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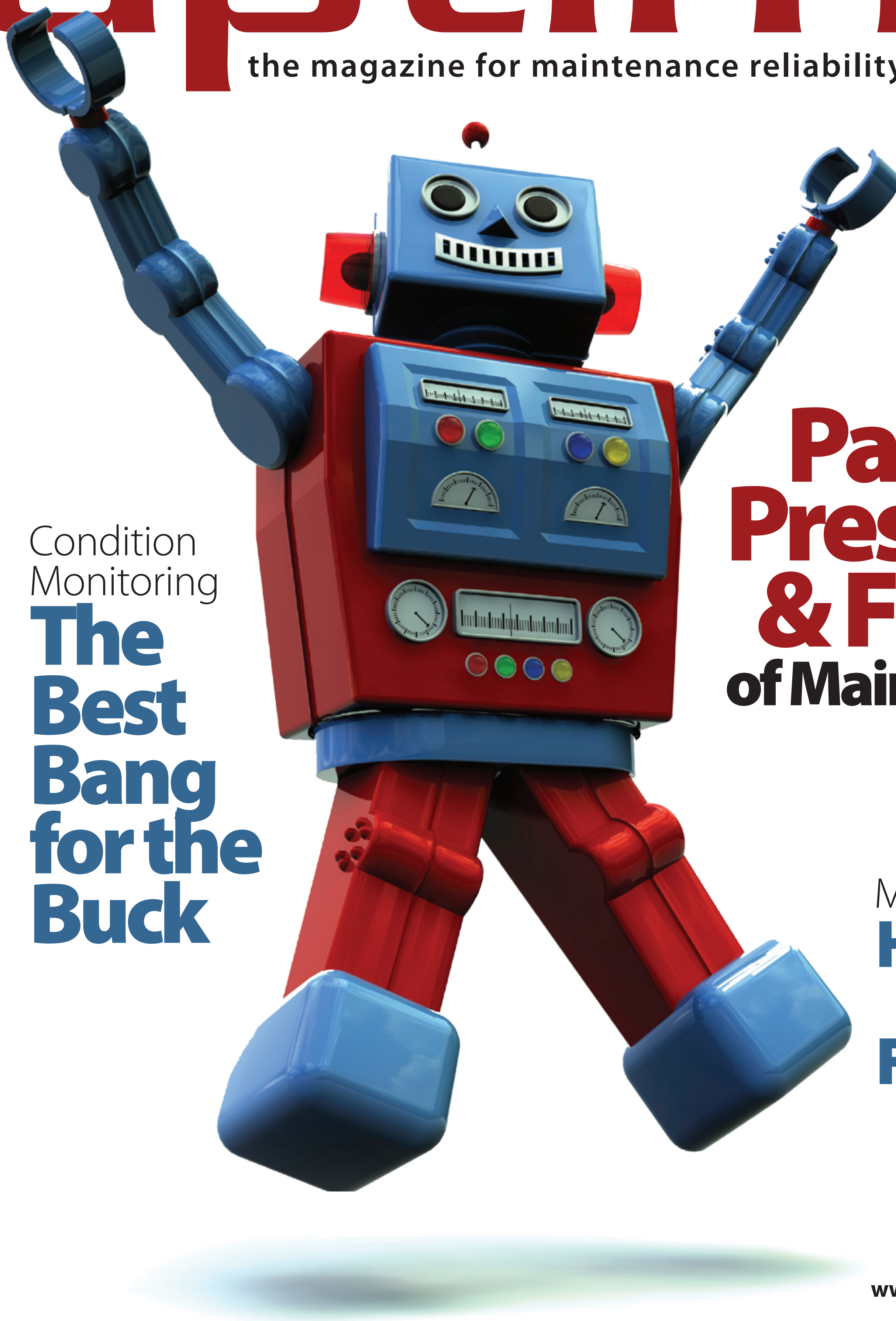

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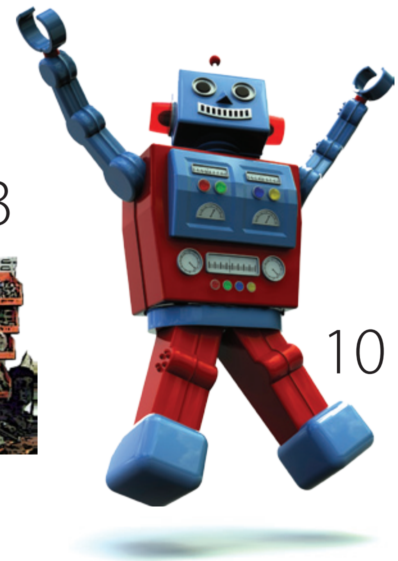

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Editorial

Line of Sight

I have been very busy lately–busier than usual since the last time I wrote to you.

I had my first trip to Africa, as we produced Solutions 2.0 Africa in Cape Town, which was collocated with Pragma's Asset Management Thought Leadership conference. The folks at Pragma could not have been better hosts and partners, and I learned a great deal from several of the asset management professionals and company management that I met.

The operating environment and challenges in Africa are different than those of many of the places I visit. Listening to how the maintenance reliability and asset management professional community meets those challenges was enlightening and uplifting.

We are planning to repeat this conference in June 2012 and hope many of our readers from various countries will take the trip with us.

Upon my return, we hosted the Reliability Forum for Water/Wastewater Utilities at the Reliability Performance Institute in Fort Myers. The pressure is on this special group of maintenance professionals who face aging assets, an aging workforce, severe budget constraints, low-bid purchasing, and intense environmental issues. It was uplifting to hear how each of the 20 utilities that presented dealt with these challenges in many unique ways.

From there I flew off to Philadelphia to lead the PC251 US TAG workgroup that is working on the draft ISO 55000 and ISO 55001 Asset Management Standard. This work is derived from the PAS55 Asset Management Specification and is on track to become an internationally recognized standard designed to create an asset management framework and policy that provides a line of sight or connection between top management intent and the reality of how assets are operated and maintained on the ground. This standard is on track for public release in late 2013 or early 2014, so early adopters will be rewarded.

While all of that was going on, Reliabilityweb.com completed the Industrial Press publishing acquisition of *The Maintenance Strategy Series*™ by Terry Wireman and *The Journey* by Steve Thomas. We also released Ron Moore's 2nd edition of *What Tool? When? Selecting the Right Improvement Tools*.

All the while, our conference planning team was putting the final touches on IMC-2012, the 26th International Maintenance Conference being held December 5-8, 2012 at the Hyatt Regency Coconut Point in Bonita Springs, Florida.

There is more, but either I would be boring you with details or you would not believe it anyway, so just stay tuned!

If you believe the Army saying, "If you want something done, give it to a busy man," then get involved with Reliabilityweb.com, *Uptime Magazine*, and The Association for Maintenance Professionals. We are way too busy not to be productive, and we promise that any attention you give us will not be wasted.

Keep line of sight in mind with everything you are doing to ensure your efforts are aligned with your organization's aim. Communicate that aim in a clear, concise way that ensures everyone from top management to the maintenance and operations teams has a clear line of sight that connects them in goal achievement.

Who wants my frequent flyer miles?

Sincerely
Terrence O'Hanlon, CMRP
CEO/Publisher
Uptime® Magazine
Reliabilityweb.com
Reliability Performance Institute

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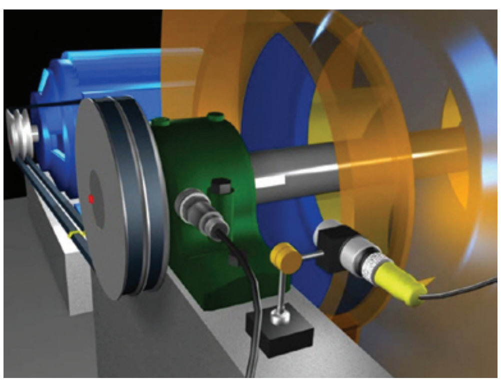

Balancing? What Could Go Wrong?

There are actually a lot of things that can go wrong during a balance job; that's why it helps if you understand the balance process and watch the vectors rather than just letting the balance program do everything for you. One of the main reasons that a balance job is not successful is that the machine is not out-of-balance, or it has other fault conditions that also generate vibration at the turning speed of the shaft. Therefore, a machine should not be balanced just because "the vibration is high"; it is important to check and correct shaft and belt misalignment, bent shaft, eccentricity, resonance, looseness, and other faults before attempting to balance the rotor. The balance process assumes a "linear" relationship between the vibration measured and the mass added. That linear relationship may not exist for a few reasons, but one of them is the presence of other fault conditions.

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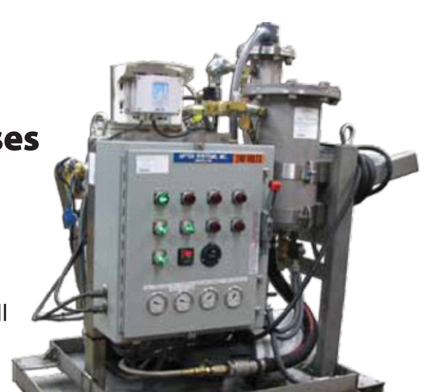

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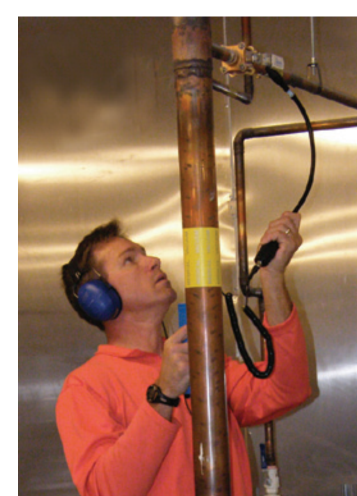

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Past, Present, and Future of Maintenance

Jordan Berkley

Maintenance reliability strategy continues to evolve as organizations seek new areas to improve performance and decrease cost. ***Uptime Magazine*** **invited Jordan Berkely to share his vision of the future with you.**

PAST

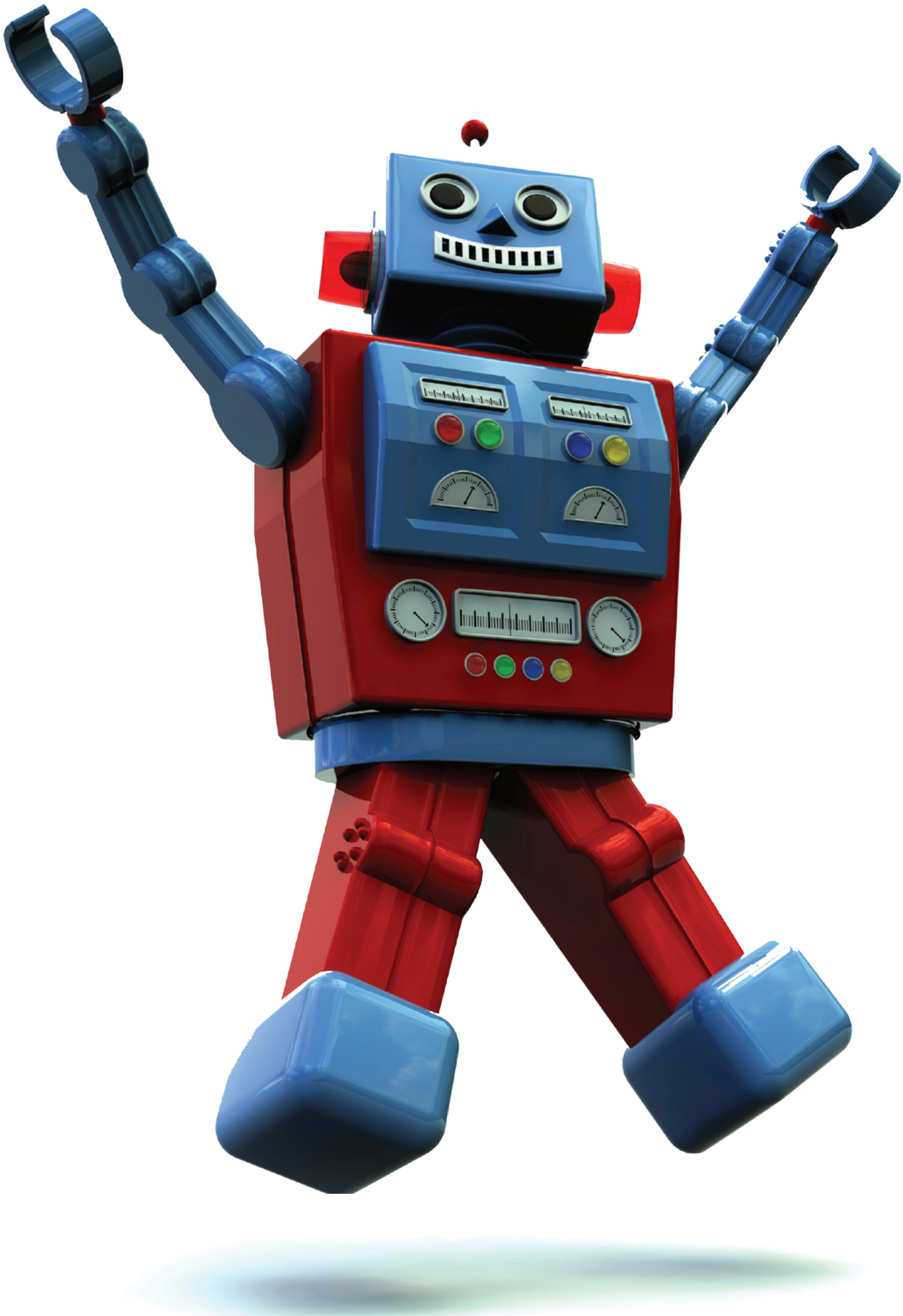
Maintenance management systems evolved from a need by manufacturers to improve labor efficiency while reducing costs. Traditional paper records were too costly to prepare – valuable "wrench time" was lost while mechanics filled out an extensive paper trail. Computerized Maintenance Management Systems (CMMS) replaced much of the need for paper-based tracking, enabling management to quickly create reports to monitor useful performance metrics such as Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR).

PRESENT

Today, many manufacturers are finding that maintenance management can be further optimized when part of a broader solution for manufacturing operations management by synchronizing with production, warehouse, and quality operations. These systems provide a better approach to preventing machine breakdowns by anticipating when maintenance is required, based on a broader scope of leading indicators, such as a production change requiring raw materials from a third-party warehouse.

FUTURE

In the future, I anticipate fewer maintenance actions, based on steady quality improvements and equipment capable of fixing itself. Location-aware applications could trigger signals to mechanics as they walk by, indicating an action should be performed. Borrowing from gaming technologies, future maintenance applications might enable mechanics to peer into sensor-enabled equipment to manipulate speeds, temperatures, and more without ever wielding a wrench or screwdriver.



Now is the Time for Maintenance 2.0

Today's global economy has put manufacturers under extreme competitive and financial pressure. In spite of the gradual recovery in the manufacturing sector, marked by higher-than-expected quarterly results and increased guidance from many in the industry, the soaring costs of fuel and raw materials continue to put pressure on manufacturers to work smarter and more efficiently.

The concept of a "Maintenance 2.0" approach eliminates information and process silos. No longer does it make sense to isolate the critical activity of maintenance management from the rest of operations.

These pressures have had a ripple effect on the industry, leading some firms to make short-term trade-offs by deferring machine maintenance and upgrades. In some cases, management has cancelled or delayed equipment purchases. This may ultimately negatively impact long-term operating performance. Ironically, delaying equipment replacements or upgrades has only made the vitality and ongoing efficiency of existing equipment even more critical.

Greater attention must now be applied to maintenance programs in order to sustain these aging and increasingly important assets. Yet, quite often, staffing levels have been reduced in search of cost reductions and improved productivity. Increasing demands have been placed on the remaining employees, creating an almost perfect "storm" for disaster.

While challenging business conditions have affected most operational areas, maintenance, which is typically viewed as a cost center, has been particularly hard hit. The importance of efficiently maintaining and utilizing aging equipment—specifically, maximizing uptime to meet production demands without increasing costs—is crucial to the efficient performance of the manufacturing process and the overall health of your business.

Increased Risk Necessitates a New Approach

The concept of a "Maintenance 2.0" approach eliminates information and process silos. No longer does it make sense to isolate the critical activity of maintenance management from the rest of operations. Industry leaders understand the value of synchronizing maintenance activities with production, quality, warehouse, and labor operations for substantial performance and cost advantages. Also, this type of approach can help you reduce the risk of production downtime or costly, unplanned equipment repairs.

Coordinating preventive maintenance with production schedules reduces ad-hoc reactionary scrambling to smooth out production schedules. Avoiding notification delays of unplanned repairs can reduce your mean-time-to-repair, getting production back online as fast as possible. On-time delivery performance can be improved, and the reduction in performance variation results in lower requirements for safety stock.

With all the potential benefits of having a more collaborative solution, one might ask why there hasn't been widespread adoption of this strategy. Why do most manufacturers still rely on legacy, traditional maintenance management applications that operate in a silo?

Legacy Maintenance Systems Are Not a Top-of-Mind Concern

One reason why maintenance system upgrades might not have been as active over the past couple of years is the fact that other issues simply necessitated greater attention, such as identifying which factories to close or how to make payroll when sales dropped by over fifty percent. In other words, there are only so many "fires" one can extinguish, and over the past couple of years there have been quite a few of them. Thus, maintenance system upgrades were just not a top-of-mind concern. If factory equipment is idle, and you're trying to soak up excess production capability, who cares if the maintenance is current on a machine or tooling?

Manufacturing operations and maintenance management systems are now becoming highly collaborative as well, offering feedback loops where information and processes can be exchanged and acted upon

Another reason I have heard to defer a maintenance system upgrade is the big wave of Computerized Maintenance Management System (CMMS) implementations that occurred over the past decade. CFOs embraced the concept of wringing greater value out of existing capital assets. However, many of these systems proved to be too expensive, too complicated or simply too cumbersome to deploy quickly and effectively on the shop floor for tracking work order progress and labor usage.

The end result?

Many software licenses were purchased, but not all were implemented. Those that were able to complete the installation process struggled to improve or upgrade their solution to match improved processes. Over time, the system no longer matches and supports the processes that are actually used on the shop floor.

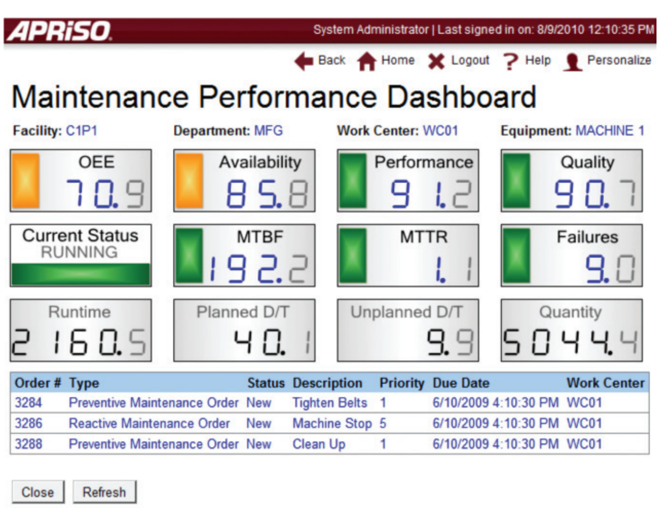


Figure 1: Sample screen shot showing the intelligence that can be linked to maintenance management operations.

Too often maintenance systems, like the maintenance departments that purchased them, have run isolated from production and quality operations and systems. Maintenance management systems have typically been deployed on a plant-by-plant basis, with local staff assigned to monitor and provide fixes as needed. There is a long history of purchasing computerized maintenance systems as point solutions with a single plant in mind.

This traditional approach used to work just fine. As long as each plant's output quotas were achieved, everyone was happy, or as some have put it, we were "on the happy path." Production continued in a predictable manner, and equipment maintenance could be reasonably managed on a plant-by-plant basis.

What Changed?

There have been several significant shifts in manufacturing operations today, due in part to new global competitive threats and the global economy's recent challenges that began a few years ago and is either gone or still lingering on, depending upon your industry and geographical focus.

Once it became apparent the "financial crisis" of 2007 and beyond was going to be significant, many manufacturers chose to shutter plants and lay off employees. This act of self-preservation was prudent and predictable; those that effectively cut costs quickly have positioned themselves for long-term survival. What is happening now is that the recovery has quickly pushed production levels back towards full capacity, given all the plants that were closed. Extra shifts are being manned, and outsourcing contract agreements are under consideration to address increased demand.

While manufacturing output has clearly increased over the past couple of years, what has lingered is a memory (some would argue a scar) of the painful decisions and adjustments that were made. Plant managers and those involved in forecasting and planning production schedules suffered on a global scale trying to best manage through the ordeal. As a result, there is a lingering fear of hiring or investing too quickly, in case further reductions are once again required. Manufacturing flexibility has become a key component of production scheduling, as well as nearly every other manufacturing process. The business with the most flexibility stands the greatest chance for survival in today's current uncertain times.

Maintenance 2.0 – Improving Flexibility in Maintenance Operations

It is the driving need for greater flexibility in manufacturing operations that is now impacting manufacturing systems purchases, including those systems managing maintenance operations. A Maintenance 2.0 solution can address these concerns due to its iterative nature and ability to change and adapt as often and as quickly as necessary. Speed of change is the new competitive weapon to keep costs down while still capturing sales opportunities and market expansions.

Let's take a closer look at what a Maintenance 2.0 solution might look like.

Recall the "Web 2.0" transformation that began in 2004 to understand what the 2.0 designation means. Quite simply, it is the ability to provide a feedback loop: two-way communications versus one-way. Websites that just posted articles and content with no opportunity for readers to respond are 1.0 websites. Blogs and most of today's news sites, however, all offer abilities to post replies, creating a feedback loop of interactions between the authors and their readers, as a 2.0 website.

Manufacturing operations and maintenance management systems are now becoming highly collaborative as well, offering feedback loops where information and processes can be exchanged and acted upon, as a 2.0 type of information exchange.

A Maintenance 2.0 approach means that your maintenance management system no longer operates in a silo. Maintenance orders are instead triggered by actual production volumes, product design changes, or even quality issues that might begin to trend out of compliance, forcing an immediate equipment inspection or repair, regardless of whether it was scheduled. This iterative flexible approach means that maintenance schedules can be frequently updated or changed, becoming highly dynamic and capable of better supporting their production environment. See Figure 1, showing a sample of what a user interface might look like where maintenance performance can be measured as part of a collaborative operations dashboard.

How Do You Achieve 2.0 Levels of Flexibility?

Not every system is capable of responding quickly to change or adapting a series of complex maintenance operations "on the fly." Fortunately, new advances and technologies are making this agility possible. A great place to start is with a system based on Business Process Management (BPM) application architecture. Quite simply, these types of applications are built on a series of business process that can be readily changed as often as necessary. Note that I am not talking about threading disparate applications together with BPM. Instead, I am talking about actual applications that at their core are really just a collection of business processes.

This technology becomes even more powerful when expanded to run all of your manufacturing operations. For example, production, quality, warehouse, time, and labor and maintenance operations could all be run from a series of BPM applications, each with business processes intersecting with manufacturing operations in a virtually infinite manner.

"Maintenance processes cannot be effective if established in a siloed fashion. It is important to have both maintenance and operations groups working closely together to optimize both operations and maintenance processes. This will be a key step in achieving the top two goals of minimizing downtime and maximizing asset utilization."

Matthew Littlefield, Senior Research Analyst, AberdeenGroup

Benefiting From Flexibility in Maintenance Operations

As I mentioned earlier, legacy plant maintenance systems have long suffered from running isolated from production, quality, and warehouse operations. This structure can lead to operational disruptions and disjointed responses to unexpected breakdowns. Further, isolation of maintenance from operations impedes root cause analysis because it is more difficult to correlate performance, quality, and equipment information.

A flexible, BPM-based system operates much differently. This type of system is capable of frequent changes and can be operated as part of a greater "whole" operations environment that might include other manufacturing operations. By operating as part of a collective "whole" that runs the entire manufacturing enterprise, greater efficiencies can be harvested from maintenance operations. Replacement parts can be managed more efficiently. Times to schedule repairs or work orders can be better coordinated based on knowledge gained via visibility to other operations across your organization.

Embed Maintenance in Support of Continuous Process Improvement

The simple act of better scheduling equipment repairs is only the tip of the iceberg of the potential benefits possible when improving collaboration and flexibility around your manufacturing operations.

One of the most important ways to improve uptime while minimizing maintenance costs is getting more "wrench time" from your existing maintenance staff. Identifying and eliminating non-value-added tasks, a form of waste, improves maintenance process efficiency while opening up more time for value-added tasks, thereby increasing your labor efficiency.

Continuous improvement initiatives, such as Lean and Six Sigma, are used by many organizations to remove waste and improve maintenance process efficiency. The challenge is that

"Everyone here at Hitachi is very glad we made the change [to a Maintenance 2.0 solution] with Apriso's FlexNet. To sum it up, FlexNet offers much more flexibility … to changing PM schedules, due dates, and assignments, while at the same time [it] is much more user-friendly. FlexNet's [Maintenance 2.0] approach gives us the ability to record both the preventive and reactive maintenance history on equipment. This is important, because it gives us a more complete look at what has happened to a piece of equipment, contributing to increased efficiency and improved uptime."

– Kristi Dean, Production Engineering, Hitachi Computer Products (America), Inc.

traditional maintenance applications are typically ill-equipped to quickly and easily adapt to new maintenance processes or improvements. Legacy maintenance applications are essentially "hard coded" applications that have implicit maintenance processes embedded in them, providing a considerable obstacle to performing a change to any process or routine.

A Maintenance 2.0 system is specifically built for change. Flexible systems based on a BPM-based architecture can provide a form of value stream mapping to model the sequence of steps required for a maintenance activity. With BPM, each step in a maintenance procedure can be visually mapped, specifications and maintenance manuals can be linked, parts and materials can be quickly identified, and skills and certifications required for the job can be validated as work assignments are made.

A Maintenance 2.0 system can direct a maintenance engineer through the departments' standard operating procedures, including notification and signoffs, to track labor usage and updates systems for parts used, equipment lineage, and work order progress. This process can be easily changed without really impacting the operators (they may not even know that the process has been changed) as long as they continue to perform their duties as directed through their custom user interfaces.

More importantly, a Maintenance 2.0 system empowers maintenance organizations to quickly and easily update their maintenance processes as improvements are identified. Process changes that remove non-value-added activities, such as travel time to the job, or time spent gathering parts and tools or filling out paperwork, means more time is available for the technician to do preventive maintenance.

Examples include enhancing the process for a regularly scheduled lubrication of motor bearings or giving visibility to all tasks that an engineer is qualified to complete within a predefined period of time or specific area of a plant. Evaluating ways to eliminate non-value-added time means more preventive maintenance can be done within the same level of staffing.

Notably, many plants achieve only 25-30% wrench time. Best-in-class organizations can achieve wrench time of 50-60%. Maintenance 2.0 empowers continuous improvement initiatives that can help you to increase your percentage of wrench time, resulting in lower costs and increased uptime.

The Role of ERP in Maintenance Management

By taking a Maintenance 2.0 approach with your Enterprise Resource Planning (ERP) system(s), it is possible to better coordinate plant maintenance activities while removing overlapping or duplicative functionality. In other words, when processes can be easily created, shared, or changed, it becomes a whole lot easier to navigate through the complex integration requirements of implementing or maintaining an ERP deployment. A dynamic system that can easily remove redundancy or overlap will function with greater efficiency and cost less to maintain, once again leading to increased equipment uptime, improved compliance, and lower manufacturing costs.

Examples of areas where there is typically too much overlapping of functionalities with ERP systems include areas such as spares procurement, work order scheduling, costing, and inventory management.

Not Just a Theoretical Discussion

One example of a manufacturer that has embraced a Maintenance 2.0 approach for their maintenance management operations is Hitachi Computer Products (America), Inc., which recently implemented Apriso's FlexNet Maintenance as their Maintenance 2.0 solution.

Working with Apriso, Hitachi put in place a new maintenance management solution based on FlexNet's BPM architecture. Their "Maintenance 2.0" system has gone beyond a "stovepipe" perspective of maintenance management by enabling greater coordination and collaboration across all of their manufacturing operations.

By reducing non-value-added activities, such as gathering spare parts and tools or filling out requisitions, engineers can now get more wrench time, enabling more preventive maintenance without increasing staff, and reducing time spent only on break-fix operations.

Conclusion

As the manufacturing industry continues to drive cost reductions, improved efficiency, and greater quality, a Maintenance 2.0 approach enables improved operational performance by synchronizing maintenance processes with production, quality and warehouse operations. Greater visibility, control, and synchronization of maintenance processes on a global scale means that equipment performance can be better understood. Broader context for root cause analysis means faster resolution of problems, resulting in improved uptime, lower costs, reduced mean-time-to-repair, and increased asset longevity.

Further, a collaborative, BPM-based solution for maintenance management helps support Lean operations and continuous improvement while providing a more simplified work environment for maintenance engineers and technicians. It enforces standard operating procedures across the enterprise to improve regulatory compliance and safety while minimizing operational impact and costs.

Implementing a Maintenance 2.0 solution on a global manufacturing platform helps maintenance organizations to both operate more effectively and reduce costs without compromising safety or productivity. In these challenging economic times, that's a change most manufacturers can live with.

Link to the white paper: http://uptime4.me/apriso_paper

Jordan Berkley is responsible for providing strategic direction for product management of Apriso's FlexNet application suite. Mr. Berkley has over 15 years of business development, product management, and sales experience, from an end user and IT solution provider's perspective. www.apriso.com

The Best Bang for the Buck

Val Zacharias

The ultimate goal is profit. The more profitable your company is, the more secure your job is, and the more opportunities you have. Profit is a good thing.

In machinery-rich plants, one really good tool to help achieve profit is well-done ***Predictive Condition Monitoring***. "Condition monitoring" is a common term, but it is a bit limited for this purpose. Adding "predictive" to the mix gives you the big returns. "Predictive" implies a time lapse between the identification of the problem and the necessity for repair. That gives you time to order parts, time to organize workers, and, most importantly, the opportunity to choose the best time to do the work. Maybe your plant has scheduled downtime, and you could add this task to the list. Maybe there are several repairs, each requiring about a half day, and with proper planning, they could all be done during one shutdown. The big financial benefit here is limiting the downtime required for the repair.

"Well-done" is the other part of the equation. To work well, predictive condition monitoring has to be a comprehensive program, with firm scheduling and dedicated personnel. It can't just be something that gets done if nothing else gets in the way. Also, the schedule has to include time for analysis and follow-up, at least as much time as is allocated for data collection. Otherwise, it's like having a Hummer in the garage and never driving it. It's just a waste of money.

Where is the opportunity for the most improvement?

Computerized condition monitoring has been around for 25 years, and people have learned the importance of a proper setup and collection of good data regularly. But what then?

In many cases, the still-to-be-realized benefit is appropriate analysis of the data and making use of the huge advantage of good history over months or years.

Too many analysts refuse to commit themselves, choosing to rely on other people or "industry standards" rather than on their own analysis of their own data. An expert who comes in when a problem has arisen and who has to make a decision without benefit of context or history has a very difficult job. Even when you need to call in an outside expert, you should insist on due consideration being given to the quality history you have developed. Compare the two jobs in the table on the right.

Always remember that the job does not end with collecting data. It does not even end with analyzing data. The point is to make a justifiable decision about each machine, act on it, and follow up. One such decision might be that you do need to hire a consultant to help solve the problem, because the problem is difficult, unusual, or potentially very expensive. If so, make sure you choose one with a proven track record, and who will add extra skills, not just duplicate yours. OWN your own machinery; don't cop out.

Val Zacharias earned a Master's Degree in Educational Curriculum and Instruction with a specialty in Communications. She spent 20 years working for Beta Machinery Analysis and Beta Monitors & Controls, where she participated in the development of the first computer-aided condition monitoring instruments and software, beginning before the existence of IBM PC's. Since 2000, she has served as Executive Director of the Canadian Machinery Vibration Association. www.cmva.com

The Outsider	You - Doing Good Periodic Condition Monitoring
Cannot know how this machine has behaved when it is in good condition. Has to rely on anecdotal evidence from operations personnel. When did it start making this noise? What else was going on at the time? Did the process change? What was the other equipment doing? Is lucky if the answers are informative at all. It's just as possible that the answer is "it was all right on Friday when I left, and when I came back this morning, this is what I found." Even worse, the answer might be "I have no idea – we hardly even look at this machine."	Have a set of baseline readings that represent that machine's behavior when it is in good condition. Can look back over several months and see when the change in condition began, what other factors were associated with it, and how fast it has progressed. Most likely, you can identify a potential problem long before someone walking by would perceive it, and thus you have more time to consider and plan maintenance at a convenient time.
Takes vibration data once and has to make use of it. What if the transmission path for the vibration signal on this machine is much better (or much worse) that expected? The reading may be misleading, though no fault of the outside analyst.	Take vibration readings regularly, and you know your data accurately represents the behavior of that machine over time, because you know the machine, use the identical technique each time, know your data collector is properly cared for and calibrated, and are certain you took data at the exact same point every single time. (You probably stood in the same spot and held your mouth the same way, too.) Maybe you use a hand-held transducer and have to drill a shallow dimple for each test point, or maybe you use a quick connect. Whatever the method, you know it gives an identical reading for the identical condition, because you have tried it out. All of this is confirmed by doing the same job time after time, because a change in the readings can be correlated to a change in condition. The absolute value of the vibration reading is not all that important. You care about whether it changes, and why.
May need to compare vibration readings to published standards. Published standards are useful, and far better than nothing, but think about it. They are an average of vibration readings taken on hundreds of machines, in several different services, resting on different foundations, and mounted with different methods. Such methodology means that "allowable" has to be a fairly wide range.	Your chosen standard might say "set the alarm at 0.3 inches per second (ips)," and in the absence of other evidence, that is fine. However, once you know this machine has run at 0.15 ips for the last 12 months, you are concerned about today's 0.25 ips, even though it is still below the published allowable. At that point, you throw out the standard, and work with what you know personally. Really, published standards have to be used when there is no history available, but once you have documented the behavior of THIS machine, in THIS service, on THIS foundation, your own data is much more useful than the standard. If you are not confident of your own data, you should improve your procedures.
Can often narrow the "allowable" based on considerable personal experience in a particular field.	Have the opportunity to use statistical alarms to improve the recognition of exceptions. It helps to understand statistics, but basically, the method takes into account the variation in readings over months and years. MAKE SURE THE DIFFERENCE IN READINGS IS NOT DUE TO A DIFFERENCE IN DATA COLLECTION TECHNIQUE, and beyond that, concern yourself with history, again. If this reading fluctuates quite a bit (because the process changes, or the weather changes) a relatively larger change will have to occur before the reading is brought to your attention. If this reading has been steady for a long time, a fairly tiny change will be reported to you in your exception or anomaly report. Thus, you might see an alarm on a reading of 0.15 ips, giving you time to react long before the reading would reach the published alarm level. After all, given a tiny steady reading, chances are good that your unit would fail before vibration ever reached 0.3 ips, so don't be caught napping.
Creates a report on today's results. What else can he or she do? The report should get reviewed the next time there is a problem on this machine, but will it? Chances are it will just sit on a shelf.	Create an ongoing history of each machine: what anomalies have appeared, what the decisions were, what was found during repair. Relate the results to changes in the process, readings taken on sibling machines, perhaps ambient conditions, whatever makes a difference. Share that information in a structured way with the whole plant, so that the general knowledge of the plant increases, not just your own personal knowledge. While it is tempting to be the go-to person who knows everything, ultimately the team player is the one who gets promoted. Take advantage of that information EVERY TIME you need to make another call. Properly done, the solutions get easier and easier.

decision support

Adi
asset data integrity

5 Critical Success Factors for Effective BOMs

Doug Wallace

If your company was manufacturing automobiles, appliances, iPads, or even cardboard boxes, you certainly wouldn't think about scheduling production without a complete and accurate Bill of Materials (BOM) for each finished product so you could determine your raw material requirements from a master schedule. So why is it that many process industries not only begin operation without equipment BOMs, but go for years, sometimes decades, without them?

When we ask people to assess the quality of their equipment BOMs, the comments we get most often are either, "they don't exist," or, "we have some of the data, but we don't know if it's accurate." When we ask why that's the case, the response is usually, "we don't have the information," or more likely, "we don't have the resources to do all that work."

So instead of taking the time to build and maintain the BOMs, they just go on without them. That means planners, maintenance and reliability engineers, mechanics, materials management and procurement personnel, and others have to go outside the system to do things like:

- Determine material requirements for planned work
- Query and locate parts for emergency and other unplanned work
- Associate critical spares to specific assets
- Evaluate part substitutions
- Assess non-moving material for obsolescence
- Identify opportunities for part standardization

Somehow there's time for most of these workarounds, and although it's hard to calculate, it probably takes 2 to 10 times as much effort to deal with the lack of information as it would to just fix the problem in the first place. Unfortunately the focus is on the reactive aspects of what really needs to be done and not on the proactive aspects of getting the information into the system. If you don't keep up, it's hard to catch up. So what are the five critical success factors for establishing and maintaining effective BOMs?

1. There's no question that the #1 thing you can do is **get the information into the system as early as possible!** As soon as you have made a commitment to buy a new piece of equipment, you should be on the phone with the manufacturer or supplier to get the BOM information. Unless there's a possibility that something could change, there's no reason not to have the BOM data in the system even **BEFORE** the equipment is installed.
2. Don't kill yourself trying to get every last little item into the database. If your system supports an automatic upload of BOM data from an electronic file, then take advantage of it. But if you have to enter the data manually, make sure you enter the most important items first. Another rule of thumb is: anything you reasonably expect to repair and/or replace should go on the BOM, with the exception of consumables and free issue parts.
3. Make sure you have a robust process in place to manage changes to the asset base. Whether you call it "Management of Change," "Configuration Management," or "Mikey," the important thing is that all equipment redesigns, material changes, part substitutions, or even significant modifications are assessed to determine the impact on the BOM.
4. Don't forget about retired assets. How many times have you had someone look at an expensive or supposedly critical part that hasn't moved in the storeroom and heard them say, "oh, we stopped using those years ago when we took out the whatever." It's so much easier (not to mention cost effective) to deal with these situations as they occur.
5. Make it part of the culture. This isn't something that can be done randomly or easily driven from the bottom up. It requires management commitment to make it a priority, with clearly defined responsibilities and expectations for each person involved in establishing and maintaining the integrity of the BOMs, and accountability for making sure it happens.

It's not easy! The easy thing is to do nothing and continue to live with the consequences. Even if you can't erase all the mistakes of the past, at least put something in place to keep the situation from getting worse. Once you can keep up, it's easier to catch up!

Doug Wallace, CPIM, has more than 30 years of combined experience in supply chain operations and management consulting, specializing in the areas of global enterprise planning, production and inventory control, and materials management. As a Materials Management Subject Matter Expert for Life Cycle Engineering, his primary focus is on implementing best practices in procurement, warehouse operations, inventory optimization, and utilization of associated business and information systems. www.LCE.com

decision support

cMms computerized maintenance management system

Orange County Container Group **Achieved Over $3 Million in Savings With CMMS Implementation**

Gene Pargas

Multi-million dollar savings is big news in any language. When Orange County Container Group (OCCG) implemented eMaint X3 CMMS (featuring bilingual customer support) to track inventory across multiple locations, they found substantial savings in what initially looked like small numbers.

In addressing the need to handle inventory management at seven production plants in the U.S. and Mexico, OCCG achieved significant savings though changes such as a decrease in overtime by half an hour each day and a 1% reduction in downtime. These numbers may not sound impressive, but when applied across multiple technicians, assets, and locations, the savings increase exponentially. Bill Chant, Director of Maintenance and Engineering at OCCG, likens the savings to picking pennies up off the floor: while not terribly impressive at first blush, the pennies quickly turn into dollars; big dollars – over $3 million.

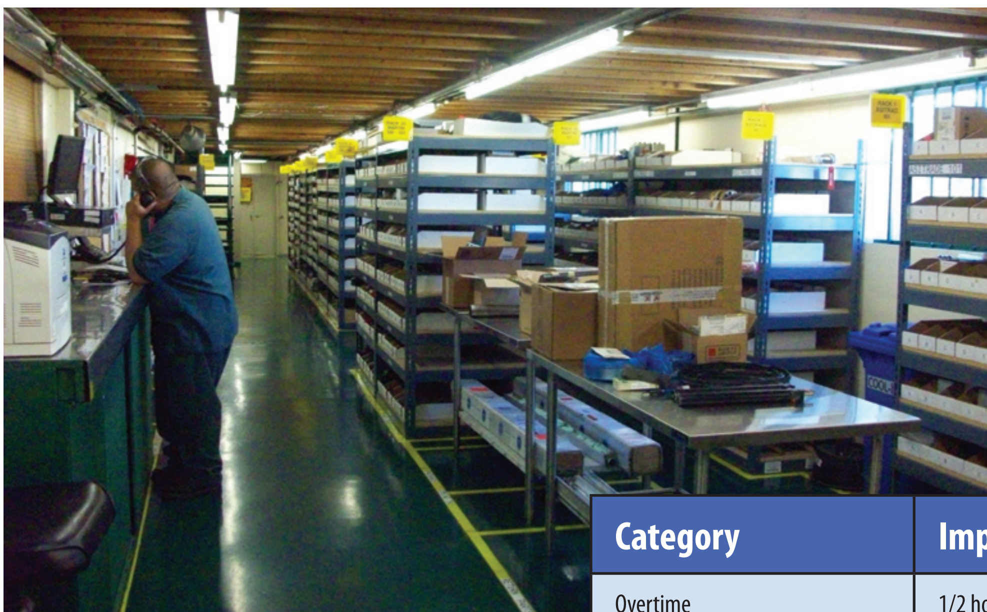
A veteran maintenance professional with 30 years of experience in the corrugated paper production and printing business, Chant ran his own field service business for seven years before joining OCCG as Maintenance Manager of Mexican operations, bringing online a facility in Nogales, Mexico. Following a five-year stint as Maintenance Manager at LA Corporation, where he implemented their CMMS system, Chant returned to OCCG in 2009 as Director of Maintenance and Engineering. He needed to replace OCCG's resident CMMS, Datastream's MP2 system, which had poor mobile connection, resulting in maintenance workers often unable to enter information into the system as the work was being done. Further, maintenance managers had poor visibility of inventory quantities at each site, so OCCG was unable to share inventory between sites, resulting in increased downtime while waiting for inventory from a distant supplier. Finally, the pervasive inventory inaccuracies not only impacted their borrowing base, but also resulted in a substandard on-time PM completion rate of 70%, along with excessive overtime caused by manual paperwork.

Faced with a corporate cost-reduction initiative and the need to track over $6 million in inventory across multiple locations, Chant knew a robust CMMS was the answer. Other considerations included recent acquisitions that lacked standardized procedures and employed multiple systems, and a need for bilingual training to support operations in Mexico. Multiple location inventory management and the ability to integrate with corporate accounting systems was essential, but Chant also wanted a web-based, easy-to-use CMMS to ensure a higher adoption rate, and he knew that

Bill Chant credits the success of the CMMS implementation and the subsequent savings to many factors, including a team effort involving maintenance, IT, accounting, auditors, suppliers, and production, all dedicated to getting it right the first time.

Spanish/English product and customer support would be critical to ensure a successful implementation. For ISO compliance, Chant needed a CMMS with security settings and the ability to limit rights by user. He also sought cost-effective barcode integration and wanted to find a CMMS that made it easy for IT and system administrators to configure settings.

The CMMS evaluation process began with the usual suspects: Oracle and SAP. Both were quickly eliminated as they exceeded the budget and were difficult for end users. Chant considered Datastream, but lack of control over handheld device selection made this solution costly, and a cumbersome reporting interface was a deal-breaker. With budget top of mind, Chant attended a free eMaint product demonstration and found the easy-to-use, web-based system promising enough to merit participating in a 30-day free trial. During the trial period, Chant determined that eMaint's browser-based X3 CMMS solution would easily integrate with OCCG's corporate systems, that it was fully customizable, and that eMaint offered Spanish language customer support. It appeared eMaint would also support their need for multi-location inventory sharing and ISO compliance. OCCG's IT, maintenance, and administrative staff were favorably impressed, and Chant appreciated the on-demand training and workshops as an important implementation aid and ongoing training tool. Based on the many positives, eMaint X3 CMMS was selected for implementation at two pilot locations, City of Industry, CA and Tijuana, Mexico.



Category	Improvement	Annual Savings
Overtime	1/2 hour a tech per day	$200,000
Next Day Air Freight Charges	70%	$70,000
Waste Spoilage	4%	$2,000,000
Downtime	1%	$500,000
Highlighted Annual Savings		$2,770,000

With the original goal of tracking and improving multi-location inventory management, a concerted effort involving OCCG's accounting and auditors was put toward accurately identifying inventory parts and costs. A min/max program was established to facilitate reordering and the program was configured so that every purchase order generates a work order. With eMaint X3, OCCG was also able to maintain ISO compliance and Lean standards. To ensure a successful implementation, extensive on-site training in English and Spanish was done utilizing eMaint's bilingual support capabilities. The results and benefits were immediate, so much so that corporate mandated a company-wide implementation of the application for Inventory Control at each site and between sites.

Today OCCG is using 80% of the eMaint system. Not only are all purchase orders entered into eMaint along with work orders for receiving parts, but also the system generates quotes for competitive bids from three suppliers, the Min/Max settings trigger parts reordering, all preventive maintenance checklists are online, and inventory sharing is occurring across multiple locations. As a result, next-day air freight charges have dropped by 70%, a savings in dollars equivalent to the annual wages of one mechanic. Chant is busy picking up the pennies and adding up the dollars. In fact, in terms of real money, OCCG "found" over $2 million in inventory (increasing their borrowing base), with one plant experiencing $1.3 million in savings in reduced maintenance costs, without increasing downtime. Chant reports that on-time PM completions have improved to a stellar 99%, and standardized procedures have been implemented across 14 locations. Downtime has decreased by 1%, which translates to $500,000 in annual savings. OCCG has further reduced waste spoilage from 13% to 9%, for an annual savings of $2 million. Suppliers are held accountable in terms of both cost and availability, and overtime has been reduced by ½ hour per technician per day, an annual savings of $200,000.

Chant credits the success of the CMMS implementation and the subsequent savings to many factors, including a team effort involving maintenance, IT, accounting, auditors, suppliers, and production, all dedicated to getting it right the first time, along with a focus on up-front training facilitated by eMaint. He relies on the on-demand training and workshops to keep the momentum going, and he seeks advanced training as he continues to bring additional plants and features online. Chant notes, "We originally chose eMaint X3 strictly for tracking inventory across multiple locations and for its bilingual support. We soon realized there were additional gains to be made by utilizing other aspects of the system; further the ease of IT integration has allowed us to quickly leverage the system capabilities." Current OCCG CMMS plans include the utilization of handheld devices and barcode integration, along with going 100% paperless on PMs, with checklists accessed through work orders online. Chant looks forward to reporting on additional savings and improvements as he further integrates eMaint CMMS into OCCG operations.

Gene Pargas leads the national and international business development efforts at eMaint Enterprises, LLC from the Marlton, NJ headquarters. A productivity expert, he has a passion for helping people and organizations to achieve their performance goals. Gene served 9+ years in the U.S. Navy, including Guided Missile Destroyers and the U.S. Dept. of State's Bureau of Diplomatic Security, Overseas Sophisticated Technologies Division. He currently works with executives to identify their CMMS requirements and plan for successful implementations. www.emaint.com

management

PaM physical asset management

The Connection Between Equipment Risk and Equipment Reliability and Its Affect on Maintenance Strategy

You can create outstanding equipment reliability, deliver high production uptime, and guarantee lower operational costs by removing the risk of failure from your machines and equipment. The more risks production plants and equipment are exposed to, the more certain it is you will get low plant reliability and high maintenance costs.

Mike Sondalini

Operational equipment reliability, and the resulting plant uptime, are inversely linked to the number of risks you allow your equipment and machinery to suffer. The contrary connection between equipment risk and reliability is not obvious, but it reveals itself to us when the risk equation is divided into its fundamental elements.

We start by examining the most commonly used form of the risk equation:

Risk ($/yr) = Consequence of Occurrence ($) x Frequency of Occurrence (/yr)

The equation says that risk is equal to the cost of a failure event multiplied by the frequency of the event.

The Frequency of Occurrence divides further, so the full form of the risk equation becomes:

Risk ($/yr) = Consequence ($) x [No. of Opportunities to Fail (/yr) x Chance of a Failure]

The Number of Opportunities to Fail is how many times a year a situation arises that could lead to a failure event. The Chance of a Failure is the odds that a failure will happen once there is an opportunity. Throw the two dice in Figure 1, and every throw is an opportunity to get one on each die, but the odds are 1 in 36 that it will actually happen in the next throw.

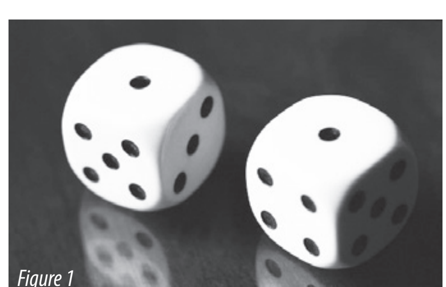


Figure 1

The Chance of Failure is one (1) if it will definitely fail every time the opportunity arises, and it is zero (0) if there will never be a failure when the situation arises. Chance uses values between 1 and 0 because the likelihood of a thing going wrong is usually possible to some degree. The chance of both dice being one is 0.0278—poor odds to bet on.

For operating plant and equipment the Chance of Occurrence of equipment failure becomes the Chance of Equipment Failure, which is the opposite of Equipment Reliability (the chance of not failing, i.e. the chance of success).

The reliability equation for equipment is:

Equipment Reliability = 1 – Chance of Equipment Failure

With a little manipulation, this becomes:

Chance of Equipment Failure = 1 – Equipment Reliability

Including equipment failure into the full risk equation, we get:

Risk ($/yr) = Consequence ($) x [No. of Opportunities to Fail (/yr) x {1 – Equipment Reliability}]

The full risk equation gives us massive insight into how we can maximize production equipment uptime. There is a direct inverse connection between equipment risk and equipment reliability. When equipment reliability is perfect (Reliability =1) the risk is zero, and if there are no opportunities to fail, there is also no risk (Opportunity = 0). If you want high equipment reliability, you must remove the possibility of a failure event arising in your machines and equipment.

Now that the connection between high equipment risk and low reliability is clear, we can make better operational and maintenance strategy choices.

Impact of Equipment Risk on Maintenance Strategy

Risk is reduced by minimizing the consequence of an event or by reducing the frequency of an event. Which focus you chose to take as your key operational risk management strategy will be a major factor in your future production success. Table 1 shows a range of the common maintenance and reliability strategies divided into chance reduction strategies and consequence reduction strategies.

Risk = Chance x Consequence

Chance Reduction Strategies	*Consequence Reduction Strategies*
• Engineering & Maintenance Standards • Design-Out Maintenance • Precision Maintenance • Standardized Operating Procedures • Statistical Process Control (SPC) • Failure Mode Effect Criticality Analysis (FMECA) • Reliability Growth Cause Analysis • Hazard and Operability Study (HAZOP) • Hazard Identification (HAZID) • Root Cause Failure Analysis (RCFA) • Training and Up-Skilling • Quality Management Systems • Planning and Scheduling • Continuous Improvement • Supply Chain Management • Accuracy-Controlled Enterprise 3Ts (ACE 3T) • Design and Operations Cost Totally Optimized Risk (DOCTOR) • Defect and Failure Total Costing (DaFTC) • De-Rate/Oversize Equipment • Reliability Engineering	• Preventive Maintenance • Corrective Maintenance • Predictive Maintenance • Breakdown Maintenance • Total Productive Maintenance • Non-Destructive Testing • Vibration Analysis • Oil Analysis • Thermography • Motor Current Analysis • Prognostic Analysis • Emergency Management • Computerized Maintenance Management System (CMMS) • Key Performance Indicators • Risk-Based Inspection • Operator Watch-Keeping • Value Contribution Mapping (Process Step activity based costing) • Logistics, Stores, and Warehouses • Maintenance Engineering
Done to reduce the chance of failure	**Done to reduce the cost of failure**

Table 1: Consequence and Chance Reduction Strategies

Consequence reduction strategies limit cost escalation by reacting to developing failure quickly. These strategies allow failure to start, and then you manage a problem so the least time, money, and effort is lost. They tolerate failure and loss as routine. They accept that it is only a matter of time before problems severely affect an operation.

Companies that use consequence reduction strategies minimize their losses by learning to fix problems and breakdowns fast and/or by doing lots of predictive maintenance to find embryonic failures. They hold many spare parts in store for insurance, set up a cache of parts by machines, train their repair people to fix things speedily, improve maintainability to do repairs faster, and have dedicated condition-monitoring groups looking at equipment for problems.

Minimizing risk by reducing its consequences means that you accept failure as normal. In an organization that mainly uses consequence failure management, its people wait for evidence of failures and then act. Reducing only the consequences of risk still makes work for everyone. This work never ends, because people and resources fix failures instead of removing failure causes so that there are fewer opportunities to have failures. In this way, a reactive culture is instilled in the organization.

The risk matrix of Figure 2 shows that reducing the consequences of an incident reduces risk since less money is lost—you move to the left on the matrix. That is the purpose of such things as emergency plans, fire brigades, and ambulances. If we react quickly, correctly, and early enough, the losses can be minimized.

The use of consequence reduction techniques on your equipment is an important risk control principle to contain costs, but it will not improve your reliability. Those activities that reduce failure consequence improve availability but do not improve reliability. You save some maintenance costs by preventing breakdowns, but there will be much frantic activity and "fire-fighting." For reliability improvement, you must reduce the frequency of

Probability (per Opportunity)	Sigma Level	Event Count per Year	Time Scale	Descriptor Scale	Historic Description	DAFT Cost per Event	$30	$100	$300	$1,000	$3,000	$10,000	$30,000	$100,000	$300,000	$1,000,000	$3,000,000	$10,000,000	$30,000,000	$100,000,000	$300,000,000	$1,000,000,000
							1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
		100	Twice per week			2	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11
		30	Once per fortnight			1.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5
1		10	Once per month	Certain		1	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
0.3	2	3	Once per quarter			0.5	2	2.5	3	3.5	4	4.5	5				7	7.5	8	8.5	9	9.5
0.1	3	1	Once per year	Almost Certain	Event will occur on an annual basis	0					3.5	4	4.5		5.5	6	6.5	7	7.5	8	8.5	9
0.03		0.3	Once per 3 years	Likely	Event has occurred several times or more in a lifetime career	-0.5							4		5	5.5	6	6.5	7	7.5	8	8.5
0.01	4	0.1	Once per 10 years	Possible	Event might occur once in a lifetime career	-1									4.5	5	5.5	6	6.5	7	7.5	8
0.003		0.03	Once per 30 years	Unlikely	Event does occur somewhere from time to time	-1.5									4	4.5	5	5.5	6	6.5	7	7.5
0.001		0.01	Once per 100 years	Rare	Heard of something like it occurring elsewhere	-2										4	4.5	5	5.5	6	6.5	7
0.0003		0.003	Once per 300 years			-2.5											4	4.5	5	5.5	6	6.5
0.0001	5	0.001	Once per 1,000 years	Very Rare	Never heard of this happening	-3												4	4.5	5	5.5	6
0.00003		0.0003	Once per 3,000 years			-3.5													4	4.5	5	5.5
0.00001		0.0001	Once per 10,000 years	Almost Incredible	Theoretically possible but not expected to occur	-4														4	4.5	5

Likelihood of Equipment Failure Event per Year

Consequence Reduction

Frequency Reduction (Reliability)

Risk = Consequence of Failure x [Frequency of Opportunity x (1 - Reliability)]

Note:

Risk Level
Red = Extreme
Amber = High
Yellow = Medium
Green = Low
Blue = Accepted

1) Risk Boundary 'LOW' Level is set at total of $10,000/year
2) Based on HB436:2004-Risk Management
3) Identify 'Black Swan' events as B-S (A 'Black Swan' event is one that people say 'will not happen' because it has not yet happened)
4) DAFT Cost (Defect and Failure Total Cost) is the total business-wide cost from the event

Figure 2: Impact of Consequence and Chance Risk Reduction Techniques

failure; you must remove the chance of failure happening.

The alternate equipment risk management strategy we can apply is to use chance reduction techniques. Fewer failure incidents occur because chance reduction stops failure opportunities from starting. The risk matrix shows that chance reduction strategies lead to fewer failure events; reliability improves because you reduce the frequency of failure. The number of incidents fall over time. If failures drop from once a quarter to once a year to once every two years to once every five years, you have created reliability. On the risk matrix, reliability improvement moves you down the table.

Chance reduction strategies focus on identifying potential problems and making business system changes to prevent or remove the prospect of failure. The chance reduction strategies

Both equipment risk reduction philosophies are necessary for optimal protection, but a business with a chance reduction focus will proactively prevent defects, unlike one with a consequence reduction focus that will find and fix failures early.

view failure as avoidable and preventable. These methodologies rely heavily on improving business processes rather than improving failure detection methods. They expend time, money, and effort to identify and stop problems so that the chance of failure is minimized.

The maintenance activities that pay-off the most are those that reduce frequency of a failure event. Stop an equipment risk incident from happening, and the equipment failure event cannot occur. If a maintenance activity does not reduce equipment risk, it is a waste of time, money, and effort. When you reduce failure frequency you automatically increase equipment reliability. With high reliability comes high availability, high throughput, and low maintenance costs.

You cannot expect to move more than a cell to the left on the risk matrix by using consequence reduction strategies. Your costs might halve, or even drop to a quarter, if you get good at spotting and managing impending failures, but when using frequency reduction strategies, you can easily move down many cells, bringing you a reduction in risk of up to hundreds of times. Consequence reduction strategies cannot achieve that amount of improvement. The use of chance reduction techniques should be your prime means of equipment risk control because they will give you both large maintenance cost reductions and far higher equipment reliability.

Both equipment risk reduction philosophies are necessary for optimal protection, but a business with a chance reduction focus will proactively prevent defects, unlike one with a consequence reduction focus that will find and fix failures early. Those organizations that primarily apply chance reduction strategies have truly set up their business to ensure decreasing numbers of failures, as a consequence they get outstanding equipment reliability and reap all the wonderful business performance that world-class reliability brings.

It is in your organization's best interest, and it will generate the most profit consistently for the least amount of work, to focus strongly on the use of chance reduction strategies. Consequence reduction strategies are still important and necessary—once a failure sequence has initiated, you must find it quickly, address it, and minimize its effects so you lose the least amount of money. But consequence reduction will not take your organization to world-class success and profit, because it expends resources. Only chance reduction strategies reduce the need for resources, because they proactively eliminate failure incidents through defect elimination and failure prevention that removes the opportunity for failures to start.

Mike Sondalini has been in engineering and maintenance since 1974. Mike's career extends across original equipment manufacturing, beverage production, steel fabrication, industrial chemical manufacturing, quality management, project management, industrial asset management, and industrial training. His specialty is helping capital equipment-intensive companies build sound business risk management practices, introduce world-class lean practices, develop ultra-high reliable enterprise asset management systems, and instill the precision maintenance skills needed to continually improve plant uptime. www.lifetime-reliability.com

The NFPA and Its Effect on Infrared Thermography and Your Infrared Electrical Inspection Program

Wayne Ruddock

The National Fire Protection Association (NFPA) was established in 1896 by a concerned group of individuals from various insurance agencies, in response to the extensive cost and great number of losses due to fires in that era.

Figure 1 (left) - Old-style, liquid nitrogen-cooled, two-piece infrared camera system that weighed in excess of 60 pounds.

Figure 2 (bottom)- Today's new compact infrared camera.

One of the main causes of industrial fires and losses, as well personal injury accidents, over the last five decades is related to electricity. This has caused the NFPA to increase its number of electrically related documents. The first electrically related document published was NFPA 70, which was published in 1987. It has been updated every 3-5 years since then. This document is also known as the National Electric Code (NEC). The NEC is approved as an American national standard by the American National Standards Institute (ANSI). It is formally identified as ANSI/NFPA 70. This document is the accepted standard for the installation of all electrical wiring and electrical equipment. It details the requirements for safe electrical installations into a single, standardized source. The 2011 NEC is the current edition (effective date August 25, 2010).

The two NFPA documents that have changed the face of infrared thermography over the last few decades are NFPA 70B and NFPA 70E. 70B is the Recommended Practice for Electrical Equipment Maintenance, while 70E is the standard that covers electrical safety in the workplace.

There is no other organization in the world that has had a greater impact on infrared thermography over the last 25 years than the NFPA with the production of these two documents.

Concerning electrical maintenance, an excerpt from the document 70B declares, "a well-administered Electrical Preventative Maintenance program will reduce accidents, save lives, and minimize costly breakdowns and unplanned shutdowns of production equipment." It further recommends that "routine infrared inspections of energized electrical systems should be performed annually prior to shutdown. More frequent infrared inspections, for example, quarterly or semi-annually, should be performed where warranted by loss experience, installation of new electrical equipment, or changes in environmental, operational, or load conditions."

Although NFPA has no regulatory power, these recommendations were given teeth when they were adopted as a standard by the Occupational Health and Safety Administration (OSHA). OSHA is the main US government agency charged with the enforcement of safety and health legislation in American industry. OSHA has the power and the authority to levy heavy fines on those who do not conform to their adopted or authored standards.

OSHA's adoption of these NFPA recommendations produced a great demand for infrared cameras in the US. Demand increased abroad as well, as many countries looked to the NFPA standards and adopted some form of them into their own regulations. Thus, there was also a proliferation of infrared camera manufacturers. Companies such as Fluke, known throughout the country for their dependable industrial metering instruments, entered the infrared camera market by buying small existing companies and growing into a major supplier of a number of infrared camera models. Flir and Fluke seem to be the major players in the North American market, with a dozen or so other companies also involved in supplying systems. This increase in sales quantities, coupled with new detector technology, has caused the price of an infrared camera to plunge from $70,000 in the 1980s to under $2,000 today. The rather heavy bulky systems have been transformed into lightweight, small, and handheld instruments that can be taken easily into any industrial situation.

Figure 3 (left) and Figure 4 (below) - Infrared semi-transparent windows for installation in electrical cabinets. They come in many shapes and sizes.

If you are performing infrared electrical inspections, and you are not following these OSHA adopted standards, you need to familiarize yourself with them and comply.

Figure 1 is an old-style, liquid nitrogen-cooled, two-piece infrared camera system that weighed in excess of 60 pounds. There was no digital technology available in that camera's era, and the image was captured on black-and-white Polaroid film directly from the display. The lack of computer technology also meant that all temperature calculations had to be determined with pencil, paper, and printed calibration curves. The liquid nitrogen had to be replenished every 1.5 hours in order to keep a grey tone image displayed on the screen.

In contrast, Figure 2 is an example of the compactness of today's new cameras. This particular system has the look and feel of a common digital camera, complete with on-screen temperature calculations and color images. It also has the capability of capturing corresponding visible light images, as well as an infrared image in a number of different color pallets.

It must be noted here that although these inexpensive new cameras are lightweight and compact and are advertised to have many functions, they are not always suited to all applications, due to their small detector size and inability to calculate the accurate temperature or temperature difference of many conductors at safe working distances.

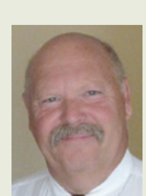
(For more information on how to choose the right infrared camera for your application, please refer to the Aug/Sept 2010 issue of *Uptime Magazine*.)

NFPA 70E, the standard for electrical safety, was first released in 1979, with its greatest impact taking place with the 2000 edition, which defined levels of Personal Protective Equipment (PPE) that must be worn when working within certain distances from live equipment. NFPA Table 130.2 defines the safe working distances from live moveable and stationary equipment. As an example, for energized equipment with moveable parts, you must be at least 10 feet from any energized component with a voltage between 50 – 300 volts. If you are any closer, you are within the arc flash protection boundary, and you must wear extensive PPE, even if you are only performing an infrared thermography inspection. This PPE includes "arc-rated FR shirt & pants or FR coveralls, **and** arc flash suit selected so that the system arc rating meets the required minimum." It also includes a dual-layer glove that when wearing, you cannot operate most of the compact new cameras.

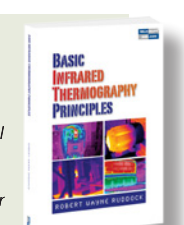
If you are performing infrared electrical inspections, and you are not following these OSHA adopted standards, you need to familiarize yourself with them and comply. Not only is your company liable for large fines, but the individual technician is also in danger of being fined for violation of these regulations.

This monumental change in the way infrared electrical inspections are performed has spawned a totally new infrared-related industry. There are now a number of companies manufacturing and distributing infrared semi-transparent windows for installation in electrical cabinets. They come in many shapes and sizes, as can be seen in Figures 3 and 4.

With these windows in place, no special PPE is required, because as the cabinets do not need to be opened, the technician is not exposed to live circuits. Placed in the proper location, electrical components can be inspected in the "energized" condition as prescribed in NFPA 70E with a 0 hazard risk factor. Both NFPA 70B and NFPA 70E are available on the internet and can be downloaded. If you have difficulty with these regulations and what they mean to your location, there are a number of companies that can be contracted to assist you in implementing these standards, as well as in the placement and installation of infrared windows. This includes most of the window manufacturers themselves.



Wayne Ruddock has been involved in Infrared Thermography and Infrared Thermographic Training since 1979. He is a seasoned veteran of hands-on infrared inspections, giving him the ability to teach real-life thermography. He has been conducting Level 1 and Level 2 training courses throughout the world since 1980. He has written and presented many thermographic papers at conferences over the last 30 years, and he is the author of Basic Infrared Thermography Principles*, available at www.mro-zone.com.*



precision maintenance

Lu lubrication

Understanding Lubrication Failures

Jarrod Potteiger

Fail•ure 1 a:
An omission of occurrence or performance: A failing to perform a duty or expected action b: A state of inability to perform a normal function

As a consultant in the field of lubrication, I've had discussions with hundreds if not thousands of maintenance professionals about the type and frequencies of the lubrication-related failures they experience. A disturbingly large percentage of the time I am told that they don't really experience many lubrication-related failures. This response always prompts another question: What is a lubrication-related failure? To those who think they have none or few, a lubrication-related failure is usually defined as one that occurs when a machine has no oil in it or someone puts the wrong oil in it. I would suggest that most manufacturers experience many lubrication-related failures and merely misclassify them. In fact, many failures are not even recorded as such because the problems were diagnosed and repaired before the machine ceased to function. In my opinion, any time a machine or component does not achieve maximum service life, a failure has occurred.

Consider the following example: A man buys a new car and drives it for a year without any problems. Then, after only 10,000 miles, the engine begins making an unusual sound. The man drives the car to the dealer for an inspection, and the mechanic informs him that the engine is irreparably damaged and he must replace the engine or buy a new car. Did the car fail? It could be argued that because the car was still functioning that it didn't fail. On the other hand, the engine is being replaced after only 5 to 10% of its expected service life.

According to an industry expert, as few as 10% of bearings ever reach their L_{10} life before failing or being replaced. By definition, 90% of bearings should reach this value, so what happened to the other 80%? Whether they ceased to function, or were replaced due to an identified defect, I would argue that they failed because they didn't reach their anticipated service life. I was recently in a paper mill that had an excellent vibration program that has, in recent years, been able to identify 100% of their paper machine bearing defects before they failed. When asked about the number of bearing failures they had in the past year, they replied "none," yet they had replaced 15. One of them had only been in service for 12 months.

To understand why so many failures are in fact related to lubrication, or more accurately, poor lubrication, one must look at typical root causes of failure. In an MIT study on "loss of usefulness" in machinery, it was determined that 50% of lost machine life was caused by mechanical wear, and an additional 20% was lost due to corrosion of machine surfaces. The mitigation of mechanical wear and corrosion are two of the primary functions of a lubricant. (Figures 1 and 2)

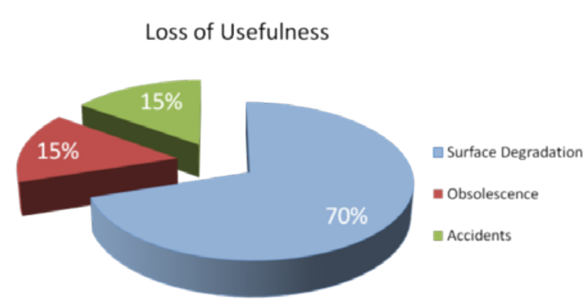


Figure 1

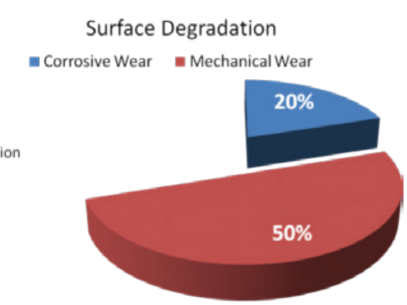


Figure 2

For those readers that still don't believe they experience lubrication-related failures, I would recommend that you take a critical look at the mean time between failures (or replacements) for common lubricated components and determine if you are truly getting the maximum life from these assets.

A more narrowly focused study was performed at the National Research Council of Canada in conjunction with the Society of Tribologists and Lubrication Engineers to determine the predominant wear mechanisms in wear-related failures of lubricated machinery. The study examined 3,722 failures across several industries, including pulp and paper, mining, forestry, transportation, and power generation. The results of this study indicate that the number-one cause of machine wear is lubricant contamination. (Figure 3)

Abrasion, erosion, and fatigue are most often caused by particle contamination in the lubricant. Adhesion is typically caused by using a lubricant with inadequate film strength. Furthermore, all of these wear mechanisms are exacerbated by the presence of water contamination in a lubricant. The point of all this is that most failures in lubricated equipment, whether catastrophic and sudden or just premature replacements, are caused by particle contamination, moisture contamination, or using a lubricant that is either incorrect for the application or has degraded beyond the point of being suitable for use. The good news is that all of these conditions can be prevented or at least controlled with precision lubrication.

Unfortunately, most maintenance professionals don't fully understand the very significant effects of lubrication on component life. Once you realize that only 1000ppm of water in the oil can reduce bearing life by 75%, or that increasing fluid cleanliness by one ISO code can extend the life of hydraulic components by 50%, it becomes apparent that much equipment life is wasted due to improper lubrication practices. Precision lubrication doesn't mean using more expensive lubricants or lubricating machines more frequently. It involves selecting the right type of lubricant for each application, identifying the correct application method, using the optimum PM frequency, and controlling the condition of the lubricant by keeping it clean, cool, and suitably free of moisture.

For those readers that still don't believe they experience lubrication-related failures, I would recommend that you take a critical look at the mean time between failures (or replacements) for common lubricated components and determine if you are truly getting the maximum life from these assets. Chances are that if you haven't put a lot of effort into developing a proper lubrication and contamination control program, you're probably not. Developing a precision lubrication program is a large undertaking, but it is totally worthwhile. Begin by ensuring that you have the proper lubricants specified for each application, and then establish cleanliness and dryness targets for each class of machines. Identify the necessary steps to reach these targets, implement them, and then measure the results. Remember, just because it didn't break, doesn't mean it didn't fail.

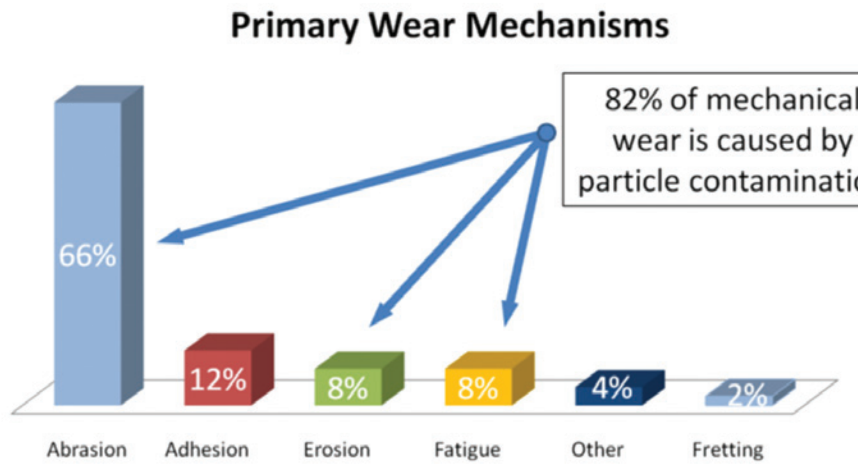


Figure 3

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MRO INVENTORY

The Expert's Monument to Failure

Rich MacInnes

Have the experts failed us? Lean experts teach us to "see" the hidden factory and all its "waste," so why can't we see the mountains of MRO materials? And while Six Sigma efforts focus on vendor lead times or improved fill rates, why do few Black Belts apply the correct statistical analysis for determining stocking parameters?

Sadly, reliability engineering efforts to predict failure and develop risk management plans have failed to stop excess investments in MRO stock.

You Are What You Think You Are Going to Eat!

Applying the adage, "you are what you eat" to MRO material stock, we get "you are what you think you are going to eat!" So what does MRO material stock tell us about the implied reliability, durability, and maintainability of physical assets? Based on the following cross-industry MRO material stats, it's a miracle we can produce anything!

- Non-moving MRO inventory typically **grows** at an annual rate of **6.7%.**
- Nearly **68%** of all SKUs purchased on an annual basis will never be used.
- On average, **58%** of MRO inventory investment does not move in any three-year period.
- Only **6%** of parts account for **90%** of the MRO inventory expenditures on an annualized basis.
- On average, only **17%** of new MRO items added to inventory will be used within the first month, with the second use nearly **8** months later.
- For initial MRO inventory orders **> 2**, on average **69%** are not issued within the first **3** years.

Stop the Expert Insanity!

If the truth be told, I have spent most of my professional career operating in the weeds and not seeing the entire landscape. I thought my purpose was to solve problems, but I was unwittingly perpetuating them. I was a roofer, wearing spiked shoes. Why? Because I didn't understand the ultimate "future perfect" objectives of production and asset management systems. Nor did I truly grasp how asset management systems operate. And I certainly did not understand how to construct and model system capabilities (flow charts and value stream maps just aren't sufficient). So experts, listen up: this advice is worth its weight in gold, which is valued currently at $1,531.29 per ounce!

Imagine Perfection, Then Pursue It!

Future perfect objectives are used to ensure directional correctness. A perfect asset is one that never fails and has zero total ownership cost over its useful life. Impossible you say? Certainly, but all asset investment decisions should be *measured twice and cut once* against this standard.

Ideally the perfect asset would be self-powering, self-scheduling, self-monitoring, self-diagnosing, self-prognosticating, self-adjusting, self-improving, self-repairing, and self-decaying to its essential elements at the end of its useful life. No such system exists, one might contend. I suggest studying the human body, or for that matter a gecko.

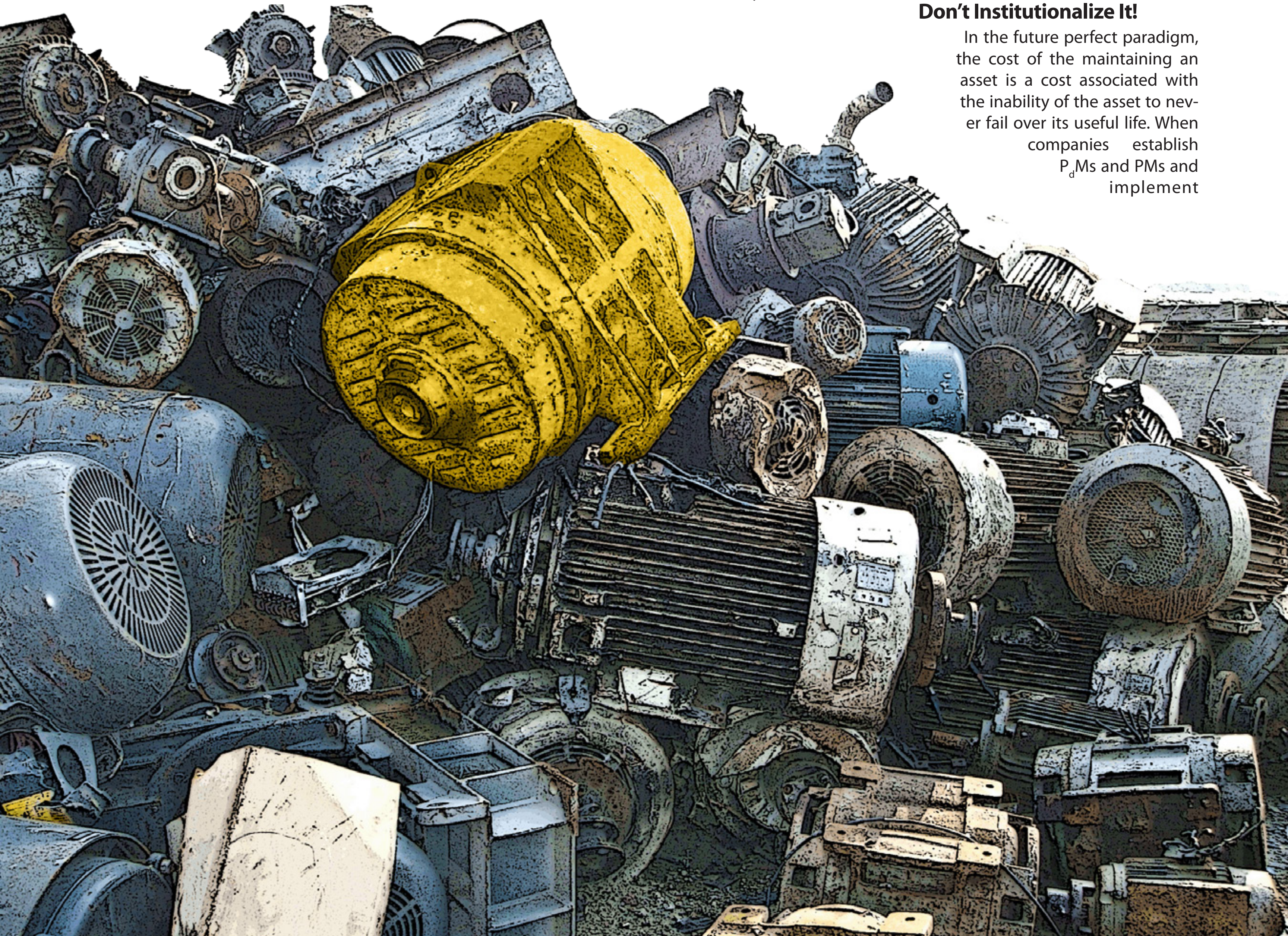
Think of your physical assets in this "future perfect" paradigm. Most things don't fail over their useful life, or else you would be afraid to drive your car, or sleep in your own home. Begin by defining the useful life of the asset–normally equal to the life of the product it produces or the service/operations it enables. Use sound methods to estimate first likelihood of failure and then criticality. A toilet is critical, but do you carry a spare?

Develop a complete profile of the nature and costs of asset demands over its useful life. If you don't like the resultant asset demand profile, then I suggest you change the way work is done or how the asset is designed, or look for alternative solutions. Understand that when an asset requires a maintenance technician to conduct weekly PMs, perform predictive maintenance analysis, or replace components on schedule or cycles, this is a real cost to the organization. For example, would you have purchased a refrigerator if it required that you to pay the reseller a weekly fee to inspect it and arbitrarily charge for parts and labor deemed necessary to keep it running? What does this service requirement imply about the refrigerator's reliability, durability, or maintainability?

To the bigger point, what if the reseller expands its services and sends a technician to your house every day for 8 hours, looking for everything that could possibly go wrong, changing your furnace filter, adding oil to your lawnmower, attending to those things that do go wrong, and replacing worn out parts before they fail. And as the home owner, it is your responsibility to stock all the possible parts and pieces that may be needed at your house, even though the reseller's stock of parts is nearby. Are you willing to pay them? Are you willing to invest in the parts, storage space, and an inventory/procurement system? After all, this investment is necessary for managing risk, maintaining the performance of your assets, eliminating unplanned failures, and preventing accelerated deterioration. You certainly don't want *risk* your house collapsing on your family.

Eliminate Failure, Don't Institutionalize It!

In the future perfect paradigm, the cost of the maintaining an asset is a cost associated with the inability of the asset to never fail over its useful life. When companies establish P_dMs and PMs and implement



planned component replacement (lifecycle maintenance), they unwittingly institutionalize failure. They see all of these proactive activities and investment in labor, tools, and materials as a good business practice, albeit a necessary evil of owning assets, where over time the "evil" descriptor disappears. Most component OEMs rightfully profess that they are improving the reliability and durability of their products. After all, warranty has a real cost, not to mention the negative impact of failure on both brand reputation and future revenues, yet end-users still overinvest in parts and labor as if nothing has changed.

One can argue I am not living in the real world. I suggest that few experts accept the real-world reality that asset components wear out and fail on their schedule, not yours. The reason maintenance is predominantly in the fire-fighting mode is because businesses must attend to real and often unpredictable "asset" demands, just like an Emergency Department in a hospital. Organizations don't like the notion of fire-fighting, so they tend to force failure or heighten the urgency of deterioration to fit into defined activities that can be planned for, queued, resourced, scheduled, level-loaded, EOQ'd, and so on. The goal: a nice, neat, and predictable model that can be budgeted a full year in advance!

Where we lack real failure data to understand and predict demand, we create it in wonderful Monte Carlo simulations, well-intentioned Weibull analyses, and standardized MTBFs. In the end, what does the magic of statistical modeling tells us? Run for the hills?

Where we lack real failure data to understand and predict demand, we create it in wonderful Monte Carlo simulations, well-intentioned Weibull analyses, and standardized MTBFs. In the end, what does the magic of statistical modeling tells us? Run for the hills?

Understand Reality, Accept Reality, Improve Reality!

I get that all of us might want to say "look Mom I did well; I kept everyone productive, and it was a good investment." But in the lean Six Sigma paradigm applied to asset management, in order to optimize supply (e.g., resources that respond to asset demands) and to meet budget objectives, "failure has to be more reliable than the asset!" We should simply recognize that in reality failure is not reliable, nor should it be, nor should we force it to be so! Stuff happens—it is just the way life is.

We need lean systems that improve our ability to predict actual bad "stuff" before it happens (they exist) and more efficient systems for queuing "stuff" based on its occurrence or the high probability thereof and its consequence, within the constraints organizational resources and the attendant supply chain. Lean thinking requires one to mentally reclassify "fire-fighting" to "short demand lead-time," and then to build lean supply chains that understand the time value of lettuce, not processed cheese.

Unfortunately, we pay huge sums of money for systems like ERP, EAM, and CMMS, yet they do little to help queue work based on real priorities. This leaves the maintenance supervisor to use a white board to list the day's work, or hand out a batch of work orders for that day/week, or produce an Excel spreadsheet that is updated daily if not more, based on events as they occur and resources as they become available.

Constraining Supply Does Not Eliminate Demand!

The only "real" way to make tangible improvements in asset management investments is to eliminate or lessen asset operating demands; then supply will follow. It is nonsensical to constrain supply thinking that it reduces "real" demand created by "real" assets. Constraining supply (i.e. how many parts we keep on the shelf, how many electricians we employ, or the number of PMs we conduct) may indeed reduce "artificial" supply demand created under the guise of being productive and economically efficient, but it does not eliminate "real" asset demand. The proof is found in the unaccounted-for back stock scattered throughout the plant, or the cannibalized equipment lying in bone yards.

So what is the success rate of the experts getting it right? 2007 estimates of U.S. industry purchases suggest that in excess of $136 billion in MRO material stock still sits in end-user operations. Are you getting this? That is $136 BILLION that could have been put to better use—"opportunity cost" for the financial experts trying to solve this conundrum. In my world, the experts have failed those they serve, and unfortunately I have the stats to prove it. I suspect you do, too.

Rich MacInnes is the Director of Professional Services for Net Results Group. Rich is the principle author of the book Strategic MRO, A Roadmap for Transforming Assets into Strategic Advantage. *Rich also has authored* The Lean Enterprise Memory Jogger for Production *and* The Lean Enterprise Memory Jogger for Service, *foundational books used to advance lean methodologies and decision making within organizations. www.netresultsgroup.com*

management

Mm maintenance management

The Next-Generation Maintenance Manager (NGMM)

John Reeve

As an Enterprise Asset Management (EAM) consultant visiting multiple industries over the years, I've noticed a new generation entering the maintenance work force. They work primarily in the maintenance organization from trades to maintenance manager, are mostly younger professionals, and are very comfortable with computers.

But, whether younger or older, they see the value of corporate systems as a means to retrieve data to help them do their jobs and stay competitive. They recognize that almost every job in today's market involves some form of computerization, and they have embraced technology. They even welcome change. The maintenance manager who is part of this new generation is what I call the **Next-Generation Maintenance Manager** (NGMM).

The NGMM understands the importance of accurate data and how the right processes and procedures facilitate better decisions. The NGMM relies on these core systems to help improve response time for when unexpected events do occur. In addition, this individual understands the importance of EAM **advanced processes,** which are critical to efficiency, performance, and cost optimization. Advanced processes, for example, include failure analysis, resource-leveled weekly scheduling, and project cost tracking. For some industries there is also a strong focus on shutdown/outage/turnaround management.

The NGMM wants to have **significant design input** relating to work processes and asset management during the EAM implementation. Implementation of an EAM system requires a strong maintenance/engineering background, plus plant and system knowledge. The NGMM is an active participant in core team training as well as developmental workshops. Key setup areas include location/asset hierarchy, preventive maintenance strategies, materials management, and key performance indicators. Other key decisions include work order priority, work type values, and job status synonyms. The NGMM wants to create a comprehensive model that supports all corporate goals.

The Next Generation Maintenance Manager pays particular attention to organizational roles supporting the EAM system. The database is only as good as the data, which means there must be clear roles and responsibilities.

The NGMM pays particular attention to **organizational roles** supporting the EAM system. The database is only as good as the data, which means there must be clear roles and responsibilities. To support these objectives, the NGMM:

- Helps **build relationships** with all stakeholders as well as with customers, encouraging close interaction between operations, warehouse, and engineering.
- Gains strong "**buy-in**" from working-level personnel. The NGMM may conduct **periodic surveys** with end-users to ascertain process or procedure problems. This proactive dialog helps create solid lines of communication.
- **Welcomes change.** The NGMM encourages staff to accept change as part of the global market place in which every maintenance organization must be prepared to make decisions quickly. Causes of change may include: aging plant, new technology, organizational change, business change, evolving best practices, or retiring staff.
- Recommends establishment of a **reliability team** to regularly review data to identify worst-offenders, suggest corrective action, and build improvement strategies. The reliability team is also involved with root cause analysis, as well as work order feedback, plus business rule creation. The NGMM

provides guidance to the maintenance/reliability team as needed.

- Hires staff having **similar qualities** and desires for excellence (i.e. keyboard-friendly as well as able to turn a wrench).

The NGMM wants to create a **true knowledge base** within the EAM system. If the data is not accurate, advanced processes will not be possible. The following list demonstrates the NGMM's involvement and oversight:

- Understanding EAM **technology,** its benefits, and power of configuration, as well as **advanced EAM processes** where the largest ROI exists. Further, the NGMM designs the **end game** and then "connects the dots," linking input to output.
- Finding ways to **store knowledge** so information is retained. Seasoned workers have a lot of knowledge. The NGMM looks to institutionalize undocumented procedures, tribal knowledge, and isolated instructions. It is important to capture this knowledge and not let it "walk out the door" at retirement.
- Knowing "ease of use" considerations. This might include setting up mobile solutions, or it may involve single point of entry (as achieved through integration or database consolidation).
- Requiring an **accurate maintenance backlog** to automate a **weekly schedule** process. This update includes accurate job statusing and timely actual labor reporting. The NGMM tracks workforce delays by using **delay codes** at time of labor reporting. The use of this information will help the NGMM manage by exception by identifying bottlenecks and communication problems.
- Promoting a **work order feedback process** that includes asset condition rating, PM task and frequency validity, safety considerations, design change suggestions, and maintainability issues. This type of feedback is instrumental to reliability-centered maintenance.

The NGMM strongly believes in **standardized procedures** (which help support normalized comparisons) and appreciates the value of **software, process, and organization,** as all three are needed to make the complete system. The NGMM:

- **Creates a failure analysis process** that leverages drill-down techniques. Next, the NGMM looks for problem areas and creates strategies for improving the worst systems. The NGMM can also track recurring problems, Pareto-style.
- Creates **standardized EAM procedures**, starting with the business rules**.** These

documents help clarify the input/output actions and responsibilities associated with staff who are required to interact with the EAM system.

- Knows that clear business rules also help promote accurate KPIs. The NGMM recognizes that KPI measurements are only as good as the data in the EAM system and therein applies a regimen of EAM database **error checks.**

The NGMM engages in several methods of cost management. These include:

- Utilizing the **EAM system** to **track outage scope** and cost data, making use of a scope freeze date.
- Tracking maintenance **budgets**.
- Managing **large project** costs.
- Enhancing capital project management.
- Tracking "**cost of lost opportunities**" (e.g., rework, delay codes, warranty work, injuries, poor planning, and lack of schedule).
- Requiring staff to document **pre-built repair/replace criteria** based on asset classification to help expedite the decision-making process by management.

The NGMM has a long-range management point it is even more difficult to implement.) The NGMM's long-range management plan includes:

- Identifying strategic goals and hierarchical KPIs. The NGMM defines the end game and then builds a roadmap to reach each of these goals, conducting periodic refresher **training** on this **end game**.
- Frequently seeking advice where needed, performing occasional **benchmarking**.
- Challenging the staff to do more with less and finding clever solutions, as well as creating **stretch goals**.
- Being cautious to prevent the IT department from getting caught up in software add-ons that do not support the long-range goals or advanced processes.

Advanced Processes – In Detail

The NGMM applies advanced processes to support the ideal model for asset performance management. Advanced processes are complex due to the large number of pre-requisites, but once understood, provide the largest potential return on investment. Unfortunately, 90 percent of all sites never achieve these results (as shown below).

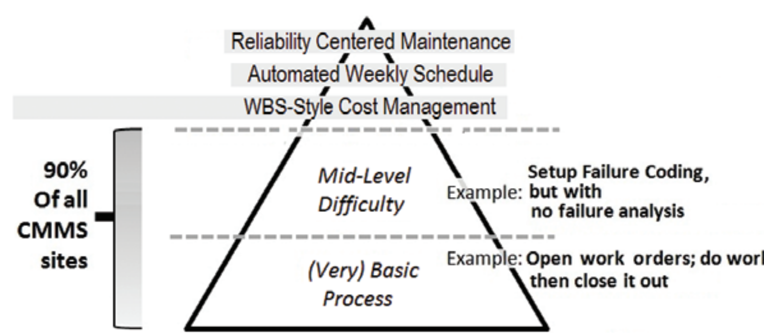


Figure 1

plan that leverages continuous improvement and encourages business process re-engineering **every 5 years.** This individual understands that most sites underutilize their EAM system. (There are several reasons for this, but normally the implementation project did not allow time for adequate process review and re-engineering. Quite often the implementation team will delay these actions until post go-live, at which

Maintenance Management Program – Ideal Model

The graphic below shows inputs from failure analysis and work order feedback (on the left) and BPI/BPR reviews (on the right). The combination of these inputs helps reduce reactive maintenance. By creating a true knowledge base, management can make better financial decisions.

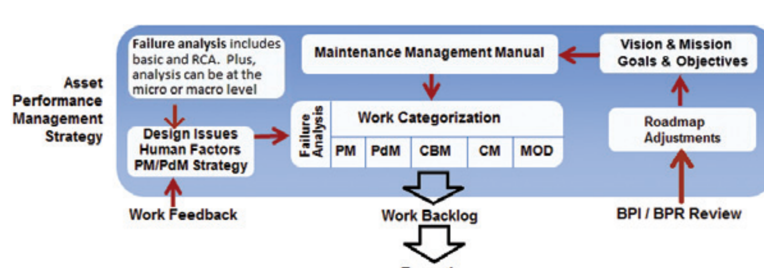


Figure 2

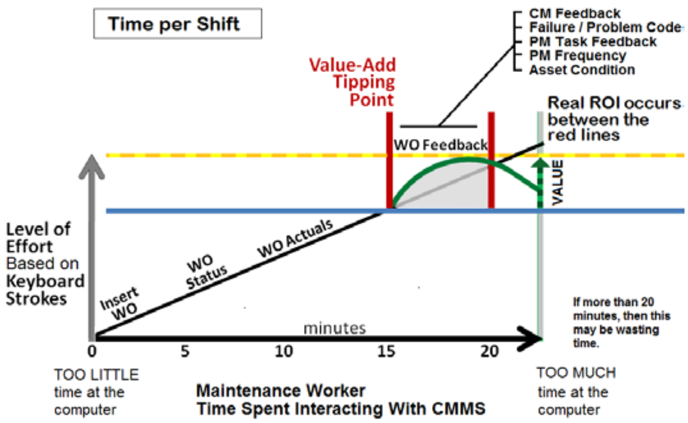


Figure 3

Amount of Worker Time to Update the EAM System

If the working level complains about the time it takes to update the EAM system, the NGMM will explain the importance of this feedback and demonstrate the usefulness of this data. The NGMM also needs to be sure the staff is not putting up false barriers. Figure 3 shows where work status and labor actuals are typically captured. Real ROI occurs with proper work order feedback that can be reviewed, evaluated, and trended.

Manage Assets, Not Workers

The NGMM does not need an EAM system to assess *employee* performance, but he or she does need it to identify *asset* performance. A proactive organization encourages input from all levels by letting workers see and understand the roadmap. The NGMM listens to concerns, as well as ideas for improvement, and then links problems to solutions. Workers expect their feedback and recommendations to be closely reviewed and acted upon. Disengagement, once it occurs, is hard to recover from. In the end, it is the overall philosophy, not the technology, that will define the long-term success of an asset performance system.

Summary

This is a new way of thinking about EAM system implementation. All aspects of the maintenance program should be working in concert to help achieve operational excellence. An effective maintenance management program should improve equipment performance, improve reliability/availability, increase worker productivity, and reduce costs. The Next-Generation Maintenance Manager is that strong leader, who by being involved and welcoming technology, helps provide a sound vision and roadmap for the future.

For the past 25 years John Reeve has travelled the world supporting CMMS/EAM clients in a wide variety of industries. Over that period, Mr. Reeve's primary focus has been asset, work and supply chain business transformation, and advanced process implementations. As a Manager and Senior Consultant for Cohesive Information Solutions, Inc., John serves as the practice leader for maintenance & reliability solutions. www.cohesivesolutions.com

condition monitoring

Oa oil analysis

A New Era

Wear Particle Analysis/ Ferrography

Raymond J. Dalley

Wear particle analysis, or ferrography, is a technique that is growing everyday. With industrial needs for reliability and higher productivity to compete in the world market, techniques such as wear particle analysis become vital in making diagnostic and specific recommendations regarding potential machine problems.

Having wear particles provide evidence of machine problems depends on the industrial application from a clean environment to a dirty one. However, showing photographic proof and describing the surface texture, size, shape, and morphology of the particles gives us evidence that something is potentially wrong with the machine prior to major damage. This article will describe improved ferrographic instrument design utilizing the new ASTM Standard description for wear particles. Additionally, we will review the basic operating process for utilizing ferrography to pinpoint any machine condition issues.

Ferrography has been recently enhanced to lessen the subjectivity and expense of diagnosing machine problems. Using a new magnet design and standardizing the wear particle description, ferrography has taken another step forward to pointing out the machine faults.

Three of the major types of equipment used in wear particle analysis are the Direct-Reading (DR) Ferrograph, the Analytical Ferrograph (FM Ferrograph) used to make the ferrograms, and the Ferroscope used to examine the ferrograms optically. Current redesign of the magnet has significantly changed the instruments' configuration in both size and shape and most significantly in wear particle capture efficiency.

Quantitative Measurements Using the DR-6 Ferrograph

The DR Ferrograph Monitor is a trending tool that permits condition monitoring through examination of fluid samples on a scheduled periodic basis. A compact, portable instrument that is easily operated even by non-technical personnel, the DR Ferrograph quantitatively measures the concentration of ferrous wear particles in lubricating or hydraulic oil. The DR Ferrograph separates out particles having positive magnetic susceptibility by means of a high-gradient magnetic field. Magnetic separation is nearly 100% effective for ferromagnetic particles larger than 0.1 micrometers due to the new neodymium magnet design (see Figure 1), which enables us to reduce instrument size and weight and increase the wear particle deposition efficiency.

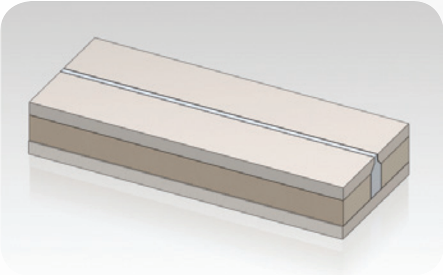


Figure 1: Neodymium magnet design

The DR Ferrograph senses wear particles at two locations. First, at the entrance deposit, usually referred to as "DL," and the second, about five millimeters downstream, usually referred to as "DS." The DR Ferrograph senses the presence of particles by measuring the amount of light attenuated at the two deposition locations. The ferromagnetic separation technique causes all ferrous debris larger than 5 micrometers to deposit a few millimeters after entering the magnetic field. Consequently, the "entrance deposit" contains all the larger particles and a representative portion of the smaller particles. No ferromagnetic particles larger than a few micrometers penetrate further than a few millimeters downstream from the entrance deposit. Particle size becomes progressively smaller along the deposition path.

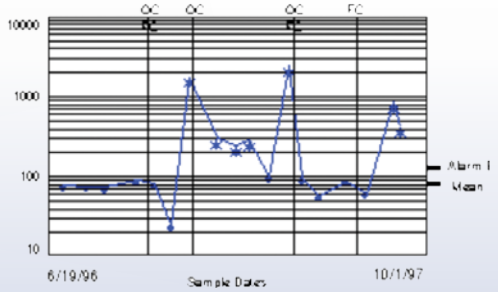


Figure 2: Wear particle trend

Wear Particle Concentration (WPC) is the sum of DL+DS divided by sample size (volume). In most cases, the sample volume is one milliliter, so WPC is simply DL+DS. Percent Large Particles (PLP) is calculated as follows:

Figure 3: DR-6 Ferrograph

Machines starting service go through a wearing-in process, during which the quantity of large particles quickly increases and then settles to an equilibrium concentration during normal running conditions. A key aspect of ferrography is that machines wearing abnormally will produce unusually large amounts of wear particles, indicating excessive wear condition by the DR Ferrograph in WPC readings. If WPC readings are beyond the normal trend, a ferrogram sample slide is made with the fluid for examination by optical microscopy.

The Analytical Ferrograph FM-6 Ferrogram Maker: Additional information about a wear sample can be obtained with the FM-6 instrument, which can provide a permanent record of the sample, as well as analytical information for viewing. The FM-6 is used to prepare a ferrogram, which is a fixed slide of wear particles for microscopic examination and photographic documentation. The ferrogram is an important predictive tool, since it provides an identification of the characteristic wear pattern of specific pieces of equipment. After the particles have deposited on the ferrogram, a wash is used to flush away the oil or water-based lubricant. After the wash fluid evaporates, the wear particles remain permanently attached to the glass substrate and are ready for microscopic examination using the ferroscope.

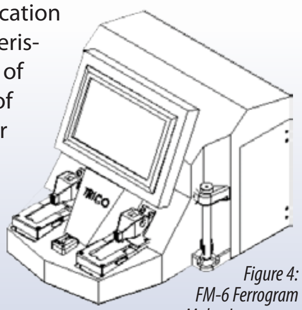


Figure 4: FM-6 Ferrogram Maker Instrument

The Microscope: Ferrograms are typically examined under a microscope that combines the features of a biological and metallurgical microscope. Such equipment utilizes both reflected and transmitted light sources, which may be used simultaneously. Green, red, and polarized filters are also used to distinguish the size, composition, shape, and texture of both metallic and non-metallic particles. A new feature of the ferroscope is the ability to measure particles within the imagery software and provide a split-screen image to compare before and after photomicrographs once the ferrogram is heat treated.

Figure 4 : Mircroscopes

Types of Wear Particles: Recently the ASTM organization standardized the naming description for all wear particles in ferrography, patch testing, and any other media. The standard is ASTM D7690. The wear particle descriptions are as follows:

1. **Rubbing Wear Particles**: Normal-rubbing wear particles are generated as the result of normal sliding wear in a machine and result from exfoliation of parts of the shear mixed layer. Rubbing wear particles consist of flat platelets, generally 5 microns or smaller, although they may range up to 15 microns, depending on equipment application. There should be little or no visible texturing of the surface, and the thickness should be one micron or less.
2. **Abrasive Wear Particles**: Abrasive wear particles are generated as a result of one surface penetrating another. There are two ways of generating this effect.
   - A relatively hard component can become misaligned or fractured, resulting in a hard sharp edge penetrating a softer surface. Particles generated this way are

generally coarse and large, averaging 2 to 5 microns in width and 25 microns to 100 microns in length.

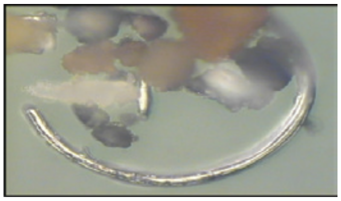


Figure 5: Abrasive wear

- Hard abrasive particles in the lubrication system, either as contaminants such as sand or wear debris from another part of the system, may become embedded in a soft wear surface (two-body abrasion), such as a lead/tin alloy bearing. The abrasive particles protrude from the soft surface and penetrate the opposing wear surface. The maximum size of cutting wear particles generated in this way is proportional to the size of the abrasive particles in the lubricant. Very fine wire-like particles can be generated with thickness as low as .25 microns. Occasionally small particles, about 5 microns long by 25 microns thick, may be generated due to the presence of hard inclusions in one of the wearing surfaces. Abrasive wear particles are abnormal. Their presence and quantity should be carefully monitored. If the majority of abrasive wear particles in a system are a few micrometers long and a fraction of a micrometer wide, the presence of particulate contaminants should be suspected. If a system shows increased quantities of large (50 micrometers long) abrasive wear particles, a component failure is potentially imminent.

3. **Spherical Particles**: These particles are generated in the bearing cracks. If generated, their presence gives an earlier warning of impending trouble, as they are detectable before any actual spalling occurs. Rolling bearing fatigue is not the only source of spherical metallic particles. They are known to be generated also by cavitation erosion and, more importantly, by welding or grinding processes. Spheres produced in fatigue cracks may be differentiated from those produced by other mechanisms through their size distribution. Rolling fatigue generates few spheres over 5 microns in diameter, while the spheres generated by welding, grinding, and erosion are frequently over 10 microns in diameter.

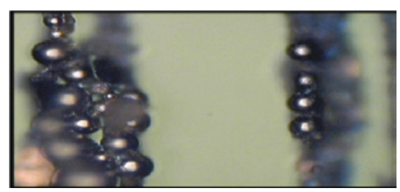


Figure 6: Spheres

4. **Severe Sliding Wear Particles**: Severe sliding wear particles are identified by parallel striations on their surfaces. They are generally larger than 15 microns, with the length-to-with thickness ratio falling between 5 and 30 microns. Severe sliding wear particles sometimes show evidence of temper colors, which may change the appearance of the particle after heat treatment.

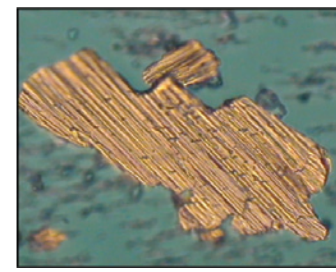


Figure 7: Severe wear

5. **Laminar Wear Particles**: These distinct particle types have been associated with rolling bearing fatigue:
   - **Fatigue Spall Particles** constitute actual removal from the metal surface when a pit or a crack is propagated. These particles reach a maximum size of 100 microns during the micro spalling process. Fatigue spall particles are generally are flat with a major dimensions-to-thickness ratio of 10 to 1. They have a smooth surface and a random, irregularly shaped circumference.
   - **Laminar Particles** are very thin free metal particles with frequent occurrence of holes. They range between 20 and 50 microns in major dimension, with a thickness ratio of 30:1. These particles are formed by the passage of a wear particle through a rolling contact. Laminar particles may be generated throughout the life of a bearing, but at the onset of fatigue spalling, the quantity generated increases. An increasing quantity of laminar particles in addition to spherical wear is indicative of rolling-bearing fatigue microcracks.
6. **Chunk Particles** Two types of wear have been associated with Chunks:
   - **Pitch Line Fatigue Particles** from a gear pitch line have much in common with rolling-element bearing fatigue particles. They generally have a smooth surface and are frequently irregularly shaped. Depending on the gear design, the particles usually have a major dimension-to-thickness ratio between 4:1 and 10:1. The chunkier particles result from tensile stresses on the gear surface causing the fatigue cracks to propagate deeper into the gear tooth prior to spalling.
   - **Scuffing or Scoring Particles** are caused by too high a load and/or speed. The particles tend to have a rough surface and jagged circumference. Even small particles may be discerned from rubbing wear by these characteristics. Some of the large particles have striations on their surface, indicating a sliding contact. Because of the thermal nature of scuffing, quantities of oxide are usually present, and some of the particles may show evidence of partial oxidation (that is, tan or blue temper colors).

Many other particle types are also present and generally describe particle morphology or origin, such as dark metallo-oxide, red oxide, corrosive, etc. In addition to ferrous and non-ferrous, contaminant particles can also be present and may include sand and dirt, fibers, friction polymers, and contaminant spheres.

Contaminant Particles are generally considered the single most significant cause of abnormal component wear. The wear initiated by contaminants generally induces the formation of larger particles, with the formation rate being dependent on the filtration efficiency of the system. In fact, once a particle is generated and moves with the lubricant, it is technically a contaminant.

By being able to show the origin of wear in a standard manner, you can easily diagnose the machine faults and provide evidence to back up your claims via photomicrographs of the wear particles. With industry needing to operate plants reliably, techniques of this nature are a must to pinpoint where potential problems may lie. Equipment life expectancies, safety factors, performance ratings, and maintenance recommendations are predicated on normally occurring wear. However, using wear particle analysis/ferrography pinpoints the problem without taking the equipment out of service. And, as you know, we are in the world of "doing more with less." Modern integrated and automated high-speed machine systems make any interval of down time costly and non-productive. Therefore, machine designers and builders are increasingly using wear particle analysis/ferrography as realistic criteria for improvements in products such as compressors, gears, bearings and turbine components. Therefore, with the enhancements and the standardization of ferrography, diagnosing machine problems becomes easier and less expensive.

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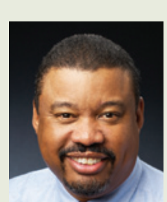

Raymond J. Dalley has been performing research, manufacturing, sales, and marketing with ferrography (wear particle analysis) for the past 28 years with Trico Corp. Currently an Instrument Business Manager, his responsibilities include being Project Manager for the Ferrographic Instrument Group. Mr. Dalley gives lectures for the Society of Automotive Engineers, National Lubricating Grease Institute, Joint Oil Analysis Program Conference, Society for Maintenance & Reliability Professionals, and the Society of Tribological Lubrication Engineers. www.tricocorp.com

Common Pitfalls of Planning and Scheduling Maintenance Activities

Terry Wireman

In the June/July 2011 issue of *Uptime Magazine*, Tarek Atout offered the article, "The Planner: The Heart of the Maintenance Process." The article presented a good overview of the planning function within maintenance. This article presents the common pitfalls that will be encountered when implementing the planner/scheduler function in a maintenance organization.

The business reason for having the planning and scheduling function in an organization is to increase the productivity of the maintenance technicians and minimize the impact that maintenance activities have on the capacity of the equipment. The planning function can increase the labor productivity of the maintenance technicians from where it typically is in a reactive environment (roughly 20%) to where it should be in a "best practice" environment (60% or greater). The increased productivity compared to the maintenance environment is shown in Figure 1. The productivity delays that will be eliminated while moving from a reactive to a best practice environment include:

1. Lost productivity running from one reactive assignment to another reactive assignment
2. Waiting on spare parts
3. Waiting on contractor support
4. Waiting on LOTO instructions and/or work permits
5. Waiting on instructions or checking out the job

In addition to the increased technician productivity, there is an increase in equipment capacity, which includes availability, performance efficiency, and quality rate. The impact is also shown in Figure 1. A typical reactive organization has a lower equipment capacity than a best practice company. However, as the maintenance practices improve from reactive environments through preventive, planned, and best practice environments, the equipment capacity increases. This is due not just to improved maintenance practices, but also to improvements in related departments. This includes operations, since they will feel that maintenance is interested and committed to making their equipment perform better. Operations will then provide input to maintenance (using a work notification/work orders system) and show a higher level of concern for the way the equipment performs. Ultimately, the data collected by maintenance and operations can be fed to the engineering group, which will also look for ways of raising the performance of existing equipment. Engineering will also use this data to look for ways of improving new equipment while it is in its design and procurement phases of the lifecycle.

All of these benefits start with planning and scheduling functions within the maintenance organization. Unfortunately, while implementing planning and scheduling maintenance activities, there are common pitfalls that must be recognized and avoided. The most common pitfalls can be classified into two main categories: strategy and execution.

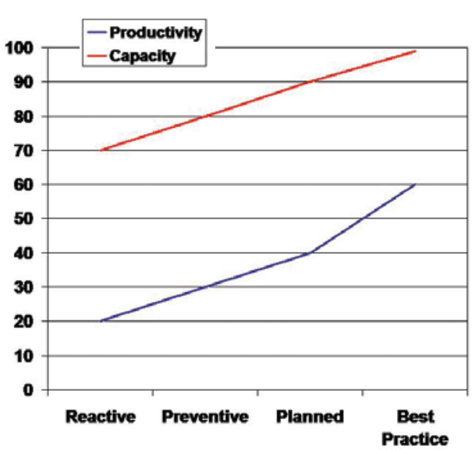

Figure 1: Maintenance Technician Productivity and Equipment Capacity

Strategy Pitfalls

The strategy pitfalls are most commonly encountered when a company is deciding where to place their planning and scheduling functions within the organization. Some companies will decide to have the planner report to the maintenance supervisor. This results in the planner becoming a clerical assistant to the supervisor. Instead of planning, the planner will be initiating, processing, and closing work orders for the supervisors and technicians. This decreases the time a planner will plan and schedule, so it does not result in an increase in the maintenance technician's productivity, and the planning and scheduling efforts eventually fail.

Another misuse of the planner when they report to the supervisor is focusing them on acquiring spare parts and arranging other logistics for the supervisors during reactive maintenance. This reduces the planner's role to that of an expediter instead of allowing a focus on planning. This also will not result in an increase in the maintenance technician's productivity.

A second strategy pitfall is whether the planner should be hourly or salaried. In many companies, the Human Resources department controls the addition of new positions in a department and will set policies as to what can be a salaried position versus an hourly position. The pitfall develops when the planner's position is going to be hourly and will be determined by seniority. This may prevent the most qualified employee from becoming the planner; instead, the position will be awarded to the most senior employee. Now this individual, who impacts the productivity of the 15 to 20 technicians they are planning for, could have a negative impact. The appearance of wasting a resource in planning and scheduling will quickly result in sending the planning back to the crew.

The decision to make a planner hourly or salaried should focus on getting the right person with the correct skills in the planning assignment. If the union forces the most senior person in the job (even if they are not qualified), then it would be best to make it a salaried function. If the union environment is cooperative and the union focuses on getting the most qualified person in the planner assignment, then there is no issue with having an hourly planner.

The solution to the execution problems is to focus on the value that is derived from planning and scheduling maintenance work: increased technician productivity or increased equipment capacity.

Although these pitfalls occur during the initialization of the planning and scheduling function, they should have been addressed while the strategy was being developed. All organizational issues should be decided before the planners are selected. This includes where the planners report organizationally, how many technicians each will plan for, and a detailed job description that will be strictly adhered to during the implementation and utilization of the planning and scheduling function.

Execution Pitfalls

Once the planners/schedulers are in place and the strategy is clearly understood by the maintenance and operations personnel, problems will still develop. These execution problems include:

1. No effective preventive maintenance
2. Insufficient MRO support
3. Poor use of a WO system
4. Poor organizational cooperation (maintenance or operations)

The first pitfall is the lack of an effective preventive maintenance program. This will allow a high rate (>50%) of reactive work to continue, even with the planner/scheduler in place. This results in plans and schedules that are inaccurate or always slipping due to a high level of reactive maintenance. The planners/schedulers become frustrated and will return (if possible) to working on a crew. Even if the planners/schedulers remain in their assignments, the organization will not see any benefits (either increased productivity or improved equipment capacity) to their job assignments and thus eventually will eliminate the positions.

The second pitfall is insufficient MRO inventory and purchasing support. This usually will show up as poor service levels (<95%) from the stores. This means that the stores either are not stocking the right parts or are not stocking a sufficient number of the right parts. The typical root cause here is the lack of sufficient staffing in the stores areas. This allows for spare parts to disappear from the stores areas with a negative impact on the service levels and inventory accuracy.

The third pitfall is the poor use of a work order system (typically in a CMMS or EAM system). Without the work order to utilize as a control document for planning and scheduling, the planners/schedulers lack the information necessary for them to be effective in their assignments. They will not have sufficient information to begin planning a job without closely investigating each request. This will require too much time, and they will be ineffective in planning for the right number of maintenance technicians. This will again make the planner/scheduler position seem ineffective and cause the planners/schedulers to become frustrated and the managers to eventually end planning and scheduling.

The fourth pitfall is the lack of cooperation from both maintenance and operations supervision with the planning and scheduling process. For example, many times the maintenance schedule is published for the next week, but when it comes time to execute the work on the schedule, the supervisor (particularly on second or third shifts) will decide not to perform the work that is scheduled. This results in the constant reshuffling of the scheduled work or the sliding of the work from one weekly schedule to the next.

The solution to the execution problems is to focus on the value that is derived from planning and scheduling maintenance work: increased technician productivity or increased equipment capacity. If the entire organization understands the costs involved and how they are minimized by best practice planning and scheduling practices, the easier it is to overcome the execution problems. If certain employees fail to cooperate in the execution phase of planning and scheduling process, perhaps it would be better for the entire organization if they are reassigned to a position where they will not impact the organization's profitability.

Terry Wireman, CPMM & CMRP, Senior Vice President Vesta Partners, LLC has authored dozens of books, including the new Maintenance Strategy *series published by Reliabilityweb.com and sold at: books.mro-zone.com.*

Risks of Using PM Templates

Anthony "Mac" Smith and Tim Allen

Some 50 years ago, a small group at United Airlines, led by Tom Matteson (then VP - Maintenance Planning) created a new way to define PM tasks for the 747-100 airplane. It was so successful that virtually every airplane since then has employed this methodology. We have known this process as Reliability Centered Maintenance (RCM) since the 1970s.

RCM Team Analysis at Greater Cincinnati Metropolitan Sewer District (MSD)

Since then, RCM has been introduced to a broad spectrum of plants and facilities across the U.S., and via the 80/20 rule continues to be recognized today as the best available process for defining applicable and effective PM tasks to control/decrease corrective maintenance and downtime in complex "bad actor" systems.

Anyone who has successfully used RCM to define their PM tasks knows two things: 1) It takes some effort to do it (no free lunch!), and 2) It works. At AMS, we exclusively use Classical RCM (i.e. like the original 747-100 process) for our client's 80/20 systems, and it continues to be the basis for our success over the past 30 years.

With that said, every so often someone proffers a so-called magic bullet to easily establish a plant maintenance program without taxing company resources. Who wouldn't want that? Deep down we know this doesn't exist, but that doesn't stop us from flirting with the notion. One such idea that is floated now and then is PM templating. The basic premise behind PM templating is that systems are all comprised of common equipment, just in different combinations and uses, so why not borrow a standardized library of PM tasks common to that equipment and skip the analytical process? It sure is tempting.

Unfortunately, such simplistic notions fail in real world application. While a portion of template tasks may work for some assets (even a broken clock is accurate twice a day), a significant portion of the PMs will be far removed from the actual operating conditions of a plant. More importantly, however, a significant number of tailored PM tasks, those that are specific only to the unique interplay of components within the assembled system, will be missed, with possibly drastic results.

The practitioners of PM templating promote their process as a better substitute for the well-known Reliability Centered Maintenance (RCM) process. The RCM process is a proven methodology used worldwide with a successful track record for over 40 years in a variety of industrial applications (see Reference 1, Chapter 12, for seven such examples). It is the recognized standard for world class maintenance plans for any asset. PM templating practitioners state that RCM is too labor intensive for practical purposes, and that PM templating frequently consumes only 15% of the time traditionally employed for RCM. Over the years, we have seen these "quick fix" claims (such as Streamlined RCM; see Reference 1, pp. 171 to 174) and have observed how they quickly fall out of favor with those who try them. So just what is wrong with PM templating?

Criticality

A tolerable failure for one component in a system (for example, internal leakage of a valve) may be entirely intolerable for an identical valve in a different application. Hence, the maintenance strategy for those identical valves should be different as well. The proper maintenance for an asset can only be prescribed once its criticality within the system is understood; in other words, its ability to degrade system or plant performance. Equipment failures that do not harm the system or plant (due to redundancies, excess capacity, etc.) should not be the focus of your maintenance resources. You simply cannot ascertain a component's criticality without a sound cause-and-effect analysis between the asset, its failure modes, and the higher-level business requirements. If you do not thoroughly document the **functions** and possible **functional failures** of the system, and associate a component's **failure modes** with those functional failures within the discussion of an **effects** and **consequences analysis** at three levels (local, system, and plant), you will misdiagnose the criticality of the asset. Moreover, if you do not engage the actual process participants, those who live with the results of failure on a daily basis, you will misdiagnose the criticality. That has been proven repeatedly in practice, and intuitively we all know that.

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System Monitoring Conditions

A comprehensive world-class preventive maintenance program is far more than a compilation of generic PM tasks. There are always system and/or plant design parameters that must be monitored and controlled to ensure the correct operating conditions. These parameters are not found in a PM template catalog or library that contains only component-level data. They are unique to your system! For instance, If one didn't specifically document that their air dryer system requires an output dew point of -28 °F to avoid moisture buildup with potential for freezing and then plant shutdown, one is unlikely to recommend a PM task to develop a dew point trend report to capture dew point data that will be visible on screen in real time to operators. One also would be unlikely to impress upon a newly hired equipment operator the necessity and value of this recommended task. This is a real-life example that did in fact occur, resulting in lost product opportunity

in the multi-hundred thousand dollar range. MESSAGE: You can not neglect to account for system or plant interactions in specifying the correct component PM tasks.

Equipment Operating Environment

The environmental conditions imposed upon a component exert a considerable influence on the maintenance strategy. Even within like industries, the stresses encountered by one asset may be entirely different from the stresses encountered by an identical component in another application. Duty cycles, wear-out rates, and dominant modes of failure will all differ. Selection of PM task frequency will likewise differ. Some process industries require their assets to operate non-stop for years at a time, while others may operate only periodically. Such differences affect the types and frequencies of PM tasks one should prescribe among like equipment. For example, would you prescribe the same PM tasks on a valve that is used every day, versus an emergency isolation valve that is generally never operated? What if that valve is 5000 feet below the ocean's surface? Questions like these get to the heart of the HIDDEN FAILURE issue and how unrealistic it is to consider the ability to identify hidden plant failures from component template data.

Organizational Culture

The preventive maintenance that works at one organization is not always the best fit for another organization. Every company and every facility has its own unique culture, with established routines and protocol for maintaining equipment, based on years of experience and refinement. Those practices may be entirely situational and not suitable for exportation to others. Should one prescribe sophisticated PdM technology or the use of handheld mobile recorders for data capture? Companies may not be ready to embrace such technologies, or the ROI may not be justified. Each company has maintenance and operational personnel with various strengths and weaknesses. RCM involves those personnel, gives them a voice, and seeks to leverage their strengths. PM templating may not take this into account because it basically bypasses the team concept in the PM decision process.

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Maintenance Plan Ownership

As facilitators for over 100 RCM projects, we have reports documenting thousands of equipment failure modes and PM tasks, and we bring this experience to each RCM team that we serve. From this experience, we could also painstakingly compile a library of tasks from our archives to apply to generic components, but we don't, and we won't. The reason is this: if you are looking for magic, that magic does not exist in a library of generic data (aka templates); it exists only when you gather a team of the equipment stakeholders in a room and develop a reliability strategy together in a structured format.

The team method isn't unique to RCM. This is the same concept used in Lean, Kaizen, TPM, Process Re-engineering, and so on. You must engage the process participants (the maintenance crafts people, the equipment operators, and the process and reliability engineers) for the cross-pollination of information, –and only in that manner will you achieve BUY-IN and obtain superior results. We believe that a PM template approach will only discourage and disengage a team. It won't be theirs, and they will tune out. Worse yet, the template data will invariably miss very critical information that will lead to incorrect decision making. At the end of the day, a team-derived RCM plan has BUY-IN at all necessary levels for implementation.

Training, Education, and Corporate Knowledge

The dividends of an RCM project far exceed the development of a maintenance plan. As is often the case, those who conduct RCM are encouraging a cultural change to move from a reactive to a proactive culture. This can only be done in the context of training and education. That is one purpose of establishing an RCM Team and RCM Champion. Moreover, as one records and rationalizes the business case for establishing a preventive maintenance task, one is in fact capturing valuable corporate knowledge that will be preserved for future training, education, and decision making. As one of our client RCM teammates said at the end-of-project brief to upper management: "It would take a person 3 years or more to learn and become proficient in understanding the possible failures and effects associated with the system that the team documented."

Project	Client	RCM Team	Components Analyzed	Number of Failure Modes	Percent of Hidden Failure Modes	Percent of Critical Failure Modes
1	A	A	48	166	20%	95%
2	A	B	43	226	47%	95%
3	A	C	52	243	38%	97%
4	B	A	125	246	22%	75%
5	B	B	106	452	32%	77%

Analysis Level of Effort

RCM was introduced to the nuclear power industry in the early 1980s by Tom Matteson (retired VP of United Airlines and creator of RCM) and Mac Smith, and rapidly moved into fossil plants, large manufacturing plants, and government test facilities in the late 1980s and 1990s. To date, AMS has supported/facilitated some 100 Classical RCM projects with over 75 Fortune 500 companies. In the beginning, a typical project would take 5 to 6 weeks to complete and was recorded by hand without the assistance of software. When it was obvious that there was no RCM software worth its salt on the market, in the late 1980s AMS initiated the development of the Classical RCM WorkSaver software in a collaborative effort with JMS Software. Today, that software has supported over 50 RCM projects and has been purchased/used by over 100 clients.

The point to this story is that the conduct of Classical RCM projects has matured to the point that AMS now conducts a standard RCM project in 3 to 4 weeks, including a 3-day up-front team training and a 1-day end-of-project briefing to client management and staff personnel. Our experience for the past 20 years has been that clients consistently find that the ROI from these projects on 80/20 systems is well worth the short span of effort required.

These projects have taken place in several product areas (e.g., waste water treatment, refineries, airplane production, aerospace test facilities, postal automation, diesel engine assembly, etc.). Some sample statistics are shown below for 5 recent projects, all of which involved 80/20 "bad actor" systems, an RCM team for the complete analysis process, documented results, and, finally, implementation. Each project involved a unique plant with different functions and would have, in our opinion, been a complete failure using PM templates as the basis for the PM results.

Notice that each project varied in the number of components involved and failure modes analyzed. This suggests that system complexity is unique from plant to plant. Also note the large number of hidden failure modes and critical failure modes that were specifically identified. This is just a sampling of the AMS experience; Reference 1, Chapter 12 presents seven case studies that can be reviewed for more details.

A survey by Reliabilityweb.com found that 50% of all RCM projects are not implemented for one reason or another. That figure should not be surprising. 50% of all business startups fail. 50% of all marriages fail. However, our experience with Classical RCM has been that implementation is in the 70% range. Those who are truly serious about obtaining reliability results make it work.

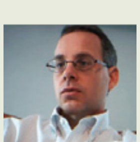
Conclusion

When we talk about how to focus resources, which are usually rather scarce these days, we need to first decide what is really important to us. That just makes common sense and should not be a controversial topic. As indicated in the above paragraphs, AMS has successfully employed the 80/20 rule for three decades to answer that question. Now if you know which systems (20%) are eating your lunch (80% of your grief), then does it not also make sense to do the best possible job in deciding how to eliminate that grief. We have presented seven arguments above to help you to understand that PM templates are NOT the way to address these important 80/20 systems.

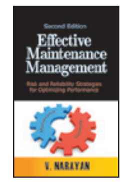
Only the Classical RCM methodology has the ability to take a top-down, zero-based approach to maintenance analysis, which starts at defining the necessary performance attributes that an organization requires from its assets (functions) and drills down through a decision methodology to ensure there are technically feasible and worthwhile maintenance tasks in place to prevent interruption of those vital requirements. To date, AMS Associates has supported/facilitated some 100 Classical RCM projects with over 75 Fortune 500 companies. Each project was a unique plant with different functions, and would have, in our opinion, been a complete failure using PM templates as the decision process to address such an important issue.

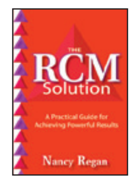
Reference 1: "RCM – Gateway to World Class Maintenance," Anthony M. Smith and Glenn R. Hinchcliffe, Elsevier 2004.

Anthony "Mac" Smith has over 50 years of engineering experience, including 24 years with General Electric in aerospace, jet engines, and nuclear power. Mac is internationally recognized for his pioneering efforts in introducing RCM to U.S. industry in the early 1980s. Since then, he has worked with some 75 Fortune 500 companies, the USPS, NASA, and the USAF, among others. He has personally facilitated over 75 RCM studies and has authored/co-authored two books on RCM that have become the standard references for Classical RCM. www.jmssoft.com



Tim Allen joined Mac in 2005 after a 20-year career with the US Navy's Submarine Maintenance Engineering Planning and Procurement Activity (SUBMEPP). During his tenure, Tim was one of the principals in developing the submarine group's RCM process and rose to the level of RCM Program Manager. His efforts helped lead the Navy away from expensive time-based overhauls of equipment to more surgical condition-based strategies. www.jmssoft.com





Safety & Reliability

Joel Levitt

During a three-month period in 2010, 58 workers died in explosions, fires, and collapses at refineries, coal mines, oil drilling rigs, and power plant construction sites in the US.

In an address to the National Petrochemical and Refiners Association National Safety Conference in 2010, Jordan Barab, who is the Deputy Assistant Secretary for Occupational Safety and Health, said, "Bluntly speaking: Your workers are dying on the job and it has to stop."

Barab went on to say, "What I'm talking about is a set of practices that define the organization and influence the individuals who make up the organization. It goes without saying, but I'll say it anyway: *Organizational safety culture must come from the top.*"

If we look at all industry in the US in 2009, there were 4,340 deaths. The injuries suffered by US workers are even more startling:

Total recordable cases	**3,277,700**
Cases involving days away from work	**965,000**
Cases involving sprains, strains, or tears	**379,340**
Cases involving injuries to the back	**195,150**
Cases involving falls	**212,760**

Think of it: if we fix some of the root causes of the fatalities or injuries more workers will go home to their families whole and intact.

There are many reasons for these injuries and fatalities. Some of the common ones include traffic accidents, falls, and a whole host of injuries and unfortunately fatalities from maintenance work. I want to discuss the maintenance-oriented injuries and fatalities. Following are some examples of serious accidents from OSHA records:

- *A massive explosion destroyed a large storage tank containing a mixture of sulfuric acid and flammable hydrocarbons at the Motiva Enterprises Delaware City Refinery. One contract worker was killed, and eight others were injured. Sulfuric acid from collapsed and damage tanks polluted the Delaware River. The explosion occurred during welding operations to repair a catwalk above the sulfuric acid tank, when flammable hydrocarbon vapor was ignited by welding sparks.*
- *Crews were doing maintenance work on a generator while a pressure test was being done. That's when a manway blew off, after the compressed air inside was released, striking two contract workers, injuring them critically.*

Why did these injuries occur?

Generally, accidents are grouped into 5 categories. According to Barab's address mentioned above, the areas are spread among many parts of the business.

Specification	**44%**
Changes after commissioning	**20%**
Operations and maintenance	**15%**
Design and implementation	**15%**
Installation and commissioning	**6%**

In this article, I want to focus on reliability of equipment. Problems in all of the categories above are causes of breakdowns. For example, in operations and maintenance a culture of expediency can contribute to procedures not being followed, design flaws, and workers not being careful. With all that going on, it is easy to see that non-standard situations can also occur.

Some of the accidents are the result of unsafe acts (hot work on a tank with an explosive mixture inside) or failing to follow procedures (pressure testing with personnel in harm's way). Of course, most accidents like these have several causes at the same time.

If we look at more maintenance-related fatal incidents, we can start to see a pattern.

- *A tragic double fatality of welders on a petrochemical plant when an argon cylinder had been left leaking into the vessel they were due to work on. The first one went in and collapsed; the second, instead of raising the alarm first, went in after him, and they both died.*

How are reliability and EHS related? The reasons behind the relationship are as follows:

Reason 1: Something was broken and had to be repaired. The breakdown caused the person to go into harm's way. So, lack of reliability can cause death and injuries.

Reliable equipment removes this cause, one of the common causes of accidents. We can be even more specific. Equipment running as designed does not require people to enter a confined space, repair (and touch) exposed electrical wires, pressure test a generator, sit on top of a tank and weld, or even fall off of a ladder.

How is reliability related to safety? Reliability removes risk from the equation, and the worker is not in harm's way. If no one was welding above the tank, the explosion would not have happened; if there was no repair needed, no one would gave been up on the ladder or on the roof.

A. Something breaks down and has to be repaired.
B. The breakdown causes a worker to be in harm's way.
C. Reliable equipment does not require maintenance workers to be put into harm's way.
D. The best solution to a hazard is to eliminate it.

Reason 2: Due to PM, the size and scope of repair is smaller, making for safer repairs.

The second part of the equation has been reported by Exxon-Mobil. They studied their maintenance-related accidents and found the following: "Accidents are 5 times more likely while working on breakdowns then they are while working on planned and scheduled corrective jobs."

High reliability implies an effective PM program that catches deterioration before it causes a failure. Since the asset is not yet broken, it is safer to work on.

A. PM activity catches deterioration early in the process before failure (and reliability is impacted).
B. At that point the repair is smaller, safer, and more manageable, resulting in fewer EHSS incidents.
C. PM also gives managers more time to plan and deal with hazards.

Reason 3: Hazards are eliminated or mitigated in the planning process.

High reliability also implies that the maintenance planners have time to plan the job properly. One aspect of planning is to consider all the hazards and figure out and describe a way to accomplish the work safely. The job plan that an experienced planner develops will reflect the safe way to do the job.

A planner should look at every job and see if any common hazards are present. Hazards would include: airborne contaminants, falls from heights, slipping and tripping, falling objects, eye damage (particle, chemical, or flash), chemicals (ingestion, skin exposure, or breathing), asphyxiation, radioactive exposure, fire, explosion, electrocution, entrapment and crushing, and temperature stress.

Every hazard identified is then eliminated (best option) or mitigated (second-best option). The safest plants are the ones where the safety of the workers is considered at every step in the job preparation process.

A. The planner plans the job to minimize downtime
B. The planner is specifically trained to look for hazards to safety, health, and environment.
C. Planners will mitigate or eliminate the hazard in the plan before the crew even leaves the shop.
D. The result is fewer EHS incidents and more reliable equipment.

Reason 4: Planned jobs allow fewer opportunities for the maintenance worker to improvise.

Improvisation is statistically less safe than following the job plan with the correct tools and spares. One of the building blocks of a reliable culture is adequate maintenance planning. Without planning, the workers are forced to make do with what spares and tools they can find. To do their job, they may have to improvise to make things work. Improvisation might be great in the theater but can be deadly in maintenance. My guess is that the following worker was making do with an improvised support:

Worker was performing maintenance on the back of a trash truck. The support gave way and the tailgate came down on the worker.

A. Improvisation is great in comedy.
B. Improvisation can be deadly in maintenance.
C. Adequate time for job planning means having the right tools, spares, equipment, skills, and drawings when the job starts.
D. The result is fewer EHS incidents and better reliability.

Reliability is the outcome of this intentional maintenance environment and is essential for a safe environment.

Action items

Management action items to transform the culture require minor modifications to the weekly and monthly Key Performance Indicators (KPI) used to run the plant or facility and for bonuses.

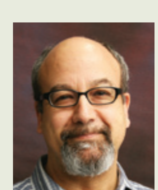
1. The ratio of emergent maintenance work to planned and scheduled maintenance work should be maintained above 80% planned and scheduled to reduce emergent jobs.
2. PM performance should be above 95%. More than 95% of the PMs generated are completed in ±10% of the PM interval.
3. Schedule compliance above 85%. That means more than 85% of the jobs scheduled are completed sometime during the week in which they are scheduled.
4. MTBF for major assets should be on an improving trend.

What if your plant doesn't measure up? Then it is time to change the culture. However, changing a culture takes time and will take three attributes:

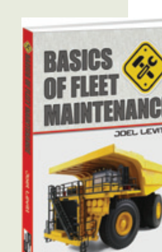
- Follow-through to keep people's eye on the goals
- Resilience to get the plant back on track when the program goes off the track
- Positive attitude: just like when teaching a child to ride a bike, keep up a positive, encouraging attitude. Don't punish honest mistakes; make sure your people learn from them.

Good luck, Joel

Exxon-Mobil studied their maintenance-related accidents and found that accidents are 5 times more likely while working on breakdowns then they are while working on planned and scheduled corrective jobs.



Joel Levitt is a leading trainer of maintenance professionals. He has trained more than 15,000 maintenance leaders from 3,000 organizations in 20+ countries in over 500 sessions. Since 1980 he has been the President of Springfield Resources. He has 25 years of experience in many facets of maintenance. Levitt has served on the safety board of ANSI, Small Business United, and National Family Business Council and on the executive committee of the Miquon School. He is a member of AFE and Vice President of the Philadelphia chapter. www.MaintenanceTraining.net



Part 2 Establishing Ultrasound Testing as a CBM Pillar

"There's lots of talk about the benefits of implementing CBM and the positive impact that condition monitoring technologies like ultrasound testing can have. It seems we all have a good grasp of what it is and why we need it. The ultimate challenge is to move from inception to launch stage. Show me HOW TO DO IT."

Allan Rienstra and Thomas Murphy

Not everyone has the same perception of what Condition Based Maintenance (CBM) is; therefore not everyone has the same expectation of what an investment in CBM will return. In Part 1 of this paper, we asserted that careful planning must precede starting down the path of CBM. We suggested a useful goal of 90-95% of your maintenance tasks being condition directed. This means not allowing your current CMMS to plan and overrule tasks. Instead, let it work with your CBM to create condition-driven work orders. We maintained that the initial CBM investment must be oriented toward the education and thus the alignment of upper management's, middle management's, and frontline staff's expectations. Part 1 provided answers to the "What" and "Why" questions of CBM: what is it and why do we need it? Part 2 confronts what many perceive to be the ultimate hurdle: How Do We Do It?

The best way to tackle this large project is to go at it in small bites. There is so much to do, and you probably find yourself with limited resources. Early frustration may be exacerbated by the pressure for and anxiety about fast success. Resist the temptation to quell your anxiety by being overzealous with failure reporting. Yes, there is pressure to show results. No, the anxiety from that pressure doesn't go away through reporting false failures; it only feeds the naysayers, those who want to say, "I told you it doesn't work."

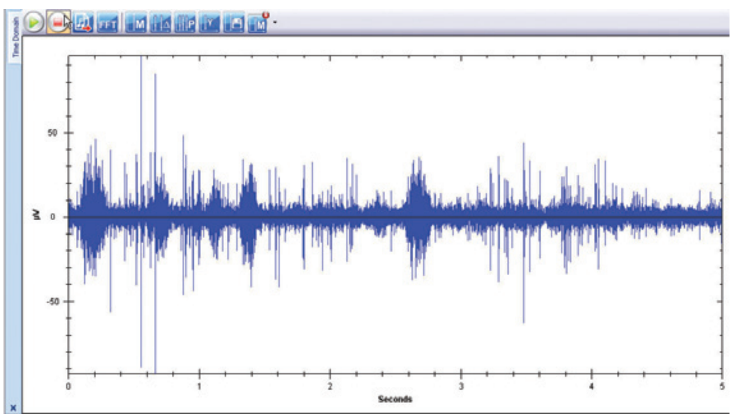
The perception that CBM can only be associated with rotating machinery is a false one. Does a compressed air leak speak to the condition of the compressed air system? Yes, of course, the same way a vacuum leak or steam leak speaks to the condition of those processes. A failed steam trap says that the condition of your steam recovery system is not being optimized. None of these defects rotate, nor are they trendable. They are only findable and fixable. They represent a huge drain on company resources in terms of energy waste and process efficiency. But do any of these defect conditions get addressed by your current Computerized Maintenance Management System (CMMS)? The answer is likely not. So take a run at the easy bits first. Start a compressed air leak management program, and while you are out there, incorporate procedures that look for vacuum and steam leaks, failed steam traps, and faulty valves. In conjunction with your infrared program quickly tie in ultrasound testing of low-, medium- and high-voltage electrical systems.

These represent aspects of your ultrasound CBM that require a lesser amount of preparation. Use of these quick hitters will achieve fast success for the program, which in turn will reduce frontline staff anxiety and satisfy middle/upper management expectations. Moreover, success early on buys the time needed for applications that require greater preparation. Those include machinery lubrication, bearing condition monitoring, and machine condition monitoring.

Not all defects are trendable. There are many defects that are purely and simply "good" or "not good." The first important task your CBM program needs to accomplish is to categorize those tasks that are non-trendable, those that require trending, and those best identified using dynamic signal analysis. Non-trendable defects include:

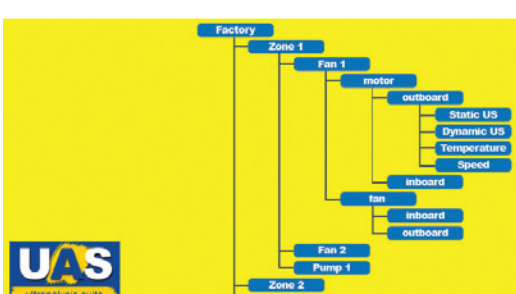
- **Compressed air leaks**
- **Steam leaks**
- **Vacuum leaks**
- **Heat exchanger inspections**
- **Tightness testing**
- **Corona, arcing, and tracking detection**
- **Steam trap testing**
- **Basic identification of some rotating defects**

The most well-known trendable defect is condition-based bearing lubrication. It is a very simple and accepted science to trend using decibels. One basic thing to consider is identification of which bearings are greasable (yes, it is quite plausible to find a sealed bearing with a grease nipple). Other basic issues to consider include: Do you have the buy-in from your CMMS to migrate time-based lubrication, or will the CMMS overrule your findings? Will you find and fix, or will your program require two passes through? Work in a routine way with a survey-driven program, and not only will this identify your lube problems, but at the same time also address larger issues.



Understanding trend changes in ultrasonic decibel data lets us decide which bearings need to be analyzed further, with either ultrasonic dynamic signal analysis or vibration analysis. Dynamic data analysis serves us in many ways. We can use it to understand and categorize electrical faults. It can be applied to steam trap testing to differentiate between a fault and flash steam. Dynamic data analysis helps us diagnose faults in slow-speed applications like bearings and gearboxes. Analysis of valves on reciprocating compressors gives us insight about the efficiency of these machines.

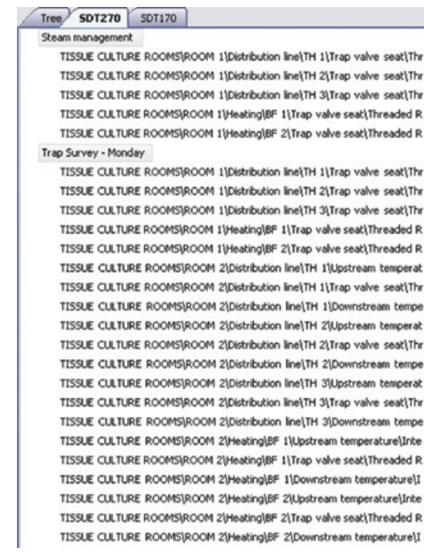
The key point to take away here is that CBM does not always have to be about bearings.



Since we identified the assets we will monitor, and categorized them as trendable and non-trendable, we can move toward the next step in our planning, which is to build a database. Don't just pick up the ultrasound instrument and head out into the plant. There are several things to consider: Where are the items to be monitored? What are they called? What does everyone else call them? Consistency when naming assets is important, both for the people handling the data and the software that uses case-sensitive search filters to mine data. Are some of the assets to be monitored affected by operational changes? Are some of them affected by process changes? If so, define those changes and train the inspectors to identify them. Use this knowledge when applying intervals to data collection.

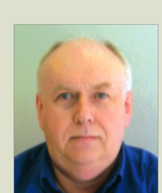
Not all defects are trendable. There are many defects that are purely and simply "good" or "not good."

Once a database of items is built, a list of manageable surveys needs to be defined. Some considerations for building surveys include defining when to go out and collect data (intervals) and which alarm definitions will trigger intervention. Your database may include every asset in your plant, which may mean thousands of data collection points. Breaking this massive library down into manageable surveys takes planning and thought. Creating groups of data points that can be started and finished in a day, or even a half day, makes good sense. Make your survey too big and it won't get finished. Eventually, it won't even get started. Organizing the tour so that the work flow follows a logical path through the plant also makes good sense. Asking your ultrasound inspector to zigzag while moving through the plant will not win his or her cooperation.



To this point, we have covered the bases for establishing ultrasound testing as a pillar of your CBM strategy. Part 1 explained what it is all about, and here in Part 2 we laid the framework for how to get it started. That brings us to the final and most important phase of implementation: communicating the results. In Part 3 of this paper, to be published in a future issue of *Uptime Magazine*, we tie our implementation strategy together by addressing the key points of communication. We will cover the objectives of good communication, the format of a sound report structure, and some examples of how those reports will inform the people who need to know. Stay tuned . . . we're almost done.

Allan Rienstra is the President of SDT Ultrasound Solutions and co-author of Hear More; A Guide to Using Ultrasound for Leak Detection and Condition Monitoring. *He has spent the past 19 years helping manufacturers around the globe establish world class ultrasound programs. www.sdthearmore.com*



Tom Murphy is a Chartered Engineer with a degree in Acoustics and 29 years of postgraduate experience in predictive maintenance using vibration, infrared, and ultrasound. He is the co-author of Hear More.

Part 3

Detecting Bearing Faults

Jason Tranter

In the two previous articles (Dec/Jan 2011, Apr/May 2011), the focus has been on how the vibration changes when a "typical" bearing fault develops. We have explored spectrum analysis, time waveform analysis, and a raft of high frequency detection techniques. But there are a number of fault conditions related to rolling element bearings that will not necessarily change the vibration patterns in the ways described thus far. Thus, in this article we will explore fault conditions that relate to poor installation (cocked on the shaft or on in the housing), current flow through the bearing (EDM damage), skidding, and slipping.

Poor installation: cocked bearing

Bearing installation is very important. If a hammer is used to pound a bearing into place, the rolling elements and raceways can be, and almost surely will be, damaged. Poor installation can also damage the shaft or the raceways via surface gouging or scratching. Those damaged areas will cause the vibration to change in ways described in the previous two articles; periodic stress waves and vibration will be detected at the key forcing frequencies (depending on the damage inflicted on the bearing).

However, if the outer race of the bearing is cocked in the housing, or the inner race is cocked on the shaft (i.e. there is an angle between the outer race and the housing or between the inner race and the shaft), then with time the additional load on the rolling elements and raceways will cause excessive wear and premature failure of the bearing. But we can detect this situation so that it can be corrected before damage is done!

Vibration amplitude will be higher than normal in the axial direction; however, instead of generating vibration at the bearing defect frequencies (BPFI, BPFO, BSF, and FT), the vibration will be generated at the speed of rotation, i.e. 1X. The vibration at twice running speed (2X) and at harmonics can also increase in amplitude. The only problem is that vibration at these frequencies can be elevated for other reasons, including unbalance, misalignment, and a bent shaft. (Figures 1 and 2)

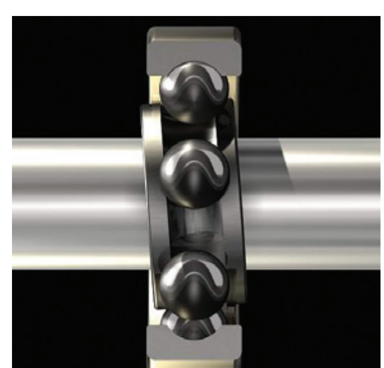


Figure 1: Inner race cocked on the shaft

Figure 2: Outer race cocked in the housing

Phase analysis can aid in this diagnostic process. In the case of the bearing cocked on the shaft, with each rotation you have a "wobble" motion. Phase analysis would reveal that as you move an accelerometer around the face of the bearing at different clock positions, the phase reading would change accordingly. For example, if the phase reading (compared to a tachometer reference or a second accelerometer) was 0 degrees at the 12 o'clock position, the reading would be *approximately* 90° (or 270°) at 3:00, 180° at 6:00, and 270° (or 90°) at the 9:00 position. (Figure 3)

If the outer race is cocked in the housing, the phase readings will depend on how it is cocked (i.e. which point on the bearing is furthest from

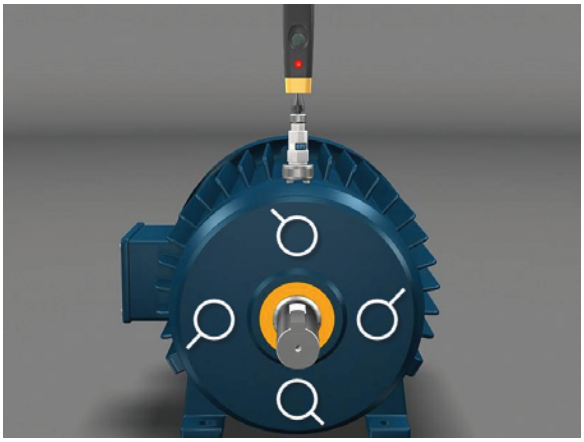


Figure 3: Phase changes when the bearing is cocked on the shaft

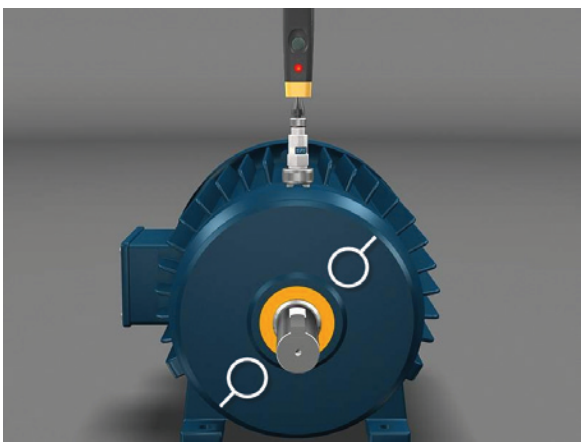


Figure 4: Phase changes when bearing is cocked in the housing

the machine face, and which is closest). By moving the accelerometer around (safely), the analyst would find a 180° phase difference between those two points. (Figure 4)

Fluting or EDM

If current flows between the inner race and outer race, through the rollers or balls, a fluting pattern will be etched onto the bearing surfaces. The pattern is quite unusual, although very recognizable, as shown in the photograph. (Figure 5)

Current flow can occur for a variety of reasons (including poor grounding when welding is performed, insulation breakdown, brush problems

Figure 5: Typical pattern seen on a bearing experiencing fluting

on DC drives, and other reasons). The fault condition is common in DC motors, and it is now increasingly common to see this problem on variable frequency drives.

Because of the "washboard" pattern on the bearing surfaces, a series of peaks is often seen clustered together up in a high-frequency band, typically between 100,000 CPM and 180,000 CPM. It is believed that the peaks appear in this range because they are exciting a bearing resonance; therefore, where they *actually* appear will depend upon the bearing. The peaks may be separated by BPFO, BPFI, or sometimes BSF; however, they are often *not* observed in the lower frequencies (i.e. at BPFO, BPFI, etc.). (Figure 6)

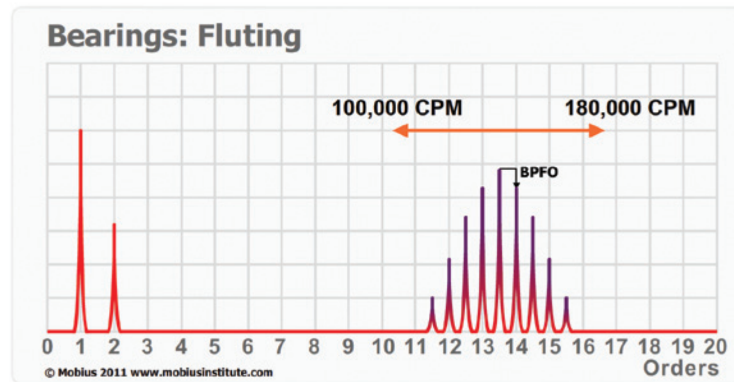


Figure 6: Sample of the vibration pattern witnessed when fluting (EDM) occurs

Skidding

If a bearing is correctly selected for its application, the lubricant is functioning correctly, and there is adequate load on the rolling elements, then the rolling elements should continuously roll around the raceways. However, it is not uncommon for the rolling elements to slide or skid from time to time when these conditions are not met. This is more common on non-drive-end bearings, especially on vertical machines, and far more commonly with cylindrical roller bearings (as against deep groove ball bearings). In many cases, when skidding is observed, a shot of grease may stop the bearing from skidding, but minutes or hours later the skidding will resume. In some cases the skidding will occur when the machine is started, or on cold days because the lubricant is more viscous.

There are actually a number of situations in which skidding, sliding, or smearing can occur, but for now the focus is where the rolling elements skid through the unloaded portion of the bearing (i.e. opposite the load zone). I think it goes without saying that skidding is very harmful to the bearing. The metal-to-metal contact causes excessive wear, and heat is also generated. In more than one case fire and/or explosions have resulted.

The vibration pattern will change when a bearing is skidding. The recording must be taken, however, when the skidding is occurring (which can be intermittent). It is common to be able to hear a high-pitched sound from the bearing when skidding occurs. That should be enough to get your attention; however, an acceleration time waveform also will show high G levels; often above 10 Gs. High-frequency "noise" is generated, which will excite the bearing resonance (as described when fluting occurs); however, in this case we may expect to see a "hump" in the spectrum, like a mountain. It is not uncommon for peaks to emerge out of the hump that are separated by BPFO.

If the surface is damaged, peaks may be observed at the defect frequencies. You may notice that the peaks become "smeared" (broader and shorter), because the frequency of vibration is not consistent.

Sliding and loose fit

Another fault condition you may encounter is where the inner race slides on the shaft, or the outer race slides in the housing, due to a loose fit. It is not uncommon to see a 3X peak (and harmonics) rise in amplitude when the bearing is slipping on the shaft, and you may also witness an increase in the 4X peak when the bearing is loose in the housing.

Observe the bearing

It is highly recommended that you look closely at the surface of a bearing when it is removed from the machine. It will tell you a great deal about the failure mode. All of the major bearing suppliers offer application notes with images that allow you to recognize the markings on the bearing surfaces, helping you to determine the root cause. If a bearing is slipping on a shaft or is loose in the housing, or if the rollers are skidding, the surfaces of the bearing will provide tell-tale signs. (Figure 7)

Figure 7: Seizing marks in the inner ring bore as a result of inner ring creeping on the shaft – FAG Publ. No. WL 82 102/2 ED

Using a stroboscope

If the cover of the bearing can be safely removed so that the rolling elements can be observed, a stroboscope can help to diagnose the slipping and skidding faults conditions discussed in this article. If you synchronize the strobe to the shaft speed, you should not see relative movement between the inner race and the shaft. If the strobe is synchronized to the cage frequency, the cage should appear to be stationary, unless skidding occurs. The relative position of the outer race to the housing should not change.

Conclusion

There are a number of fault conditions related to rolling element bearings that can be detected with vibration analysis. As always, serious thought must be given to the root cause of these fault conditions. You need a good vibration monitoring program, but you also need to adopt precision maintenance practices. In the fourth and final article we will explore how vibration analysts can contribute to reliability improvement.

Jason Tranter is the founder of Mobius Institute and author of iLearnVibration *and other training materials and products. Jason has been involved in vibration analysis in the USA and his native Australia since 1984. Before starting Mobius Institute, Jason was involved in vibration consulting and the development of vibration monitoring systems. www.mobiusinstitute.com*

Rhys Davies, second row, 6th from left. PC/251 Delegates for the Melbourne meeting in February 2011 at the Melbourne Cricket Ground.

Q&A

Uptime Magazine Publisher and Editor **Terrence O'Hanlon** recently caught up with **Rhys Davies, Chairman of the ISO PC251** activity that is working on an International Standard for Asset Management based on PAS55, for an update on that activity.

Q Rhys, will you explain what the International Standards Organization (ISO) is doing in terms of developing an Asset Management Standard?

A Following the success of two versions of BSi PAS 55 in 2004 and 2008, I started working with British Standards Institution (BSi) to engage with ISO with a view to developing a formal International Standard in Asset Management to build upon the work already captured in PAS55. In August 2010, ISO authorized the formation of a Project Committee (ISO/PC251) to develop a set of three International Standards in Asset Management. The three standards are:

Three International Standards in Asset Management	
ISO 55000	Asset management – Overview, principles, and terminology
ISO 55001	Asset management – Management systems - Requirements
ISO 55002	Asset management – Management systems - Guidelines on the application of ISO 55001

In forming ISO/PC251 we have engaged with many countries through their national standards bodies and currently have an active international participation in the process. The current participation is strong, with 24 countries registered as participants and a further 12 as observers (who get to see and comment on drafts but do not vote). The complex and inclusive nature of asset management also means that we get to engage with another 12 or so international standards committees whose activities interface with asset management. These numbers are growing all of the time.

Q What is the current status of this activity?

A ISO has fairly standard programs for the development of international standards, and we follow the default three-year program. This sounds very relaxed, but in practice ISO/PC251 will actually only get its hands on the real technical content for about half of that time. The rest is taken up with translation, international review, and balloting, as well as formatting for publication.

Stage name	Product name	Acronym
Preliminary stage	Preliminary work item (project)	PWI
Proposal stage	New proposal for a work item	NP
Preparatory stage	Working draft(s)	WD
Committee stage	Committee draft(s)	CD
Enquiry stage	Draft International Standard	DIS
Approval stage	Final draft International Standard	FDIS
Publication stage	International Standard	IS

The three-year program takes us through a number of stages shown in the diagram. We are currently in the middle of the preparatory stage and have recently circulated the second set of working drafts around the committee members, with a view to having detailed comments returned in time for our next meeting in Arlington, VA in October this year.

Our plans are to enter the committee stage shortly after our Arlington meeting. Currently we are running on schedule, and as this continues we expect publication of our three standards in the first quarter of 2014

Q The British Standards Institution's PAS55 Asset Management Specification has received a great deal of attention recently. Will the upcoming ISO standard build upon this work?

A Definitely. The Institute of Asset Management was a key driver in the development of PAS 55, and it remains so in the ongoing development of the ISO5500x series of standards. Its aims are to grow the discipline of asset management and capture good practice wherever it can be found. With this in mind, the key aim of ISO/PC251 is to build on the consensus already gained with PAS 55 and develop it further into the ISO5500x series of standards.

We see no point in just taking PAS 55 and putting it into a new cover, though. As the chairman of ISO/PC251, I can confirm that we have very enthusiastic and vigorous debate about many of the points. Following our first meeting in Melbourne early in 2011, we were already seeing an evolution in the structure and content of the document. This is being driven by the inclusion of people, industries, and countries who were not previously involved in the development of PAS 55. For me this is exciting and refreshing.

Q Why should organizations be interested in an International Asset Management Standard?

A The original intent of PAS 55 was to develop a common language for asset management. This common language will enable people from different functions within an organization, such as accountants, engineers, senior management, and technicians, to talk to each other about the fundamental issues we all face regarding how we invest in the assets we manage. Moreover, it is intended as a common language to enable companies to talk to each other whether they are in the same industry or not, as well as across national boundaries.

In developing this common language over a period of almost 10 years, so far PAS 55 has captured a significant amount of good practice from a wide variety of industries and from around the world. Whilst PAS 55:2008 had input from around 49 organizations representing 15 industries in 10 different countries, the ISO/PC251 committee has 24 countries and many hundreds of organizations providing input to grow this common language around asset management good practice. It is difficult to conceive of any organization not wanting to learn from this collective experience.

In terms of cross-sector learning, I regularly witness and facilitate organizations from completely different industries exchanging techniques, approaches, and practices related to asset management using PAS 55 as a starting point. This can only be good for all asset managers.

Q We think that industry regulators and possibly risk insurers will take a keen interest in an International Standard for Asset Management. Do you agree with that assessment? Why or why not?

A This is a no brainer, a definite yes. Within a year of PAS 55 being published back in 2004, we had interest from industry regulators in the UK seeking to use a risk-based management system approach like PAS 55 to demonstrate to consumers that private companies with stewardship responsibilities for critical infrastructure like power grids, gas pipelines, and railways are being looked after appropriately and for the long term.

I am now aware of regulators in the Netherlands, Canada, and Asia who all encourage the use of PAS 55. There are, however, parts of the world where a specification published in the UK is seen as not being appropriate for their geography, and I have had feedback from several countries where an ISO International Standard would be much more readily accepted. I genuinely believe that uptake of the ISO5500x series of standards will result in an explosion of enthusiasm for risk-based approaches to asset management in a selection of new territories. It could become a case of get engaged or get left behind!

Regarding risk insurers, I am aware of at least one power generation company who has used its PAS 55 certified status to reduce its insurance premium costs. The risk-based approach flows into the new ISO International Standards for Asset Management and should prove a useful tool for organizations to demonstrate to their insurers that they understand their risks and have them under control.

Rhys Davies speaking at the ISO PC-251 meeting in Melbourne (above) and at PAS-55 in Fort Myers, FL (right)

Q Are there any actions organizations can take now to prepare for an International Standard for Asset Management?

A Definitely. There is no need to wait until 2014 to get started. You should start to look at the benefits of adopting such an approach. There are more and more documented benefits cases from organizations that have reduced costs, improved performance, and used PAS 55 to align activities and break down silos in their operations. The work in ISO/PC251 is definitely evolving, but, you should remember that change is likely to be evolutionary, not revolutionary.

Whilst we evolve the way we describe the discipline and improve some areas of it, I can assure your readers that I see significant consensus around the intent of the developing international standards at my PC251 meetings. In my role as Director of Smart Asset Management Solutions, I am advising clients in a variety of industries about improving their processes. I still very much advise that they should start with PAS 55, as it will not prove to be wasted effort when the ISO5500x document come along.

For those more mature asset management organizations, they can still engage in the development of the ISO work. There is a US Technical Advisory Group (TAG), as well as similar committees in Canada and other countries around the world. Anybody interested in engaging and starting to network with other asset management enthusiasts should contact me for more information about how to get involved locally.

Q Looking 10-20 years ahead, what do you predict for the future of asset management?

A That is a really interesting question. I guess as a starting point, I would expect to see much greater uptake of the ISO5500x series of standards than there currently is for PAS 55. If you ask me what I see evolving in some of the best practice organizations with whom I work now, I think we could comfortably say there will be significant advances in some of the following areas:

- Greater alignment between engineering systems and accounting systems. Currently there is still a big divide between them in many organizations.
- A better grasp and understanding of enterprise risk management approaches in making asset management investment decisions.
- More confident use of risk-based inspection and maintenance regimes linked strongly into an understanding of the corporate risk profile.
- Greater use of real-time and near-real-time remote condition monitoring.
- Greater use of more complex deterioration models to aid planning.

I am sure there are more, but when you look at that short list, a key thing to note is that best practice asset managers are much more closely tied into the business end of their organizations. We need to be driving the business and not just looking after assets.

If you are interested in contributing to the new asset management standard working group, please email Terrence O'Hanlon at tohanlon@reliabilityweb.com.

PAS 55 2011

International Benchmark for Optimal Management of Assets

Scrapbook

MRO bookstore at PAS-55

Grahame Fogel, Pragma Acuity

From left: **Roy Cunningham (ScottishPower), Bill Fulton (Ivara), and Eddie Launhardt (ScottishPower)**

Lucky iPad winner Thiago Gontijo (right)

Ramesh Gulati, Author, Maintenance & Reliability Best Practices

PAS-55 Conference in session at RPI

Rhys Davies, Chairman ISO-PC251

Panel discussion from left: **Eddie Launhardt, Alan Roe,Grahame Fogel, Rhys Davies, Roy Cunningham**

Clive Deadman, Author, Strategic Asset Management

The conference gave a great overview of PAS-55 standards for AM and also for further developments.

Ulrich Neumueller
Senior Consultant
Siemens AG

The PAS-55 International Benchmark was EXACTLY that. International. It was very interesting to know where the ISO 55000 is headed. And, especially culture and leadership are being given equally important consideration along with the other elements of PAS-55.

John Wimmer
Senior Manager - Asset
AES Corporation

Like-minded professionals striving for asset management excellence.

Kim McArthur
Manager - Asset Stewardship
Hydro One Networks, Inc.

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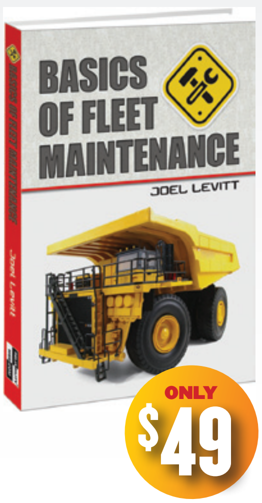
Basics of Fleet Maintenance

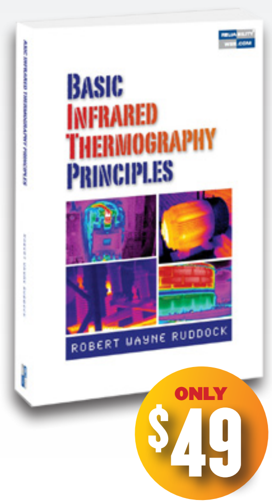
by Joel Levitt



This book is written in a clear, straight-forward style as it identifies important issues for managing fleet maintenance in today's environment. In addition to providing strategies and techniques for fleet maintenance management, this book is full of useful checklists, self assessments, real world case studies and a special list of 50 action items that you can use to rapidly direct your improvement efforts.

Basic Infrared Thermography Principles

by Wayne Ruddock

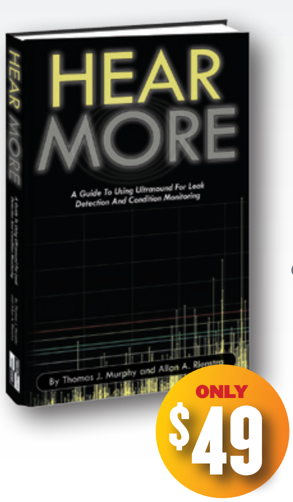


At last, a book written by and for infrared thermographers.

Although this book does cover most popular applications for infrared thermography, it provides deeper learning by explaining the physics and theory of this technology. Readers will be empowered to discover anomalies that could shut down your organization, or worse, cause a serious accident or injury.

Hear More

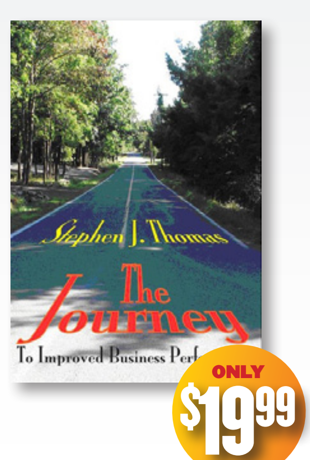
by Thomas J. Murphy and Allan A. Rienstra



In Hear More, the authors guide you through the use of ultrasound in condition monitoring, with each chapter dedicated to one of the many applications of this technology, along with real-life examples.

The Journey

by Stephen Thomas



While the storyline is a fictional account about business change made in a plant environment, readers will quickly realize that the tools found here can be successfully applied in all lines of business. Anyone working to make a change for the better in their business will benefit from this book.

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