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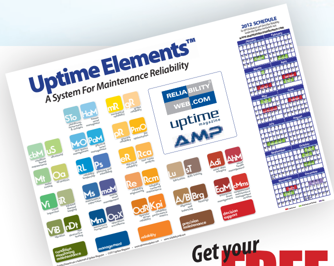


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## Features



## Elements



# Editorial

## Time For an Upgrade?

We all know how fast technology moves these days. I am the proud owner of an original Apple iPad™ but I have to admit, every time I see an iPad2 I think about all the things I could do if my iPad only had a camera and the other new features.

Do you remember the Apple II™ or Windows 95™ or even burnable CDs? These were huge innovations at the time but the speed of change in the world has accelerated. Now your smart phone has more power, speed and memory that your PC did just a few years ago.

Why this walk down technology memory lane?

Perhaps your maintenance reliability program could use an upgrade.

One of the most common phrases I hear when I ask a maintenance reliability professional why she is doing a particular task is the reply "because that is the way we have always done it" or "things will never change around here."

In fact, many organizations are upgrading to new maintenance reliability strategies, new maintenance reliability technologies and new maintenance reliability techniques to create world-class asset operations excellence. Just because you have not seen change at your organization does not mean the world is standing still. It is not.

We are seeing more and more maintenance reliability programs from South Africa, Brazil, even Russia, that are achieving results far beyond what we find in many North American and European plants. To be fair, we are also seeing some great programs right here in the USA and Canada but they are getting much harder to find.

More common are the memos and letters that friends share with me – as the corporate brain trust make the decision to end the reliability program. One such letter I read recently was written as a thank you.

*~ Thank you for all the great work on this long reliability journey. We have determined that as an organization we have now received all possible benefits from this work and we will be disbanding the reliability group immediately.*

Seriously, all the benefits have been realized? Either someone is smoking the latest harvest of California's number one cash crop or they are preparing the company or its assets for sale. Reliability is a journey, not a destination.

If that was the only letter of its type I see on a monthly basis, I would not pay much attention. It sometimes seems that it is more a matter of when a letter like this will be sent rather than a matter of if.

I had another friend who was hired less than 2 years ago to lead a maintenance reliability change for a large organization. That program has been cancelled after just 24 months. He emailed his resume to find out if I knew any companies that were hiring as he lamented, "*they offered to make room for me elsewhere but I asked myself if I wanted to invest my future with an organization that does not value reliability?*'

OK – have I bummed you out yet?

Take heart, we have just completed the Uptime Magazine Best Maintenance Reliability Program of the Year Awards and the competition was tougher than ever. These overachievers do not all take the same road to reliability, but they do share many common "winner" traits. You can see a list of the Uptime Award winners on page 59.

You are invited to gain inspiration, borrow their ideas and get their advice as they present their award-winning programs at IMC-2011, the 26th International Maintenance Conference being held December 5-8, 2011. (www.imc-2011.com)

Upgrade your maintenance reliability program and join us at IMC-2011 for the Uptime Awards, but also for three business-oriented keynotes, certificate workshops and incredible practitioner case studies.

You will also hear about our plans to provide even more access to the people, strategies, technologies and training you need so we can speed this maintenance reliability evolution and perhaps cause a maintenance reliability upgrade revolution.

Thank you for allowing us to do the good work we love to do and for letting us contribute to this incredible community.

I hope to meet you in person at IMC-2011 in December.

Warmest regards,

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


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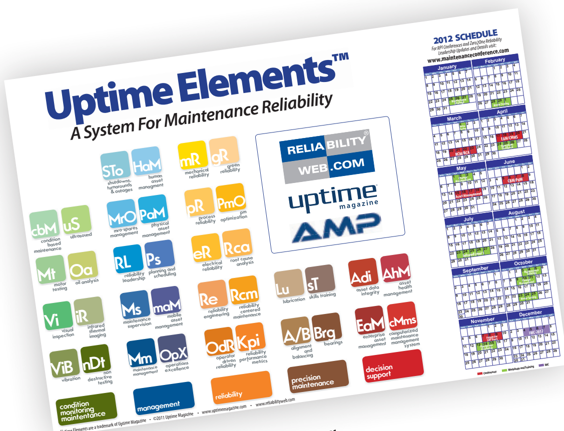


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## Communication - The Key to Effective Planning and Scheduling

Since maintenance planning and scheduling involves activities performed on the company's assets, all departments that use these assets should be involved. These departments include engineering, operations, facilities, MRO inventory and purchasing. Any of these departments can make the maintenance planning and scheduling activities successful or reduce them to failure. Communicating to these asset-related departments during interactive planning and scheduling meetings will significantly increase the probability of having a successful planning and scheduling process.

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Applying Best Practices to

# Improve System Availability

## at Metropolitan Sewer District of Greater Cincinnati (MSD)

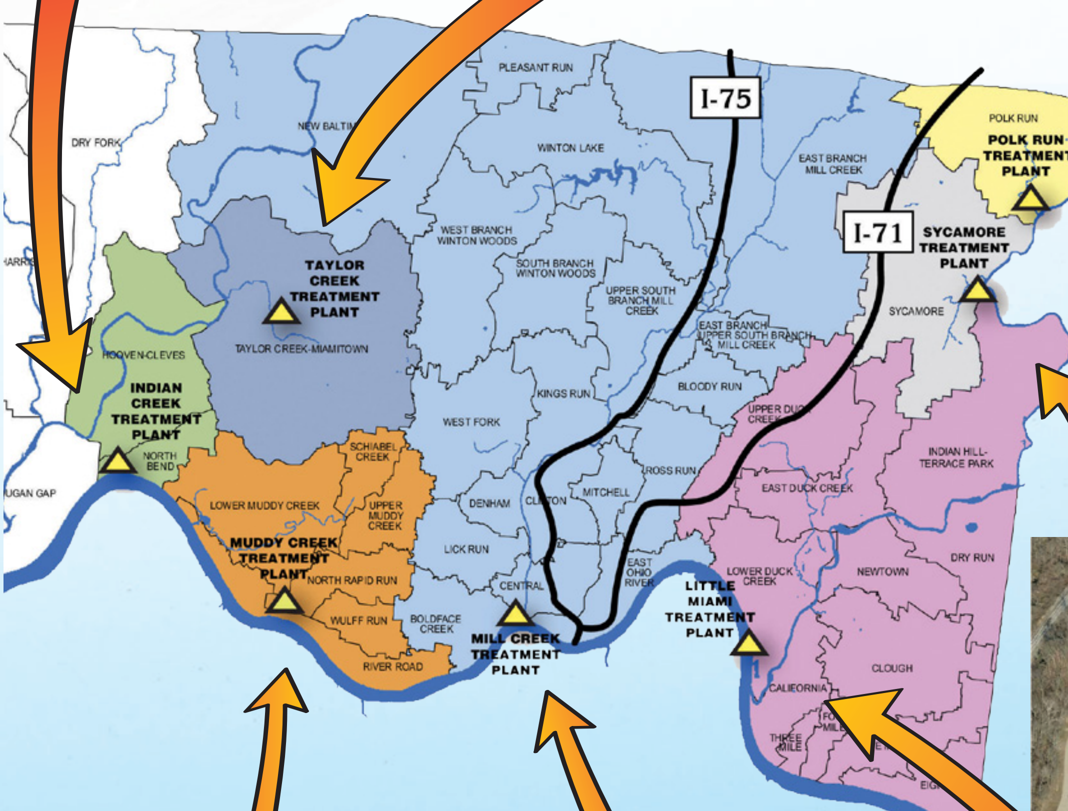
John Shinn, Jr. , Sam Paske, Anthony "Mac" Smith and Tim Allen

**The City of Cincinnati – Metropolitan Sewer District of Greater Cincinnati (MSD) serves 850,000 customers and has approximately 600 employees that work at facilities located throughout Hamilton County, Ohio. The Wastewater Treatment Division (WWT) within MSD operates and maintains seven major treatment plants and over 100 smaller treatment facilities that process an average of 180 million gallons of raw sewage per day. Most of the major treatment facilities were built in the 1950s and contain over 15,000 discrete assets that are critical to meeting MSD's mission of protecting public health and the environment through water reclamation and watershed management.**

Indian Creek Treatment Plant

Taylor Creek Treatment Plant

Polk Run Treatment Plant




Sycamore Treatment Plant

Muddy Creek Treatment Plant

Mill Creek Treatment Plant

Little Miami Treatment Plant

MSD faces many of the same challenges other organizations face – tighter budgets, increasing regulatory requirements, retiring workforce (disappearing knowledge) and aging/degrading infrastructure. To overcome these issues, the WWT Division is employing equipment reliability-centered maintenance (RCM) tools and methods. The RCM process is part of MSD's Strategic Asset Management Plan to sustainably meet customer expectations and reduce the risk of regulatory noncompliance due to asset failure while controlling costs. Supported by senior and executive management, MSD is implementing RCM to focus resources where the potential benefits are greatest to enable sophisticated operating strategies that improve system availability, regulatory compliance and costs.

Like many asset-based organizations, MSD has a long history of operating and maintaining a complex, capital intensive infrastructure. While MSD has a strong preventive maintenance program, the amount of corrective maintenance (CM, which is defined as repair work due to unexpected failures) and associated system downtime were undermining efforts for automation and energy savings. For the past five years during MSD's journey to move from a reactive to a proactive culture (Figure 1), our objective has been (and continues to be) the achievement and sustainability of high levels of availability (aka uptime) in the plants and treatment facilities.

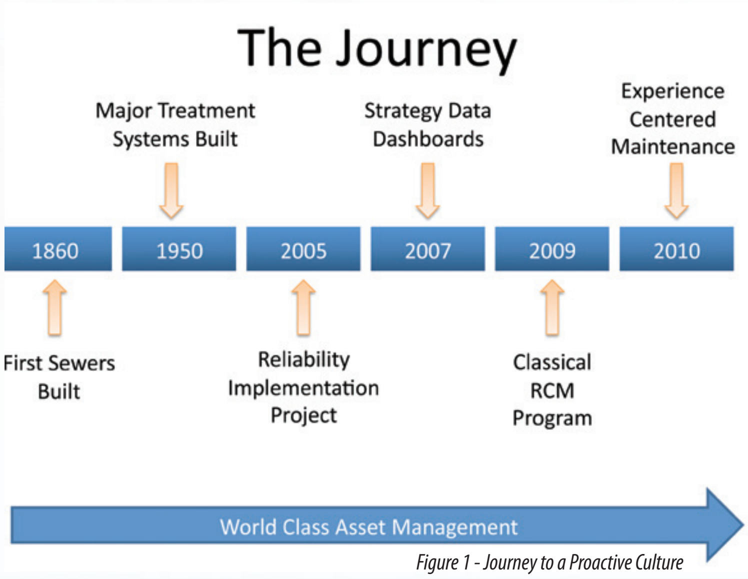



*Figure 1 - Journey to a Proactive Culture*

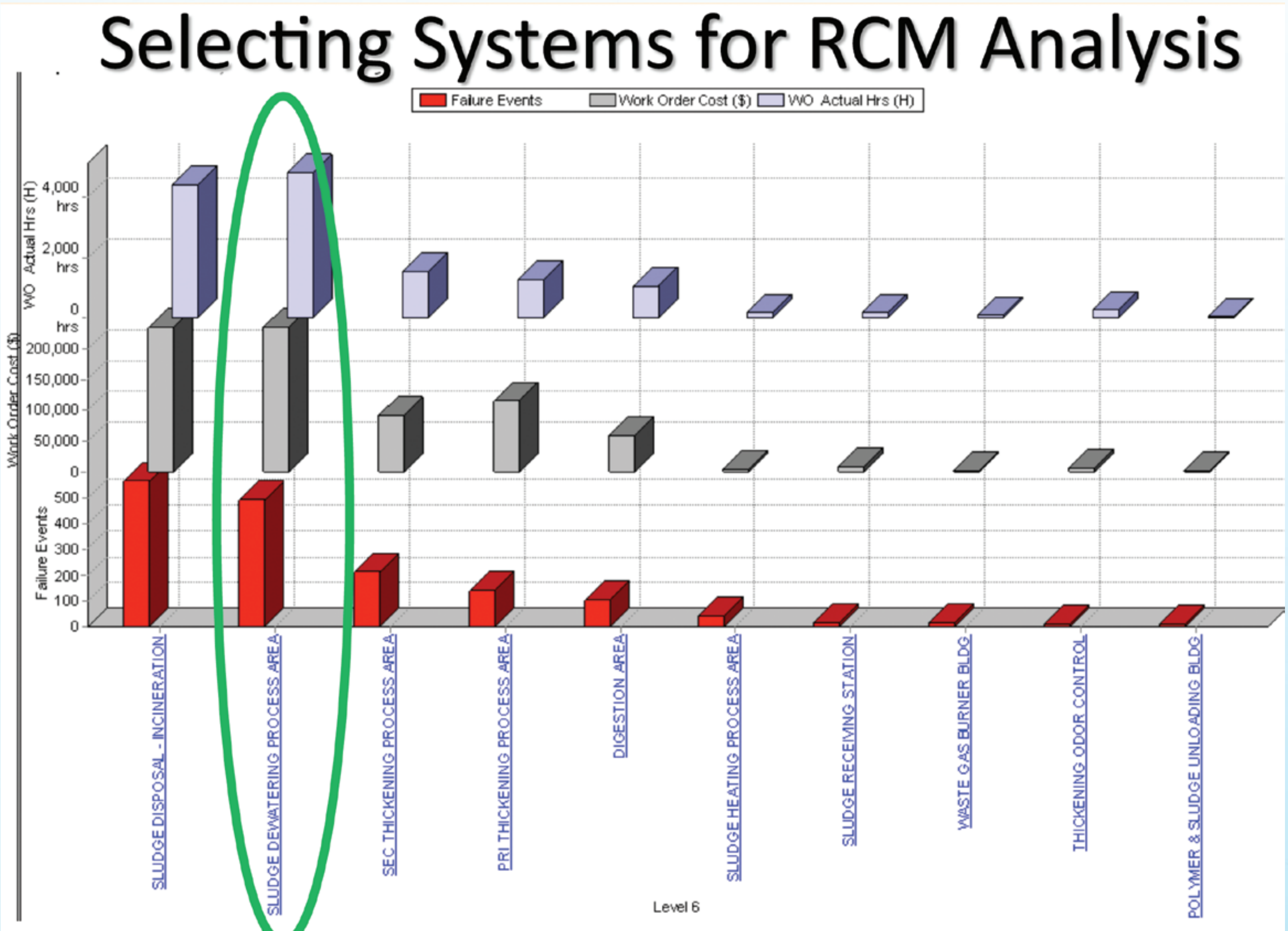
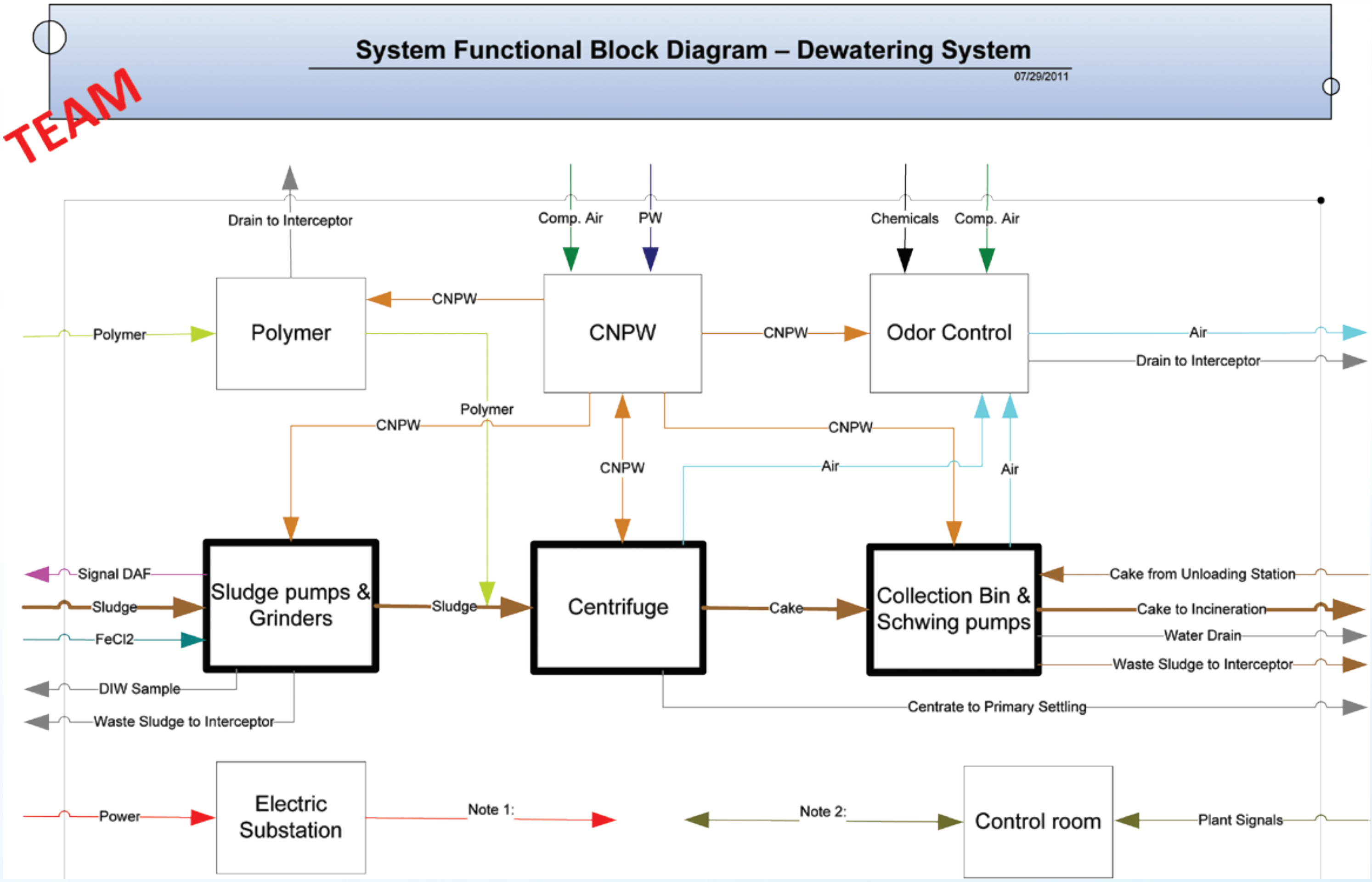



*Figure 2 - Selecting Systems for RCM Analysis*




Note 1: To all Subsystems   Note 2: To all Subsystems except Odor Control monitor only

*Figure 3- Defining the Analysis*

Simply put, this requires that we focus on two key parameters – Mean Time Between Failures (MTBF), which is a measure of reliability (how long the plant can run without a critical malfunction), and Mean Time To Repair (MTTR), which measures our capability to reduce plant downtime when these unexpected malfunctions may occur. To achieve this, we also needed to foster an important mindset shift within the organization away from preserving equipment (which often requires our attention on equipment problems that do NOT hinder the treatment process) to preserving function (which requires that we prioritize our attention and resources on assuring that critical functionalities are maintained). Making this priority distinction is also the underlying logic behind why some failures can be designated run-to-failure (RTF) – that is they do not defeat function, but just fix them at a time of your choice. Think airplane engines as opposed to passenger overhead reading lights!

Our traditional approach to improve process reliability has often been to use capital resources in troublesome systems to make design changes that increase MTBF. For the past three years, we have also embarked on the use of Classical RCM to restore (or maintain) the system's inherent reliability (MTBF) and to also decrease MTTR. The RCM process identifies critical plant or system functions and those equipment failure modes that can defeat them, and then prescribes preventive maintenance (PM) tasks to prevent, detect onset, or if hidden, discover these failure modes.

Initially, we looked at our largest treatment plant, Mill Creek, and specifically focused on selecting a system in the solids process stream using the 80/20 rule to address one area that was consuming a large proportion of maintenance resources. Using the past 12 months of corrective maintenance history for the 10 major systems in the solids stream, we compiled

| Number of | Collection S/S | Centrifuge S/S |
|---|---|---|
| System Functions | 6 | 6 |
| System Functional Failures | 12 | 12 |
| Components in System Boundary | 30 | 18 |
| Failure Modes Analyzed | 107 | 59 |
| - Critical (A,B, D/B) | 102 (95%) | 56 (95%) |
| - Hidden | 22 (21%) | 12 (20%) |
| PM Tasks Specified (including RTF) | 137 | 81 |
| Active PM Tasks | 101 | 58 |
| Items of Interest | 22 | 15 |

*Figure 4 – RCM System Analysis Profile*

data for failure event count, maintenance work order costs and work order labor hours. As you can see in Figure 2, all three data counts produced almost identical Pareto diagrams with sludge disposal and sludge dewatering being the obvious systems with the most corrective maintenance activity. We selected the dewatering process for our first RCM project. The sludge disposal system was not selected since it was in the midst of a capital improvement project.

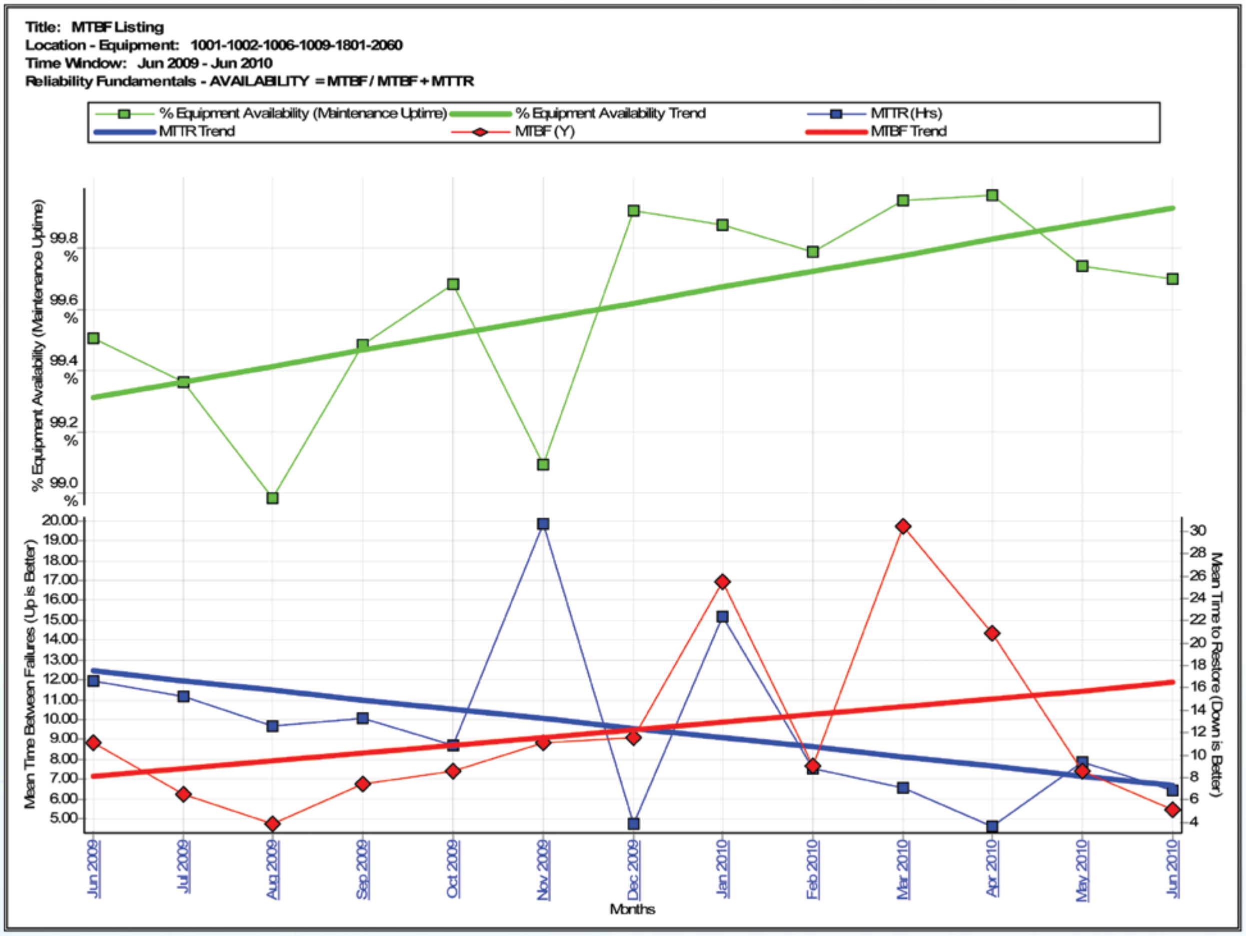



*Figure 6 – Dewatering Results, 6/2009 to 6/2010*

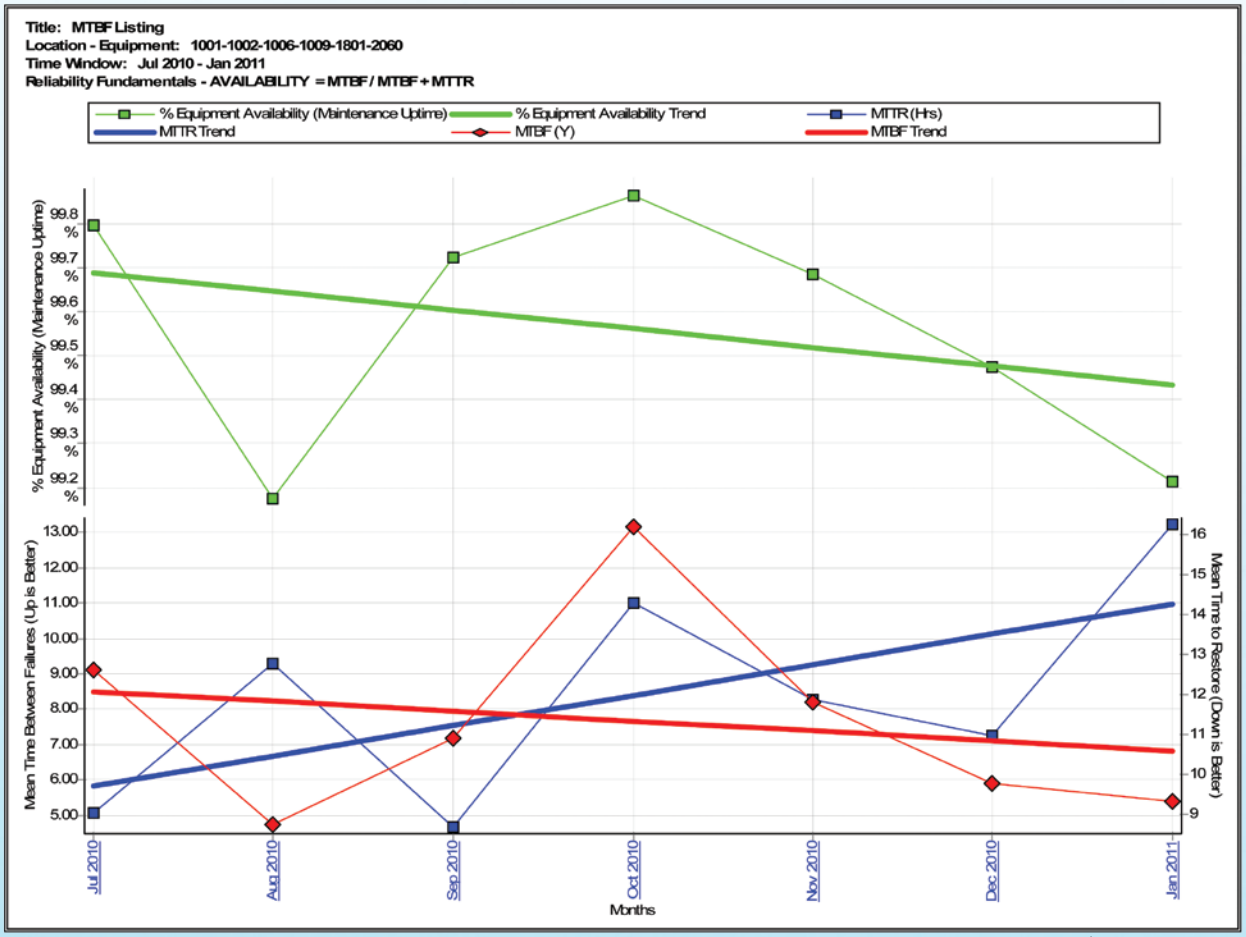



*Figure 7 – Dewatering Results, 7/2010 to 1/2011*

Figure 3 shows how we divided dewatering into eight separate subsystems. Our data further revealed that the three subsystems in heavy black boxes were the leading culprits responsible for the majority of corrective maintenance and downtime issues.

A team of six craft technicians (both maintenance AND operations) performed the RCM analysis on two of the subsystems (collection and centrifuge). The results are summarized in Figure 4. Notice that we had 12 functions to preserve – or conversely 24 functional failures that could lead to unavailability issues. Our detailed Failure Mode and Effects Analysis (FMEA) then identified 166 failure modes in the 48 components unique to these two subsystems that could lead to one or more of the functional failures. Of these 166 failure modes, 95% were critical (safety or outage consequences) and 20% were found to be hidden from the operator! This then led the team to define 159 active PM tasks to address these failure mode concerns. The analysis also identified 59 failure modes as run-to-failure – failures that were not critical to concerns about loss of function.

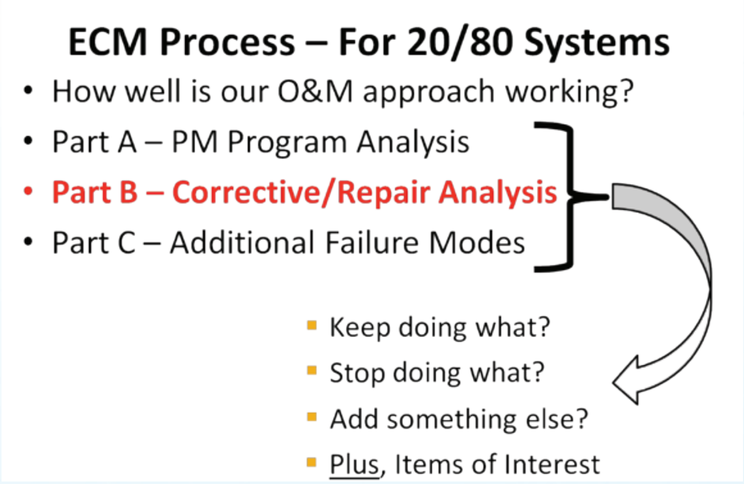



*Figure 8 – Experience Centered Maintenance (ECM) Process*

In Figure 5, we further review the significance of the 159 active PM tasks in a Similarity Profile – that is what is similar to or different between the current PM tasks and those recommended by the RCM analysis. The answer of most significance is shown in Line III (red) where overall some 40% of the failure modes in the RCM results suggest a PM task where currently NOTHING is being done. In other words, 40% of the critical failure modes were being ignored because they were NOT recognized as such.

The RCM-based PM tasks were implemented and the results looked great! Their impact on MTBF (red), MTTR (blue) and equipment availability (green) are shown in Figure 6. The benefits achieved from the RCM project

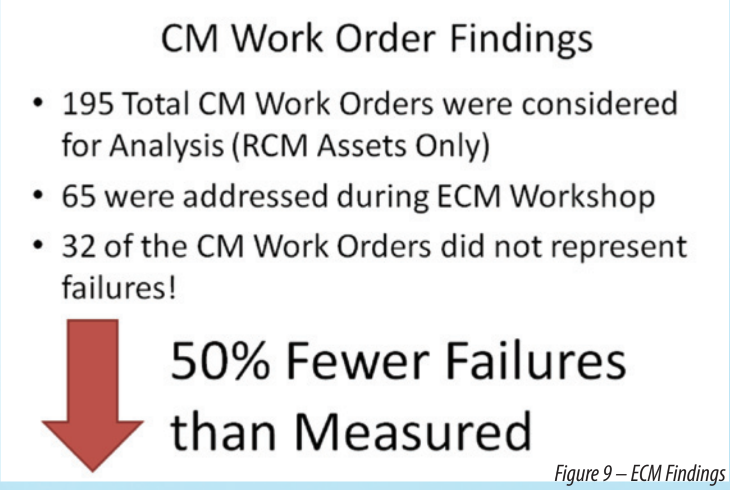



*Figure 9 – ECM Findings*

| Task Type | Collection | | Centrifuge | |
|---|---|---|---|---|
| I. RCM Tasks = Current Tasks | 22 | 16% | 27 | 33% |
| II. RCM Tasks = Modified Current Tasks | 9 | (7%) | 5 | (6%) |
| III. RCM Specifies Task, No Current Task Exists | 67 | (49%) | 26 | (32%) |
| IV. RCM Specifies RTF, No Current Task Exists | 35 | (25%) | 23 | (27%) |
| V. Miscellaneous | 4 | (3%) | 0 | (0%) |
| Total | 137 | (100%) | 81 | (100%) |

*Figure 5 – PM Task Similarity Comparison*

are striking. All of the important measures moved in the proper direction. Everyone was delighted.

As part of our living program, we reviewed the post-implementation dewatering system reliability and maintainability results as shown in Figure 7. Hey, what happened? Although the system availability was still high, all three measures reversed their positive trends. WHY?

The original RCM team was reconvened and a detailed review of the CM work orders was conducted. We used the experience centered maintenance (ECM) format (Figure 8), a data-driven analysis process employed for studies on the 20/80 (well behaved) systems to organize and document the review findings. We selected Part B of ECM, corrective/repair analysis, for a majority of the review effort.

We reviewed a total of 195 post-RCM implementation work orders, designated as CMs from the computerized maintenance management system (CMMS) for the components in the two subsystems studied in the original RCM project. We singled out 65 of these on the basis that they were the largest CM cost contributors and examined their history in detail. This led to a surprising finding – 32 or 50% of this group did NOT even represent component failures, but rather were mislabeled actions that were in reality maintenance craft hours spent in support of contractor work on upgrades to the dewatering system at its interface with a new fluidized bed incinerator (Figure 9). In other words, we had data quality problems in the crucial area of work order assignments to the correct action category. The problem was rooted in a lack of proper communication and focus on the importance of accurate labeling of the work order categories.

In light of this previous finding and its association with the incinerator interface upgrades, the team also revisited the original list of RCM-based PM task recommendations originally implemented. Surprise #2! The findings are shown in Figure 10. Notice the column of red numbers which, it turned out, indicated a total of 16 critical failure modes where the recommended PM tasks were NOT yet implemented in 2010. This was because some sections of the subsystem components were removed temporarily during the incinerator upgrade, and when they were returned to service, the PMs were not reinstituted. We also found, from further analysis of the valid CM work orders, that 11 new PM tasks should be instituted. Bottom line is the whole system was significantly "DISTURBED" and that had interfered with doing proper maintenance. Both of the above findings were being corrected as this paper went to press.

In summary, bringing in the best resources to enlighten us on our strategy, help people understand and apply it, and using internally the best A-Team staff (both maintenance AND operations) has been very effective. The Classical RCM approach really made the connection for us between critical process functions and the equipment that provided those functions - as described in the book "RCM – Gateway to World Class Maintenance" - as the necessary "connective tissue" that gives failure mode analysis real world meaning.

| Component Description | Part AM Tasks for RCM Failure Modes | | | Part B New FM from CM | Part C New FM, No CM |
|---|---|---|---|---|---|
| | Current & Working | New Task | Incomplete Implementation | New Task | New Task |
| Spur Gearbox | 1 | 1 | **2** | 1 | 1 (RTF) |
| Hydraulic Motor | 1 | | **1** | | |
| Schwing Pump, Feed Screw and Hopper | | | **1** | | |
| Screw Feed Conveyor Auto Greaser | 1 | | | 1 | |
| Schwing Cake Pump #2, Pump Unit | 2 | | **2** | 1 | |
| Main Hydraulic Unit (3 Internal Pumps) | 1 | | **8** | 8 | |
| Centrifuge AC Motor | 1 | | **2** | | |
| Total | 7 | 1 | 16 | 11 | 1 |

*Figure 10 – ECM Study Recommendations*

Some did not understand how important it was to implement and *continuously follow* the strategy developed by the RCM team. Some felt it was another flavor of the month. We learned that continuous communication and reinforcement is absolutely necessary. Without the continuous involvement of craft people, it will continue to be very difficult to make progress towards improvement. The craft people need to be the highest priority to ensure progress on the reliability-centered maintenance journey.

When it comes to implementation and execution, we must remember this is not a perfect process. RCM is very good at identifying what should be focused on and sets the stage for continuous process improvement. Once the RCM process has developed a maintenance strategy, we have found that focusing on implementation, continuous development and reinforcement is the key. When people stop adding value, the program will immediately begin to lose support.

Our approach to RCM has focused on delivering the best return on investment (ROI), both in time and money. In order to deliver the highest ROI, we attacked the worst actors (highest cost systems) with RCM based on maintenance history data. Basing business decisions on desired and actual results is a key management competency for MSD, but putting that into practice also involved cultural change. We learned that attention to data quality had to improve in order for us to be able to trust the information impacting our decisions. It is natural when reviewing results to identify imperfect areas in a strategy. But what if continued monitoring of the results shows them still not moving in the right direction? We learned that repeatedly tweaking the strategy only produces a continuous tweaking loop – not improved results. Rather, our focus should have moved from improving the strategy to ensuring 100% implementation of that strategy before any tweaks were made. The ECM process highlighted the fact that implementation, execution and data quality are just as (if not more) important as a good maintenance strategy. The ECM process was originally created to address non-bad actor systems (20/80) as a more efficient way to improve maintenance where the potential ROI did not justify a full investment in RCM. MSD's application of ECM to identify cultural issues related to a prior RCM study was a new approach and was effective in helping the most difficult aspect of continuous improvement – focusing the people in the right ways to make the best use of resources. The Metropolitan Sewer District of Greater Cincinnati has been nationally recognized for being a pioneer in this application of the ECM process; which was originally designed for 20/80 systems.

The continued support and vision of senior and executive management on this journey has been an essential element in fostering a culture that is striving towards becoming a world-class reliability-centered maintenance organization in the public and private sectors.

We've found that our simple approach to fostering a proactive culture based on proven best practices works, but it requires energy and, most importantly, time, considering MSD's significant number of assets (over 15,000) spread out over seven major treatment plants and 100 smaller treatment facilities. Commitment to follow-through at all levels is delivering results, and our efforts to continuously improve are being rewarded by noticeable culture change and success stories.

*John Shinn Jr., Maintenance Manager, Metropolitan Sewer District, City of Cincinnati. John has over 27 years of electrical, mechanical, instrument & controls, engineering and maintenance reliability management experience. He has developed and implemented both maintenance and reliability programs designed to optimize resources, enhance asset performance, increase operational availability and improve lifecycle cost of assets while working in the public sector. www.msdgc.org*

*Sam Paske is a Principal Consultant and Associate with Brown and Caldwell, an Environmental Services firm. He provides Enterprise Asset Management/Information Technology solutions focused on improving asset reliability to meet organizational objectives. He has more than 15 years of experience serving Public Utilities and Municipal Governments across the U.S. www.brownandcaldwell.com*

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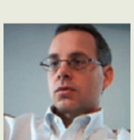


*Tim Allen joined Mac in 2005 after a 20-year career with the US Navy's Submarine Maintenance Engineering Planning and Procurement Activity (SUBMEPP). During his tenure, Tim was one of the principals in developing the submarine group's RCM process and rose to the level of RCM Program Manager. His efforts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

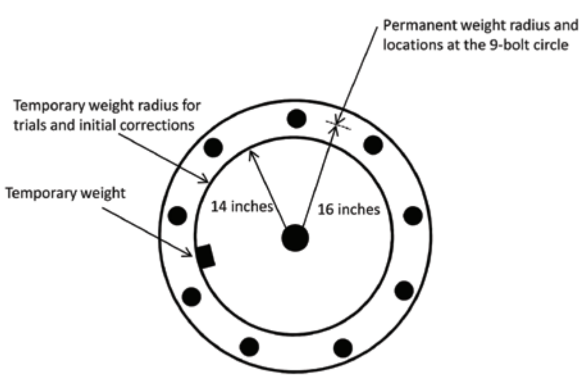
# Balancing Weights
# Radius Changes & Splitting

Dennis Shreve

**Oftentimes in real-world balancing applications, you will come across a way to get a quick measurement and make and verify an unbalance correction via a temporary solution with clamp-on weights or some type of balancing compound (like modeling clay or bee's wax).**

Now that you have pinpointed that the original vibration problem was indeed unbalance, you need to arrive at a *permanent* solution with the proper correction weights and locations.

As a hypothetical example, let's take a look at trying to balance a rotor, where weights (washers) can be placed only at nine evenly-spaced bolt head positions at a radius of 16 inches. See the illustration below.




For this example, it is determined that the rotor can be balanced within acceptable tolerance with a temporary weight of 2.2 ounces placed at an angle of 250 degrees and at a radius of 14 inches. Strictly for convenience and expediency, this is the same radius where all trial (calibration) and corrective weights were placed.

Now we need to go back to a fundamental relationship where unbalance is defined by weight X (times) radius relationship. Thus, to figure the proper weight at a radius of 16 inches at the same angle, we simply do a proportional calculation, where

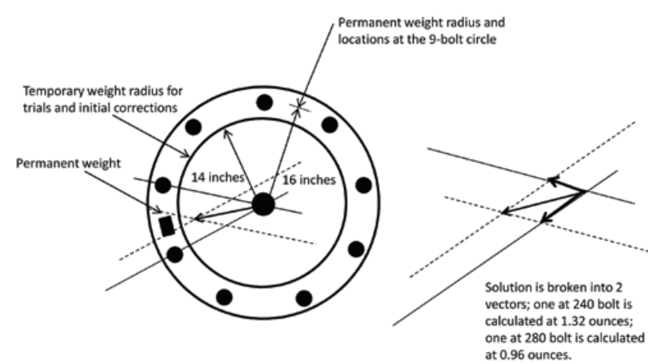
$w(t) \times r(t) = w(p) \times r(p)$

and *w* represents weight, *r* is radius, *t* is trial and *p* is permanent.

Plugging in the numbers,

$w(p) = [w(t) \times r(t)]/r(p) = [2.2 \times 14]/16 = 1.925$ ounces.

If a bolt head existed on this rotor at 250 degrees, we would simply pull out a combination of washers at a total weight of 1.925 ounces and we would be done. However, this is not the case, so we have to work out a weight splitting at the exiting bolts – one located at 240 degrees and one located at 280 degrees. This is accomplished with trigonometry and the "law of sines" for triangles or by a "vector splitting," as addressed below. First, let's take a look at the geometry one more time and concentrate on the balancing area on the rotor. See the figures below.




For vector splitting, we ideally would use polar graph paper for precision, but the procedure is to first draw a vector length at the 250 degree angle to represent the balance weight of 1.925 ounces. Next, we draw lines from the center at the angles where weights can be placed, in this case, at 240 and 280 degrees. After that, we complete a parallelogram with sides cutting through the end of the weight vector. Where these parallel lines pass through the angle lines then determine the proportional weight splitting. For this example, my original weight vector representing 1.925 ounces was drawn exactly at one inch. The length of the line at 240 degrees was measured at 25/32 inches, hence specifying 1.50 ounces. The line length at 280 degrees was measured at 9/32 inches, hence specifying 0.52 ounces.

Thus, we have arrived at a final clean solution, with washers weighing 1.50 ounces being placed at the bolt head at 240 degrees and washers weighing 0.52 ounces being placed at the bolt head at 280 degrees.

In concluding this discussion, it is interesting to note that even with all the sophisticated computer algorithms out there today doing most of the work, it is sometimes good to go back to basic principles and examples to better understand how radius changes and weight splitting can figure into your final balancing solution.

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# The Business of Asset Management

Terry Wireman

**This is the first of a two-part article focusing on the current attempt to produce an ISO standard for asset management. This article will focus on the business reasons for asset management and the first two phases of an asset lifecycle.**

Currently, there is an international effort to develop an ISO standard for asset management. While various committees work through the details surrounding the standard, it is necessary to review the business reasons that led to the need for an asset management standard. First, it would be beneficial to review the reasons that other standards, particularly ISO-9000, came into existence.

For any standard to receive wide acceptance by the international asset management community, it has to have a positive impact on overall business. Otherwise, it will be a standard that some can point to, but senior executives will not worry about compliance. The only reason ISO-9000 standards gained worldwide acceptance was because compliance became a business requirement. Once senior executives realized the importance the standards had to their continued profitability, they mandated that their companies become compliant.

This is why "line of sight" for any business is so important. Line of sight is basically organizational alignment to achieve a goal. For asset management, line of sight is connecting a company's business processes to accomplishing the company's overall business objectives. This could be compliance to governmental regulations, which is important to many organizations. However, for most companies, it is going to be profitability. For these organizations, it will be the answer to the question: "How will achieving an asset management standard help my company become more profitable?"

For profit-oriented companies, their line of sight could be illustrated by a diagram such as Figure 1, which illustrates a sample line of sight.

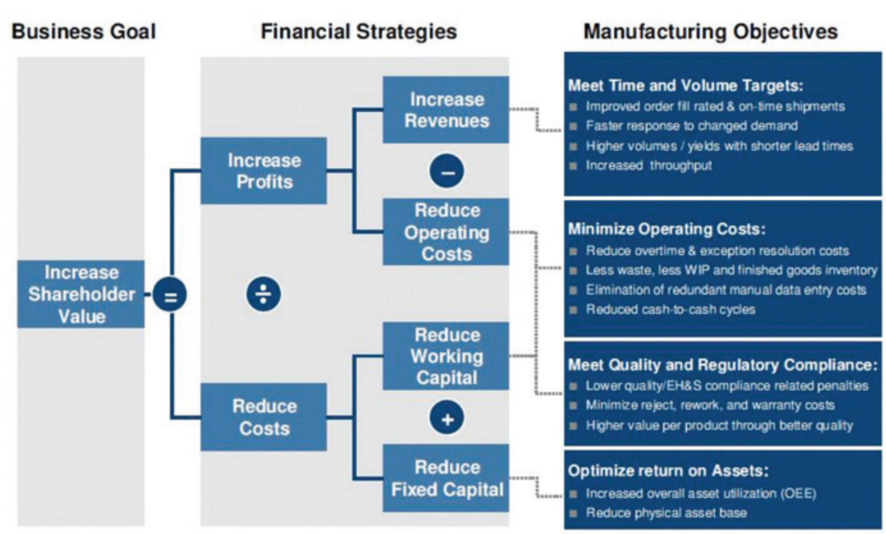


*Figure 1 used courtesy of SAP-AG*

Increasing shareholder value is the reason companies are being measured by indicators like Return on Invested Capital (ROIC) or Return on Assets (ROA). Both of these indicators (in the simplest terms) are profits divided by the investment in assets required to provide the profit, which most shareholders are interested in seeing. The investment in the assets is why an international asset management standard is going to be important to most companies. True asset management means to manage the asset through the entire lifecycle. Many companies over-invest in assets and literally have spare process/production lines in their plants/facilities just in case the primary line breaks down. One can quickly see what this business model will do to a company's ROIC or ROA indicator. An MIT study has shown that there are over two trillion dollars in under-utilized assets in the United States alone. One has to wonder what that number would be worldwide?

Other companies will design and install equipment/assets that do not meet the current business needs. When entering the operations and maintenance phase of the equipment/assets lifecycle, if it does not meet production/utilization demands,


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• 2.4" Armoured LCD display
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companies will push it beyond its design capacity. This results in the equipment/asset being unreliable, breaking down more frequently and wearing out prematurely. This also has a severe impact on the ROIC or ROA indicators. Capital dollars are then reinvested in rebuilding the equipment to bring it back to an acceptable baseline for some measure of the rest of its (now shortened) lifecycle.

This should highlight the fact that when a company uses the line of sight term, they have to be focusing on achieving business objectives, which for the majority of organizations is going to be increasing shareholder value by increasing profitability. When organizations examine the benefits of implementing an asset management standard, almost all of the existing data shows that the majority of the financial benefits are derived from improving maintenance and reliability practices. If a company focuses on achieving an asset management standard, it should steer the company in a direction that improves business; otherwise there is no business reason to adopt it.

## Asset Lifecycle Management and Asset Management Standards

Why is the asset lifecycle terminology so important to the development of an asset management standard? If companies are going to adopt an asset management standard that has any real meaning, it has to be built on the documented science of asset management. There are literally scores of facility management, plant management, engineering design, etc., textbooks that discuss this topic. There are scores of engineering courses taught worldwide on this topic. If an asset management standard does not contain accepted engineering principles, the acceptance of the standard will be diminished by the business communities that will benefit the most from accepting the standard.

Figure 2 highlights the main phases of an asset lifecycle.

Proper understanding of asset management requires a review of each of the major phases of an asset's lifecycle. This will highlight the potential business benefits of improving each phase of the asset lifecycle.

### 1. Investment Planning (Needs and Feasibility Assessments for Assets)

This phase of an asset's lifecycle begins with the discovery that there is (1) a new product or service that can be produced and sold, (2) a greater demand for an existing product or service, or (3) another facility location required to meet customer needs. The demand for new assets may also relate to meeting increased regulatory requirements for existing assets. The investment planning may involve:

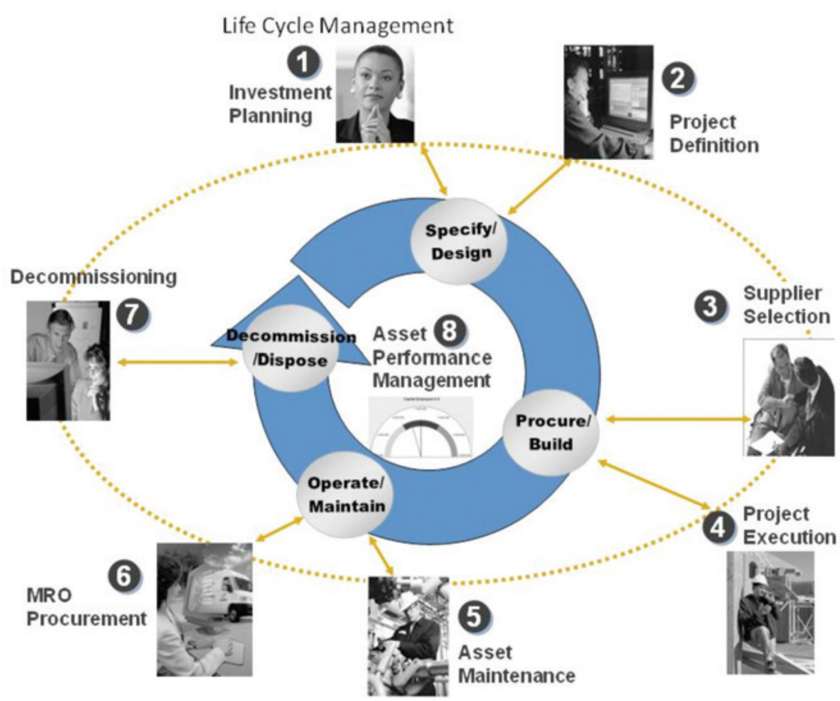



*Figure 2 used courtesy of SAP-AG*

***If an asset management standard does not contain accepted engineering principles, the acceptance of the standard will be diminished by the business communities that will benefit the most from accepting the standard.***

A. Strategic Planning
- The company direction is to diversify, expanding into new markets.
- The company direction is to expand their share of an existing market.

B. Customer Needs
- The customer demands modifications or enhancements to existing products or services that requires new assets.

C. Regulatory Requirements
- There may be new regulatory requirements that require extensive modifications (new assets) to existing buildings, facilities, processes, equipment, etc.

### 2. Project Definition (Design of Assets)

In this phase of an asset's lifecycle, the scope of the asset(s) is defined. For the asset to meet the demand (identified in Phase 1), it will need to meet certain requirements. There are certain reliability (how long the equipment operates in between maintenance periods), maintainability (how long it takes to restore the equipment to service), projected life and total cost of ownership (TCO) requirements that all assets need to meet to support the business requirements identified in Phase 1. For example, how long will the company occupy the facility? How many people will occupy the building? What is the volume of air the HVAC system must move to make the building comfortable? What is the thermal load the HVAC equipment must be able to handle during the four different seasons? The list can be quite extensive. (Note: There are a considerable number of books written on this topic. One is *Facilities Operations & Engineering Reference* published by RSMeans in 1999).

In addition to facility concerns, there are others that need to be considered. For example, what business need is met by a new production line? A new process? These assets will also have certain design reliability, maintainability, projected life and TCO requirements that all assets will need to meet in order for them to support the business requirements identified. What is the production volume that must be achieved to meet the business need identified in Phase 1? Will the assets be required to perform in 24/7 operations or will it be a 24/5 schedule? Reliability and maintainability are critical to the decision on capacity of the asset and the profitability (ROIC or ROA) of the new product/service.

This leads to the cost-benefit analysis. Will the company specify a facility building that is designed for 500 people when the business plan requires 100 employees? Conversely, will the company design a building for 500 people when the business plan requires 1,000? Both mistakes will be expensive. When considering production assets, if the assets need to produce, for example, 1,000 bottles of beer per hour, will the company design a line that produces 10,000 bottles of beer an hour? Or will it design a line that is only capable of producing 500 bottles of beer per hour? Any mistakes in designing assets, where the design is not based on the company's long-range strategic plan, will result in extreme financial penalties for the company.

It must be kept in mind that the asset at this phase of its lifecycle is still only a document, a drawing, or a blueprint. There have been no major costs (other than studies) done to this point. In fact, dozens of books written on lifecycle costing show that up to 90% of the lifecycle costs are specified (knowingly and unknowingly) by the asset design engineer. However, the same 90% of asset lifecycle costs are not incurred until the asset is in its operational and maintenance phases of the lifecycle. However, most companies overlook this fact and fail to achieve the profitability projections in the Phase 1 business study.

There are three calculations that a design engineer will focus on during the design of an asset. They are:

A. Reliability – A design specification that determines the period of time an asset will perform its intended function without failure. This is typically measured by the Mean Time Between Failure (MTBF) calculation.

B. Maintainability – A design specification that determines the length of time it takes to restore an asset to its functional state once a failure has occurred. This is typically measured by Mean Time To Repair (MTTR) calculation.

C. Cost-Benefit Analysis – A design study that shows the profits required from an asset versus the cost the asset will incur throughout its lifecycle. It may be measured by ROIC or ROA calculations.

How does the asset move from the drawing board to the plant floor? How do these calculations impact the asset during the rest of its life? How does a company maximize their return on investment in the asset? These and other questions will be answered in the second part of this article in the next issue of *Uptime Magazine*.

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

# Foundation for Maintenance & Reliability Excellence

## *A Comprehensive Asset Management System for a New Project*

Sridhar Ramakrishnan

**A robust asset management program is key to achieving operational excellence in any operating facility. This article explains the steps taken to put in place an asset management system for Suncor Energy Inc.'s new steam assisted gravity drainage (SAGD) facility in Alberta, Canada, before the plant is even commissioned.**

Identifying ahead of time the right kind of maintenance to be performed at the right time for the right equipment using the CMMS/EAM system is a challenge that can only be overcome through effective partnership with all stakeholders.

The maintenance and reliability team in Suncor Energy's In Situ Business Unit followed a systematic three-pillar approach to set up master data, manage spare parts and develop maintenance programs. These three pillars form the Asset Management System (AMS).

In the AMS model, SAP (systems, applications and products) is at the front end and is used to drive the maintenance and reliability processes and tools – the three core pillars of AMS comprising of master data development, spare parts management and maintenance program development. The scope was divided into three parallel parts based on the engineering disciplines of mechanical, electrical, and instrumentation and controls (I&C). One of the important attributes of this model is the tag-based approach versus the much broader material requisition (MR), purchase order (PO), or criticality based approaches generally followed in the project phase.

Each and every maintenance significant tag is identified and included in this model. The AMS work started during the detailed engineering phase of the SAGD expansion project at Firebag and was completed just before commissioning and start up. The maintenance and reliability team collaborated with 12 different functional groups that included reliability engineering, site maintenance and supply chain, among others.

The AMS work also addresses all maintenance and reliability related hazards and operability studies (HAZOPS), technical decisions and deviations, and nonconformance reports (NCRs), in addition to those related to safety and regulatory requirements, like the measurement accounting and reporting plan (MARP), continuous emissions monitoring system (CEMS) and safety instrumented function (SIF) testing.

As a first step, approximately 100,000 physical pieces of tagged equipment were screened based on documented guidelines and close to 23,000 maintenance significant equipment were identified. Piping and instruments had the largest population comprising of 9,000 and 8,000 tags, respectively. Electrical and mechanical equipment tags formed 5,000 and 1,000 tags, respectively.

All 23,000 equipment (tags) were risk-ranked based on Suncor's corporate risk matrix. Master data was created in SAP for all of them based on master data standards and guidelines.

For spare parts, the maintenance and reliability team followed a failure modes driven approach and identified all those spares that were likely to be utilized during commissioning and start up and for a few years of operations thereafter. Materials masters (stock codes) were created in SAP for all such spares. The spare parts were then rationalized following documented guidelines and purchased. In certain cases, spare parts were rationalized in partnership with the equipment vendors. These spares were linked to the parent equipment in SAP through bill of materials (BoM).

Equipment strategy data sheets (ESDS) were developed for groups of equipment (tags) based on similarities of preventative and predictive maintenance tasks and their frequencies. The maintenance tasks themselves were identified through basic failure modes and effects analysis (FMEA). Maintenance procedures and check sheets were developed for all maintenance tasks identified on the ESDS. All ESDS, maintenance procedures and check sheets were reviewed by site teams, approved and uploaded in Suncor's electronic document management system.

The strategies were then translated into maintenance programs in SAP. The operations in task lists in SAP listed only *"what to do"* by way of key maintenance and inspection steps. *"How to do"* is made available in the maintenance procedures linked to individual operations in task lists using production resource/tool (PRT) functionality. This would enable maintenance proce-

*The group photo shows the Project Integration (Maintenance & Reliability) team turning over the completed AMS work to the Maintenance & Reliability management team at the operating site. Sridhar Ramakrishnan is standing 4th from left.*

dures to be printed off automatically along with the work orders.

For fixed equipment, risk-based inspection (RBI) studies were carried out for the loss of containment failure mode and the resulting inspection work plans (IWPs) were used as ESDS for such equipment.

It was observed that maintenance programs developed through the AMS work were distributed evenly between predictive and preventative tasks, and that the estimated costs for planned maintenance in the expansion project were approximately two-thirds of the planned maintenance costs for the existing operating unit (of comparable capacity and number of equipment). In addition, it is estimated that doing this kind of detailed work upfront has the potential to halve the annual corrective maintenance costs, too.

In addition to the linkages to the maintenance program in SAP, the ESDS, maintenance procedures and checklists were also linked to the associated equipment master data in SAP. All the HAZOPS, technical deviations and NCRs related to maintenance and reliability were also linked to the master data of related equipment in SAP, thus making all such critical information available throughout the equipment lifecycle.

The AMS work has helped commission the new facility with a comprehensive asset management system in place to address and manage all the new equipment and systems over their lifecycle. Doing so has also enabled the capturing of equipment maintenance costs and history, even during the commissioning phase.

The entire project involved 30,000 direct man-hours spread over 18 months. A tracking sheet was developed to measure and track every significant element in each of the three AMS pillars. The score was measured in terms of percentage completion for individual AMS pillars as well as for overall AMS.

The AMS work was turned over to the end users in the form of a main report containing the high-level summary of the work, supported by 19 appendices in Microsoft® Excel spreadsheets and Microsoft® Word documents that contained every detail of the work done. This report was signed off by senior management members. The scorecard recorded a 97% completion rate when the AMS work was finally turned over to the end users.

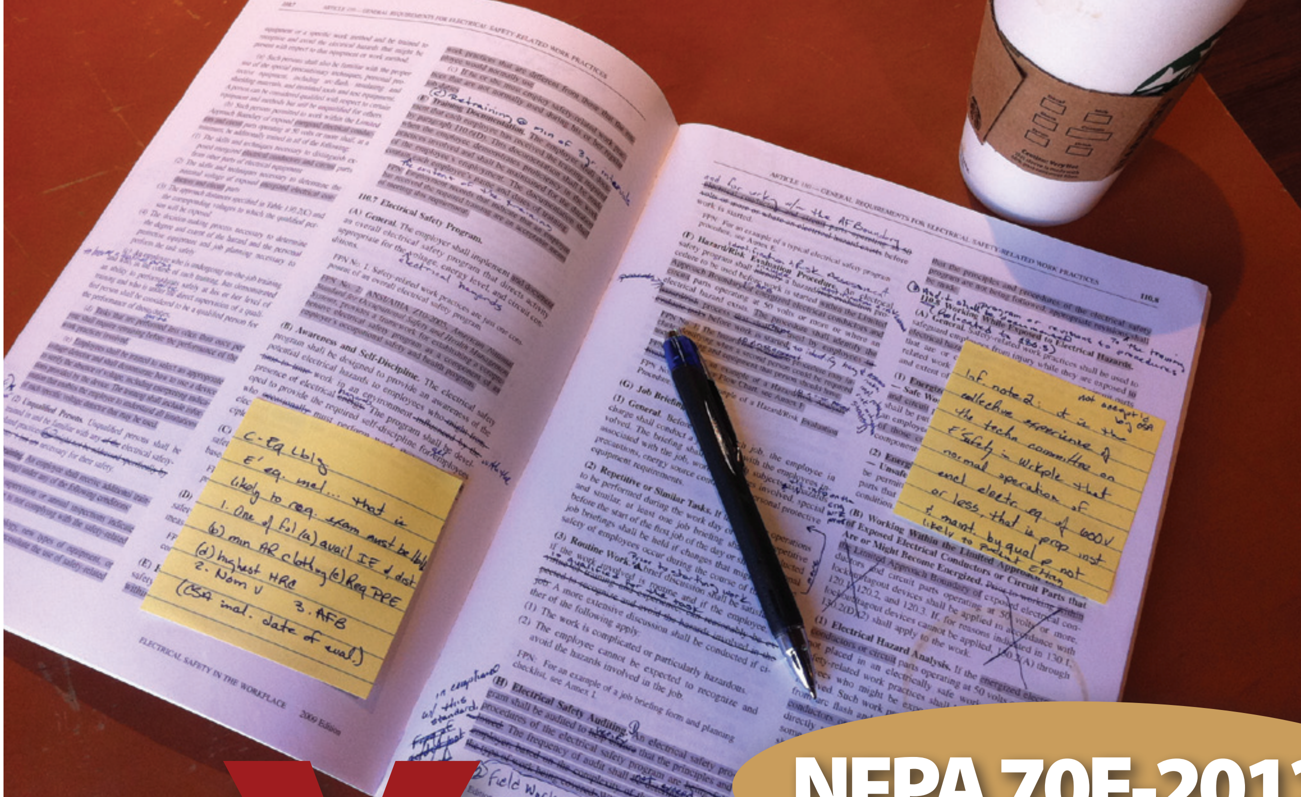
In addition to the hard copy binders, the complete AMS report was uploaded in Suncor's document management system. The report was also made available on CDs and distributed widely.

As part of operational excellence, the maintenance and reliability team is working on a plan to offer selective onsite support to end users for a period of one year. The support would be mostly on monitoring and controlling the changes to the maintenance strategy (part of the third pillar of AMS) in the first year.

This type of structured, diligent and detailed work will set up the end users for success by providing a head start on the maintenance maturity curve – thus laying the foundation for maintenance and reliability excellence. The AMS work is only a beginning in the journey for operational excellence. In the following years, efforts will be made to improve the work based on site feedback received from actual equipment usage and failures experienced.

Going forward, there are plans to replicate this work on all new SAGD projects in Suncor.

*Sridhar Ramakrishnan, P.Eng., MMP, Senior Reliability Engineer with Suncor Energy Inc., Calgary, Canada since 2007. His current role is to help establish sound systems, processes and methodologies to support Maintenance and Reliability excellence on new In Situ projects. Sridhar has been working in the upstream oil and gas industry for 22 years. www.suncor.com*



NFPA 70E-2012

# Are You Ready for the Changes?

Tim Rohrer

## The Evolution of a Standard

Standards can be thought of as an evolution. Generally speaking, any standard is a series of compromises between those who are attempting to change standard practices to reflect advancements in technology or knowledge and those attempting to maintain some version of the status quo. A friend of mine who introduced me to the standards process compared it to sausage making - "a pretty ugly process to watch, but the end product can be quite good."

NFPA 70E-2012 will be the ninth edition of the electrical safety standard since its inaugural publication in 1979. This revision cycle evaluated and weighed 500 proposals for changes to the 2009 document, and then considered over 400 comments on those proposals. The process is driven by these proposals and corresponding comments submitted by interested parties like you and me. So after this new revision is published, take some time to digest it and then fill out the Document Proposal Form in the back of the standard to propose any changes you would like to see in the next edition.

This article offers an overview of many of the likely changes you will see in NFPA 70E-2012. The changes noted are based on the 70E Technical Committee's *Report on Comments* (ROC) document from its meeting in Savannah, Georgia, in September 2010. Please keep in mind that actual changes to the standard could be different than those listed herein, depending on input received during the June 2011 Association Technical Meeting.

Note: The section numbers referred to in this document are based on 70E-2009. The clauses discussed herein may be numbered differently due to additions and subtractions in the revision, or some clauses moved to different sections of the standard. Furthermore, the author has taken some degree of license to add emphasis with bolding and italicizing that may not be reflective of the way those passages appear in the actual standard(s).

## Scope

Changes to Scope 90.2(A) clarify that the standard relates to "work practices," while it also adds "inspection" to the list of covered tasks (installation, operation, maintenance and demolition). The broader language "also includes safe work practices for employees performing other work activities that can expose them to electrical hazards."

## Electrical Safety-Related Work Practices

Using the philosophy "if it isn't documented, it never happened," 70E-2012 has added several requirements for documentation and record keeping. The first such requirement, added to Section 110.5(C), will be for documentation of the meetings required between host employer and contract employees.

## Training and Observation

Training documentation has included the trainees' names and the training dates. Section 110.6(E) will now require employers to also record the "content of training" related to the standard.

The 2009 requirement for first aid and CPR training for "employees exposed to electrical hazards" in Section 110.6(C) will be broadened to include "those employees responsible for taking action in case of emergency." This change was made in consideration of sites with trained first responders on the premises. Training will also now include the proper use of an Automatic External Defibrillator (AED). Statistics show that when an AED is properly administered within three minutes after the heart has stopped, survival rates are as high as 74% versus just 5% without an AED.

New language mirroring OSHA 29 CFR 1910.269(a)(2)(iii) has been added under the training of qualified employees in NFPA Section 110.6(D)(1)(f), mandating employers to "determine through regular supervision and through inspections conducted on at least an annual basis that each employee is complying with" the standard. Additionally, Section 110.6(D)(3)(d) will be changed to require retraining on at least a *three-year* interval. This change is in keeping with the typical/anticipated revision cycle of the standard.

## Electrical Safety Program

Just as an electrical safety program and procedures outlined in Section 110.7(E) have been required for work performed inside the limited approach boundary (LAB), this requirement has been extended to work performed within the arc flash boundary (AFB) as well. Similarly, the requirement for a Hazard Identification and Risk Assessment in Section 110.7(F) will now be extended to work performed within the AFB as well. And in keeping with the theme, the requirements in Sections 110.9(A) and 130.4 restricting testing, troubleshooting, voltage measuring, etc. to qualified persons will apply not only to work done inside the LAB, but also the AFB.

In addition, the term "hazard/risk evaluation" has been changed to *hazard identification* and *risk assessment*. This change was generally carried through most parts of the standard. The basic logic being that the *hazard* is consistent regardless of a worker's interactions within a given application and should, therefore, be *identified*. However, the *risk* of triggering an incident is higher or lower based on several factors, including personnel tasks and interactions with the equipment, therefore, the level of risk should be *assessed* for each given situation.

Job briefings in Section 110.7(G)(1) will now be required to include the information on the Energized Electrical Work Permit (if such a permit is required). This was a logical addition when you consider why paperwork and documentation was needed in the first place if the information was not being shared with everyone exposed to the hazards.

Due to the important role that audits play in any continuous improvement plan, program audits under Section 110.7(H) will now be required at least every *three years*. Previously, this interval was left up to the employer. Additional requirements for auditing field work and documentation of audits were also added.

## Portable Tools and GFCI

Working with Ground Fault Circuit Interrupters (GFCI) Protection Devices received a full rewrite in Section 110.9(C). Workers will be required to use GFCI protection not only when required by local, state and federal codes and standards, but also when the worker "is outdoors and operating or using cord and plug connected equipment supplied by 125V, 15-, 20-, or 30-ampere circuits." When using equipment connected to other voltages/amperages, an "assured equipment grounding program shall be implemented."

An information note (IN) ("INs" have replaced "fine print notes" in the latest revision) has been added to Section 110.9(B)(3)(d) dealing with the use of portable electrical equipment in conductive locations. The hazard identification and risk assessment procedure "could also include identifying when the use of portable tools and equipment powered by sources other than 120 volts AC, such as batteries, air, hydraulics, etc., should be used to minimize the potential for injury from electrical hazards for tasks performed in conductive or wet locations." In fact, their justification for adding the note - as stated in the Report on Proposals (ROP) document - called the use of corded electrical tools/equipment "a last resort" in such environments.

## Underground Electrical Lines and Equipment

A new segment providing guidance on excavation has been added to the end of Section 110. It reads: "Before excavation starts and where there exists reasonable possibility of contacting electrical or utility lines or equipment, the employer shall take the necessary steps to contact the appropriate owners or authorities to identify and mark the location of the electrical lines or equipment. When it has been determined that a reasonable possibility for contacting electrical lines or equipment exists, a hazard identification and risk analysis shall be performed to identify the appropriate safe work practices that shall be utilized during the excavation."

***Just as an electrical safety program and procedures outlined in Section 110.7(E) have been required for work performed inside the limited approach boundary (LAB), this requirement has been extended to work performed within the arc flash boundary (AFB) as well.***

## LOTO

The permissible lockout/tagout (LOTO) controls in Sections 120.2(C)(2) and (D)(1) have been changed, eliminating the "individual employee control" method. The 2012 revision will only allow simple and complex LOTO methods.

## Electrically Safe Work Conditions

Section 130 now starts with a general statement that "all requirements of this article shall apply whether an incident energy analysis is completed or if the tables in Sections 130.7(C)(9) and (C)(10) are utilized in lieu of incident energy analysis." This should clarify the confusion among some table users who would overlook the other requirements of Section 130, such as energized work permits, etc.

Users will also notice that "Justification for Work" in Section 130.1 has been retitled "Electrically Safe Work Conditions." This subtle change emphasizes that de-energization is the preferred defense against electrical hazards, as prescribed in both NFPA 70E, OSHA 1910 and virtually every electrical safety regulatory document throughout the industrialized world. Also, where the standard had previously only required a de-energized state or "electrically safe work condition" when working inside the LAB, the same requirement now exists even when "conductors are not exposed, but an increased *risk of injury from arc flash exists*."

## Energized Electrical Work Permits

Energized Electrical Work Permits (EEWPs) under Section 130.1(B)(1) will now be required "when working within LAB or AFB of exposed energized conductors or circuit parts." This change tightens up the previous language: "when working *on energized electrical* conductors or circuit parts…"

EEWP documentation will also require additional details regarding all boundaries and Personal Protective Equipment (PPE) and other protective equipment to be used to protect workers from shock and effects of arc flash.

## DC Approach Boundaries

The new revision will provide some much needed guidance to direct current (DC) system users. Approach boundaries for DC systems will now be listed in a chart similar to the alternating current (AC) approach boundaries table in Section 130.2(C). Additionally, users of the HRC classification table for AC systems in Section 130.7(C)(9) will notice a similar table has been set up for DC systems and will be located immediately following the AC table.

## Arc Flash Analysis

The word "protective" has been removed from the "arc flash boundary" since there is nothing inherently "protective" about the boundary.

In addition, the exemption for 240V systems under Section 130.3 has been reworded. In the 2009 revision, the exemption was based on IEEE/ANSI 1584. But this section has been widely misinterpreted and is likely being clarified within the 1584 standard. The reworded exemption will be moved to an information note that reads: "An arc flash hazard analysis *may* not be necessary *for some* three-phase systems rated less than 240 volts. See IEEE 1584 for more information."

An information note has also been moved to this section from the HRC classification tables in Section 130.7(C)(9). The note warns that available arc flash energies may be higher than expected if current levels, or clearing times, are other than anticipated. The relocation of this statement is significant because the referenced increase in energy levels will occur regardless of whether one is using the incident energy calculation or the table methods of determining PPE and approach boundaries.

Users also will notice a shift throughout the document from "flame-resistant" or "FR" to "arc-resistant" or "AR." This simple change should help to protect workers from the few unscrupulous manufacturers. Unfortunately, certain manufacturers have been promoting PPE that complies with FR standards for curtains or other irrelevant products, rather than for PPE.

The definition of the arc flash boundary in Section 130.3(A) has been simplified, eliminating the "four-foot rule" for low voltage applications. The new text will read: "The arc flash boundary for systems 50V and greater shall be the distance at which the incident energy equals 5 J/cm$^2$ (1.2 cal/cm$^2$)." Users of the table method will find guidance on AFB distances imbedded into the actual tables.

## Labeling

Previously, labels required "incident energy calculations or required level of PPE." This section has been expanded, giving workers more information to conduct their work more safely. "Electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field marked with a label containing all the following information:

1. At least one of the following:
   A. available incident energy and the corresponding working distance
   B. minimum arc rating of clothing
   C. Required level of PPE
   D. Highest hazard/risk category (HRC) for the equipment
2. Nominal system voltage
3. Arc flash boundary."

An exception has been provided for labels that comply with previous requirements and were applied prior to September 2011. However, the exception also requires documentation of "the method of calculating and data to support the information for the label."

***Personnel who work in the vicinity of overhead lines will sometimes mistake protective guards for insulation and consequently put themselves and coworkers in grave danger.***

## Personal and Other Protective Equipment

A new information note has been added to Section 130.7(A), relocated largely from the definition for arc flash hazard in the 2009 revision. The note states: "It is the collective experience of the Technical Committee on Electrical Safety in the Workplace that normal operation of enclosed electrical equipment, operating at 600 volts or less, that has been properly installed and maintained by qualified persons is not likely to expose the employee to an electrical hazard."

Factors in Selection of Protective Clothing under Section 130.7(C)(12) removed language suggesting that PPE "will normally be used in conjunction with each other as a system…" The committee also added the following very important change: "Garments that are not arc rated shall not be used to increase the arc rating of a garment or clothing system."

**New additions and changes were also made to these requirements:**

<u>Hearing Protection [Section 130.7(C)(number not yet assigned to this new requirement)]:</u> Hearing protection is now required when working

within the AFB. This requirement is now consistent with the Section 130.7(C)(10) table revised in 2009, which requires the use of hearing protection (inserts) for all HRC levels. Recent research shows that arc blasts can exceed the 140dB OSHA limit, generating sound levels similar to that of a gunshot and exceeding those produced by a jet engine.

Face Protection [Section 130.7(C)(13)(b)]: When inside the AFB and anticipated exposure is 12 cal/cm$^2$ or less, employees will now be required to wear either an arc-rated balaclava with an arc rated, wrap-around style face shield (protecting face, chin, ears, forehead and neck), or an arc-rated hood like that used in an arc flash suit. But when anticipated incident energy exposure is greater than 12 cal/cm$^2$, then an *arc-rated hood* will now be required.

Hand Protection [Section 130.7(C)(13)(c)]: "*Heavy-duty* leather gloves or arc-rated gloves shall be required for arc flash protection." An information note has been added, defining heavy-duty leather gloves as at least 0.03" thick, unlined or lined with non-flammable, non-melting fabric. This style of leather glove has been shown to provide a 10 cal/cm$^2$ arc thermal protective value (ATPV) or better. Also in this section, the information note regarding insulating rubber gloves received a makeover. Verbiage regarding layered FR material, HRC levels and shrinkage has been eliminated, leaving simply: "The leather protectors worn over insulating rubber gloves provide additional arc flash protection for the hands for arc flash exposure." Clarifying and simplifying this section is important because hands are often exposed to the highest levels of incident energy since they are often closest to the point of arc origination. Furthermore, research shows how effective this "low-tech" solution has been in preventing countless hand injuries to workers.

The 2012 edition will also provide users with a table in Annex H, matching PPE and clothing requirements to results from an arc flash hazard analysis. This is similar to the concept of the Section 130.7(C)(10) table that defines the PPE and clothing required for HRC level, which was often misapplied in the field. This action reaffirms the committee's stance that a facility that has performed an arc flash hazard analysis should not be using the tables associated with HRC values. Instead, those facilities should rely on the incident energy calculations and approach boundaries defined by their study - the more thorough and accurate manner of defining hazard levels.

Users of simplified, two-level PPE systems (8 cal/cm$^2$ and 40 cal/cm$^2$) will also find new guidance in Annex H for PPE selection when working on low-voltage systems and high-voltage systems with known short-circuit clearing times.

## HRC and PPE Related Tables

The Standards on Protective Equipment Table, and the corresponding Section 130.7(C)(8), will now follow the details regarding PPE requirement and care. Similarly, the famous HCR Classification Table in Section 130.7(C)(9), the corresponding sections and tables matching PPE and HRC levels in Section 130.7(C)(10)] and PPE characteristics with HRC levels in Section 130.7(C)(11) will now be located at the end of PPE Section 130.7(C). The positioning of these tables will assist with the flow and usability of the section and further limit confusion between the arc flash calculation method and HRC table method. One common misuse of the standard has been the mixing and matching of the two methods when they are intended to be an either/or proposition.

Some table footnotes and other critical information have been moved from the back of the HRC Classification Table in Section 130.7(C)(9) into the body. This change should help to highlight the characteristics of the systems to which the table applies. That information was easily overlooked in the previous revision, but is critical given the standard's direction that "for tasks not listed, or for power systems with greater than the assumed maximum short circuit current capacity or with longer than the assumed maximum fault clearing times, an arc flash hazard analysis shall be required…" Translation, if you are working on a system other than that indicated in the tables, then the HRC Classification Table is not an appropriate tool.

**Information now contained in the heading of each system class will include:**

1. Available short circuit current
2. Maximum fault clearing time
3. Working distance
4. Arc flash boundaries

Table users who work on panelboards and other equipment rated greater than 240 volts or up to 600 volts with molded case or insulated case circuit breakers will notice three new job tasks:

1. Removal of bolted covers - HRC 1, insulated gloves and hand tools not required;
2. Opening hinged covers - HRC 0, insulated gloves and hand tools not required;
3. Removal/installation of CBs or fused switches - HRC 2, requires insulated gloves and hand tools.

The committee has eliminated the HRC 2 classification in Section 130.7(C)(10). Face protection has been upgraded so that HRC 2 is the same as HRC 2*. Now, performing HRC 2 tasks will require either the use of an "arc-rated arc flash suit hood, or an arc-rated face shield and arc-rated balaclava."

New requirements for arc-rated hardhat liners have been added as well, with "as needed" (AN) for HRC 1 and HRC 2 and "as required" (AR) for HRC 3 and HRC 4.



## Overhead Lines

Personnel who work in the vicinity of overhead lines will sometimes mistake protective guards for insulation and consequently put themselves and coworkers in grave danger. The Section 130.5 standard will help to further protect such workers with the addition of the following requirement: "A qualified person shall determine if overhead electrical lines are insulated for the lines' operating voltage."

## General Maintenance Requirements

The standard will now include a statement that further underscores the importance of proper maintenance practices as a *vital and ongoing safety measure*. The new Section 205.3 will read: "Electrical equipment shall be maintained in accordance with manufacturer's instructions or industry consensus standards to reduce the risk of failure and the subsequent exposure of employees to electrical hazards."

Again, additional requirements are added to improve record keeping and documentation. Section 205.2 requires single-line diagrams to be kept current and legible, and the maintenance, tests and inspection of overcurrent protective devices will need to be documented.

## The Rest

Many additions, clarifications and changes were made to *Safety Requirements to Batteries and Battery Rooms* in Section 320 and throughout the annexes. Most notable are the significant rewrites and new titles to Annex F, *Hazard Identification & Risk Assessment*, and Annex H, *Guidance on Selection of Protective Clothing and Other Personal Protective Equipment*. Both will contain considerably more direction and detail on their topics.

## The Future of Electrical Safety

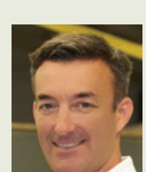
In the case of NFPA 70E, many of the changes through the years have been based on research presented at venues like the IEEE Electrical Safety Workshop (ESW). It is the stated mission of this conference to "change the culture of electrical safety."

The next ESW will be held in Daytona Beach, Florida, in January 2012. There you will see the future of electrical safety and the related standards, practices and technology. You will also be able to meet many, if not most, of the members of the NFPA 70E committee.

## In Conclusion

The 2012 edition of NFPA 70E is packed with too many changes to list in their entirety here. For a more in-depth look into these changes, as well as the logic behind the proposals and the committee's acceptance or rejection thereof, download the ROP and ROC reports from the NFPA 70E website (under the "Next Edition" tab). It is a great way to educate yourself on the evolution of the standard.

I was fortunate enough to attend the ROC meeting in Savannah, where most of the final revisions were debated and voted upon. I came away with an appreciation for how thoughtful and deliberate the process is. Yes, it had its sausage-making moments, but by and large it was an impressive, regimented process that will again yield a standard that will continue to be the model for the rest of the world.

*Tim Rohrer is President of Exiscan LLC, manufacturer of Infrared Windows. He was a guest at the NFPA 70E ROC meeting that finalized most of the changes for the 2012 revision and is very involved with several electrical safety standards committees, including CSA Z462, IEEE 1584, IEEE 1814 and IEEE 1683. Mr. Rohrer is a Level 2 Thermographer who has been involved in the Maintenance and Reliability community for most of the past decade. visit www.Exiscan.com.*

# Even I Can Understand That!

## Equipment Lubrication Made Simple

Paul Llewellyn

**My company recently hosted a Top Performers Meeting to which we invited our top ten lubrication consultants from the previous year to a getaway destination for relaxation, fun, fellowship, good eats and roundtable discussions.**

During a roundtable discussion on lubrication best practices, Dave Piangerelli, owner of Lubrication Technologies, Inc. of West Springfield, Mass., mentioned that lubricating equipment was a difficult task. I made the mistake of asking, "What's so difficult about lubricating equipment?"

The floodgates opened, answers spilling forth from all of the participants. I listened, but it was like trying to sip water from a fire hose. This is some of what I heard: polyalphaolefin (PAO), polyalkylene glycol (PAG), diesters, polyol esters, group I, group II, ball bearings, tapered roller bearings, environmental conditions, speeds, loads, temperatures, food grade, non-food grade, helical gears, herringbone gears, pins and bushings, hydraulic pressures, pneumatic actuation, cubic feet per minute (CFM), rotary screw compressors, blowers, exhaust fans, viscosities, elastohydrodynamic lubrication, combustion engines, pulverizers, ball mills, open gears, automatic lubrication systems, ….. My response to all of this: "Ahhhhhh … make it stop!"

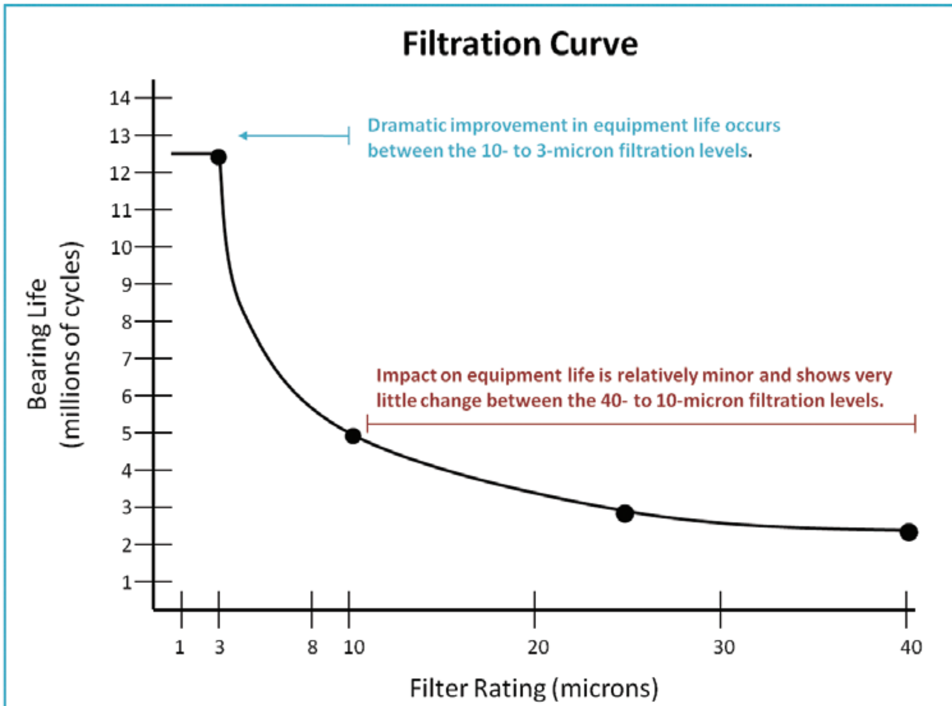



*Figure 1*

Source: *Influence of Wear Debris on Rolling Contact Fatigue (Sayles, R. and Macpherson, P.)*

The flow of information seemed endless. I thought to myself, "Wow, this is what maintenance and operation personnel must feel like every day. They must be overwhelmed! How in the world do they sort through all of it and still protect the 'rights' of the equipment (right lubricant, right place, right time, right amount, right quality, right personnel)?"

To make matters worse, there are fewer and fewer of these personnel, forcing them to take on more responsibility. They cannot afford to make a mistake. Cost per downtime hour is outrageous in manufacturing. The pressure on lubrication technicians must be intense.

### Embrace the information overflow

I found myself pondering ways that we could help these overloaded lubrication technicians. How can we take the abundance of information and the potential confusion related to equipment lubrication and wrap our arms around it – not to contain it but to embrace it and turn it into a positive? How can we use all of the information to increase production output while decreasing downtime? How can we turn this equipment lubrication monster into a moneymaker?

First, let us look at what we are trying to accomplish with a lubricant. At its most microscopic layer, no matter the piece of equipment, we are simply trying to separate two opposing moving metal surfaces with a very thin layer of oil. When I say thin, I mean two to seven microns thin. Remember, the smallest size we can see with the naked eye is forty microns.

### Start with viscosity

If viscosity is the most important variable when selecting a lubricant, how do we know what viscosity oil to choose? Should we just use the OEM-recommended oil?

Think of the tolerance between the opposing moving pieces of metal as a gap that needs to be filled. If the tolerance is tight like in an engine, it needs a thinner viscosity oil to fill the void. If the tolerance is loose like in a gearbox, it needs a thicker viscosity oil to fill the gap.

Can it really be that simple? Unfortunately, no. There are many other variables to consider, such as contamination and its effect on surface separation.

## Don't forget contamination

Leading bearing manufacturers tell us that 60% to 80% of all bearing-related failures are contamination-related. For the sake of this article, we will consider contamination to be particulate ingression of some kind, although water ingression is equally as detrimental.

Figure 1, which is based on a helicopter gearbox test, shows that the roller bearings only had marginal lifecycle increases when the oil was filtered of particles ranging from forty microns down to ten microns. A twenty-five micron rating is where filtration starts and finishes on most standard systems with an in-line filter. These results indicate that standard lubricant filtration will not effectively increase the life of the equipment that we depend on to make a profit.

For improved cleanliness that significantly impacts equipment lifespan, we need to take the oil offline, slow it way down, clean and condition it with quality filtration equipment, and then put it back in-line to perform its designed function. Look at the dramatic improvement in bearing life when we make it a point to improve the filtration below the ten micron level. When we improve from ten to three micron cleanliness levels, we go from five million to twelve million cycles of improvement – a more than twofold increase in bearing life.

At this point, the world of separating two opposing moving metal surfaces with a thin film of oil and the world of contamination come together. This is also the point where we can take what some people think of as a difficult task and turn equipment lubrication into a thing called making money.

## Proper lubrication + contamination control = profits

It makes sense. If we can limit the number and size of particulates that enter our oil reservoirs to as small as or smaller than the film of oil we are counting on to run interference between two opposing moving metal parts, then we can accomplish the following:

- Lengthen lifespan of parts, equipment and lubricant
- Increase time between failures/increase production
- Reduce friction, heat and wear
- Reduce energy consumption
- Reduce oil temperatures
- Increase oil change intervals/decrease waste oil/decrease new oil purchases
- Increase profits.

*Figure 2*

*Figure 3*

***Grandma always said that cleanliness is next to godliness. Well, I say that oil cleanliness is next to productivity and profitability.***

Grandma always said that cleanliness is next to godliness. Well, I say that oil cleanliness is next to productivity and profitability. It is a stretch, I know, but bear with me for a moment. If your lube room is a contamination nightmare with drums being stored on bare concrete, bungholes left open or filled with dirty rags, open top galvanized transfer containers with an inch of who-knows-what oil in the bottom, and dirty funnels lying about, then you are destined for failure. You might not fail with the Man upstairs, but you certainly will experience failure with the life of your oil and, more importantly, with the equipment that you rely on to make a profit. (See Figures 2 and 3.)

## It's up to you

So, make it a personal decision to be responsible for the protection of the equipment assets that your company relies on to make a profit, as well as the protection of the lifeblood of those assets – the lubricant. If you do, your reward will be increased uptime and an improved bottom line.

Remember, you are the one paying for the cost of failure – not the machine supplier, not the oil supplier, not the bearing supplier, not the filter supplier and not the analysis laboratory. All of these suppliers would love to sell you more stuff; trust me. Ultimately, it is up to you to decide what is best for your company. When you do decide, know that there are certified lubricant suppliers ready and able to assist you with the implementation of a comprehensive reliability program.

If you do not already have in place a lubrication reliability program playing a major role at your facility, there is no better time than the present. The old saying holds true: "Pay me now or pay me later," or said another way: "Don't pay for the cost of reliability with the consequences of unreliability."

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Will Templeton and Niels Martin

# Taming Your MRO Spend

## *While Unlocking the Hidden Savings in Your MRO Spares Inventory*

**Organizations spend over $500 billion annually on spare parts and supplies to support maintenance, repair and operations (MRO). So why do MRO and other "indirect materials" remain the ugly stepchildren when it comes to inventory and cost reduction initiatives? In short, it is because these initiatives can be both complex and risky. How do you keep enough material on the shelf to maintain equipment availability, uptime and service management while not breaking the bank? Read on…**

Asset intensive organizations often manage tens of thousands of items – spare parts, materials, equipment and supplies – to keep plants and facilities running. Procuring and storing this MRO inventory (indirect materials) is expensive, with large enterprises often maintaining tens of millions of dollars of inventory. A.T. Kearney's 2010 Indirect Procurement Study (http://www.atkearney.com) reports that indirect spending sometimes accounts for 50% of third-party spend in manufacturing organizations. Still, many organizations perceive direct materials to be more important, as reflected in relative perception (Figure 1) and procurement headcounts (Figure 2).

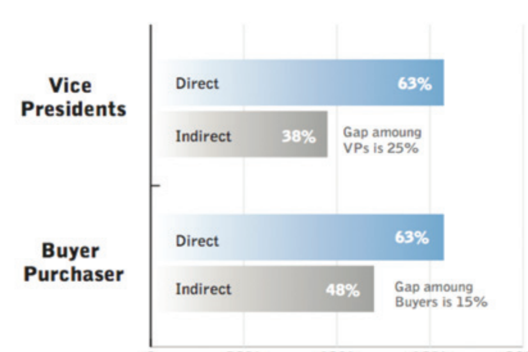
With this investment and activity, you'd think that organizations would focus more on managing their indirect/MRO materials spend. In fact, most try, but lack the proper information and analytics. This article will focus on optimizing your MRO spend by providing the proper information and analytics to tell you:

1. What to buy
2. When and how much to buy
3. Where to buy.

### "What to Buy" – The Importance of Clean Data

MRO data is notoriously 'dirty,' with incomplete, inconsistent and incorrect descriptions. Plant users can't find what they need and order "new" parts, while procurement can't determine what they are spending money on.

The solution is description cleansing and standardization. Unstructured, free-form text needs to be converted into structured data using a cataloging methodology and 'data dictionary' developed specifically for MRO. Industry standards, such as the Standard Modifier Dictionary™ (SMD™),[2] do this by providing:




*Gap in perception of Indirect procurement value among executives*

*Figure 1 Source: MSC Industrial Supply Company - Strategic Opportunities for Indirect MRO Procurement*

- Nomenclature specific to industrial MRO, which is more complex than that needed for direct materials. This should include a hierarchical classification such as a noun (class), modifier (subclass), characteristics and valid values.
- An unambiguous classification structure with a consistent and repeatable set of rules to characterize and catalog inventory. An item must be classified in only one place.
- Classification guidelines, definitions, images and synonyms/aliases. These not only assist users to choose the correct classification, they also assist those who search the catalog.
- Capability and rules to create short and long standardized descriptions for use in ERP/EAM systems.
- Compatibility and cross-referencing with upper-level classification systems (such as the United Nations Standard Products and Services Code® (UNSPSC®), covered later in this article).

The cleansed and standardized descriptions support users who work in the plant or procurement by making clear what exists, what is being used and what is being bought. Clarity eliminates duplicates and wasted spend.

Some companies choose to cleanse and standardize the descriptions themselves using a standard such as the SMD™, or outsource to companies that specialize in these activities.

## When and How Much to Buy – *The Importance of Correct Order Metrics*

MRO inventories are unique in that there are pockets of items with consistently high demand, while others sit stagnant with occasional demand spikes. Stockrooms hold critical "must-have" insurance spares, as well as over-stocked and obsolete items that you'll likely never use. ERP and EAM systems do not dynamically monitor and adjust order points, order quantities and lead times. This information is typically entered once when an item is first added to inventory and then managed by exception – such as when a stockout causes downtime.

It is vital in controlling costs to make sure that you are not over-ordering parts because you have the wrong order quantities and lead times (while also making sure you are not under-ordering). Common planning tools don't take into account the sporadic nature of spares usage. To address this, many companies have implemented an MRO inventory "decision support" service to optimize order points, order quantities and lead times. A Web-based service, such as xIO Inventory Optimizer™ [3], tailored specific for MRO can be swiftly implemented and interacts seamlessly with your ERP or EAM system, thus improving material availability and achieving cash flow savings.

## Where to Buy – *Addressing the Categorization Conundrum*

Companies often look to common categorization methodologies (such as UNSPSC®) to better understand where they are spending their funds in the hope that this will help them to improve performance and lower costs.

Since UNSPSC® categorization (and other similar approaches) have functioned reasonably well for direct materials, many assume that MRO/indirect spend can be managed the same way. Unfortunately, the complexities of indirect spend in general, and MRO in particular, have proven difficult to manage via UNSPSC® and similar tools.

For example, choosing a UNSPSC® category for a standard washdown duty 25 HP Baldor VL5000A motor requires categorization at either a generic "Electric Motors" category, or one of a number subcategories that could equally well describe the motor depending on usage (e.g. Compressor Motor) or design (e.g. Single Phase Motor). However, there is no category for perhaps the most relevant characteristic (i.e. washdown duty motor). As a result, users are unable to effectively group spend into relevant buckets using a standardized coding approach alone.

A customized categorization approach is needed that provides for "actionable" categorization. Categories must be both commercially relevant and manageable in scope. In addition to existing coding information, the customized categorization approach must account for such characteristics as description, usage, manufacturer, supplier/distributor, purchase methodology and geography.

For some categories, standard coding will be sufficient. For others, supplier or manufacturer information may be enough to effectively define an actionable category. More commonly, however, a combination of factors will be needed to develop effective categorization. Continuing with the motors example, one category that might be relevant is: Integral Horsepower AC Washdown Duty Motors. This category might be best identified by combining UNSPSC® data (Motors and all underlying codes), Descriptions (parsing for information such as "wash" in the description), Manufacturer (e.g. Baldor) and Manufacturer part numbering schemes that indicate washdown duty design.

| Area | Spend | Procurement Headcount (Corporate) |
|---|---|---|
| Total | ~$3.0 Billion | 101 |
| Direct | ~$1.2 Billion | 60 |
| Indirect<br>(MRO/Technical) | ~$2.8 Billion<br>($900 Million) | 41<br>(11) |

*Figure 2 - This example of a leading food manufacturer shows headcount often diametrically opposed to spend and complexity levels of direct materials versus indirect materials.*


*Figure 3 - Before and After Diagram*

What constitutes an "actionable" category? It is a grouping of goods and services that can be defined as a market. A category might be driven by a group of suppliers who provide similar goods/services (i.e. janitorial services) or a grouping of items that compete with one another (e.g. washdown motors), even though they can be obtained from a variety of sources (who also sell other goods/services and may not even consider each other competitors).

Effective categorization provides the foundation for a powerful sourcing program by enabling buyer specialization and the development of meaningful category sourcing strategies.

A recent project[4] for a leading protein processing company (revenues of about $15 billion) led with the development of actionable categories and followed with sourcing strategy development and implementation. Within eighteen months of engagement, supplier fragmentation for four major category groupings was reduced from over five hundred suppliers to ten suppliers. In addition, $90 million spend was reduced by 28% or $25 million, and the company was positioned to self-manage category strategies going forward.

## Actions You Can Take

Developing actionable spend categories depends on understanding what your organization is buying. The integrity and completeness of item master data is a critical input factor into the quality of categorization. It is recommended that item data cleansing, including an ongoing data management program, be implemented before or in concert with a categorization program. One approach that can drive quick benefits while retaining product quality is to do an initial (high-level) categorization based on existing data, cleanse item master data and then complete the lower-level categorization once the cleansing process has been completed.

**To summarize:**

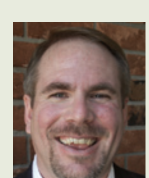
- What to buy - cleanse and standardize MRO item data
- When and how much to buy - optimize inventory levels
- Where to buy - analyze and reform your vendor spend.

Doing each of these has a direct impact on your bottom line by driving unnecessary costs out of your MRO inventory. The tools and processes covered in this article have been repeatedly demonstrated to bring not only a sustained impact on the bottom line, but positive ROI.

More information on this topic can be found at www.mroconnection.com.


References/Notes:

1. Source MSC Industrial Supply Company - Strategic Opportunities for Indirect MRO Procurement
2. SMD is a registered trademark of IHS Inc.
3. xIO Inventory Optimizer is a registered trademark of Xtivity Inc.
4. Project performed by OptiSource Solutions (www.OptiSourceSolutions.com)

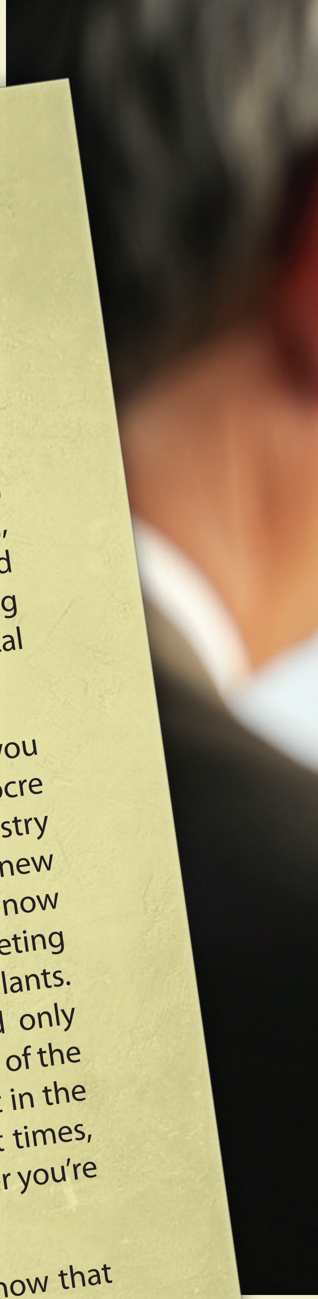

*Will Templeton, Intermat Solutions Specialist, IHS Inc. Will is a senior sales engineer for IHS Inc., working with IHS Intermat Solutions for MRO data cleansing, cataloging and inventory optimization. Will has over 15 years experience dealing with data and data management issues. www.ihs.com*



*Niels Martin, Founder & Managing Director, OptiSource Solutions LLC. Niels is the Founder and Managing Director of OptiSource Solutions LLC, which develops and provides customized solutions and strategies in the Operations, Procurement and Sourcing arena. Niels has over 20 years of Technical Procurement and Operations experience. www.optisourcesolutions.com*

management

HaM human asset managment



# Dear CEO:

The purpose of this letter is to provide you with the benefit of my observations over the past few years with the hope that it will help in your efforts to move the company forward. These observations are blunt and intended to inform, not to offend. Specifically, my hope is that they will help you understand the negative impact that your compensation is having on the organization, and ultimately, the success of your company. But before continuing, let me introduce myself. I'm Ron Moore, a middle manager and one of your most loyal and longtime employees. I've served the company for the past thirty years, but will be retiring next week. Before leaving, however, I wanted to share these observations, which are typical of most all my peers and subordinates, and indeed the majority of your employees.

While we think you've done an OK job, perhaps a C+ or B- overall, we don't think that you deserve the millions that have been showered upon you for what amounts to mediocre performance. Our company's profit over the past several years has been near our industry average, likewise for our return on capital and revenue growth. We currently have no new "blockbuster" products pending that I know of. In fact, we've been concerned for years now about how little we've spent on R&D for new products and processes; on our marketing and distribution systems; and particularly, on maintenance in our manufacturing plants. Even more troubling is that these modest profits seem to have been achieved only because of the company's short-term cost-cutting in these areas, putting the future of the company at risk. Perhaps you'll be gone by the time these effects are realized, but in the meantime, you certainly do talk a good game. Your eloquence is mesmerizing at times, but given the company's performance compared to your pay, it's not clear whether you're dazzling us with brilliance or baffling us with bullstuff.

Let's be clear. We believe you deserve to be paid handsomely. But did you know that you've received pay raises of 10% to 25% per year over the past five years, but we folks doing the work of keeping the company running have received 3% to 4%? Or, did you know that your pay over the past several years has been some 400 times that of our average hourly employee? That's up from 40 times the average some 30 years ago. Imagine – you could have saved 300 jobs by receiving a mere 100 times that of the average worker. It feels like we do the work and you get the money. Somehow that doesn't seem fair, nor does it align our interests with company interests. Quite the contrary. There's just something wrong about this – you are getting a huge payout at the expense of your employees, particularly those who have been laid off. It's demoralizing. Many of us (not me, I'm retiring) spend our time worrying about whether we're next to be laid off, as opposed to looking for ways to help the company do better. Did you know that we surveyed fifty of my peers last year regarding your pay? It revealed that middle managers were resentful of what they considered your excessive pay. While they were committed to their jobs, they were *not* committed to the company, *nor* fully engaged in executing your strategy. It gets even worse when you talk to the union leadership. They're questioning giving up

*Continued on page 42*

# CEO Compensation and Company Performance

# An Open Letter to the CEO

Ron Moore

**This letter is fictitious, but it is based on data from over 20 different studies, as well as anecdotes from various companies and the experience of the author. Feel free to pass it along to your CEO.**

*Continued from page 40*

benefits and pay when you're being rewarded excessively at their expense; and they're questioning improving productivity only to see jobs going overseas, or simply going away. Something is wrong when regular payrolls are skinny and your pay is obese. This situation makes your strategy untenable and puts the company's future at risk, notwithstanding how eloquently you present it.

Now, just so you feel better about all this, your situation is much like most of the Fortune 500 companies. There are numerous studies (I've read several personally) that show there is no correlation between CEO pay and company performance. One study found that over a five-year period, top executive pay increased by 77%, while earnings growth increased by only 17%. Your pay mirrors this performance. How would you feel if we expected huge annual pay raises for performance like that?

We understand that there are a lot of very intelligent people, including your board of directors, who rationalize your pay with certain arguments. By the way, Merriam-Webster says that to rationalize is "*to attempt to justify behavior normally considered irrational or unacceptable by offering an apparently reasonable explanation*." That describes our observations of your pay, which seems irrational and unacceptable, in spite of the efforts of your board to rationalize it.

One rationale that is often used to justify CEO pay is the sports star analogy. That is, sports stars command huge salaries commensurate with what the market will bear. So, too, the argument goes, should CEOs. *This argument is faulty*. Sports stars don't have thousands working for them or people who look to them as a role model for leadership, and fairness! Sports stars focus on their personal success more so than the team's, often with ego-maniacal behavior. Is this the model you want to emulate? Is this the model of behavior that will inspire your employees to make the company successful? Hardly. We believe that you have a fiduciary duty to put the needs of the company above your personal needs; and that you must lead by example, one that creates a sense of fairness, alignment and teamwork within the company. You currently do not.

Another rationale is the competitive parity argument. Unfortunately, all CEO compensation over the past two or three decades has been rising sharply, with each successive CEO chasing ever-increasing compensation packages using peer averages that have been climbing 10% per year while corporate profits have grown only modestly. If you listen to *Prairie Home Companion*, you'll recognize this as the Lake Wobegon effect, where *everyone* is above average. It's a statistical impossibility.

**So, what should you do?** We think you should use the principle that compensation must be **"internally equitable and externally competitive"** as a basis for developing policies and guidelines for executive pay. This simple principle is discussed below.

Internal equitability has to do with the perception that compensation is fair. If pay isn't perceived as internally equitable, morale and motivation will deteriorate and affect company performance, as demonstrated by the survey of fifty middle managers. We understand that totally eliminating any sense of inequity is highly unlikely, but having a clear policy that provides a transparent, well-communicated approach to compensation will help. You currently do not.

The vast majority of individuals expect that people of higher rank, authority, or responsibility will be paid more. How much more? Dr. W. Edward Deming suggested that once the CEO's compensation goes beyond about 20 times the wage of the average employee, a sense of *in*equity prevails. Warren E. Buffett has called executive pay the acid test of governance and "…often tells corporate chiefs to end practices ranging from huge CEO pay to incomprehensible financial reports." That's because the higher the gap between CEO pay and the regular worker, the greater the sense of inequity that's likely, therefore reducing morale and productivity. And, the greater the inequity, the more militant unions will be. This inequity is a huge distraction from the success of your company.

*As a matter of policy*, we believe you and your board of directors should follow the principle of internal equity and external competitiveness, applying the following in setting your compensation:

Overall industry performance must be used effectively as a normalizing factor. As the old saying goes, "Everyone's boat rises in a rising tide." Current policy ignores this. If the company's industry shows strong annual growth, return on equity, profits, etc., and the company is performing near the industry's average, then your pay should reflect average performance.

Strategic issues, and your pay, should relate to the company's success in three, five and ten years. Being strategic relates to your ability to understand the consequences of your decisions over the time frame associated with your level of responsibility. Incentivizing you with huge pay packages and stock options that vest in one or two years is ***not*** being strategic at your level of responsibility.

The concept of being strategic also requires fairness. Our annual results have been at the expense of reduced R&D and marketing, layoffs, low pay increases and longer hours for the people who do the day-to-day work to make the company successful, and you wealthier. These create a perception of unfairness, or inequity in the compensation system. If executive salaries are seen to reflect greed and abuse of power, an atmosphere is created where lower productivity, tweaking of expenses and other less than honest practices become common. It currently does.

Finally, as the lead representative of shareholders, you have an inherent fiduciary duty to lead the company in achieving a high level of performance, *long term*. You should not be paid extravagantly for doing the job you were hired to do. How would you respond to employees demanding significantly higher pay, year after year, for doing what they were hired to do?

In closing, we understand that in a global, capitalistic economy, the intense competition for survival and prosperity dictates that wages be constrained, *including yours*, and that productivity improvement be substantially greater than wage and cost increases to assure a continued competitive position. Those situations that lead to a dysfunctional and unsustainable outcome, i.e., extravagant pay for one person in an organization at the perceived expense of all others, must be avoided. Adam Smith, the father of free market thinking, believed that free markets also required sympathy, or caring for others and sharing the gains, and without that there would be a breakdown of the trust on which the market depends for its healthy operation. Moreover, Darwinian thinking is associated with the processes that create self-sustaining ecological systems, not simply the survival of the powerful for a brief period. Think of this as having equity and fairness in the pay structure so that the business system has a greater probability for survival and sustainability.

We believe that you have a fiduciary duty to diligently work toward the best interests of the company in applying these principles. How can we be a high performance organization if 99% of the people don't believe they share equitably in the success of the company? It's your responsibility to assure that they do.

We hope this has been thought provoking and that you will take appropriate action to address this issue. The company and its employees deserve no less.

Sincerely,

Ron Moore

*Ron Moore is the Managing Partner of The RM Group, Inc. He is the author of* Making Common Sense Common Practice: Models for Manufacturing Excellence, *and of* Selecting the Right Manufacturing Improvement Tools: What Tool? When? *www.MRO-Zone.com*

# Estimating Failure Avoidance Costs

Michael Cook and Michael Muiter

**Predictive Maintenance (PdM) programs bring value to an organization by detecting potential failures and determining how to correct them before the failure can occur.**

Many PdM programs are under-resourced or abandoned because the return on investment (ROI) generated by PdM groups is not obvious to management. If PdM programs are measured by their ability to avoid failures and the resulting failure avoidance costs (FAC) are quickly and accurately calculated and reported to management, the ROI will quickly become evident. Additionally, using the results of these savings from each predictive technology, i.e., vibration analysis, oil analysis, thermography, ultrasonic leak detection, etc., a determination can be made to decide if the technology is properly applied and if the frequency of inspections is appropriate to produce the highest possible ROI.

The FAC can range from correcting a loss of system efficiency - typical of air and steam systems - to partial or complete functional failures. Some failures have the potential to incur huge costs related to capital, labor, services, product materials and equipment. The FAC method attempts to estimate the most likely cost of a failure avoided using a standardized method for partial or complete failures.

The two basic elements of the FAC method can be easily explained through the P-F curve and a simple Risk Analysis matrix.

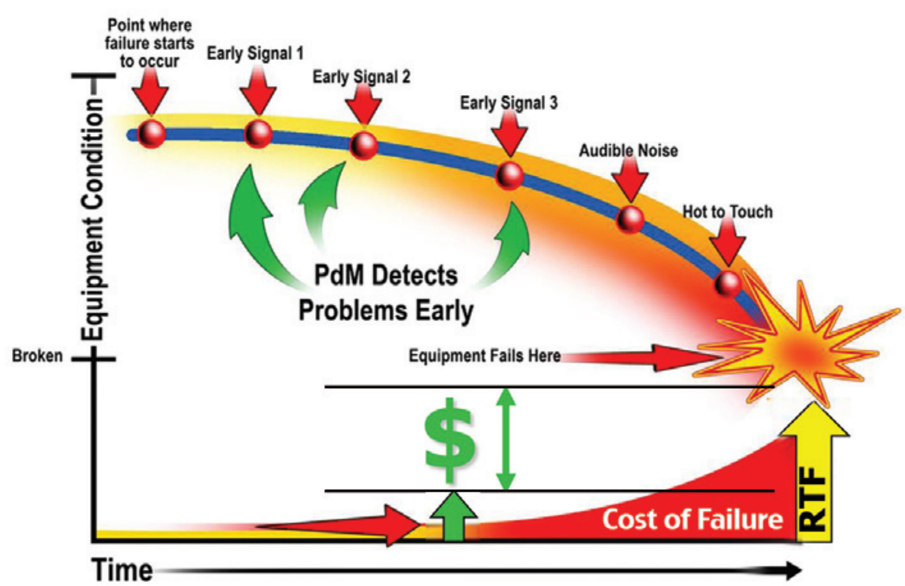



*Figure 1 - Copyright 2011, GP Allied*

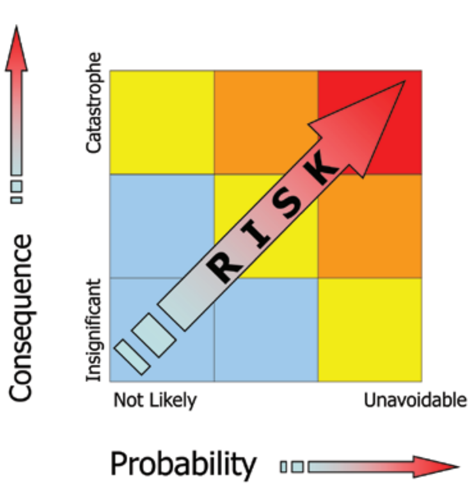



*Figure 2*

Savings are realized by avoiding failures that carry a high cost to repair and have an adverse effect on production, safety, or the environment. As shown in Figure 1, if condition monitoring identifies a problem at "early signal" points one through three, then the correction will have a minimal cost to repair and will have little or no effect on production. The failure avoidance costs are estimated by comparing the PdM costs to the higher failure costs when equipment is allowed to run to failure (RTF).

With differences in the FAC method, estimating this savings accurately lies in the use of a Risk Matrix to approximate the total risk for each failure avoidance case based on the conditions related to the failure and the criticality of the

# Calculating Return on Investment for Your Predictive Maintenance Program

equipment. PdM early fault indicators can run the gamut from symptomatic (loose belt, looseness, unbalance) to problematic (defective bearing or gear) and the consequence can run from no effect to catastrophe, as shown in Figure 2.

By estimating the potential risk and assuming that there is a point P that occurs before point F on the P-F curve in Figure 1, failure avoidance costs can be estimated.

Probability and consequence define risk and are used to accurately determine the potential of the individual failure scenarios without having to resort to an all-or-nothing estimation method.

- Consequence - Equipment/area specific information related to the range of severity of historical failures.
- Probability- Potential for the event to occur based on the current conditions associated with the PdM monitoring results.

### Information Collection

After an item is repaired as a result of a PdM find, information is collected related to the current installation and the identified failure mode. The following questions should be addressed: "If left to its own devices, what would normally happen if PdM did not find this problem?" in terms of consequences and "What are the most likely range of scenarios for the failure mode identified by condition monitoring?" in terms of probability. Failure avoidance savings are calculated by subtracting the PdM repair costs from the total of the three "most likely" *minor*, *moderate* and *severe* case scenarios.

To estimate the risk of allowing the equipment to run to failure, the following information is collected - which then can be used to build a reference table for future cases in the area (See Tables 1 and 2).

*Table 1*

| Criteria | Consequence | Probability |
|---|---|---|
| Equipment type | Is there an early detection point possibility on the P-F curve or will any problem lead to a catastrophe? Is there a cost difference between repair/refurbish/replace? | Do failures always follow a repeatable pattern because of equipment design or size? |
| Equipment location | Will the location of the equipment allow for a prompt repair? Will more severe damage require special rigging/access? | What are the odds of this failure being detected by operations walking through an area, or will we be relying on PdM monitoring? Is the item totally enclosed and will catastrophic failures be noticed only after some loss of system function? |
| Spares in place? | Can we recover from a failure? | What are the odds of a successful swap over? Does it need to be instantaneous? |
| Stock in stores? | Will production be affected by an extended repair time while spares are located/expedited? | Are there enough spares to service the number of installed equipment based on the Mean Time Between Failures (MTBF) of equipment? |
| Mean Time To Repair (MTTR) for minor, moderate, severe scenarios | What are the elapsed times required to return the unit to service and how will that affect production? | How often have the minor, moderate and severe cases occurred and how long was the duration of these events? |
| Production losses for minor, moderate, severe scenarios | What are the hold times, upstream and downstream restrictions on this piece of equipment? | How often have the minor, moderate and severe cases occurred and what was the production costs related to each event based on the MTTR? |
| Maintenance costs for minor, moderate, severe scenarios | Can there be collateral damage to equipment? | How often have the minor, moderate and severe cases occurred and what was the maintenance costs related to each event? |
| Severity of parameter measured | Is there a direct relationship between the parameter measured and the amount of production loss? | Is the severity of the damage to the equipment proportional to the severity parameter measured? |

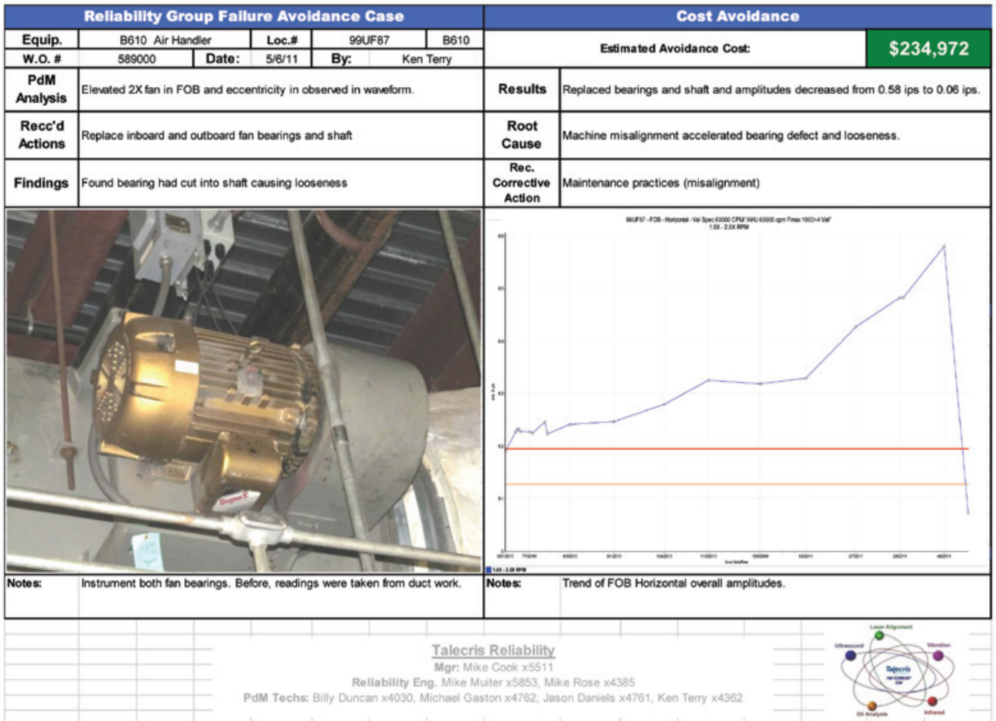



*Figure 3*

## "Just the FAC's ma'am"

The answers to these questions are normally available from common maintenance knowledge, PdM information forms, a Criticality Assessment database, the CMMS system, or by interviewing a production partner. The information can be stored in a common lookup table for future reference. Tabulating standard production downtime costs by area, as well as the maintenance cost for repairing common components like motors, compressors, pumps, or air handlers, will save time in generating future failure avoidance cases.

## A Sample Failure Avoidance Case

Air Handler Example:

This is an example of an air handler defect shown in Figure 3 that was detected through normal periodic vibration monitoring. This unit was misaligned during an earlier maintenance repair. The misalignment caused looseness in the air handler bearing and the shaft was beginning to be cut as a result of the condition.

These cases were based on the information collected and the inspection made to the air handling unit. The unit was destined to fail in one form or another. Because of the location of the unit and the type of failure, the problem would have been detected when the damage to the shaft had become well developed. There was a slim chance that the bearing defect would have been detected before the failure progressed to shaft damage. There is a low probability that the failure would have been catastrophic once the shaft was cut further.

The vibration trend shows that this equipment was getting worse at an accelerated pace and had gone undetected by operations up to this point. The information related to probability and consequences are summarized below.

The three scenarios were researched and summarized in Table 3, on the right, compared to the planned and scheduled PdM originated repair. The only remaining step is to assign the risk factor for this failure mode.

## Risk Determination

The matrix in Figure 4 was constructed from historic failure data that showed increasing risk carries a higher cost. Low probability and low consequence events almost always result in a minor cost, while high consequence and high probability events almost always result in the highest costs.

The information from the sample case indicates a relatively "low" level of **consequence** because:

*Table 2*

| Criteria | Consequence | Probability |
|---|---|---|
| Equipment type | Return air fan for larger critical air handling unit. Relatively low hp. | 2007 – 10%-15% failures/year for a fan of similar population |
| Equipment location | Some difficulty in accessing and rigging fan in elevated position | Overhead fan – more likely to be detected if looseness condition worsened |
| Spares in place? | None | None |
| Stock in stores? | Bearings, belts, sheaves, replaced with available parts | Stock available for bearings, belts, sheaves; Shaft not immediately available |
| MTTR for minor, moderate, severe scenarios | 12 hrs. bearing replacement<br>16 hrs. bearing & shaft replacement<br>24 hrs. bearing & shaft replacement & rotor/duct repair | Bearing failures 90%<br>Bearing & shaft>10%<br>Bearing & shaft rotor>5% |
| Production losses for minor, moderate, severe scenarios | Production loss associated with all unplanned repairs | In majority of cases, production related shutdowns result from loss of this fan, causing air handler outage |
| Maintenance costs for minor, moderate, severe scenarios | $500 labor, $350 parts<br>$1,000 labor, $600 parts<br>$1,600 labor, $350 parts | Bearing problems not normally noticed until a well developed fault is present. Shaft damage often audible, but irreparable. Rotor/duct damage noticed immediately, but damage is unavoidable |
| Severity of parameter measured | Noise always indication of bearing problem, often accompanied by shaft damage | Normally, loss of function occurs before audible noise |

| Type of Repair | Maintenance effect | Production effect |
|---|---|---|
| PdM Planned Repair | Scheduled downtime<br>No product impact<br>10 hours to repair | Bearing replacement<br>No lost production time<br>No product lost |
| Planned repair<br>(**minor**) | 12 hours to repair<br>Unplanned | Bearing replaced<br>No product lost<br>Lost production time |
| Unplanned repair<br>(**moderate**) | 16 hours to repair<br>Unplanned | Bearings and shaft damaged<br>Possible product impact<br>Lost production time |
| Unplanned repair<br>(**severe**) | 24 hours to repair<br>Unplanned | Bearings, shaft, rotor damaged<br>Lost product<br>24 hours lost production time |

*Table 3*

- the evolution of the failure is slow;
- the equipment is in a relative accessible area;
- the failure will likely be detected through noise generation prior to total failure.

Because the **probability** of this occurrence is inevitable once the failure mode is initiated and the damage to the bearing and shaft is irreversible, the probability of failure is determined to be "high."

Based on the low consequence and high probability, the total risk is estimated in the lower right hand corner of the risk matrix shown in Figure 4 and has this distribution of risk:

- In **30%** of all historical failures with a similar risk profile, a **minor** failure occurs (emergency bearing replacement).
- In **60%** of failures, **moderate** failure occurs (emergency bearing and shaft replacement).
- In **10%** of failures, **severe** failure occurs (emergency bearing and shaft replacement and rotor/duct rework is required).

The data collected from the previous table and the risk percentages are now entered into the spreadsheet in Table 4. Actual repair costs, as well as previous average repair costs, are researched and entered to provide the most accurate estimate of the MTTR for each failure case.

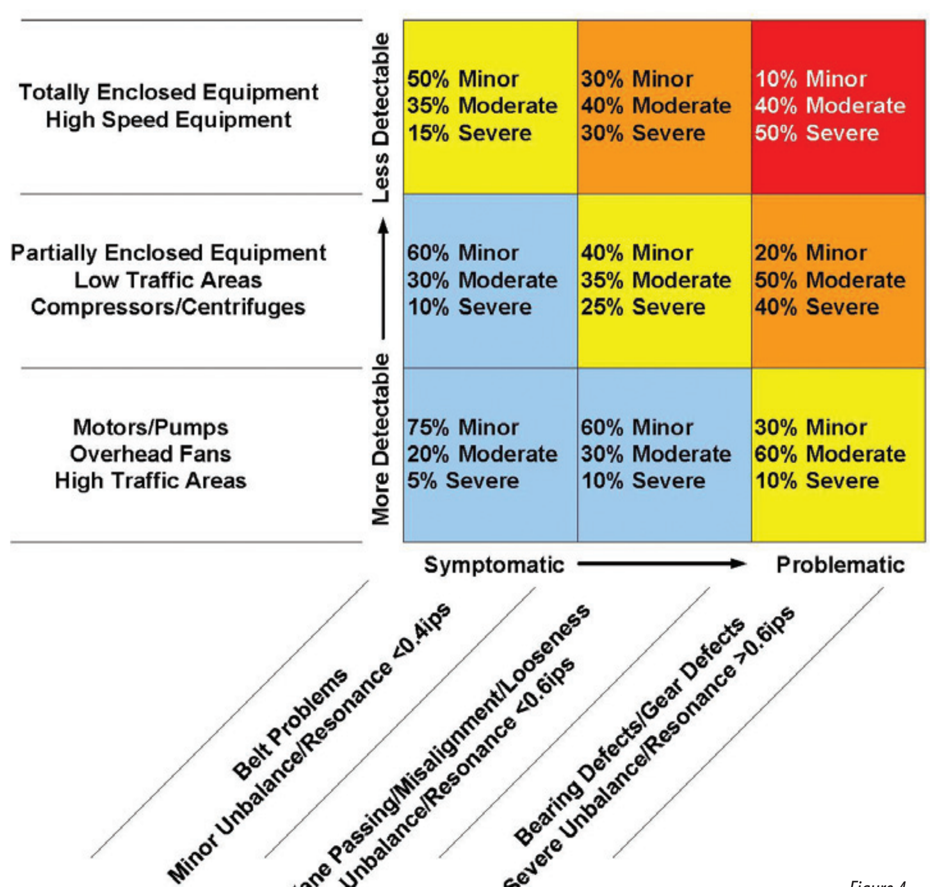



*Figure 4*

## Predictive Maintenance (PdM) Avoided Costs Worksheet

| Location | Equipment ID: | Survey Date | Technology | Report Date |
|---|---|---|---|---|
| B610 | 99UF87 | 4/23/2011 | Vibration | 5/6/2011 |

**MINOR CASE Description:**

Failure is detected and only requires inboard and outboard fan pillow block bearings.

**MODERATE CASE Description:**

Damage caused to shaft due to failed bearing. Inboard and outboard fan pillow block bearings, shaft and belts replaced.

**WORST CASE Description:**

Have to replace inboard and outboard fan bearings belts and shaft and sheaves.
Extensive damage caused to rotor/ductwork due to failed bearing.

| Inputs: | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| | MINOR CASE | MODERATE CASE | WORST CASE |
| Probability of Occurrence (%): | 30% | 60% | 10% |
| Avoided Hours of Lost Production | 12 | 16 | 24 |
| Maintenance Labor Hours Avoided | 12 | 16 | 24 |
| Maintenance Overtime Hours Avoided | 0 | 0 | 0 |
| Avoided Parts Cost (Unscheduled Repair): | | | |
| Bearings/Belts | $365 | $365 | $365 |
| Shaft | $0 | $220 | $220 |
| Sheaves | $0 | $0 | $200 |
| Avoided Costs Calculation: | | | |
| Avoided Lost Production Costs | $180,000 | $240,000 | $360,000 |
| Labor Avoided Costs | $540 | $1,080 | $1,620 |
| Parts Avoided Costs | $365 | $1,585 | $3,585 |
| Benefit of Each Scenario | $180,905 | $242,665 | $365,205 |
| Probability Weighted Benefit | $54,272 | $145,599 | $36,521 |

| Actual Parts and Labor Cost for PdM initiated repair: | |
|---|---|
| Standard Labor Hours for PdM Repair | 10 |
| Overtime Labor Hours for PdM Repair | 0 |
| Bearings | $285 |
| Belts | $80 |
| **Shaft** | $220 |
| **Total PdM costs:** | **$1,035** |

| Projected Avoided Cost: | $235,356 |
|---|---|

*Table 4 - Spreadsheet derived from: Dr. Robert Manning, copyright 2000, Flir Systems, Inc.*

This information is used to calculate production losses based on average downtime duration. While this process appears cumbersome, most of the data is available from the CMMS, the criticality database, or historical tables from previous FAC sheets and takes about two to three hours to complete.

This $235,356 savings case (the average documented savings amount is $200,000) becomes a single record in the total PdM savings database and the following data field are associated with the avoided:

- Technology used
- Date of the failure repair
- Classification of equipment (fan, pump, etc.)
- Plant area affected
- Root cause of the failure mode
- Recommended corrective action.

The goal of Grifols, Inc.'s PdM department is not to collect data, analyze data, or even diagnose problems. The mission is to make appropriate permanent repairs to extend equipment life in order to meet production requirements.

To meet this goal, it is important to focus on what actions should be taken to avoid the types of failures that we encounter on a daily basis.

By combining the results of all technologies and all individual failures, distribution charts can be generated that are sorted by date, equipment type, location, failure mode, or root cause. Because this information is monetized instead of just a count, the results of all PdM technologies are judged by how they impact the bottom line. Figure 5 summarizes the savings realized by years and Figure 6 is a distribution of the failure avoided by the corrective actions needed to avoid future occurrences.

We can also estimate ROI for each technology based on the actual failures and inefficiencies corrected, as shown in Figure 7.

The PdM department monitors over 600 machine trains and 15% to 20% of the total number of machines monitored have had a case completed against them. The number of success repairs averages two to three cases per month and the estimated avoided failure savings have totaled over $25 million dollars. Since the baseline readings taken in 2008, the total number of machines on the "watch list" has dropped from 15% to below 4%.

The legitimacy of the FAC methodology is that the savings are estimated only for failures that were avoided through a condition monitoring assessment and returned to service without requiring further action. The worst case scenario is not always considered the most likely outcome of a failure and real plant historical data is used to estimate how often each type of scenario will occur.


*Michael Cook, MSMRE from UT/Monash, is currently the Maintenance Reliability Manager at the Grifols Inc. (formerly Talecris) Clayton, NC plant. Mike has 22 years of leadership experience in the U.S., Mexico and Canada implementing Predictive Maintenance and Reliability Engineering programs in a variety of industries, previously with Duke/Progress Energy. The plant Reliability Group won the Emerging PdM and Ultrasound Programs of the year in 2010 through Uptime Magazine. www.grifols.com*

*Michael Muiter is a Senior Reliability Engineer for Grifols Inc., Clayton NC. Mike has 25 years hands-on experience in Maintenance and Reliability Engineering in Steel processing, Motorcycle manufacturing (Harley-Davidson), Automotive (General Motors), Textile and bio-pharmaceutical industries. Mike is a Certified Maintenance and Reliability Professional (CMRP) and a certified Level I Vibration Analyst and Level II IR Thermographer. Mike managed the award winning Ultrasound Program of the year in 2010 through Uptime Magazine. www.grifols.com*

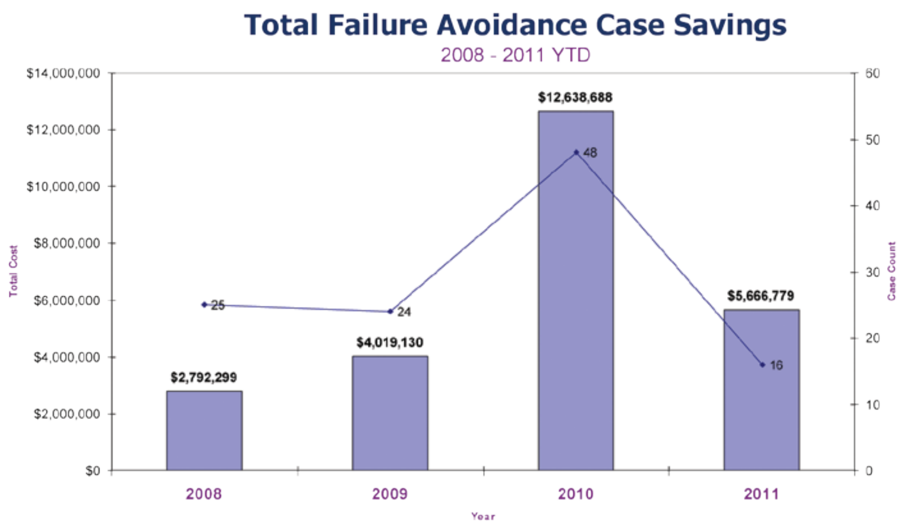



*Figure 5*

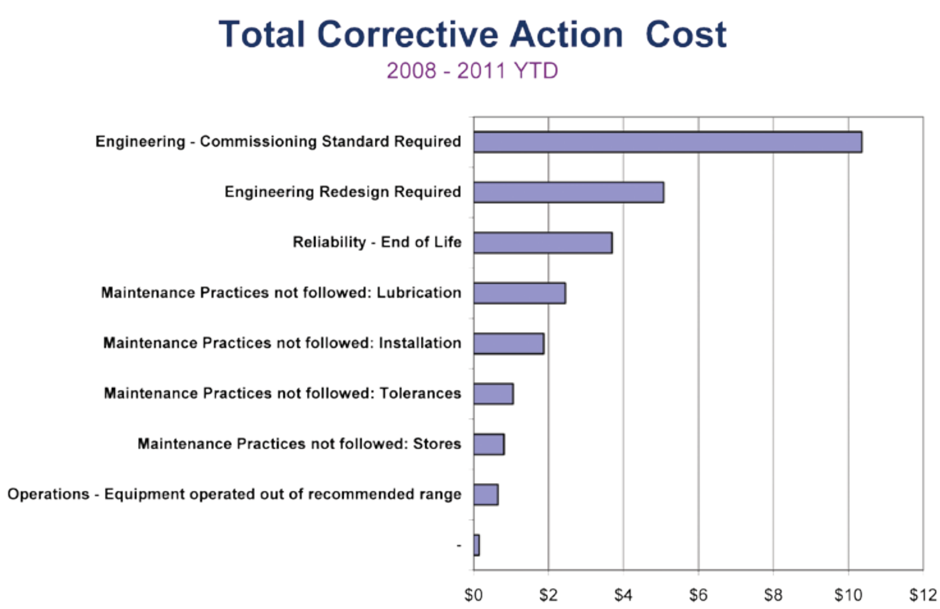



*Figure 6*

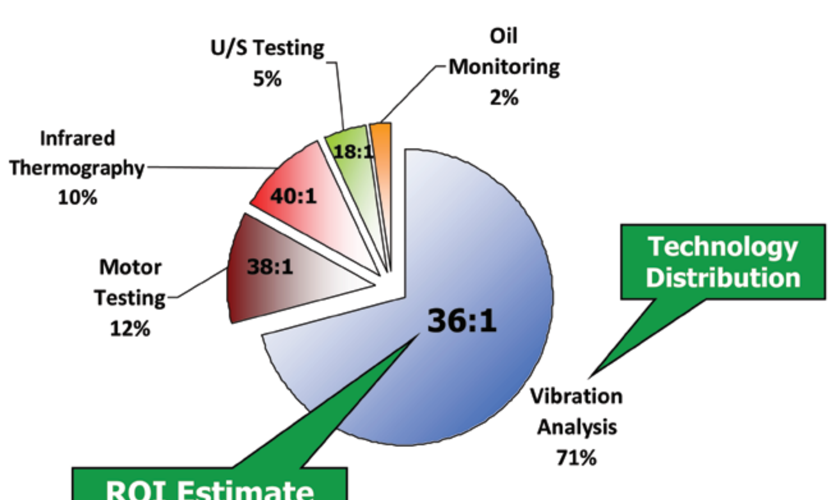



*Figure 7*


# Safe Electrical Work Planning & Plant Reliability

Mike Doherty

**It is agreed upon by most that the electrical system in any plant is a major factor in its reliability and therefore, profitability.**

*The Greatest Engineering Achievements of the 20th Century* website at **www.greatachievements.org** states that *"Electrification"* is the single most important of the top 20 engineering achievements. The next 19 would not have been possible without electricity. The same holds true for electrification at your plant and its reliability. Without an outstanding electrical system that is maintained at the highest standards, reliability can and will suffer.

Competent and qualified permanent staff, contractors, or combinations of both are mandatory to ensure a smooth and well-functioning electrical system.

**In the Ontario Health and Safety Act a "competent person" means "a person who,**

A. is qualified because of knowledge, training and experience to organize the work and its performance,

B. is familiar with this Act and the regulations that apply to the work, and

C. has knowledge of any potential or actual danger to health or safety in the workplace."

Furthermore, if they *"organize the work and its performance,"* they are usually considered to be the supervisor. In electrical work, the supervisor is the "key component" when it comes to ensuring that work is completed safely, on time and in a manner in which it can be depended on by the process. This definition was written for health and safety, but it can be applied to work tasks at all levels and skills, not just safety. Defining what a qualified worker really means in the workplace is a point of debate in many instances.

***First and foremost, a truly competent and qualified electrical supervisor ensures staff safety, and secondly, takes great pride in the execution of their tasks in a timely manner.***

Competent, qualified electrical supervisors need to be developed and nurtured within their organizations. Too often, they are promoted from the ranks because of the great amounts of work they get done at the end of the day. This is admirable and important, but is just one segment of what an outstanding electrical supervisor must do.

They need to be *masters* of electrical safe work planning.

First and foremost, a truly competent and qualified electrical supervisor ensures staff safety, and secondly, takes great pride in the execution of their tasks in a timely manner. It must be in that order. Any other way is just not an acceptable cost morally, socially, or economically.

Electrical supervisors must be highly trained not only in the electrical skill sets required to complete the work, but in the skill sets to plan the work. Is this something your supervisory staff does? Do you have the training records to back it up? Does upper management go to the field and regularly audit the safe work planning skills of their electrical supervisors?

If the answers to the last three questions are "no," then your electrical workers are at risk, your electrical equipment is at risk and ultimately, the reliability of your plant is at risk.

How then do you proceed when looking for opportunities for improvement in the area of electrical safe work planning?

**A simple five-step process is described here as one concept:**

1. Identification of "all" electrical hazards for any specific task

2. Quantification of all identified hazards for any specific task
3. Strategies based on the above two steps
4. Document, document, document
5. Communicate, communicate, communicate.

## STEP 1:

*All* electrical hazards must be identified before starting work. In electrical work, this could include:

A. low, medium and high voltage direct contact
B. flashover
C. induced
D. step potentials
E. arc flash/blast.

## STEP 2:

All identified electrical hazards must then be *quantified*. This is relatively straight forward for electrical hazards A through noted above if done correctly, but not so evident for identified arc flash/blast hazards. They can be comprised of radiative and convective heat, dangerous decibels to ears, hazardous IR/UV to eyes, super heated noxious metal vapor harmful to lungs, shrapnel, molten metal and, of course, blast pressures. IEEE standard 1584 really only addresses the heat in cal/cm$^2$. ArcPro software can do the same for single phase in open air with factors to be applied for three-phase in enclosures. Existing engineering formulas exist as well. The ongoing IEEE/NFPA Collaborative Research Project is doing much of this testing to give hard scientific evidence for most of these other hazards to be quantified. Additional information about this project can be viewed at: http://standards.ieee.org/about/arcflash/index.html

## STEP 3:

Once all the hazards have been *identified* and *quantified* to current knowledge, supervisors must draft the required strategies to ensure safe work and no destruction of the electrical equipment, in particular from an arc flash/blast event.

The number one strategy bar none is TURN OFF THE POWER, complete with a comprehensive and effective Lockout-Tagout or Utility Work Protection Code. A high-level electrical supervisor is also a master of this strategy in the isolation and de-energization (grounding) of electrical equipment as required.

There should be justification for doing "energized work" from upper managers who are accountable and will sign off on it. Sometimes tasks like troubleshooting or diagnostics require energized work. If so, electrical utilities have very detailed and safe work practice procedures to follow. It is highly recommended that industrial establishments use the outstanding "Energized Electrical Work Permit" concept from current editions of the U.S.'s NFPA 70E or Canada's CSA Z462. Used correctly, these documents cover all the bases from an electrical safe work planning and due diligence viewpoint.

## STEP 4:

**Document, document, document.**

It cannot be emphasised strongly enough just how important this step is. It is a critical component of Step 3. Electrical workers, and in particular electrical supervisors, who execute work using only "tribal knowledge" or verbal instructions as a work practice instead of written procedures, put themselves at risk of injury and put the plant's reliability at risk. If electrical task descriptions are not clear, concise and documented, the risk is much higher. Good documentation can also exonerate supervisors and upper managers from liability where extensive injury and/or destruction of plant equipment have taken place.

## STEP 5:

**Communicate, communicate, communicate.**

An outstanding electrical supervisor who lowers the risk of injury to workers and reduces potential significant downtime to the plant is also a master communicator.

Master electrical supervisors know their crew. They get to know any electrical contractors that may be involved. They issue clear, concise and documented safety and work instructions at all times. They ensure that their crews listen and understand all portions of the work, otherwise they stop and regroup. They look for error likely situations and use repeat backs from their staff to ensure that they are totally engaged.

Upper managers need to audit supervisors' skill sets often for electrical safe work planning. If there are gaps, upper managers must get the supervisors the comprehensive training required.

Ultimately, every plant that wants to be safe, world-class, profitable and offer good, honest work to its community needs to ensure that their potential "Achilles heel" - their electrical system - is maintained by top guns in all phases of the work.

Having safe electrical work planning that is a recognized and valued component of your reliability chain and executed by competent and qualified electrical supervisors defines the statement, "Good Safety is Good Business."

*Mike Doherty has over 36 years experience as a licensed industrial electrician, industrial instrumentation technician, control technician, electrical skills instructor, and utility safety department professional and electrical safety trainer across North America. He is Chair of CSA Z462 Technical Committee, Workplace Electrical Safety, Canada and an NFPA 70E Technical Committee Member, Electrical Safety in the Workplace – USA. www.ihsa.ca* condition monitoring

Oa oil analysis

Jason Kopschinsky

# Oil Sampling: Still the Foundation for a Successful Oil Analysis Program

**A decade ago, I learned the true value of an oil sample.**

I was working in a steel mill, sampling roll mill gearboxes and screening them onsite for ISO particle count, ferrous density, moisture and viscosity. As you can imagine, these gearboxes get pretty beat up both inside and out, so it was not uncommon to see high particle counts and associated ferrous wear in many of the samples. On one occasion in particular, one of the gearboxes had exceeded the cleanliness target by a small margin. This too was not uncommon. Contamination control, storage and handling, and relubrication practices were all in need of improvement in this facility. What was significant was that the ferrous density for the sample from this gearbox was off the charts. Clearly, this was information that I needed to pass on immediately. To my surprise, my warnings fell on deaf ears. I wrongly assumed that when I passed along this information to the maintenance foreman that alarms would sound, maintenance staff would assemble and the problem would be dealt with. Instead, nothing happened. What eventually happened was this gearbox failed catastrophically, resulting in twenty-seven hours of lost production time and a host of associated costs and lost revenue.

***Consistency in our sampling will always lead to repeatable and dependable oil analysis results.***

## Sampling Goals

It's clear the maintenance foreman was counting on the data being unreliable, or perhaps he simply did not understand oil analysis and that the gearbox in question would continue to chug along as usual. However, I was sure the data that I gave him was accurate and true. I knew this, in part, because I was certain that I had extracted a high-quality, data-rich oil sample and had tested it according to the procedures required for the instruments I was using. Being able to extract quality samples is the foundation of any successful oil analysis program. It is important to remember what we are trying to accomplish when we take a sample of oil from a machine or component for analysis:

1. Capture a snapshot of the condition of the component and the lubricant. Each sample taken from a machine represents that machine at that point in time. It quite literally is a snapshot of the health and condition of the machine and the lubricant at the time the sample is taken. These properties will continue to change within the machine and in-service lubricant as time passes. For this reason, expeditious delivery of the sample to the lab is critical. Each day the sample remains in the plant or in transit to the lab, the further the data gets from current condition.
2. Provide repeatable and dependable data from which to base maintenance decisions and activity. The most effective way to use oil analysis data is to base maintenance decisions and activity on the results of the analysis. However, without a history of repeatable and dependable data, no one is likely to use the data to their advantage with fear of making the wrong decision. Repeatable and dependable data is a direct result of the hardware installed on the machine to extract the sample, the accessories used to collect the sample from the hardware and the proce-

dure that's followed when the sample is being taken. Also, the test slate that is applied to the sample is very important. If we're not looking for the right things, we're going to miss the meaningful indicators.

3. Trend the rate of change of physical and chemical properties at each sampling interval. Oil sampling is all about precision. The instruments used for analysis can be very precise, but without a precision sample, the data is going to be hard to trend. We look to trends in the data to help us predict the future health of the machine or the lubricant. A powerful tool in the oil analysis arsenal is the rate of change trend. Of course, when specific parameters break limits in oil analysis, automatic and manual alarms are the typical response. However, rate of change checks are important for those occasions when specific results don't exceed set limits, but do change dramatically signaling the early stages of a potential fault.

## Location, Location, Location

Routine oil analysis requires the use of specialized hardware permanently installed in the machine or component from which we can extract an oil sample. As important as the hardware used for sampling is, also extremely important is extracting the sample or installing the sample valve in an ideal location. The ideal location for extracting an oil sample from a sump or reservoir is as close to the return line, gear set, or bearing as possible. You also need to make sure there is enough room surrounding the termination point of the hardware you've chosen to use. Maintaining a distance of two inches from any static or dynamic surface within the component puts you on the right path to a quality sample. Hardware that extends too far into the machine risks contacting machine surfaces and causing damage. Hardware that terminates on or close to the surface of the machine or component risks collecting contaminants that can skew the data and result in unreliable analysis.

The preferred location for sampling circulating systems is on the return line, not the reservoir. Another rule of thumb is to sample at 50% of the oil level. Sumps and reservoirs were designed to hold a large volume of oil, to dissipate heat and to allow air to rise and contaminants to settle. Therefore, the most concentrated contamination is on the bottom of the sump or reservoir and the cleanest oil towards the top.

## The Key to Success

The key to success is to be consistent. Consistency in everything oil analysis-related allows us to identify machine or lubricant problems without having to first exclude issues with how we got the sample or how we tested it. It is of the utmost importance that we have a consistent approach to:

- Sample location
- Sampling receptacle
- Sample extraction procedure
- Sampling frequency
- Sample testing methods.

Consistency in our sampling will always lead to repeatable and dependable oil analysis results. As we know, the most successful oil analysis programs have taken a long time to develop and mature into a program that truly drives maintenance decisions within an organization. Kicking off your oil analysis program with consistency will prove to be a jumpstart toward a truly rewarding maintenance initiative.

*Jason Kopschinsky, CMRP, C.E.T., MCPM, joined Des-Case as the technical services manager in April of 2011. Prior to joining Des-Case, Jason spent over a decade coaching clients in asset reliability and lubrication management. www.descase.com*



# Are You Proactive?

## A Daily Planner for Effective Maintenance Management

Ricky Smith

**In the maintenance and reliability industry, the definition for proactive is:**

- To act before the cost of doing so increases
- To act before the necessity of the situation demands it.

"A great maintenance manager sees the relationship of poor performance and the lack of good maintenance routines."

"Poor performance always leads to the lack of maintenance routines or poor execution of existing routines."

*- Rick Mullen, Global Reliability Leader, Anheuser-Busch InBev*

Mr. Mullen's statements drive home the fact that a maintenance manager holds the key to a plant, site, or mine's success. That person's knowledge of the site's maintenance strategies, how they are executed and their effectiveness is key to a successful maintenance manager. It is also the difference between high performing and poor performing operations.

***Think about Rick Mullen's statement and its relation to Figure 1.***

What is the goal of a maintenance manager? To ensure that all maintenance personnel are aligned and executing the company's proactive work to standard so that the company meets its business goals 100% of the time.

### Morning:

The maintenance manager begins the day by spending 30 to 60 minutes visiting with each maintenance supervisor for five minutes after their shift has begun to look for abnormalities from the past 24 hours that may impact this week's production goal or maintenance's schedule.

**Example:** Breakdown last night on line one caused production loss of 12,000 units of production because of loose bolt; investigation initiated by maintenance engineering; one mechanic assigned to assist ME. Report due to maintenance manager within 48 hours when the loss exceeds a specific amount.

**Production Manager Informal Meeting (10 to 15 minutes max):** The maintenance manager meets with production management first to determine if any issues have occurred in the past 24 hours that he or she was not aware of, or any issues that may arise within the next 24 hours. They both review the 24-hour production rate, quality and problems.

**Key Performance Indicator Review (10 minutes):** Next, the maintenance manager takes a quick look at the maintenance Key Performance Indicator (KPI) dashboard to see if any problems exist or may happen in the next week to one month. There should be KPI owners listed on the dashboard who will send a report to the maintenance manager if a KPI

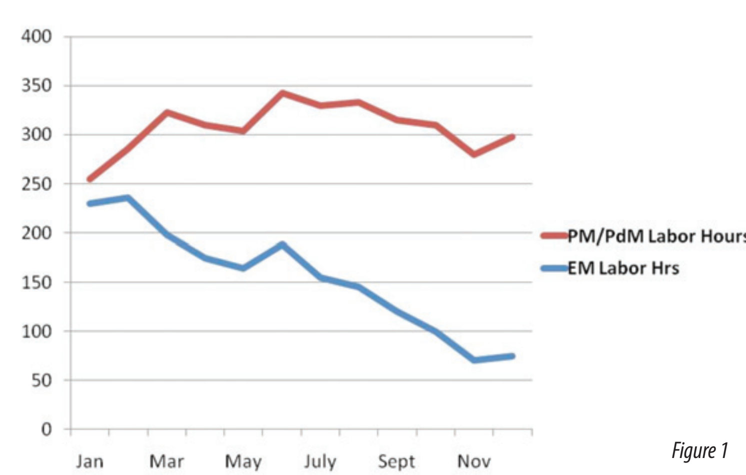



*Figure 1*

is acting in a state that maintenance and production leadership would consider unacceptable, along with an exception report for any exceptions to expectations. Here are some examples of what a maintenance manager looks for in a key performance indicator review:

- Emergency versus PM/PdM labor hours (is the PM/PdM program working?)
- Mean Time Between Failure (MTBF) of critical assets
- Production/Quality rate stability
- MTBF by maintenance supervisors' areas
- Preventative maintenance (PM) compliance using the 10% rule on critical assets by crew
- Schedule compliance
- Safety incidents and near misses within the past 24 hours.

Exception reports are sent to the maintenance manager if any of the above metrics are not within the agreed upon range.

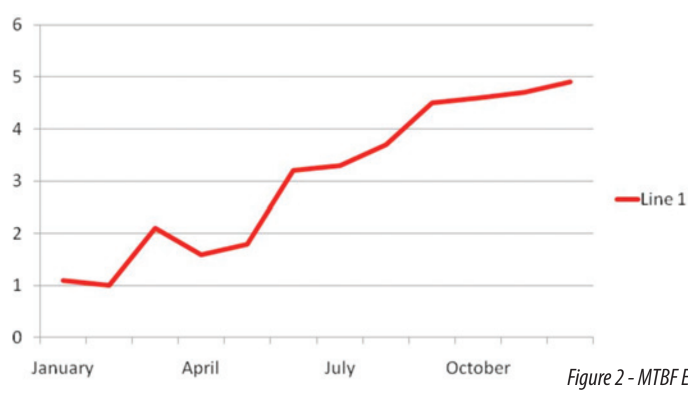



*Figure 2 - MTBF Example*

**Plant, Mine, Operations Site Manager Meeting (60 minutes max):** The maintenance manager takes about 10 minutes to describe any issues within the past 24 hours that caused losses or issues that may cause losses in the next seven days. If additional time is needed to discuss these items, this should be addressed outside of this meeting with specific individuals.

**Plant Visit:** Randomly, the maintenance manager should visit each crew area to see what is happening. Sometimes, a picture truly is worth a thousand words. The maintenance manager first talks with the maintenance supervisor to review any issues he/she is facing and need to be resolved. A meeting time to discuss the issues may be scheduled later in the day, or on another day, depending on the importance to the maintenance supervisor. While on the visit, the maintenance manager greets everyone and asks operators and maintainers how things are going. The maintenance manager generally spends no more than 30 minutes in each crew area.

## Guiding Principles for a Proactive Maintenance Manager

**Leadership Principles:**

- Treat everyone as your equal and demonstrate respect and humbleness.
- Know each maintenance person by name.
- Know each planner by name.
- Take time to talk to someone who has an issue at a scheduled time and place, and respond back to that person within 48 hours. Make it policy.
- Maintenance management should not be rude or report on trivial things that do not matter to anyone in the organization.
- Know yourself and seek self-improvement every day.
- Never ask anyone to execute a task you would not do yourself.
- Treat others as you would like to be treated; put yourself in their position.

**Organization Principles**

- Randomly check on planning, scheduling, stores and tool storage areas.
- Require wrench time studies be conducted of each crew by specific crew members after they have been trained and certified in the process. These should be conducted every three to six months depending on previous trends. All reports should be presented to the maintenance manager by the maintenance supervisor and no one else. This should be a private conversation.
- Ensure that work order data is under control and providing accurate reports.
- Ensure that a Failure Reporting, Analysis and Corrective Action System (FRACAS) is owned by each maintenance supervisor and request monthly reports from them.

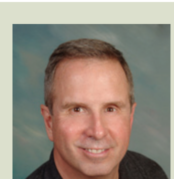
**Management Principles**

- Guide your organization through the use of KPIs so you know your group is headed in the right direction. If a KPI is driving in the wrong direction, initiate a team to identify the problem and recommend a solution within 48 hours.
- Post only KPIs that may be important to each maintenance crew.
- Require a 30-minute Single Point Lesson to be presented and discussed by each crew on a weekly basis. These training workshops should be technical in nature, not safety related. Safety meetings should be scheduled separately.
- Maintenance and Reliability Engineering should have direct access to the maintenance manager during specific hours of the week and exceptions should only be made on an emergency basis.

Maintenance managers hold the key to success or failure of any maintenance organization. If the manager is weak, then he/she must be given assistance first and only removed from the position after a three-month period of not showing improvement.

***Require a 30-minute Single Point Lesson to be presented and discussed by each crew on a weekly basis.***

Proactive maintenance managers are the unsung heroes of any organization. People look up to them with respect and calmness, even in tough situations. It's a difficult job, but maintenance managers who feel they have areas that need further development should find a mentor to assist them. Just be sure the mentor is competent and studious.



*Ricky Smith, CMRP, CPMM, is the Senior Technical Advisor for Allied Reliability. Ricky has over 30 years in maintenance as a maintenance manager, maintenance supervisor, maintenance engineer, maintenance training specialist and maintenance consultant, and is a well-known published author. www.gpallied.com*

# Risk & Criticality
## Understanding Potential Failure

Terry Nelson

**Many businesses and public service organizations use a hope-based system for managing risk. But most business and physical risks can and should be managed by a more proactive approach.**

### What is Risk?

At the most basic level, risk is a combination of consequences and likelihood-of-occurrence associated with an event. Consequences and likelihood are different dimensions, just like spatial dimensions, and should be combined in the same way using a distance-in-space formula (also known as Euclidean distance) using the Pythagorean equation: $a^2 + b^2 = c^2$. As demonstrated in Figure 1, *A* represents likelihood-of-occurrence (probability), *B* represents consequences and *C* represents combined or overall risk. This provides for accurate comparison of relative risk associated with different events, as displayed using a risk matrix in Figure 2.

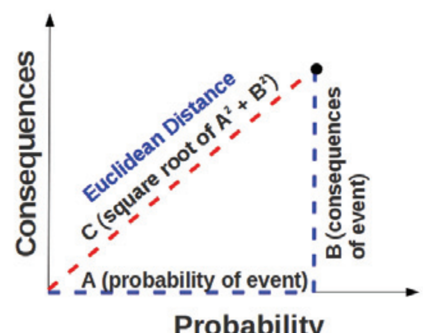



Figure 1

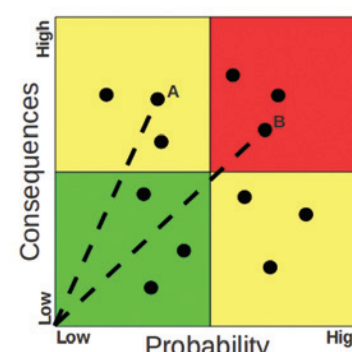



Figure 2

### Multiple Dimensions of Consequence

Consequences of an event come in many forms. They may include safety and health, environmental, operating costs, and others. The set of consequence dimensions that apply to different organizations or systems vary. Identifying the applicable dimensions is integral to the analysis process. Consequence dimensions are associated directly with the mission and level of service required of the organization or systems, *not* the events being considered.

A simple sum of ratings from the various dimensions would yield inaccurate results, just as

Figure 3

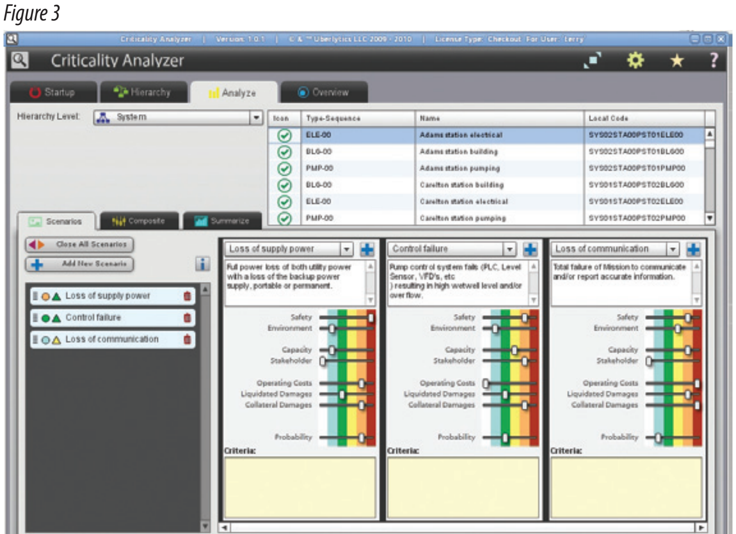
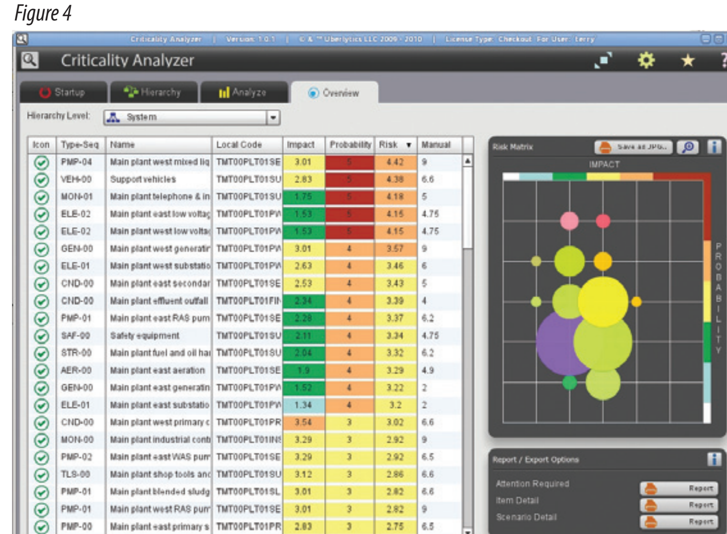



Figure 4



combining consequences and likelihood. So a Euclidean distance formula should be used in calculating overall consequences. The formula is simple even with many dimensions: square the rating for each dimension, add the results, then square root the total.

Good software tools have these calculations built in so the analyst need not be conscious of them during analysis. Figures 3 and 4 (screen-captured images from Criticality Analyzer™ by Uberlytics, LLC) show how sliders are set for each consequence dimension. The overall consequence value is automatically calculated by the software.

## Proportioning Consequence Dimensions

Dimensions may not have equal contributions to overall consequences. Safety and health should normally be given greater weight than costs. Software tools should allow setting contribution proportions for consequence dimensions. Figure 5 shows how Criticality Analyzer™ provides contribution factor settings for each dimension. Once a tool is configured, calculations should be automatic so that personnel performing the analysis need not track proportions during the analysis.


*Figure 5*

## Care in Managing the Basis of Consequence and Probability

Consider the risks involved when traveling by air, car and motorcycle. Associated event definitions are based primarily on the context and level of service criteria being considered. In one case, the occurrence of any accident may be the event of concern. In another case, only an accident that results in injury or death may be the event of concern. In the first case, a consequence dimension may evaluate potential injury associated with the event. In the second case, consequence dimensions should assume injury or death, not merely accident occurrence. Assumptions by analysis participants can be different in these cases.

***Consequences of an event come in many forms. They may include safety and health, environmental, operating costs, and others. The set of consequence dimensions that apply to different organizations or systems vary.***

Likelihood of occurrence is greatly affected by the form of the event. If occurrence of an accident is the basis for consideration, likelihood will be higher than if the event under consideration is an accident that results in injury or death. The latter is a compound likelihood based on the likelihood of both an accident *and* injury. If evaluating an accident with injury, there is a higher compound likelihood for motorcycles because *both* likelihood factors are higher than for other modes.

## Denominator Considerations

Traveling by commercial air might involve about the same likelihood of being in an accident as traveling by car - *if* the denominator for likelihood is *hours traveled*. However, since commercial airplanes travel up to ten times faster than cars, flying may be ten times less likely to result in an accident if *miles traveled* is the denominator.

Which denominator is correct? If the number of miles traveled is fixed by the context, miles should be the denominator. If travel time is fixed by the context, hours should be the denominator. Experience and care are necessary in order to select the correct applicable denominator and to communicate it to the analysis team.

## Consequence Scales

Confusion between outcome of an event and changes in the risk profile associated with the event compromises analysis validity. This is managed by the scales assigned for consequences. The safety and health dimension is often scaled by the extent or significance of injury, such as these examples of scaling values:

- Low = no injury
- Medium-low = minor injury
- Medium = reportable injury
- Medium-high = requires medical attention
- High = permanent injury or death.

However, in most cases, the concern is *not* specific outcome or results of events, but rather changes in the risk profile caused by the event. For safety and health, *any* injury is unacceptable, so if even a minor injury is *certain* to occur, the highest possible consequence rating should apply. Normally, injury is neither assured by the event nor precluded by the event not occurring. A better safety scale might be:

- Low = injury occurrence is not affected by the event
- Medium-low = injury may occur if event occurrence is not addressed in a timely fashion
- Medium = injury may occur if occurrence of the event is not addressed promptly
- Medium-high = injury may occur if the event is not immediately detected and addressed
- High = injury is likely to occur immediately upon occurrence of the event.

This may be confusing because the scale is almost completely probability based, apparently overlapping with likelihood of the event. However, the likelihood score for an event is based on the likelihood of event occurrence, not a specific outcome of the event.

## Risk and Criticality Differences

Risk evaluates *events* without focusing on the specific systems leading to the event. Criticality evaluates failure of a *specific item* within a larger system. Risk can be represented by the potential for dying of a heart attack based on overall lifestyle. Criticality can be represented by death from failure of a heart-lung machine. In the risk case, it is an event (heart attack) that is central to the analysis and in the criticality case, it is the heart-lung machine (specific item) that is central to the analysis.

Analyzing risk is important in order to prepare for, mitigate, or reduce the likelihood or impacts of events on a broader scale than the specific item leading to the event. Earthquake risk management does not prevent earthquakes, but allows improvement of response and mitigation of impacts from earthquakes.

Establishing criticality allows attention and resources to be allocated to the reliability and fault detection of critical systems or components. The proper goal is to proactively prevent bridges falling into rivers, not simply get better at emergency responses to bridges collapsing.

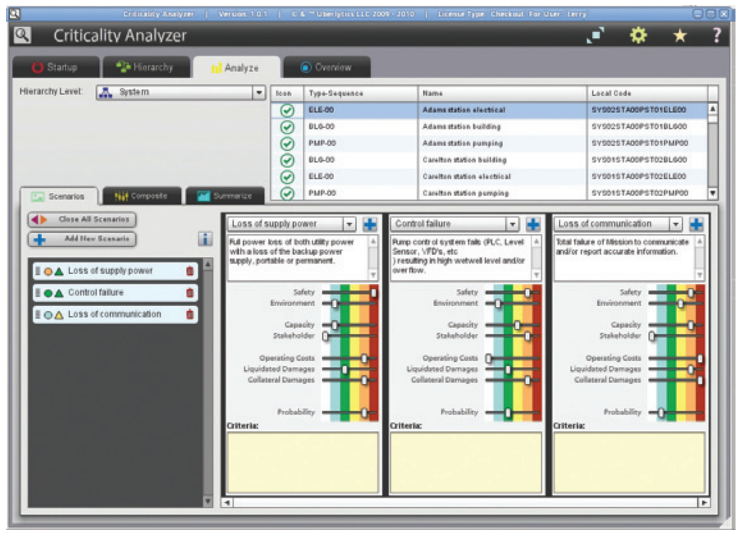


*Figure 6*

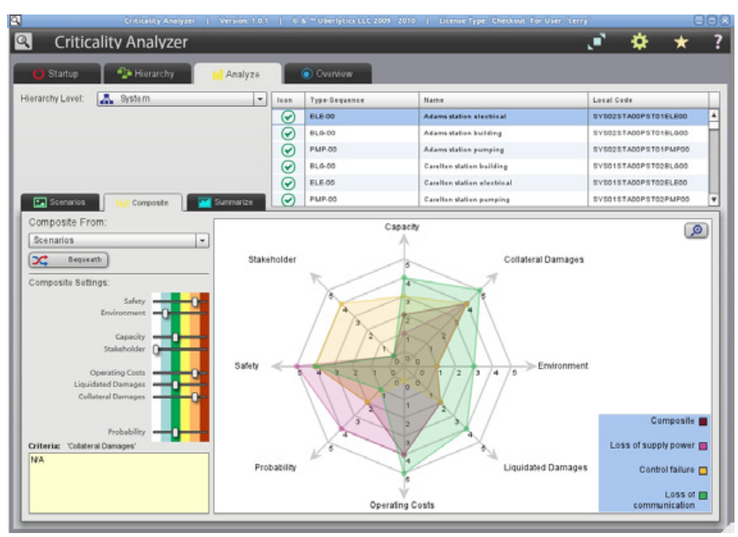


*Figure 7*

Understanding criticality often requires *multiple* events to be considered and risk evaluation for each item in a system being evaluated. A valve, for example, can stick closed, stick open, stick in mid-position, leak, or rupture. Worst-case conditions define each event; and each may have differing consequences. There may be more than one worst-case event for any single item.

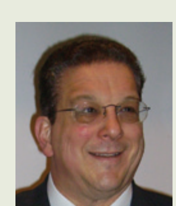
A pumping system rupture may have important environmental ramifications, while the same system failing to pump may impact operational dimensions. This means that criticality analysis is often more complex than risk analysis. Multiple significant events must be risk-evaluated for each item during criticality analysis. Worst-case consequences from the set of events can be then composited into an overall rating for the item.

Criticality Analyzer™ provides the user with the ability to analyze and composite multiple failure scenarios for each item of a larger system. Figure 6 shows multiple scenarios for a single item, with each scenario having its own consequence ratings.

Figure 7 shows how Criticality Analyzer™ plots the dimensional consequence scores for each scenario on a radar chart. This allows the analyst to adjust a set of composite sliders to form a best-fit representation of all scenarios to produce overall consequences and likelihood for the item under analysis. These overall values are then combined into an overall consequence score to be plotted with the overall likelihood score on a risk matrix and calculated for an overall criticality rating value for the item.

## Conclusion

Risk and criticality are of great value in managing systems and processes, allowing preparation, proactivity and prevention. High profile events, such as the BP oil spill and Japan's nuclear reactor issues, put a spotlight on the need to manage risks. Expectations of system owners and operators are higher than ever and will continue to increase. Diligence, proactivity, prevention and preparation all depend on understanding risk and criticality.




*Terry Nelson is a consultant and thought leader in physical asset management. Based in Washougal, Washington, he has decades of experience in nuclear power, water utilities and other industrial processes. He designed and created Criticality Analyzer™ and currently provides facilitation and training services for users and clients. Terry can be contacted by email at terry@inspiraworks.com. Information about Criticality Analyzer™ is available by visiting www.uberlytics.com.*


Part 4

# Detecting Bearing Faults

Jason Tranter

**This is the final part of the series on dealing with rolling element bearing defects. In previous articles, we looked at how vibration analysis can be used to detect a range of faults conditions, including lubrication problems; wear, spalls, cracks and other defects; and problems that relate to poor installation practices. In this article, we will discuss how the vibration analyst (and others within the maintenance and operations group) can minimize the number and severity of bearing faults. This is arguably the most important of the four articles.**

If you asked most people whether vibration analysis improved reliability, they would answer, "*Yes.*" But I would disagree.

## What is your definition of reliability?

If your definition of "reliability" is whether or not bearings are failing catastrophically ***and unexpectedly***, then it would be true to say that vibration analysis does improve reliability. But let's draw a parallel with your car for a moment.

## How would you feel if your car failed as often as most rotating machines?

If you found that every three months your car engine failed and thus you often found yourself stranded on the side of the road, then you would correctly say that your car is unreliable. But if the mechanics added a red light to your car's dashboard that warned of imminent failure so you could avoid being stranded on the side of the road, you would feel like that was a step in the right direction. But if the red light comes on every three months, you would still feel as if your car is unreliable. You would be within your rights to ask the mechanics to make a change so that your car would run six years – or much longer – without the red light coming on.


## We need red lights on our motors and pumps

The same is true with your rotating machinery. In most plants, the vibration analysts are the "red light" on the dashboard. They take readings, see that there is a problem, then wave their hands to say, "you need to take action because the bearing is about to fail." If the vibration analyst does a good job, then there will be more time between the red light coming on and the machine failing. As a result, the maintenance department will have more time to deal with the repair: order the parts, find the most convenient time to shut the machine down, operate the machine through a critical period, operate the machine more safely, etc.

But there is *much more* that the vibration analyst and the maintenance and operations departments can do. The goal has to be to *increase the life of the bearing* – that's what makes a machine more reliable.

## How can you improve reliability?

There are four key components to improving the reliability of rotating machinery.

### Purchase and design

Rotating machinery and its support structures should be designed and purchased with reliability in mind. The lifetime costs should be prioritized over the up-front purchase price. Vibration analysts can contribute to the design and selection process by referencing the experience gained from similar machines – that is, if a certain design has proven to have problems, do not use it again. Vibration analysts can also contribute by performing "acceptance testing" (incoming inspections) of new and overhauled machines to ensure that they are fit for your company's use.

**Operation**

If a machine is operated correctly, there are less stresses on the components (bearings, shaft, seals, etc.). It is primarily up to the operators to ensure a machine is operating correctly, but the vibration analyst and other condition monitoring technicians can perform tests to verify that it is operating properly.

**Maintenance**

Similarly, if a machine runs more smoothly, there will be less stress on the components and it will be more reliable. The maintenance department has an important role to play. The bearings and gears should be lubricated correctly. In addition, the shafts should be precision aligned; there should be no soft foot; the rotating elements should be correctly balanced; there should be minimal resonance; the bearings should be installed correctly; and so on. If the maintenance department gets all of the fundamental maintenance issues right, then the machine will be far more reliable. As a result, the vibration analyst should see very few fault conditions develop.

So what is the role of the vibration analyst? The vibration analyst may be involved in precision alignment and should be involved with field balancing. The vibration analyst can certainly take the required readings to check for misalignment, soft foot, lubrication problems, bearing installation problems, unbalance, looseness, resonance, flow problems, and so on. If these tests are performed correctly and the conditions are corrected quickly, the machine will provide many years of reliable operation.

Yes, it will take cooperation between maintenance and the condition monitoring group, and it will require the vibration analyst to master all the necessary skills, but it is definitely worth it.

**Continuous improvement**

Even with the best intentions, there will still be failures. The important factor is to learn from failure. Root cause failure analysis can be used to determine why a machine failed – *but it is important to go back and make changes so that the failure does not occur again*. A vibration analyst can play a very important role. The vibration data can hold the clue as to why a machine failed. It may be that a bearing failed, for example, but careful examination of the data may identify a condition (unbalance, misalignment, resonance, etc.) that led to the failure. When the bearing is removed from the machine, it should be examined to determine why the failure occurred. In the example in Figure 1, the pump was in standby mode for long periods and experiencing vibration from a second unit, thus "false brinelling" occurred.

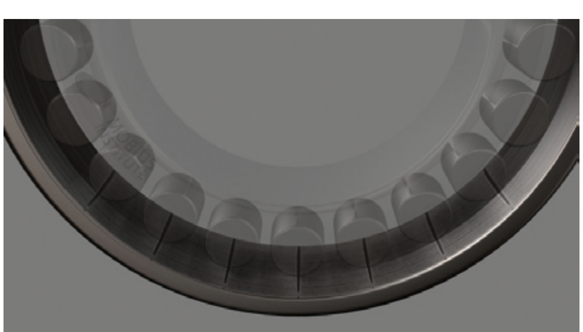


*Figure 1 - This bearing has failed due to false brinelling.*
*Image adapted from FAG Publ. No. WL 82 102/2 ED*

## How do you make all this happen?

The answer is training and communication. Unless you have buy-in at all levels in the organization, reliability will always be a seemingly impossible dream. Everyone must believe that reliability is a very high priority (safety may be a higher priority, but reliable plants are safer plants). Reliability adds to the bottom line of the balance sheet. While there will be an initial investment (training, instrumentation, design modifications, etc.), the improvements in production, quality and energy efficiency, and the reduction in maintenance costs (parts and labor) and safety incidences will result in a very fast return on investment.

## What type of training is required?

In this author's opinion, you need three types of training: awareness, management and practitioner.

Awareness: Operators, millwrights and everyone up through to management need to have basic training on the concept of reliability, condition-based maintenance and the condition monitoring technologies. People should not feel threatened by the technology; and everyone should be pulling in the same direction. And they should all believe in the philosophy so that when recommendations for repairs and changes to procedure are made, they are followed without question.

Management: Managers, engineers and purchasing personnel need a deeper understanding of the same three areas (reliability, condition-based maintenance and the condition monitoring technologies) so the program can be run correctly and all design and repair decisions are made with reliability in mind.

Practitioner: It may seem obvious that the vibration analysts, aligners, balancers, lubricators, bearing installers and other people need training to do their job properly, but you would be surprised at how few actually have adequate training. Assumptions are made about a person's knowledge; sadly each person learns the same mistakes from their fellow workers. Companies may buy modern vibration analyzers, state-of-the-art laser alignment systems and other high-tech equipment, but without adequate training, the money is wasted (and the opportunity is lost). See Figure 2.

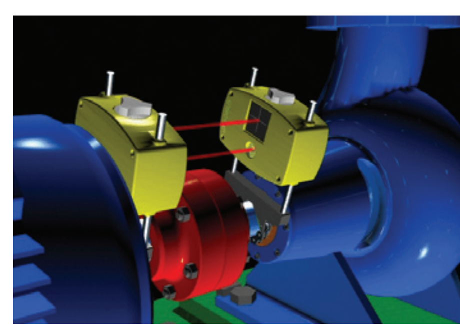


*Figure 2 - Laser alignment systems are great, but without adequate training, they will be misused*

## Conclusion

A good vibration analyst will detect a bearing defect before it fails. A better analyst will detect the defect earlier and communicate the status so action can be taken to minimize the cost of repair. But the best vibration analysts do everything possible to reduce the likelihood that the bearing will ever develop a defect in the first place.

*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*

# Q&A

*Uptime Magazine* CEO/Publisher and Editor **Terrence O'Hanlon** recently caught up with noted maintenance expert and author **Terry Wireman** to discuss the Reliabilityweb.com acquisition of the 10-book Maintenance Strategy™ series from Industrial Press.

**Q** Please tell us why you decided to write the 10-book Maintenance Strategy series?

**A** I have humorously referred to it as my "retirement" project. Currently I have half of the series written and they are now being published by Reliabilityweb.com. The motivation for writing came from a realization that there has been no comprehensive text detailing a methodology for improvement. There are many good texts that discuss the "theory" of maintenance and reliability strategies, but this has left many maintenance and reliability managers frustrated since the practical implementation details have not been published. The objective for the current five volume Maintenance Strategy series is to detail "how" to implement the various processes to make an organization successful at improving their maintenance and reliability processes. You might say the series is a "knowledge capture" of all the successful hints and tips learned over my career so that maintenance reliability managers trying to improve their processes don't have to reinvent the wheel.

**Q** What is the status of the series now?

**A** At the present time, the first five volumes are available in print form. The last five are being developed on a two per year schedule. Since implementation of a full maintenance strategy is a three- to five-year project, if an organization purchased the first five volumes now, the series will be finished before they catch up.

**Q** Is there a central theme or connecting thread that runs through the entire series?

**A** The underlying theme in all of the volumes is how each of the strategies adds value to the organization. Since each of the books highlights how to achieve a strategy component, each will examine how the strategy delivers a return on investment. In addition, each volume in the series will provide sufficient detail so a manager desiring to implement the strategy will be successful. Finally, the books are sequential, meaning that if a manager implements them in the order they are published, their probability of success is greatly enhanced.

> ***The objective for the current five volume Maintenance Strategy series is to detail "how" to implement the various processes to make an organization successful at improving their maintenance and reliability processes.***

**Q** Are you planning any live training or online events related to the Maintenance Strategy series?

**A** Yes. I will be leading the first Maintenance Strategy Master Class Level 1 on January 25-27, 2012 at the Reliability Performance Institute in Fort Myers, Florida. I would recommend this for anyone who has been tasked with making maintenance reliability performance improvements.

Reliabilityweb.com also plans to produce a series of videos available on DVD and online that would accompany each of the books, so a reader can read the text, as well as hear/see a lecture. I would envision the lectures recorded in the form of interactive workshops so the managers viewing the

Terry Wireman


video would have the opportunity to hear the interaction of their peers in the audience. This would be similar to the "Best Practices in Maintenance Management" DVD series that Reliabilityweb.com just published as part of their Reliability Leadership series.

We are also discussing an online version of the Maintenance Strategy Master Class for those who have budget or time constrained situations. Check the Reliabilityweb.com for dates and more information.

Finally, Reliabilityweb.com is in the process of converting the publications to e-reader format for devices like the iPad, Kindles and Nook.

**Q** What are your goals for the future impact of the Maintenance Strategy series?

**A** In many other skilled professions, there are certifications that highlight an individual's proficiency in that discipline. I would like to see the Maintenance Strategy series become part of the curriculum for certification or a certificate.

In the future, I envision a degree program for maintenance and reliability. Not a program that focuses on the theoretical, but rather one that educates to the level that allows individuals achieving the degree to be able to manage a maintenance and reliability organization. I would like to see the Maintenance Strategy series become part of the course material for such a degree program.

Finally, I would like to see the Maintenance Strategy series continue to evolve. I would like to see future editions updated with additional success stories that highlight the value organizations have achieved by implementing the strategies contained in the 10 books. If this occurs, then

# What Tool? When?

## A Management Guide for Selecting the Right Improvement Tools

Author: Ron Moore • Reviewed by: Terrence O'Hanlon

**When Ron Moore approached Reliabilityweb.com to publish the 2nd edition of *What Tool? When? A Management Guide for Selecting the Right Improvement Tools* we jumped at the opportunity.**


For years, when people asked me to recommend a book that best aligns with the Society for Maintenance & Reliability Professionals (SMRP) 5 Pillars of required knowledge for maintenance and reliability professionals and its CMRP exam, I always recommended *What Tool? When?* as a starting point.

It is one of the few books that clearly details the relationship of maintenance reliability best practices with improved safety, lower costs and improved production or mission delivery.

Moore has a way of communicating technical approaches to business improvement that center on maintenance reliability, but are understandable from the highest level of the organization all the way down to the plant floor.

Besides covering technical approaches, this book also stresses the need for strong leadership and demonstrates how leaders can create an environment that brings out the best in everyone involved. He also covers the need for mastering the "little innovations" that cumulatively result in lower cost and improved output and quality.

Moore goes beyond simply detailing the technical approaches for business improvement. Rather, he covers in-depth the development of cross-functional teams to apply these technical approaches. He also explains how to establish performance metrics and measurements that will demonstrate that operational and business goals are being met.

One of the more powerful elements in the book is a Business Level Failure Modes and Effects Analysis (FMEA) method that will help readers identify the appropriate improvement tools to use at the right time. The Business Level FMEA is well worth the price of the book itself.

Ron Moore's 2nd edition of *What Tool? When? A Management Guide for Selecting the Right Improvement Tools* takes a quantum leap over the first edition with a new chapter on using the Weibull Analysis method, which quickly and easily separates operations-controlled losses versus maintenance-controlled losses.

The new edition also includes additional data that uncovers causes for a poor success rate related to implementation of the improvement tools, as well as new information on organizational alignment.

It also provides additional information on managing cultural change, and particularly demonstrates that the best way to change and sustain an organizational culture is by first changing management behavior.

Furthermore, *What Tool? When?* adds additional clarity and data to specific tools, such as Total Productive Maintenance (TPM), Reliability-Centered Maintenance (RCM), Predictive Maintenance (PdM) and lubricating practices.

The 2nd edition of *What Tool? When? A Management Guide for Selecting the Right Improvement Tools* is a must read for everyone on your maintenance reliability, operations excellence and quality teams. With the holidays rapidly approaching, you also might want to consider getting copies to gift wrap for your plant manager, business unit vice president and even one for your CEO!

Copies are available at:
MRO-Zone.com bookstore (www.mro-zone.com) and at Amazon.com (www.amazon.com).
(Reliabilityweb.com ISBN: 978-0-9832258-3-6).