loading stations, 45 conveyors, Luminant's railroads and 500 pieces of mining rolling stock spread across eight separate mines in Texas. The area encompassing the mines stretches nearly 325 miles from northeast to central Texas.

Luminant's MMS group is the driving force behind implementing, maintaining and auditing its condition monitoring program and, over the past few decades, the MMS team has helped develop it into a world-class program. We like to consider the MMS group as many faces, but one name.

Our goal is asset preservation. We do this by identifying changes in the condition that indicates a potential failure (P-F curve). Each of these characteristics is measured, analyzed and recorded to help our team recognize trends and take appropriate actions before they become an issue.

Our corporate maintenance standardization initiative, Conduct of Maintenance (COM), allows us to allocate funding, using reliability centered maintenance (RCM) analysis, to do the right tasks at the right time in an efficient, cost-effective and safe manner. Over the past four years, we have seen an eight percent improvement in asset availability and an 18 percent reduction in maintenance spend.

The COM was also developed to help standardize fleet-wide procedures with a repeatable and measurable workflow process that would improve reliability and availability. The new program also uses metrics to track progress and set goals. Maintenance superintendents, supervisors and technicians are given goals based on factors they can control, instead of factors they cannot, such as reducing maintenance costs.

Employees of each MMS department have different levels of expertise, which combined provide quality electrical engineering support; mechanical engineering support; technical support; maintenance control that maintains the mining computerized maintenance management system (CMMS); and RCM and predictive maintenance (PdM) reliability support, planning and performance, training, supplier quality and project management support.

MMS unifies the functional departments of each site with the support organizations to maintain mining assets and improve asset health and reliability. The MMS toolbox consists of many activities to prolong and maintain the life of our assets, including:

- Condition-based maintenance (CBM);
- PdM and non-destructive testing (NDT);
- RCM.

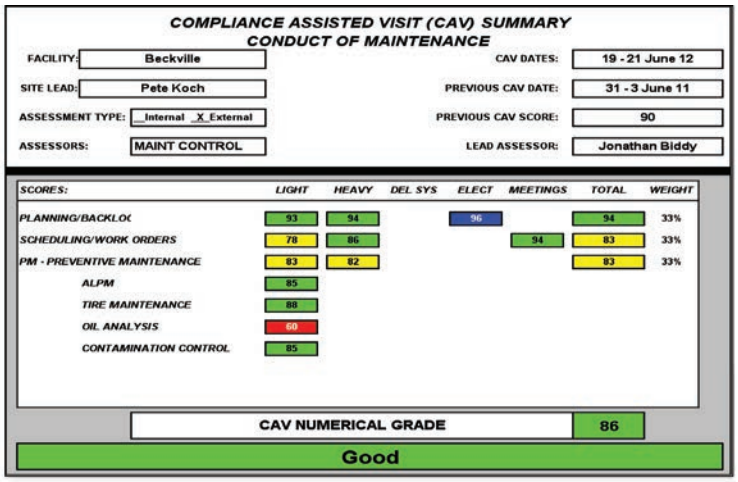

Figure 1: Site equipment and reporting grade

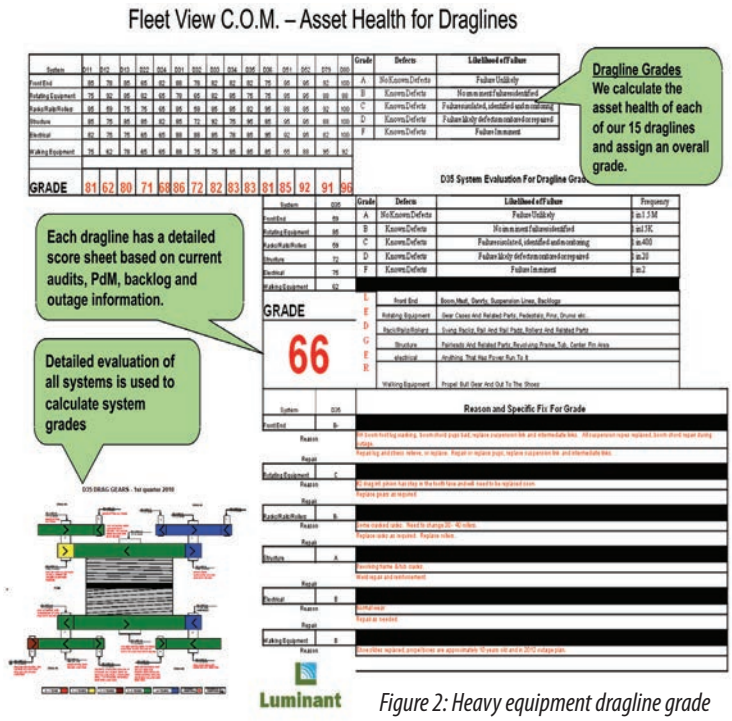

Figure 2: Heavy equipment dragline grade

Luminant's condition monitoring program is broken down into several departments, equipment, components and systems, including:

MAINTENANCE CONTROL – Monitors and maintains all data coming and going from our CMMS.

- Mining CMMS (MAC/MAXIMO)
- COM – Work management guidelines and rules to live by
- Maintenance-Compliance Assisted Visit (M-CAV)
  - ◊ Yearly site assessments;
  - ◊ Review scoring, planning, scheduling and Preventive Maintenance (PM) optimization (RCM courtesy);
  - ◊ CAV measurements;
  - ◊ Corrective Action Process;
  - ◊ Corrective Action Program (CAP) overview – Closeouts identify Corrective Actions (CAs) and owners and are then posted on Safety Tracking Program (STP) site for weekly review with a status of M-CAV;
  - ◊ Year-end updates – For each section review, bring Systems Maintenance Engineer (SME) all questions for scoring, validity and improvements; communicate changes to sites;
  - ◊ RCM – Data.
- Standardization Information Sharing – Training new employees and working with training group.
- Information Sharing – Manager, superintendent, planner, first line and tech meetings.
- Planning Strategy – Absorb scheduling role, share day-to-day activities, training, office locations, review with managers, superintendents and supervisors.
- Metrics.

MOBILE EQUIPMENT MONITORING

- Mining Power Optimization Center (POC) provides us the capability to run numerous reports for specific evaluation including, idle time, location, haul cycle time, equipment operating parameters and fuel burn for engine performance monitoring. Mining POC tracks and manages all equipment alerts and warnings, which are sent by email and text to designated mine personnel. Software report samples are shown in Figures 3 and 4.

Figure 3: Equipment health report

Figure 4: Site health report

- Total Tire Care (TTC) – Track and evaluate large mining tire performance. Manage the inventory, performance and forecast usage of all equipment tires, from forklift size all the way up to our largest earthmover tires, critical to maintaining equipment operation. Key indicators are tracked for each individual tire, including pressure, tread depth, position on the equipment, remaining life and value remaining.

OIL ANALYSIS TRACKING AND REPORTING

- Contamination Control, Bulk Tank and Point of Use (POU) – The single greatest opportunity for increasing component life and lowering operating costs is to effectively manage fluid cleanliness. Several key initiatives are in progress at Luminant to improve our fluid cleanliness, including specialized software for oil analysis tracking and reporting.
- The ISO cleanliness standard has improved from an average of 21/19 to an average of 18/16, which is a 700 percent improvement.
- The use of all oils and lubricants, as compared to August 2011, has decreased by 65,000 gallons and resulted in $520,000 in cost avoidance.

Figure 5: Assembly Line Preventive Maintenance (ALPM) oil sample station

Figure 6: Bulk oil filtering system

HEAVY EQUIPMENT MONITORING

- Dragline Booms (I-beam and pressurized pipe) are monitored by taking data from the motors. It is also looking at strain gage data from intermediate suspension lines and other data sources to evaluate damage created in the boom due to loading of the boom – both static and dynamic loading. This system takes into account any shocks or other dynamic phenomenon that occurs as the machine is in operation and in near real time. Through the use of a boom model, the interface indicates areas where damage is occurring and alerts the user to areas of potential risk due to aggregated damage. This data can be used, along with our camera footage that watches work going on around the machine, traffic, or personnel on the ground while the machine is digging and viewing the machine house while running. It has been utilized by the mine sites as part of a root cause analysis (RCA) event or to help correct errors. Wireless, online air pressure boom monitoring is used to help locate leaks from cracks in the main boom and mast cords. We use the data to help determine the urgency for scheduling an inspection and repair.
- Dragline and conveyor motors are monitored for real time temperature, vibration, voltage, current and other process values. Motor components are also audited internally twice a year for on-site repairs or for outage replacement.

PDM/NDT TECHNOLOGIES - From ultrasonic, ultrasound, infrared (IR), vibration, magnetic particle, liquid penetrant, weld inspection and electrical motor analysis are used to monitor and evaluate components. Currently, 100,000 points are inspected and monitored yearly across the eight mining sites.

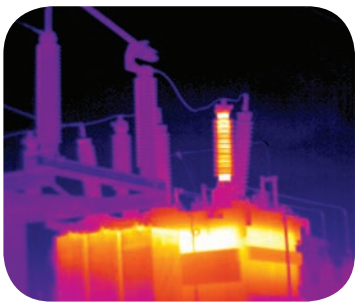

Figure 7: Infrared leaking insulator

Figure 8: Ultrasound inspections on bearings

Note: Ultrasound is used with Luminant's IR program to help find early stage corona and tracking during days or nights.

Through successes and challenges, we have obtained a significant amount of data, which has helped build and modify procedures and processes in condition monitoring. Sharing our results with original equipment manufacturers (OEMs) of heavy and mobile equipment has led to new and better designs in some components, which has helped the industry as a whole. One premature failure is one failure too many in our industry, but continuing to deploy sustainable technologies and measuring our results will guide us to the next level in condition monitoring.

We believe that where you have started is just as important as where you are now. As far as the future, we believe the best is yet to come.

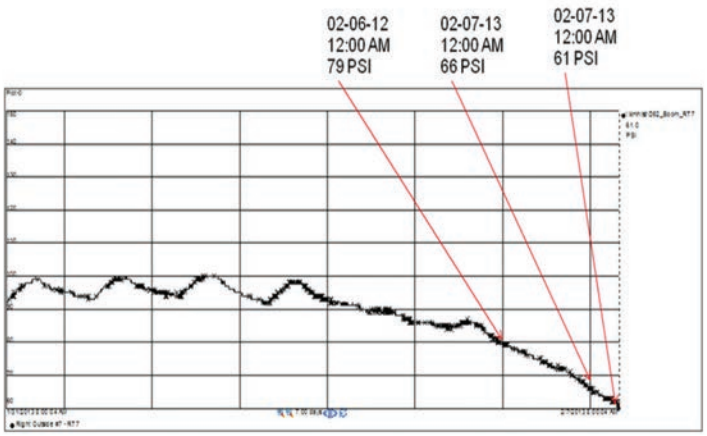

Table 1 - Air Pressure Graph

Past, Present and Future....

Keith Lawson is a PdM specialist supervisor for Luminant. Luminant has nine mines located from Central Texas to Northeast Texas. Keith has 33 years of mining experience in maintenance, operations and railroad. He has been in the mine maintenance support department since 2006; he started as a maintenance analyst and in 2007 he became the PdM specialist supervisor.

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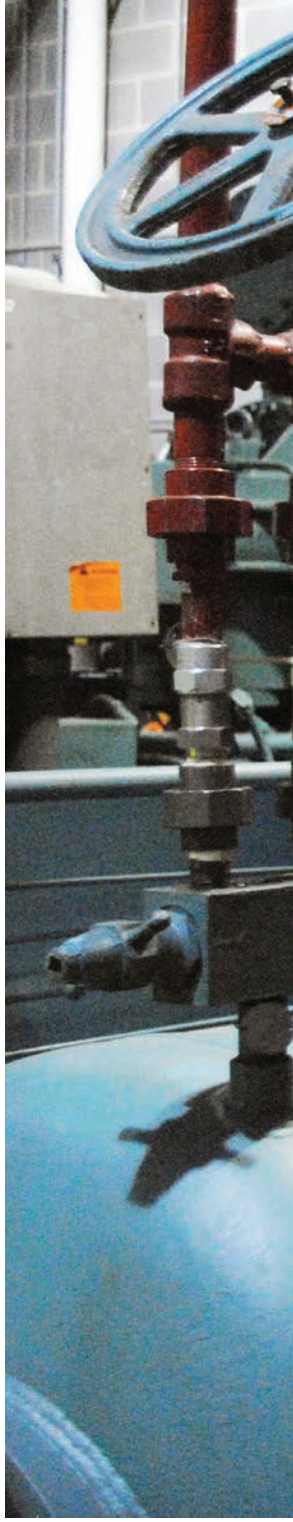

A worker at a commercial refrigeration warehouse installs wireless sensors on a compressor

Wireless Sensors Work

In the World of Vibration Monitoring, Wireless Sensors Can Provide a Cost-Effective Alternative to Traditional Machine Monitoring Methods

Matt Cowen and Christopher Shannon

Traditionally, machine vibration monitoring is performed in two ways: machines can be periodically monitored by utilizing a temporarily mounted sensor and a portable analyzer machine, or machines can be continuously monitored by permanently mounting sensors and wiring them into a high-end diagnostic system in the plant.

The advantage of a portable system is that it can cost less to procure and install since there is no permanent wiring required. However, if a facility decides to hire an outside firm, even this option can be costly, running between $600 and $1,200 per day[1] while still providing some level of predictive monitoring. The disadvantage of a portable system is that machine problems do not follow a schedule and there is a very real possibility that a machine can develop problems or even fail between the periodic assessments.

Permanently mounted sensor systems attempt to address the issues presented by portable systems, but they do so at a very high cost. Acquiring and installing a permanent system can run into the hundreds of thousands of dollars when you factor in the costs of the sensors, diagnostic machine and software, and the installation and maintenance of long wire runs that are necessary to power the sensors and collect the vibration data. These costs can dramatically affect the return on investment (ROI) of continuous machine vibration monitoring for predictive maintenance and put such systems beyond the financial reach of most companies.

While permanent machine monitoring has traditionally been performed using wired sensors, costs for wiring vibration sensors are high, ranging from $50 to $100 per foot[2]. Wire installation costs are a driving factor that limits the affordability of vibration monitoring. Wireless sensors address this cost issue. Additionally, wireless sensors offer to simplify sensor installation, reduce maintenance associated with wiring faults, permit new sensor locations that would not have otherwise been accessible with wired sensors, and offer greater flexibility with easy installation or removal, as required.

In summary, wireless sensors have the promise to make vibration monitoring practical for most companies.

However, with all of the upsides to wireless monitoring, it does not come without its drawbacks. To begin with, battery life has traditionally presented usability problems because battery replacement is an additional maintenance activity that can offset the savings provided by wireless sensors. Also, in the past, wireless sensors have been limited by the usable bandwidth available for transmitting vibration data. Either a lim-

ited amount of data could be sent over a narrow bandwidth or more data could be sent over a wider bandwidth, but battery life would greatly suffer.

With recent advances in wireless technologies, however, companies can now achieve better battery life, longer transmission distances and more robust data delivery. This is achieved by using a wireless protocol that is optimized to use short power-on times, brief on-air times and ultra-low power acknowledgments that minimize the time the sensor node is on while still transmitting a full dynamic vibration spectrum over the air on a frequent basis.

WIRELESS SENSORS HAVE THE PROMISE TO MAKE VIBRATION MONITORING PRACTICAL FOR MOST COMPANIES.

As an example of how wireless sensing technology can benefit industry, a large, privately owned company with a sizeable commercial refrigeration warehouse in Virginia purchased a wireless sensor system after experiencing inconsistent results in vibration data.

The warehouse consists of 13 total compressor units. Each unit has 15 monitoring points, varying between vertical, horizontal and axial locations.

Before investing in its wireless sensor system, the company paid a consulting service to visit its facility once a month to take one vibration data point

per point on the compressor units. This totaled 195 (13 compressors, 15 points each) single data points per month for the cost of $1,000.00. This method yielded inconsistent data, resulting in unnecessary maintenance work done to the machinery.

On occasion, the vibration consultants highly recommended having equipment sent to the manufacturer to have maintenance work done. However, in several of those instances, the manufacturer said the equipment was within spec and working as it should. This happened on more than one occasion, costing the company time and money only to find out its machines were working properly.

Wireless sensors placed in the vertical and axial positions on a compressor at a commercial refrigeration warehouse

With its new wireless system, the company was able to easily install sensors and monitor the compressors for several days each month. The solution the company purchased consisted of software, a collection server, two primary receiver nodes and 15 total vibration sensor nodes (enough to cover one compressor).

WITH RECENT ADVANCES IN WIRELESS TECHNOLOGIES, HOWEVER, COMPANIES CAN NOW ACHIEVE BETTER BATTERY LIFE, LONGER TRANSMISSION DISTANCES AND MORE ROBUST DATA DELIVERY.

This solution has enabled the company to collect vibration data per compressor unit for an average of 2.3 days per month (since the company moves its sensors between compressors every few days). This means the company can now monitor machine vibration trend lines of roughly 3,000 points per monitoring location per month compared (when monitoring once per minute) to the one data point per monitoring location per month when using the consultant.

The wireless monitoring system has paid for itself very quickly. Whereas the company was previously paying $12,000 per year, with its new system, the company only paid a one-time installation cost of $13,425 for the equipment and software. Furthermore, the company is able to monitor its machines for 56 running hours per month (compared with the two minutes per month using the consulting service), which is leading to better diagnostic information. Finally, the company's cost per sample taken for assessing machine health is reduced from $5.13 per sample to less than a penny per sample.

In conclusion, while wireless vibration monitoring is not necessarily the right solution in all cases, as the example shows, the recent introduction of powerful and low-cost wireless vibration monitoring systems is appropriate for many situations.

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The Qualities of a Great RCM Facilitator

Doug Plucknette

During the last International Maintenance Conference in Florida, a global reliability leader at a major company asked if I had a list of traits common among all good reliability-centered maintenance (RCM) facilitators. He also wanted to know the background experience a good facilitator would have and some qualities he should look for when selecting these people.

As I was about to tell him that I could e-mail a document I had created on how to select a good RCM facilitator, an interesting thought came to mind.

Are you really looking for someone to become a good facilitator or would you really like for him or her to be a *great* facilitator?

When it comes to facilitating a process or event like RCM, root cause analysis (RCA), or any other group problem-solving method, I have met hundreds of good facilitators in my life thus far, but only a handful of great ones. If I were thinking about investing the money to train an RCM facilitator, I would want to train a great one.

So, what is the difference between a *good* facilitator and a *great* one?

What type of background or experience should a great RCM facilitator have?

What qualities should you look for in selecting an RCM facilitator?

To me, the difference between *good* and *great* facilitators is as obvious as night and day. Great facilitators have a skill that allows them to lead a team of people through a thorough RCM analysis in a way that is non-threatening and, believe it or not, enjoyable.

While RCM can be a very painful process at times, great facilitators know how to keep the analysis on track; they stick to the process knowing where to add their own insight, experience and humor.

Great facilitators understand the importance of staying true to the RCM process by asking the right questions in the right order so the RCM team develops not only the list of failure modes for their asset, but also the resulting maintenance strategy intended to mitigate each failure. In doing so, the great RCM facilitator has assisted in delivering a product that the team will own.

Great facilitators have highly tuned listening skills. They have learned over time not only the importance of asking the right questions, but listening and often waiting for the team to discover what may have been clear to him or her for some time. They understand the extreme importance of every "ah-ha" the team uncovers and have learned the art of leading their team to each discovery rather than just pointing them out.

Great RCM facilitators do not tell RCM teams what they should do; instead, when needed, they share their knowledge and experiences and allow the team to make their own recommendations. They understand that patience and sound leadership have a reward that is returned in increased pace, understanding of the RCM process and ownership of the end product.

Great RCM facilitators seem to have the following background and experience:

- They have worked in the trenches before as maintenance technicians or operators, or in lead or supervisory positions. They know the pressures of day-to-day business and the relationship between equipment reliability and success.
- They have a proven ability to lead a team through a structured process to solve problems.
- They have worked with or have a thorough understanding of predictive maintenance (PdM) technologies.
- They have above average computer and typing skills.
- They have shown the ability to be a proven leader or instructor.
- In learning to instruct or facilitate, they honed their skills from many diverse instructors/mentors.

The qualities of great RCM facilitators include:

1. They are patient.
2. They have above average listening skills.
3. They value teaching over telling.
4. They understand different learning styles and try to use them all.
5. They recognize the strengths and abilities of each team member.
6. They lead by example through action and a positive attitude.
7. They openly share their knowledge and experience.
8. They have the proven ability to set and achieve goals.
9. They are uniquely driven to continuously improve their own facilitation skills.
10. They have an above average and appropriate sense of humor.

Well, there you have it. The same advice I have given to well over a hundred managers who were looking to train their employees as RCM facilitators. While we have been successful at training and mentoring hundreds of facilitators over the years, the difference between *good* and *great* starts with selection and is perfected through personal drive and experience. In the end, good facilitators have another skill to add to their resume. The great facilitators… they have found a new career!

Doug Plucknette is the worldwide RCM Discipline Leader for GPAllied, creator of the RCM Blitz® Methodology, author of the book Reliability Centered Maintenance using RCM Blitz *and co-author of the book* Clean, Green & Reliable. *www.rcmblitz.com. Purchase at www.mro-zone.com.*

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H. Paul Barringer

Where Do Failures Originate?

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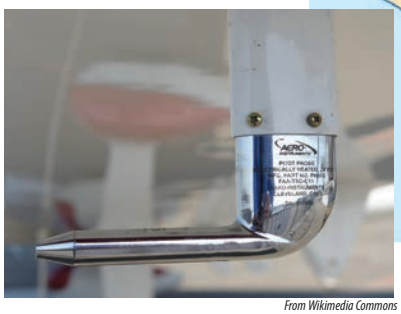

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The aircraft crashed after temporary inconsistencies between the airspeed measurements—likely due to the aircraft's Pitot tubes (shown on the right) being obstructed by ice crystals—caused the autopilot to disconnect, after which the crew reacted incorrectly and ultimately led the aircraft to an aerodynamic stall from which they did not recover.

Reliability of people, processes/procedures and equipment terminates with a failure. Want higher reliability? Get rid of your failures. But that's easier said than done. There are many buckets to hold the different types of failures. Each bucket has a different name for the root of the failures. Frequently, the failure buckets are collected into three major categories for simplification: 1) People, 2) Processes + Procedures and 3) Equipment. You must know where to attack problems to resolve the issues for a failure-free environment. Failures don't correct themselves!

For nuclear reactor systems, you are required to confess your "sins" related to the failures. No one gets fired for confessions of failures; however, termination occurs by hiding failure details. Here's the categorization of failures for mature nuclear power production failures that has been constant for many years:

- People → 38%
- Procedures + Processes → 34%
- Equipment → 28%

For boiler and pressure vessel failures, ASME's National Board published failure statistics[1] for a 10-year interval highlighting ASME's boiler test code equipment. The statistics show:

- 23,338 accidents → 83% human oversight or lack of knowledge
- 720 injuries → 69% human oversight or lack of knowledge
- 127 deaths → 60% human oversight or lack of knowledge

Air France Flight 447 Crashes

The crash occured from Rio de Janeiro to Paris offshore near Brazil on June 1, 2009, following a flight through a thunderstorm at an altitude of ~30,000 feet under autopilot control, which breaks a practical flight commandment: "Thou shall not fly through strong thunderstorms unless the enemy is on your tail and both you and your aircraft can sustain ±9 g's of loading." Inside the thunderstorm, the Pitot tubes, which sense airspeed, froze from the storm's moisture intensity. With apparent stall conditions sensed by the airspeed instrumentation, the autopilot disconnected, putting aircraft control directly in the hands of the pilots of the Airbus A330.

Pilot control of the Airbus is by joystick, similar to those used with a video game. When the autopilot disconnected, the Airbus rolled right and the pilot responded by pushing the joystick to the left but pulled the nose of the aircraft up, breaking another practical flight commandment: "Thou shall push the aircraft nose downward to gain airspeed in a stall condition." The second pilot pushed his joystick downward as endlessly taught to every new pilot. Another near flight commandment is: "When everything is screwed up and nothing makes sense, try taking your hands and feet off all controls and let the airplane straighten itself out for ±30 seconds."

On the Airbus, there is no tactical connection between the joysticks, so the second pilot had no knowledge of the first pilot's fatal and amateurish error of pulling the aircraft nose up until Flight 447 reached an altitude of 38,000 feet. The stalled Airbus lost lift at 38,000 feet. In 3 minutes and 30 seconds, the aircraft pancaked into the sea, resulting in the loss of life of 216 passengers and 12 crew members. The Boeing 777 and 787 aircrafts, as with the Airbus 330, are fly-by-wire aircrafts, however the Boeing aircrafts have tactile sensors so each pilot knows what the other pilot is doing with a traditional wheel configuration.

The flight data recorder or "black box" was recovered on May 1, 2011 and the contents downloaded for study by an international team of safety experts. The Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) released the final report on July 5, 2012, with the accident resulting from the following events:

- Temporary inconsistency between airspeed measurements, likely following the obstruction of the Pitot probes by ice crystals that, in particular, caused the autopilot disconnection and the reconfiguration to alternate law [special mandatory operating rules for the Airbus].
- Inappropriate control inputs that destabilized the flight path.
- The lack of any link by the crew between the loss of indicated speeds called out and the appropriate procedure.
- The late identification by the pilot not flying of the deviation from the flight path and the insufficient correction applied by the pilot flying.
- The crew not identifying the approach to stall, their lack of immediate response and the exit from the flight envelope.
- The crew's failure to diagnose the stall situation and consequently a lack of inputs that would have made it possible to recover from it.

See http://en.wikipedia.org/wiki/Air_France_Flight_447 for more combinations of failure event factors.

So where were the major problem(s): people, processes + procedures, or equipment?

IF YOU THINK WORKING ONLY ON THE HARDWARE WILL REDUCE YOUR FAILURES, YOU'RE RIDING THE WRONG HORSE IN THE RACE TO SUCCESS!

In addition, statistics[2] from the Federal Aviation Administration (FAA) are available for a 10-year time interval for many different classes of aircraft and their operation. However, the conclusions are not so obvious because of the "slicing and dicing" of the data by aircraft category. The FAA model for system safety methodology is similar to five disks on a common shaft spinning at different speeds and each disk has a hole in it at the same size and radial distance from the axis. When all five holes line up, an accident or incident occurs. Of course, the objective is preventing the failures from occurring.

1. The first disk in the model is the **underlying cause** framed by **management's** actions or inactions that introduce latent errors into the organizational system in areas of planning, organizing, directing, controlling and staffing. Basically, the environment is what is wrong.
2. The second disk is **basic cause** where latent **system reaction errors** are reacted to both inappropriately and appropriately. The second disk and the first disk become **preconditions** for an accident. An example would be lack of enforcement for breaches of policy or regulation.
3. The third disk is the **immediate cause** of an accident. Individuals commit **active errors** by just doing their jobs or mechanical systems can break. An example is lifting loads that are too heavy.
4. The fourth disk is **safety defenses**. The organization oversight and safety programs are the **intervention** countermeasure or filters that defend against errors. Examples are crew rest policies, stabilized approach criteria, "sterile" cockpits below 10,000 feet and checklists.
5. The final disk involves consequences. If all defenses work, the result is no accidents. Accidents occur with catastrophic failures. Incidents are minor failures or recorded close calls.
   - For large turbofan/turbojet/turboprop aircraft, the top five categories are: 1. Controlled flight into terrain; 2. Loss of control in flight; 3. Acts of aggression (sabotage, hijacking, war acts, military acts, etc.); 4. Takeoff procedures; and 5. Unknown reasons.
   - For helicopters, the top five categories for failure are: 1. Lack of avoidance of object contact; 2. Improper flight control; 3. Collisions with ground/water; 4. Low rotor RPM; and 5. Engine/turbine failures.
   - For small, fixed gear, aircraft, the top five categories are: 1. Visual flight rules problems with clouds, low visibility and night flight;

2. Stalls; 3. Judgment and low level operation contact with object; 4. Recklessness and acrobatics flight; and 5. Stalls involving reckless low altitude operations.

This data illustrates the need for strongly improving human performance among professional and private pilots for all three flight categories. **If you think working only on the hardware will reduce your failures, you're riding the wrong horse in the race to success!** Improvement opportunities and usually money saving opportunities are with the people and processes + procedures. Attacking the correct root cause of the problem says you have better opportunities by working with people and procedures + processes; engineers find this effort very difficult because they mainly want to work on things!

Consider this old, simple and well-known failure problem from aviation. The cockpit of airplanes, beyond simple trainers, is filled with instruments and switches. Many of the switches are simple toggle switches with up or down positions indicating their intended actions. Flap switches are down for landing, just as landing gear switches are down for landing. Flaps increase the curvature of wings for increased lift, but suffer much drag during landing so their stowed position is up for retraction of the delicate flap mechanisms. In the '40s and '50s, there were many mix-ups from busy pilots performing the necessary multitasking flight efforts. The calamity of landing gear switches moved from the down position to the up position while on the runway, rather than the intended flap switch retraction resulting in the destruction of the flap system, damage to the engine, fuselage and propeller, high repair costs and embarrassing events for the pilots. No one can deny an aircraft on its belly is a failure!

How would you classify the major category for landing gear failure and how would you resolve the issue? Today, you rarely hear of pilots withdrawing landing gear on the runways. The solution was simple: Smooth toggle switch arms of landing gear switches were changed to a sharp edge as a tactile warning to the pilot that the switch in their fingers had big consequences and was not the correct switch to energize for retraction of flaps. The solution to the root of the problem rests with the design engineers and not the busy pilots without time for making thoughtful, contemplate your navel type of conference decisions, in a fast moving, real-time, multitasking environment. Oh, by the way, you do hear of landing gear never being extended with the consequential belly landing because the pilots did not adequately run their landing checklist. **Of course, you use written checklists and the organizational requirement to follow written checklists for your operators and maintenance folks to prevent failures—right?**

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Paul Barringer is a reliability, manufacturing and engineering consultant. His worldwide consulting practice involves reliability consulting and training with a variety of discrete and continuous process manufacturing companies and service industries. Barringer has more than fifty years of engineering and manufacturing experience in design, production, quality, maintenance and reliability of technical products. His experience includes both technical and bottom-line aspects of operating a business with an understanding of how reliable products and processes contribute to financial business success.

Asset Management Tools for Change:

Social Network Analysis

Grahame Fogel, Jan-Hendrik Baum and PJ Vlok

Much has been written and commented on regarding the complexity of invoking change within the asset management environment. In an attempt to create a stabilized procedural approach to implementing a management system in alignment with business goals, the Institute of Asset Management (IAM) in the UK and, more recently, the International Organization for Standardization (ISO), have developed standards for asset management.

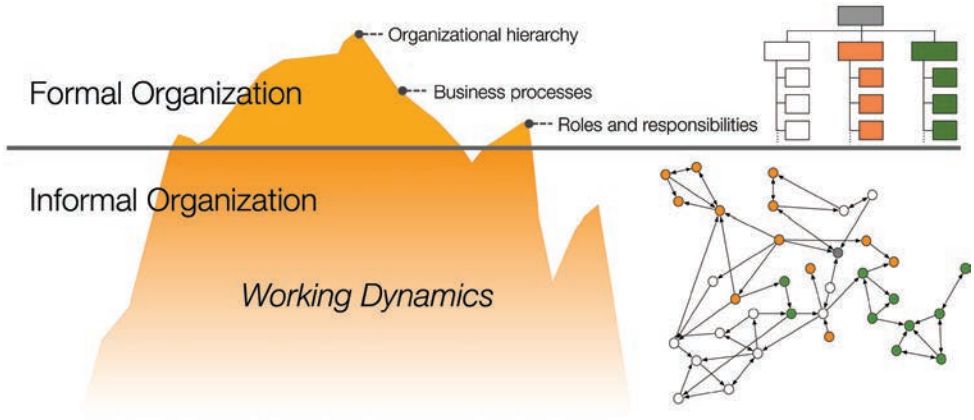

Figure 1: Formal vs. Informal Organization

The goal of these standards is to drive performance of the assets over the lifecycle of ownership in alignment with business needs.

This, by definition, involves change and where a procedural approach will go only so far. We argue that in order for successful change to take place, it is essential to understand the social context in which this change is to take place. This is especially important if the change is going to require new decision-making, new information processing, new knowledge pathways and, ultimately, new ways in which decisions are made across previous functional boundaries.

Within every complex organization, there is the formal organizational structure that is apparent, charted, normally understood and provides a clear understanding of the hierarchy of structural alignments.

However, equally important are the informal structures that exist within organizations that provide coherency, and at their best, flexibility and nimbleness to address new situations. Conversely, these informal structures can overrule formal structures and become a hidden obstacle lurking unseen in the background, preventing progress towards achieving objectives. It has been argued that the informal relationships among employees are often far more reflective of the dynamics inside a company. They are much more capable of describing how "work happens" than relationships established by positions within the formal structure (Cross et al. 2002). Figure 1 illustrates the crucial contrast between the formal and informal organization.

In anatomical terms, the formal structure has been compared to a skeleton and the informal structure to the central nervous system, drawing together the collective thought processes with the information flow and decision-making patterns that create actions and reactions within organizations.

Attempting to create sustainable, meaningful, positive change requires the understanding of both the formal and informal structures within an organization.

Supporting our arguments, an extensive study by Neilson et al. (2008) found that streamlined information flow and clear decision rights are the core requisites for successful strategy execution (Figure 2). We are convinced that this finding is also applicable to asset management. In fact, understanding information flow and decision rights may be significantly more valuable than directly engaging in structural changes and establishing incentives in the hope that they will invoke the required change.

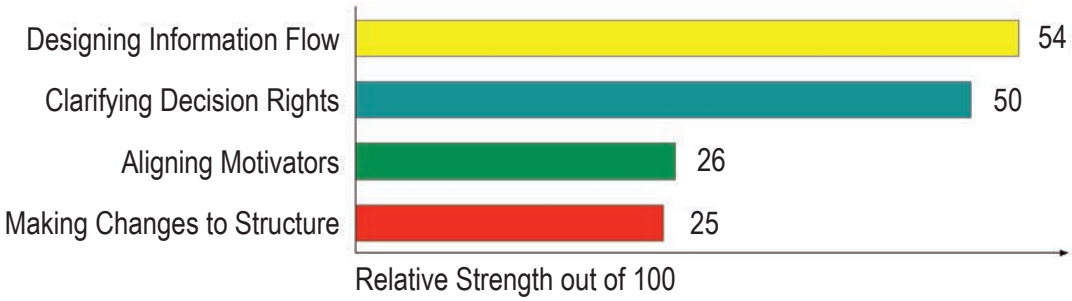

Figure 2: Building blocks of successful strategy execution.

SOCIAL NETWORK ANALYSIS (SNA)

SNA is a methodology for determining and analyzing relationships between people in order to show how information flows and decisions are made, ultimately investigating how work gets done. This enables managers and teams to understand:

- Who the prominent players are and whom others depend on to solve problems and provide technical information. Who do people turn to for advice?
- The actual nature of the communication network in reality, demonstrating how communications actually occur regarding work related issues and who is central to these communications. This illustrates both informal collaborative relationships and holes within the structures.
- Whether subgroups emerged that are disconnected or partially connected to the core.
- Which individuals are isolated and limited in their roles or, conversely, who faces a situation of overload.

INFORMAL ORGANIZATION THE EMPIRICALLY DETERMINED RELATIONSHIPS THAT EXIST BETWEEN PEOPLE, AS OPPOSED TO RELATIONSHIPS THAT ARE IMPLIED BY FORMAL ORGANIZATIONAL STRUCTURE.

SNA is a means to analyze the informal organization beyond the organizational chart. The analysis allows managers and teams to visualize and understand the myriad of relationships that can either facilitate or impede information flow, decision processes and knowledge creation. Thus, mapping opportunities and constraints in invoking change within the organization.

SOCIAL NETWORK PEOPLE AND THE INFORMATION ON THE RELATIONSHIPS BETWEEN THEM.

The purpose of this article is not to describe how to undertake such an exercise, but rather to illustrate using real data the tangible benefits of understanding informal networks from an asset management and change management perspective. However, for the sake of completeness, we will briefly discuss data collection and analysis.

DATA COLLECTION AND ANALYSIS

There are various ways to collect SNA data and construct networks. Fundamentally, SNA aspires to resemble the real interactions of a group of people. Therefore, we have to decide on questions, such as: Who do we include in the analysis? How can we obtain data that resembles interactions and avoid measurement error? Do we want to consider the "strength" of relationships, if so, how? Do our decisions add value and is the analysis feasible? The works by Wasserman and Faust (1994) and Carrington et al. (2005) provide a detailed discussion about network measurement.

The case study presented in this article was conducted at a mineral processing plant in South Africa. The studied networks span the plant management and the three major departments of production, engineering and the technical metallurgical department; the analysis does not include artisans. Throughout the study, we tried to balance theoretical SNA considerations with pragmatism, focusing on added value for the partner organization. As a result, data collection by questionnaires only required 16.2 minutes per individual surveyed. The questionnaire asked questions in the form of, "Who do you receive work-related information from," where each interaction between two individuals was attributed with a frequency of interaction of either "hourly," "daily," "weekly," or "monthly." Data processing led to the construction of three networks:

- Information exchange network,
- Decision approval network,
- Decision-making advice network.

The networks captured the plant's informal working dynamics, delivering comprehensive insight into an array of potential constraints in asset management strategy execution.

Throughout the investigative process, we warranted confidentiality to all research participants. On the one hand, this protected individuals, and on the other hand, it promoted the integrity of data.

KEY LEARNING Number 1

MAPPING THE INFORMATION EXCHANGE NETWORK

The first exercise in the project was to map the information exchange network in order to understand the consistency or lack thereof. This would allow us to comprehend who is key to the system and has a high likelihood of becoming a bottleneck for the plant's information flow and conversely, who is isolated from the information exchange network and is therefore isolated from making a contribution.

The information exchange network is illustrated in Figure 3. Nodes represent plant staff, so-called actors, and each arrow represents an information exchange interaction between two actors, where the node at the origin of the arrow receives information from the node that the arrow is pointing to. The color-coding of each node represents which group the individual represents.

A more revealing presentation of the network in Figure 4 shows the number of people each individual receives information from (outdegree) and passes information on (indegree). There are four quadrants, depending on where an individual is located. We refer to the individuals of each quadrant as pivots, sources, outsiders and seekers. A pivot is a high intensity transmitter and absorber of information, such as a13 in Figure 4. In contrast, a14 is secluded and a50 is a seeker absorbing large amounts of information. The crux of the matter is that the central quality of pivots and sources is twofold. The high connectivity elevates these individuals into influential positions, but with increasing requests by other network members, they run the risk of becoming overloaded and turning into bottlenecks in the information flow.

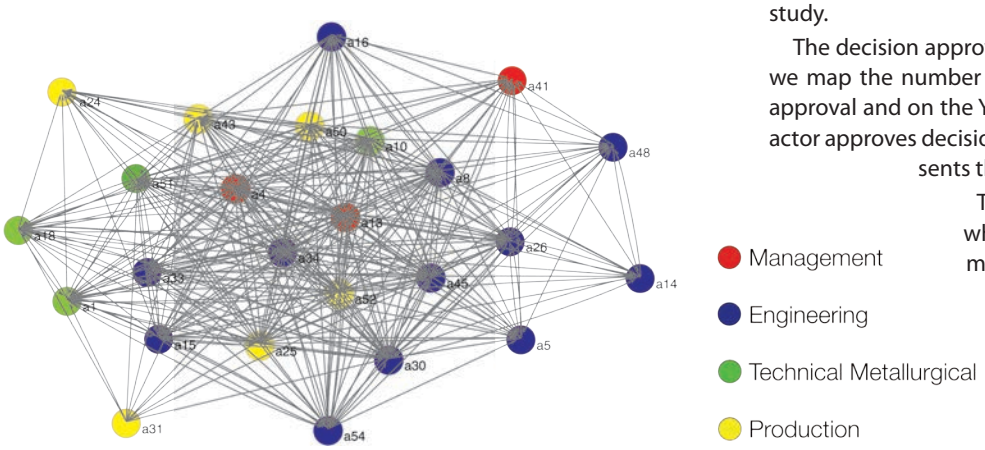

Figure 3: Information Exchange Network

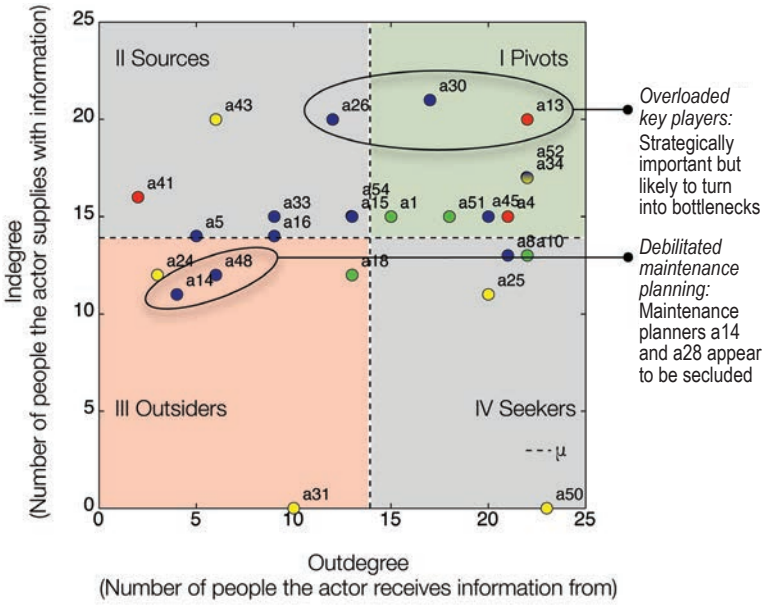

Figure 4: Illustrating the involvement in information exchange

KEY LEARNING Number 2

MAPPING THE DECISION APPROVAL NETWORK

Key to any asset management or asset performance program is how decisions are made and who is making the decisions. This can be from the most fundamental basis when an artisan strips a unit and makes decisions as to how and the extent of the repair, to the strategic where decisions are made as to the adjudication of priority and resources. The consequences of both good and bad decisions and the potential of ineffective actors making poor decisions or isolating expertise from the decision-making process prompted us to analyze decision-making in this study.

The decision approval network is presented in Figure 5. On the X-axis, we map the number of people from whom an actor receives decision approval and on the Y-axis, we map the number of people for whom an actor approves decision. As with Figure 4, the color of the indicator represents the group to which the actor belongs.

There are some immediate clear indicators of risk, which stand out in this mapping. Firstly, we have the manager a13 who is approving a high number of decisions and receives very few completed decisions. This is a clear problem where a13 is carrying a too high day-to-day workload with his subordinates shying away from making decisions. As a manager, a13 has to have the time to manage and improve. With the current workload, this is clearly going to be a challenge.

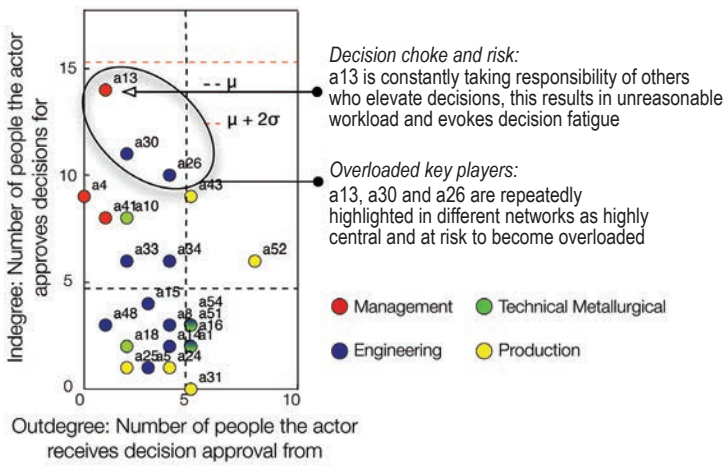

Figure 5: Illustrating the network of decision approval

The mapping shows there is either something structurally wrong, or a13 is working at too low of a level.

Secondly, actor a26 is from the technical (non management) group and is processing a significant number of decisions while receiving a low number of completed decisions. Both a13 and a26 have pivotal positions within the network and they are imperative for the functioning of the plant. The SNA suggests that these key players may be overstrained and need support. Additionally, a13 and a26 may be affected from what is termed decision fatigue. Research into decision-making shows that the quality of decision-making deteriorates with the number of decision that are made – so-called decision fatigue (Tierney, 2011). Research further shows that the simple act of making a decision degrades one's ability to

KEY TO ANY ASSET MANAGEMENT OR ASSET PERFORMANCE PROGRAM IS HOW DECISIONS ARE MADE AND WHO IS MAKING THE DECISIONS.

make further decisions. In other words, the more decisions you make, the poorer the quality of decision-making.

The SNA indicates a point of clear vulnerability. The appropriate management response would be to provide more finished work to these individuals, investigate the reasons for overloading and recognize that overloading can be a choke point either holding up decisions or having a direct affect on the quality of decision-making within the network.

KEY LEARNING Number 3

STRATEGIC COLLABORATION AT RISK

Figure 6 is known as a block model. Each field in the block model represents a relationship between two individuals, where the interaction frequency of information exchange is interpreted in a gray scale. The block model represents the network's adjacency matrix that treats a selection of individuals as an aggregate social unit, termed block (within the study's context, these are the different departments). Here, each block indicates the information exchange habits between or within departments, where

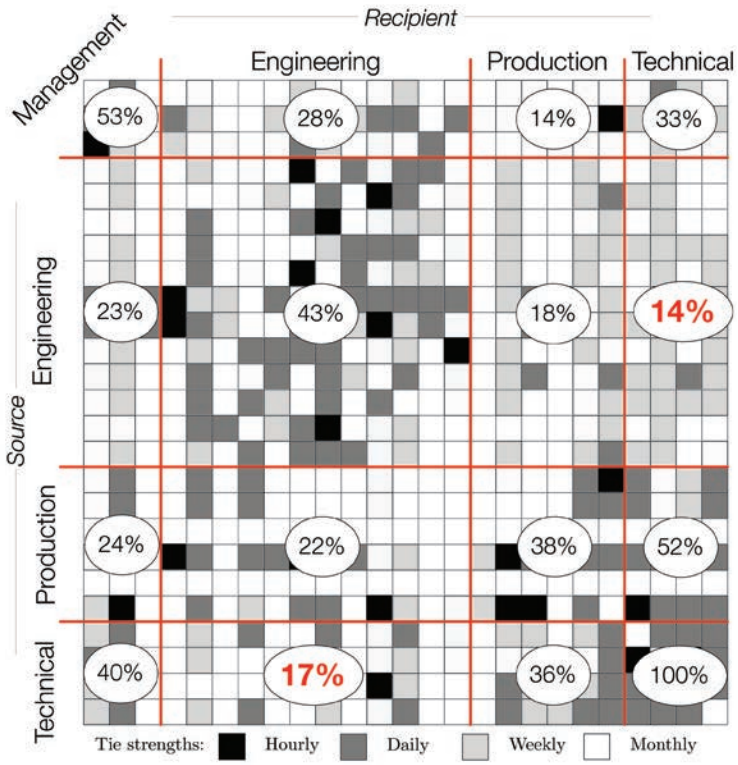

Figure 6: Interdepartmental Information Exchange

percentage values indicate the density of information exchange between two departments.

The block model reveals that the information exchange between the engineering and technical metallurgical departments is the weakest interdepartmental relationship at the plant at 14 percent and 17 percent, respectively. This is especially perilous for asset management because, in the case of this plant, improvement projects are supposed to be carried out in collaboration between these two departments. However, the informal networks clearly indicate a deficient partnership.

Secondly, there is excessive cohesion within the engineering department, which is a function of the dysfunctional state of planning we discovered in Key Learning 1. This has forced engineers and supervisors into self-reliance and finding alternative solutions when coordinating maintenance tasks. This results in extra workloads, poor logistics and integration, and a distortion of roles and responsibilities. The effects are visible in the next Key Learning Point.

KEY LEARNING Number 4

EFFECTS OF INEFFECTUAL MAINTENANCE PLANNING

Analysis of the decision-making processes indicates a so-called strong component within the plant's network, illustrated in Figure 7. The strong component is a highly connected sub-network that exists within the plant's entire network. It indicates a close linkage between individuals where every arrow indicates an approval request for a decision. The multiple bidirectional arcs indicate mutual dependencies in decision approval between individuals.

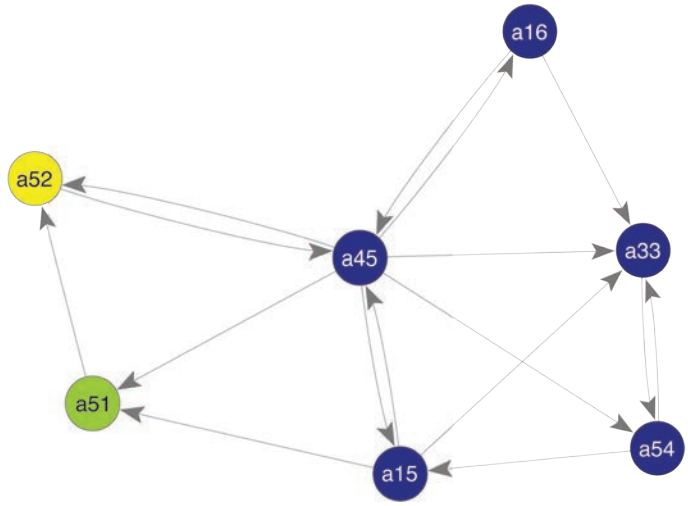

Figure 7: Illustrating unhealthy bidirectional decision-making

The learning here is there is not a clear designation of decision rights that addresses the issue of who has the rights to decision approval. The lack of clarity leads to both delays in decision-making and the potential for an inappropriate person making the decisions. The recommendation here would be to clarify the business processes to ensure the effectiveness and appropriateness of decision-making.

LIMITATIONS

Network data was collected via questionnaires and is dependent on individuals being open and candid in their feedback. In order to achieve this as best as possible, staff were openly engaged in understanding the goals of the project and were given a guarantee of confidentiality. An attempt was made to show the benefits of understanding the social network with regards to both systemic and individual contributions an optimized network could provide.

The confidentiality element of the study may have limited some of the outcomes, but it ensured the integrity of inputs and ultimately provided for a successful and well-accepted set of conclusions that the teams agreed with. This agreement is the first point in creating a foundation for change.

IN OTHER WORDS, THE MORE DECISIONS YOU MAKE, THE POORER THE QUALITY OF DECISION MAKING.

CONCLUSIONS

This article represents the core findings of a research project in the application of social network analysis within the asset management environment. The results have exceeded expectations in that with a refinement of method, we were able to quickly get rewarding results.

In summary, we were able to learn:

1. About the cross-functional and informal dynamics at the plant.
2. How the organization makes decisions formally and informally.
3. Who was connected to information flows and who was isolated and needed to be drawn back into the network.
4. That a manager is overloaded due to subordinates who shy away from their responsibilities and frequently elevate decisions.
5. That the decision approval network showed up inefficiencies in decision-making, which with an adjustment to the business processes could be corrected.

THE LEARNING HERE IS THERE IS NOT A CLEAR DESIGNATION OF DECISION RIGHTS THAT ADDRESSES THE ISSUE OF WHO HAS THE RIGHTS TO DECISION APPROVAL.

6. That the partnership between two departments requires attention to ensure the success of future asset management initiatives.

7. That the work management (planning and scheduling) function was ineffectual and was being compensated by engineers and supervisors taking alternative corrective actions that overburdened their responsibilities.

SNA is an effective tool in change management because it has the ability to highlight some of the barriers before they obstruct asset management aspirations. Understanding the informal networks of a plant can be the first step towards pinpointing and then removing barriers to change. We therefore conclude that SNA as an asset management tool will strongly support execution efficiency.

Acknowledgement: The authors would like to thank and acknowledge Anglo American Corporation for their support with this project.

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Q&A

***Uptime* magazine recently caught up with Lanny Floyd, principal consultant and global electrical safety competency leader for DuPont. In his 40-plus year career with DuPont, Lanny has had a series of assignments in the design, construction, operations and maintenance of electrical systems in industrial manufacturing facilities. For the past 30 years, his work has focused on advancing the state of the art in electrical safety, including management systems, competency renewal, work practices and the application of technologies that reduce injury risk from electrical hazards.**

Q *Your career has focused on occupational electrical safety for more than 30 years. Where are we today versus 30 years ago?*

A There has been dramatic improvement. From 1980 to 2010, the number of U.S. workplace fatalities from electrical contact has been reduced by nearly 70 percent. The hazards of electric shock and arc flash have certainly not gone away; if anything, the potential for exposure to hazardous electrical energy has increased due to dependence on electrical technologies for energy, control and communications in industrial applications, as well as a more than 30 percent increase in population. Closer to home, in DuPont, we were averaging an electrical fatality every 33 months prior to 1990. It has now been 20 years since an employee or contractor working in our facilities suffered a fatal injury from electrical hazards. Even with this improvement, contact with electricity remains the seventh leading cause of occupational fatality in the U.S.

Q *What has enabled this improvement?*

A Certainly a number of things. U.S. OSHA regulations introduced in 1970, followed by additional regulations focusing on electrical hazards, was a start. The National Fire Protection Association began development of NFPA 70E, *Standard for Electrical Safety in the Workplace* in 1976 and IEEE started work in 1982 on *IEEE Guide for Maintenance, Operation and Safety of Industrial and Commercial Power Systems*. The work on these two standards helped spawn forums and collaborations that impacted technology innovations with inherently safer equipment design and maintenance technologies. The Electrical Safety Foundation International was launched in 1994 to promote awareness and education on electrical safety. These are just a few positive forces for change in electrical safety. The digitally connected world has expanded our ability to collaborate and share problems, opportunities and solutions, and has been a significant factor in accelerating changes and improvement.

Q *What do you see as next opportunities?*

A I believe there is a real opportunity to examine how we think about electrical reliability, in particular, the equipment having the sole function of preventing or minimizing the consequences of electrical injuries. That is really what brought me to the International Maintenance Conference (IMC) and Reliabilityweb.com. I'm looking for better ways to bring attention to the reliability of equipment and systems critical to the safety of the people who interact with electrical equipment. Much of the focus on electrical reliability is based on uptime objectives. Motors and trans-

formers represent a large investment and unscheduled downtime can be very costly, so this equipment gets a great deal of attention in the maintenance reliability community. The reliability of protective devices, such as circuit breakers and fuses, bonding and grounding, and even the integrity of equipment enclosures, have some, but relatively little impact on uptime, but are absolutely critical to electrical safety. We need to articulate the application of the proven elements of reliability to the unique application of equipment and systems whose function is to be available and perform reliably in the moment an arc flash or electric shock is imminent.

Q *You must have some examples to illustrate this. Can you share one?*

A One of our plants was experiencing reliability problems with its 480-volt power circuit breakers. The plant had several instances when a circuit breaker failed to trip due to an overload condition. A backup breaker further upstream in the power systems eventually tripped to clear the overload. When I arrived at the site, the maintenance supervisor took me to a file cabinet and said, "I think these files may have something to do with this. The electrician who took care of this retired five years ago and since we weren't having any problems with our circuit breakers, we didn't reassign the responsibility." When I opened the drawer, there were nearly 100 files, one for each of the power circuit breakers in the plant's electrical system. There was a well-organized record of inspections, tests, as-found conditions and corrective actions. I noticed the last entry on any of the records was at least five years old. Management didn't understand the risk and the maintenance reliability management system was crude and not robust.

Q *One of the current hot topics in electrical safety is arc flash hazard mitigation. What is your viewpoint on this topic?*

A Many companies have invested significant resources in performing arc hazard assessments, training employees, changing work practices and using arc rated personal protective equipment. All decisions are based on the expectation that fuses or protective devices that operate circuit breakers will operate as designed. If they do not, the thermal energy from the arc flash event can be orders of magnitude greater than predicted by the arc hazard analysis.

Q *This seems like a great application for RCM. Is it?*

A Indeed! It is an excellent tool to help an organization sort through the electrical systems to identify the equipment and systems critical to electrical safety and prioritize application of maintenance resources.

Q *What do you feel is limiting application of these proven tools?*

A I am actively involved in three professional communities. The Institute of Electrical and Electronics Engineers (IEEE) provides forums for advancing electrical technologies. The American Society of Safety Engineers (ASSE) provides forums for safety management systems, risk management and safety competency. Reliabilityweb.com and the Society for Maintenance & Reliability Professionals (SMRP) provide forums for reliability and asset management. To varying degrees, all three communities are addressing aspects of electrical safety, but the dialogue is somewhat stovepiped. There are exciting developments addressing electrical safety in all three, but I feel the potential is dependent on how we can cross-pollinate ideas and collaborations across these different disciplines.

Q *Can you elaborate on what you see as positive developments in electrical safety within the maintenance reliability community?*

A Well to start with, this interview is an example. Providing the opportunity to make *reliability for electrical safety* a topic of discussion is wonderful! The body of knowledge that Henry Ellmann shared at IMC-2012 on hidden failures is right on target with addressing reliability for protective devices and bonding and grounding systems. Infrared thermography and ultrasound technologies are well accepted in contributing to electrical safety, but the relatively recent innovations in viewing windows and ports that enable inspection without exposure to electric shock and arc flash are gaining wide acceptance as examples of inherently safer maintenance technologies.

Q *What has been most helpful in your professional career development?*

A Maintaining a curiosity to learn new things, and understanding the current state of anything is a work in progress and that there is always opportunity to accelerate that progress. Having great mentors certainly is powerful, but those relationships don't just happen. You have to take the initiative. Networking is essential. It is not enough to be "connected." Being actively engaged in conversation, debate and collaboration with an expanding network of professional colleagues will stimulate and accelerate possibilities and solutions. Building networks entails creating and nurturing relationships with people from a broad range of experiences and disciplines. Don't limit yourself to maintenance reliability disciplines. Sometimes the greatest breakthroughs in a technology are inspired by people outside the particular discipline. Value other perspectives and look for analogies in other fields of study. Your network may be within your own organization and could extend into different functions. Organizations provide valuable opportunities where others who are dealing with the same problem may be applying different solutions. On that note, I hope to see many of the *Uptime* readers at IMC-2013.

Zero Breakdown Strategies

Written by Terry Wireman • Reviewed by Tony Buffington

"I have to do more with less."
"We have to do more training from within."
"We're getting back to basics."
"Where do I even start?"

These are just a few of the phrases that come to mind when reading Terry Wireman's *Zero Breakdown Strategies*. The material in this book answers "How?" to each of the above statements.

In the very first chapter, the author begins to outline the situation, which has you questioning whether a zero breakdown environment is even possible. Is it conceivable to have zero breakdowns? Don't Six Sigma and lean manufacturing concepts promote zero defects? Then why not zero breakdowns?

The zero breakdown strategies can be categorized into five activities:

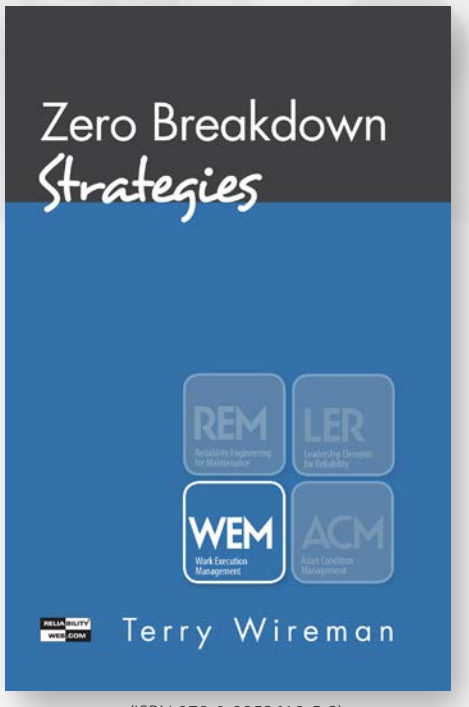
1. Maintaining basic conditions;
2. Maintaining operating standards;
3. Restoring or preventing deterioration;
4. Improving or eliminating design weaknesses;
5. Preventing human error.

Each of these activities is explained in detail to give the reader an understanding of how these activities are applied in the context of the zero breakdown methodology. The author also does an excellent job aligning these activities with the enablers to build a sustainable and successful maintenance program.

The zero breakdown enablers are:

1. Preventive maintenance program;
2. Organizational structure;
3. Skills of the workforce;
4. CMMS or EAM usage and support;

A review of equipment component fundamentals makes up the majority of the book's content, but the level of detail in what to look for in breakdown prevention makes this an invaluable reference for technicians and planners alike. These are the fundamentals covered in the material: lubrication; fastening; bearing; belt drive; roller chain; gear drive; coupling; sealing; fluid power; hydraulic system; and pneumatic.



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The sealing fundamentals section, for example, has details that at first glance may have you asking, "Do I really need to know that?" But as the author explains, with each type of seal and the techniques to inspect, repair, or replace these components, you begin to understand why things like the packing material for a seal are so important. Did you know there are many basic styles of construction for packing materials?

The standard cost justification for implementing zero breakdown strategies consists of four main parts:

1. Asset maintenance labor costs;
2. Asset spare parts costs;
3. Downtime/availability costs;
4. Project cost savings.

In discussing each of these parts, the author makes a very real-world statement: "Zero breakdown strategies are more than just another program that companies can implement. It is really an operating philosophy that is tied to the company's profit picture. Unless efforts are connected to the bottom line, there is little chance of it really succeeding in a company."

This book provides a framework to what industrial maintenance is all about. It can be used as both an introduction and a reference for any mechanic or technician level. For maintenance planners, it provides a guide to building detailed procedures in each of the disciplines. And for maintenance managers and engineers, it can provide a very broad understanding into building the zero breakdown strategies philosophy into any maintenance organization's role for supporting operations.

Zero Breakdown Strategies provides a roadmap to improving our manufacturing assets and is a valuable reference that is well worth a read.

Mr. Tony Buffington, CPMM, CMRP, is a maintenance and financial specialist with more than 16 years experience in business process strategy and optimization of maintenance management systems. He is a certified SAP associate.

Terry Wireman, CPMM, CMRP, Senior Vice President Vesta Partners, LLC has authored dozens of books. www.vestapartners.com

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