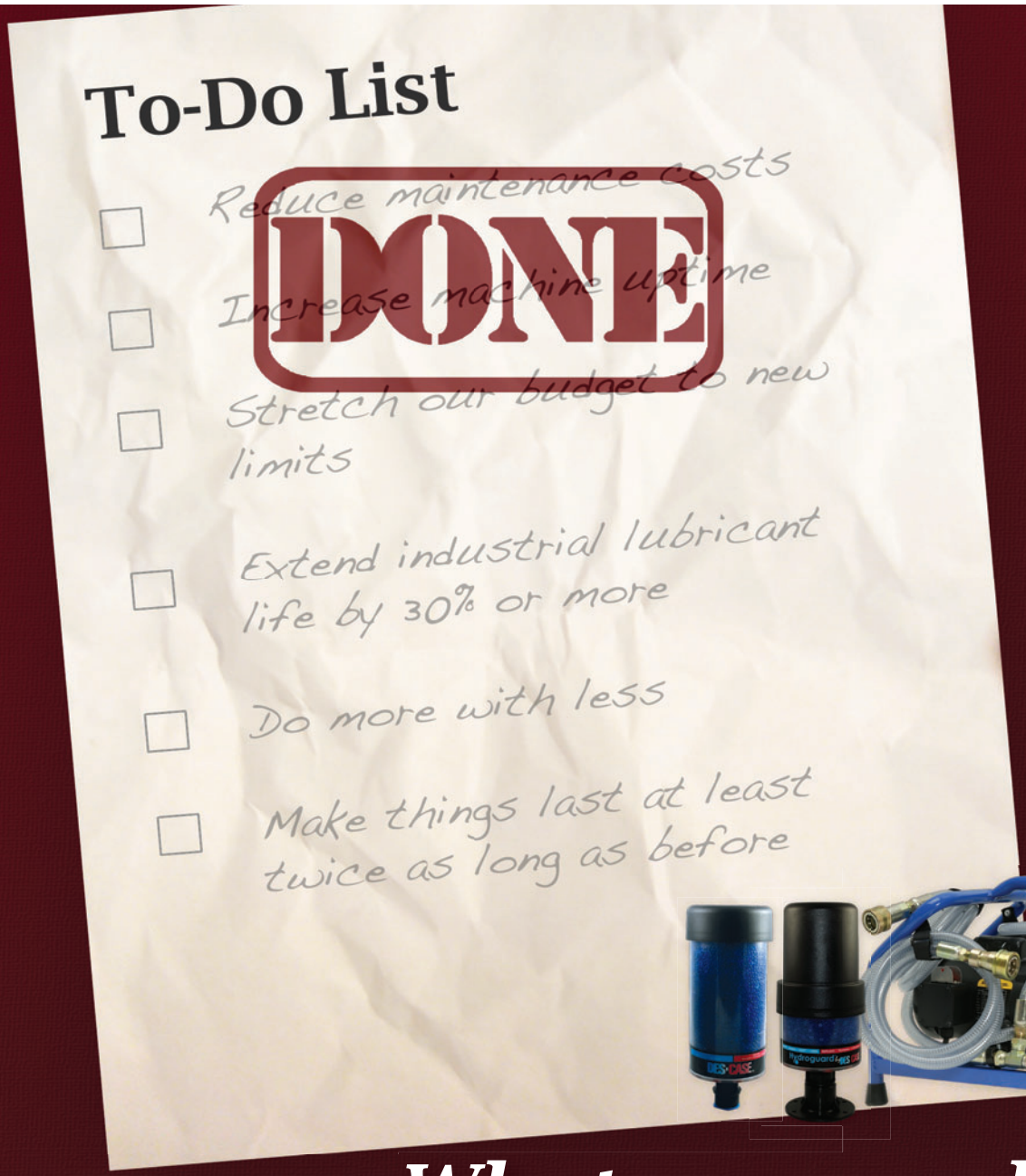


What you need to get reliability done.

DES-CASE® CORPORATION

(615) 672-8800

done@descase.com

www.descase.com

You have more on your to-do list than ever … and probably have less to do it with. Des-Case products get it done – without a big investment.

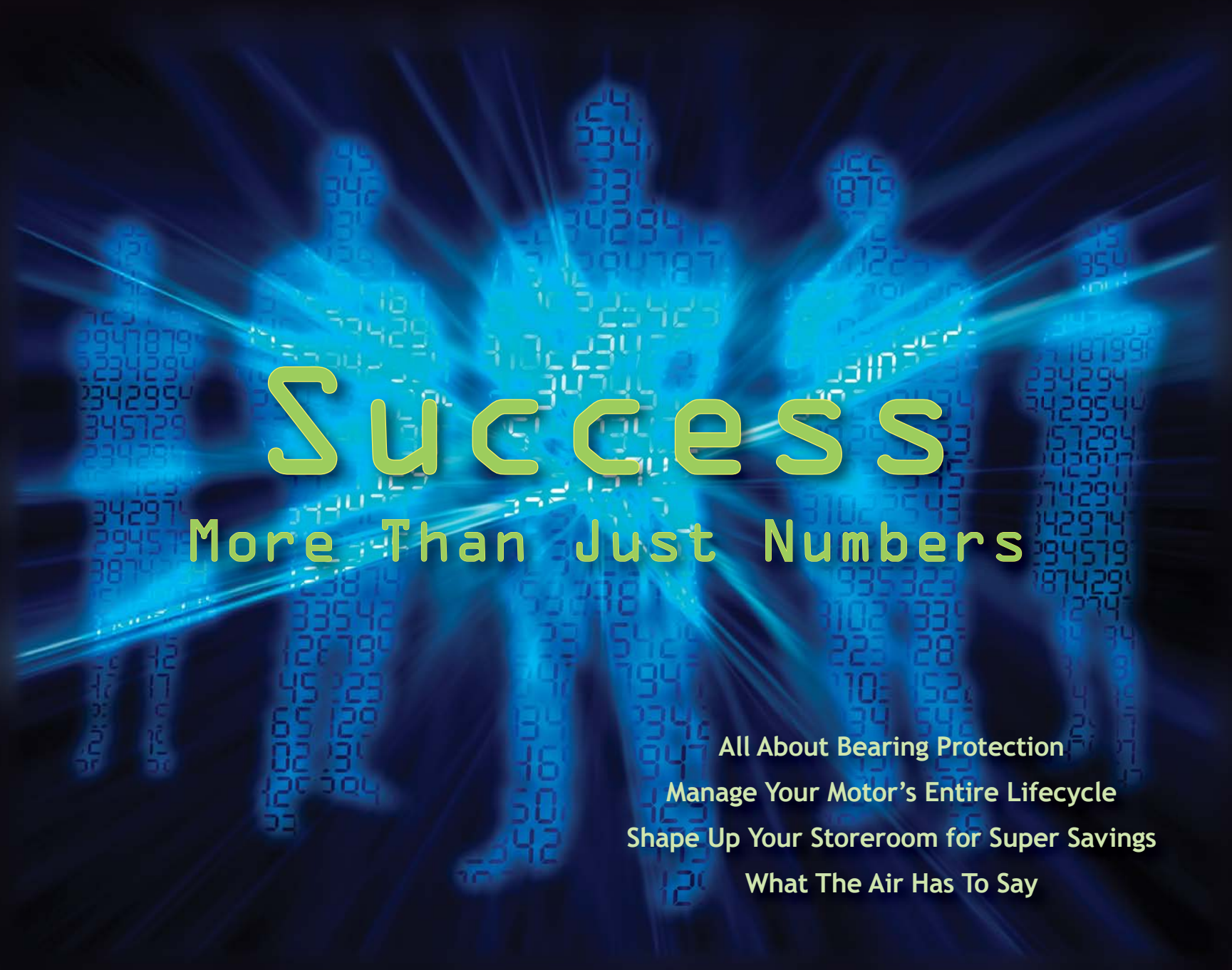
Our breathers and fluid handling products will help you stretch your budget, lengthen the life of your oil, and protect your equipment.

Want to see for yourself? To get started with a free breather, visit www.descase.com/done.

uptime®

june/july 09

the magazine for maintenance & reliability professionals



Success

More Than Just Numbers

All About Bearing Protection

Manage Your Motor's Entire Lifecycle

Shape Up Your Storeroom for Super Savings

What The Air Has To Say

www.uptimemagazine.com

ONE MEASUREMENT POINT

ONE SENSOR

THREE AXIS READINGS

Why Choose TRIAXIAL?

Save Time.
Save Labor.
SAVE MONEY.

VIBRATION ANALYSIS HARDWARE

COMPLETE TRIAXIAL VIBRATION MONITORING SOLUTIONS

AC115 & AC230

Low Cost Triaxial Accelerometer | **Premium Triaxial Accelerometer**

- Collect 3 axes of data
- Reduce data collection time
- 100 mV/g/axis (Premium & Low-Cost)
  ±5% Sensitivity (Premium)
  ±15% Sensitivity (Low-Cost)

Triaxial Cabling

CB105, CB117, CB218

- Straight, coiled, or armored cabling
- Teflon®, armored or Polyurethane
- Triple BNC and multi-pin connections

TSB1000

Triaxial Switch Box

- Simultaneous 3 channel switching
- Optional signal pass through for continuous monitoring
- BNC and multi-pin connections

Unconditional, Lifetime Warranty

IF ANY CTC VIBRATION ANALYSIS HARDWARE PRODUCT SHOULD EVER FAIL, WE WILL REPAIR OR REPLACE IT AT NO CHARGE.

US & CANADA: 1-800-999-5290 INTERNATIONAL: +1 585-924-5900

WWW.CTCONLINE.COM

2009 Inspired Training Series

In March of 2009, Allied Reliability and General Physics created GPAllied to bring together the unique capabilities and synergistic strengths of two thought leaders. This combination allows for global consulting, training and engineering implementation never before realized by the industry. This opportunity to increase our collective service offerings to the marketplace makes it possible for us to increase the value of our public training offerings in Reliability Engineering and Asset Health Assurance.

Our hard-hitting, impactful training addresses the specific needs of your employees, delivers value for your training dollars, and produces bottom-line results.

- August 24-26, 2009
  Asset Health Assurance Electrical
  Chicago, IL | $1495/per person
- September 19-21, 2009
  RCM Blitz™
  Tampa, FL | $1495/per person
- September 21-23, 2009
  Asset Health Assurance Overview
  Salt Lake City, UT | $1495/per person
- November 16-18, 2009
  Asset Health Assurance Stationary
  Philadelphia, PA | $1495/per person

GPAllied
INSPIRED.RELIABLE.GLOBAL

Call 888-335-8276 to register!
Group Rates Available

For more information about training, please email us at training@gpallied.com

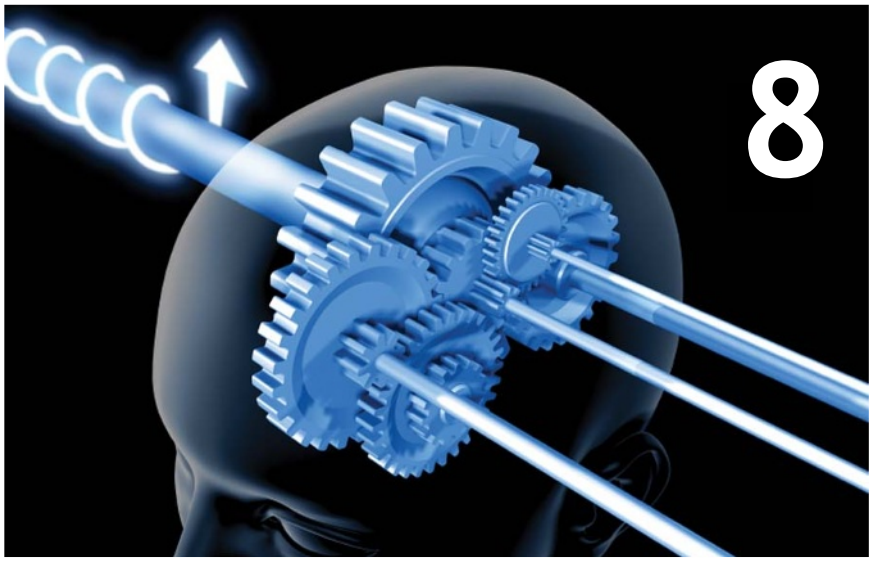
contents

uptime

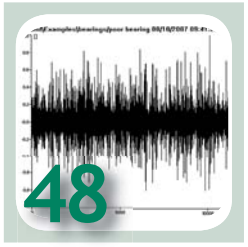
Web Exclusive Articles
www.uptimemagazine.com/uptime

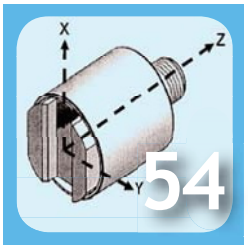
Why PdM Programs Fail: Personnel
In this article from a continuing series, read about some pitfalls to avoid concerning PdM programs and the personnel chosen to staff those programs.

Now More Than Ever: Action Steps Needed
Read about mean time between failure in pumps and why your number may not be as high as it could be. You'll learn pertinent questions to ask and some intelligent action steps to move MTBF in the right direction.



upload





Tapping Into Resources

In the best of times, success is a moving target. In economic times like these, it can seem more like a mirage. However, even though the definition of success is in constant flux, there are some constants on any journey to success.

This issue's feature article by Jeff Smith takes a look at what it takes to successfully implement any initiative that requires changing the culture of an organization. Here's a hint, numbers are nice, but don't get so caught up in them that you miss the human elements, which are the real key to achieving your ultimate goal.

In tough economic times, making the right decisions is even more crucial than when times are good. The best way to insure that good decisions are made is to have a well trained work force. Even though many companies have slashed training budgets, there are still tools available that allow professionals in the maintenance and reliability community to continue learning and improving. Here are a couple that are worth your while to check out:

The Reliability Roadmap Series of Web Workshops – There are several multi-part, educational workshops available for free. These workshops are led by some heavy hitters in the industry and cover topics like Root Cause Failure Analysis, Reliability Centered Lubrication, Infrared Thermography, Electrical Safety, Culture Change and more. There is no cost, no obligation and you can conveniently sit in on these learning sessions right at your desk. The complete schedule can be found at www.reliabilityweb.com

The Association of Maintenance Professionals (AMP) – This is a professional organization that you can join for free at www.maintenance.org. AMP has over 6,000 members spread throughout the world. To join, simply go to the website and fill out a profile. You can make connections easily with people that have the same interests as you do (whether that be RCM, Vibration Analysis, KPI's, the Pan Flute, or all of the above). The more complete your profile, the more chance you have to connect with, learn from and share experiences with maintenance professionals who share your interests. There are over 50 (and growing) groups you can join, blogs to read, a body of knowledge to explore and multiple forums in which you can participate. AMP is an excellent resource from which you can learn a great deal.

If we keep doing the right things, we will eventually reap the rewards. At Reliabilityweb.com, we believe that shared knowledge is the cornerstone of a strong community. Community enriches our lives, both professionally and personally, and in the process, builds stronger organizations.

I hope you enjoy this issue. As always, thank you for reading. We appreciate your support, and hope you find value within these pages and on our newly revamped website. If you have any questions, comments or suggestions that will make Uptime more useful to you, please let us know.

All the best,

Jeff Shuler
Editor In Chief
jshuler@uptimemagazine.com

uptime®
volume 4, issue 35

PUBLISHER
Terrence O'Hanlon

EDITOR IN CHIEF
Jeffrey C Shuler

ADVERTISING SALES
Bill Partipilo
888-575-1245 x 114
sales@uptimemagazine.com

EDITORIAL INFORMATION
Please address submissions of case studies, procedures, practical tips and other correspondence to

Jeff Shuler, Editor In Chief
Uptime Magazine
PO Box 60075
Ft. Myers, FL 33906
888-575-1245 x 116
jshuler@uptimemagazine.com

SUBSCRIPTIONS
to subscribe to Uptime, log on

www.uptimemagazine.com

Uptime Magazine is a founding member of

AMP
the association for maintenance professionals

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

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

RELIABILITY LEADERSHIP COUNCIL

A Reliabilityweb.com® Event

PROGRAM:

Selecting the Right Improvement Tools Master Class

CLASS:

What Tool? When?

by Ron Moore

DATE & LOCATION:

July 29-30 • Ft. Myers, FL

2-DAY OUTLINE

DAY ONE

8:30am-10:15am	**Manufacturing Excellence – The Basics** • Introductions • Overview of manufacturing excellence • The Reliability process for manufacturing excellence • Leadership principles • Teamwork • Change management • Organizational Structure
10:15am-10:30am	**Break**
10:30am-11:15am	**Workshop: Current Tools in Use, Benefits, Problems** • Self Audit of Current Management Support and Plant Culture, Operating Practices, Maintenance Practices
11:15am-12:30pm	**The Hawthorne Effect; The Pygmalion Effect; The Beginning and End; Business Level FMEA - Selecting the right improvement projects and tools; Business Level FMEA – Case Studies**
12:30pm-1:15pm	**Lunch**
1:15pm-2:45pm	**Lean Manufacturing** • Kaizen, including the Quick Changeover Process • Total Productive Maintenance (TPM) • OEE as a Means of Measuring and Managing Waste
2:45pm-3:00pm	**Break**
3:00pm-4:15pm	**Workshop – Business Level FMEA**
4:15pm-5:00pm	**Summary and Close**

DAY TWO

8:30am-9:00am	**Discussion, Questions and Comments**
9:00am-10:15am	**Six Sigma; Supply Chain Management - Two Approaches**
10:15am-10:30am	**Break**
10:30am-12:15pm	**Reliability Centered Maintenance (RCM), plus:** • Predictive Maintenance • Maintenance Planning and Scheduling
12:15pm-1:00pm	**Lunch**
1:00pm-2:30pm	**Workshop: Case Studies – What would you do?**
2:30pm-2:45pm	**Break**
2:45pm-3:45pm	**Root Cause Analysis; Performance Measurement Cascade**
3:45pm-4:30pm	**Workshop: Personal Reflection and Action Plan**
4:30pm-5:00pm	**Summary**
5:00pm	**Close**

APPENDICES

- *Training Guidelines*
- *Predictive Maintenance Technologies – Details*
- *Shutdown/Turnaround Management*
- *The Manufacturing Game®*

TAKE HOME WORKSHOPS

- *Business Level FMEA – Clean, Inspect, Restore – At Your Plant*
- *Developing Your Action Plan for Manufacturing Excellence*
  Assuring Process Consistency during Normal Operation
  Optimization Your PM Practices

PLEASE REGISTER TODAY! SEATS ARE LIMITED.
Call toll free (888) 575-1245 or visit www.maintenanceconference.com

Looking Beyond the Numbers

by Jeff Smith, CMRP

"Management by numerical goal is an attempt to manage without knowledge of what to do."

W. Edwards Deming

KPI's are a great management tool, but the numbers themselves will never insure success. Yes, your indicators will contain a wealth of statistical and mathematical information. And, yes, having the numbers may guide you in the correct direction, and the actions you take because of the numbers you have gathered may lead to success. However, just as one cubic yard of dirt fills a pickup and a million cubic yards make a mountain, ultimately, they are what they are - numbers and dirt.

The simple fact that you can even get the information required to give a KPI shows you have been somewhat successful. And, if the information within the KPI is actually real (that is, not subject to the maxim of garbage in, garbage out) then you are even more successful.

However, it is important to realize that numbers are not everything, and, as the following example will clearly show, they can be downright misleading. In other words, you have to go much deeper than numbers to find the keys to success. Hopefully, this article will give you some good ideas about where to begin, or to recharge, your journey.

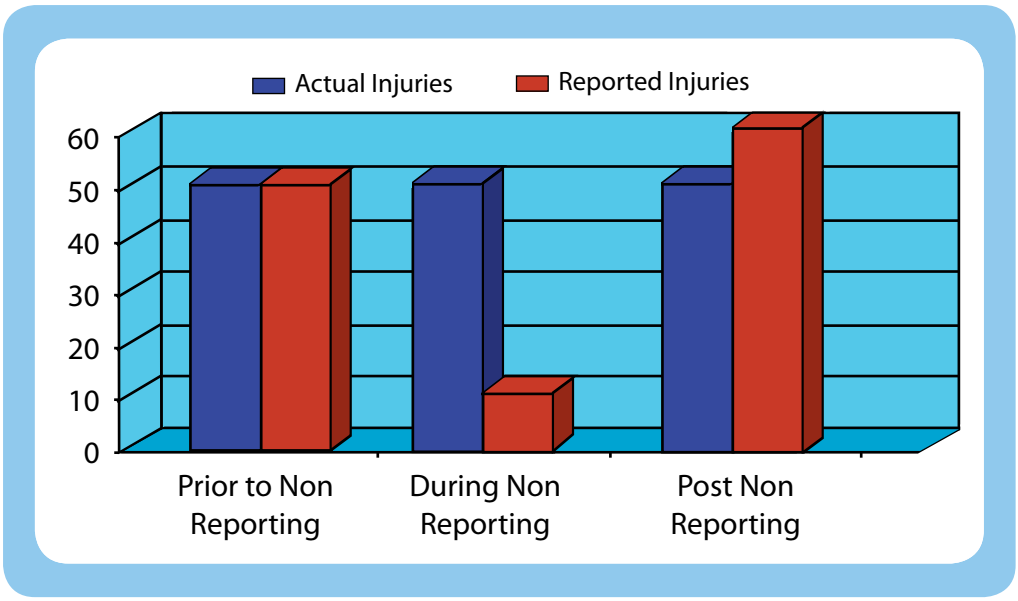


Figure 1 - Reporting of Lost Time Injuries at a Major Railroad

Here is an interesting example of managing to the numbers. A major railway decided that in order to improve its safety record, it needed to reduce the number of reportable injuries. So, they decided that the solution to their issue was an old school management technique. They simply threatened the unit managers. Amazingly, this "solution" resulted in a major reduction in reportable injuries. But, did the "solution" actually work? Not really, because, as you might have guessed, the injuries still occurred, but unit managers just stopped reporting them.

In fact, several years later it was found that previously injured people were now working in light duty situations to cover these injures, which further aggravated things because the railway was sued. So the next memorandum that the unit managers received stated, "All injures must be reported". With this new direction even the most minor injuries were reported, which resulted in a dismal safety record for the railroad. This is a classic case of managing to the numbers, not to the underlying issue. Had they actually addressed the safety issues they would have successfully reduced the injury numbers.

The lesson to be learned is that we should be very cautious of the numbers, because statistics can be misleading.

Please do not misinterpret this article as discrediting KPI's, because accurate numbers are one of managements greatest assets. However, the emphasis must be on the word 'accurate' for numbers to have any meaning whatsoever.

So let's try to create some numbers that induce change. One thing that's surely needed is inspiration. What is the unit of measure we should use? Well, there isn't a standard, so we will make one up and call it "insp". Now all we have to do is ask Joe how many "insp" he has towards the latest change initiative! Hmmmm....Joe must be a little slow, because he doesn't understand. When we ask for the "insp" numbers, he thinks we mean how many inspections has he done.

So what's the moral? Well, I know this may be hard to believe, but it turns out that inspiration can't be measured.

In fact, most things that lead to success, and actually deliver the sought after KPI's, are immeasurable. So how do we obtain immeasurable success?

Why Do Some Implementations Fail?

We All Know Change Is The Only Constant In Life. Why Do Industrial Facilities Resist It?

There are a myriad of circumstances and situations that promote failure within an organization, but there are three in particular that are common across all industries.

Culture of Resistance

The culture of resistance is most predominant reason for a failed implementation. Within so many organizations, the methodologies and processes have been stagnant for long enough that the current employee group has not embraced, or have not been guided, to constructive change. Change may have been attempted, but was successfully avoided (Yes, unfortunately, the ingrained culture would consider this a success). This formula allows the critics of change to wave the flags of past failures in the faces of new initiatives. Basically the more failed attempts, the more flags, and flag bearers, the organization will have lining up against the next initiative. Interestingly, this ingrained culture is quite predominant within successful companies that have experienced years of profitability due to market dominance or product recognition. What the culture does not understand is the basic line you hear with stock and mutual fund forecasts, that is, "Past performance is not an indication of future success".

Change Fatigue

This is another common cause of failure. Organizations with constant fluctuation in management and organizational strategies tend to burn out the change agents. One initiative has been started and dropped midstream. only to be replaced with another. This approach grinds away the commitment of even the most optimistic change agents.

Changes that do progress under this approach seldom have the stabilization period required for the change to be ingrained into the culture of the organization. Therefore, under this scenario, the initiatives lack sustainability. Change fatigue is a pitfall commonly found in organizations that are fairly immature and/or have experienced rapid growth.

Initiative Selection

This decision of which initiative to implement can often lead to failure, either perceived or real. Many organizations often focus on improper solutions to drive the changes in the required areas. They will implement a solution, work through the transition stages, then arrive at the realization that the solution has not addressed the original concern. The most common industrial example of this is implementing a new CMMS without addressing business processes. Using a new CMMS in the same way as the last one was used seldom has quantifiable benefits. Management often looks to salesmen for quick fixes to internal issues and selects the most convincing salesmen's solution without doing the industrial soul searching required to understand the barriers to success.

What Are the Barriers to Success That Seem to Repeat Themselves With Each New Initiative?

One Solution Will Never Solve All Problems, So Why Do We Expect It To?

Unrealistic expectations are a surprisingly common barrier to success. When we are initiating an improvement, we overrate the benefits that will result. For example a maintenance supervisor decides to initiate a vibration analysis program. To justify the cost of the program, he paints an unrealistic picture of the reliability gains the plant will attain. The program is well implemented and delivers some good results, but the promised jump in reliability is not attained. So, in striving to deliver the promised results, the supervisor adds more equipment to his vibration surveys which requires more dedicated personnel. More personnel drives up the cost of the program and the wins become progressively smaller as the equipment analyzed is lower on the criticality score. At some point, the vibration program is criticized and then dropped, with the all too familiar refrain, "we tried vibration analysis, but it doesn't work here!"

Foundational instability is the most prevalent barrier. Success in any venture requires some basic ground work to be in place within an organization. Things like organizational structure, business processes and workflow management act to make the next steps stable. Many initiatives have been doomed to fail as they have been developed on an unstable foundation, which makes them inherently unsustainable.

Underdeveloped communication channels create a substantial barrier to success. Many organizations will have pockets of excellence. They will be noted, and the word will go out that "All business units will initiate this great solution!" Unfortunately, by the time the information is passed through many hands, the 'how' and 'why' is often lost. The change agent implementing the solution at another business unit has partial information, and his success (or lack thereof) does not reflect the proclaimed success of the original implementation.

Faulty communication often results in skepticism of the next corporate initiative and further fragments the business units.

What Is Required to Deliver Successful Reliability Improvements, Regardless of the Solution Utilized?

We Don't Start School in 12th Grade. Why Do We Try To Implement High Level Solutions Before The Basics Are Covered?

In order to make progress, organizations must first understand their current state. If you do not understand exactly where you are, how do you really know where you are going, and what it takes to get there? We often evaluate ourselves with skewed perception. That is, we seldom can give a fair or impartial evaluation of ourselves. If our natural tendency is to be

optimistic, we will gloss over our shortcomings. On the other hand, if we are basically pessimistic, we will harshly criticize minor shortcomings. In many cases, an external assessment by a reputable organization works best to provide a clear perspective of our current state. Regardless of external or internal assessments, the resulting evaluation should cover all facets of reliability, should clearly identify the facilities ranking among similar industries, must include evaluation of perception within the organization and must provide supporting evidence of these conclusions.

Beware of business cases masked as assessments! If your assessor has a product to sell you (other than the assessment), there is a good chance that outcomes will be biased towards the need for that product. The assessor/sales person may not be intentionally misleading you because he normally truly believes in his product – though this may be another skewed perception. At this point, you should not be looking for a transition tool. First, you must have a clear understanding of where you are, how you stand with comparative industries and the perception of your organization's employees about your current state. You should also have hard evidence to support your conclusions.

When you objectively understand your organization's strengths and weaknesses, the next logical step is to define your desired state. At this point, generalization will negatively affect your chances of success. You need to clearly and specifically define your desired state. You're desired state should be defined in multiple levels. The highest level should resemble a mission statement, and sequential levels should define your desired state for each improvement initiative. And, at this stage, be sure to include measurable targets. For example, your assessment has concluded that you have poor lubrication contamination exclusion practices, so your desired state would include statements with ISO targets for various oils and should read as if it is a current reality, "Our hydraulic oils are maintained at under 17/15/13".

Simply stated know where you. Then define where you are going BEFORE you embark on your journey.

We Know Where We Are, We Know Where We Want To Go. Let's Grab a Bowl of Acronym Soup and Go.

Wait! What Route And Which Vehicle Are We Taking?

The path to reliability has both parallel and linear streams. Some solutions work best if foundational programs are in place and stable. Your organization should re-

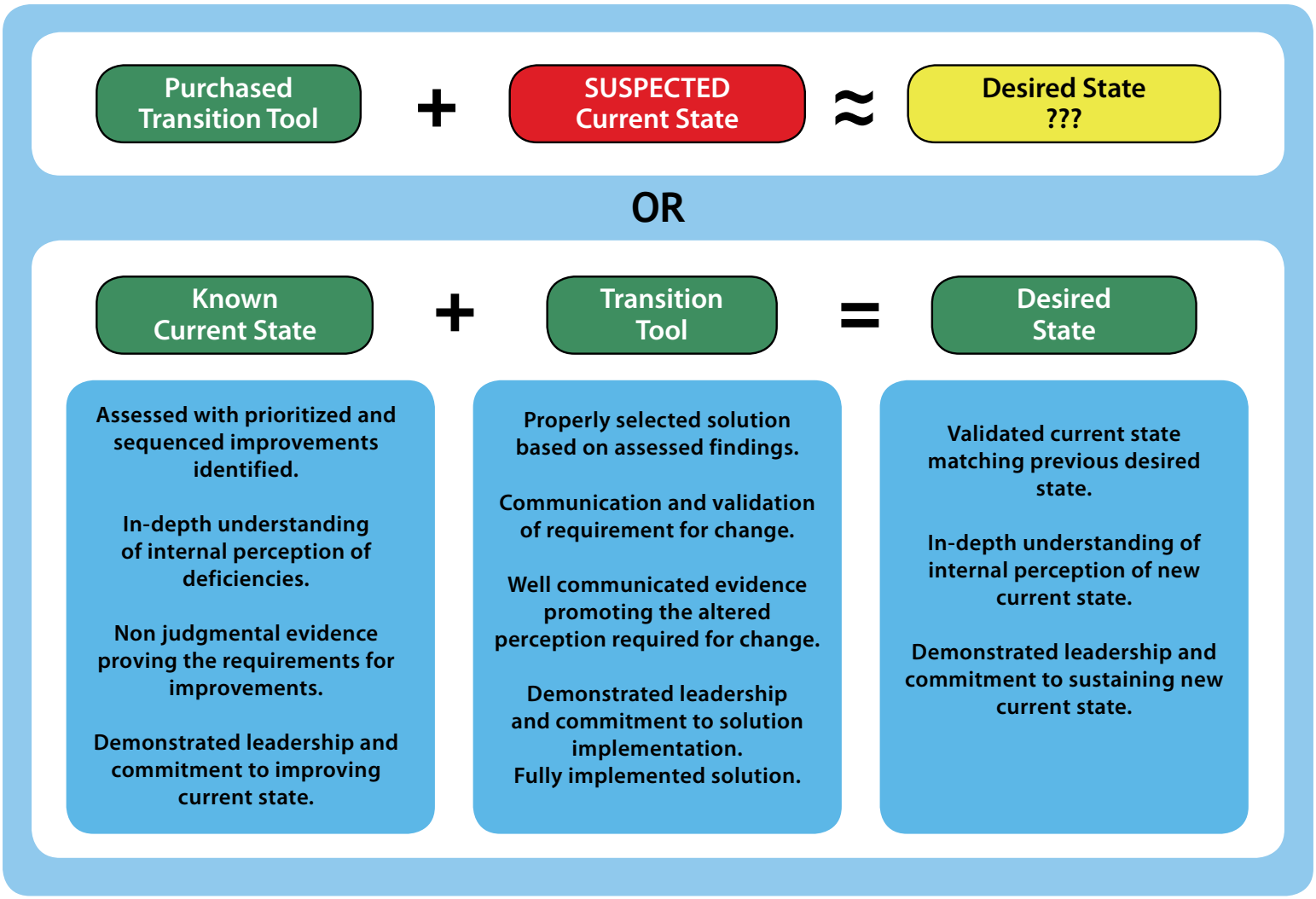


Figure 2 - Careful definitions of the known current state and the desired state will lead to a successful transition flow (bottom). Looking for a quick fix without the proper groundwork will lead to an undefinable result (top).

view the assessment findings and list the recommendations in a flow chart. Which elements are foundational elements? Which recommendations can be simultaneously implemented?

Develop an improvement plan at this point. Breaking the initiative into smaller parts and addressing them individually lessens the impact of the change. What should be promoted at this point is that this is the logical sequence of steps that will help your organization to reach your destination, as stated in your desired state proclamation.

Now that you have a clear picture of your organizational issues, a well defined desired state and a flow chart, now is the time to select the transition tools required to address your organizational requirements. Transition tools can be anything you require to address the inadequacies in your current state. They could be both tactical tools (processes/strategies) and/or technical solutions (hardware/software). It is important to remember that transition tools do not necessarily have to be external resources or recourses, they can easily be internal teams or groups.

Both your current state and your desired state must be clearly communicated during the selection process of transition tools. This is where we are, and this is where we want to be, so how can this potential solution get us to our desired end point?

Define your version of success, and insure both you and the solution provider will be evaluating with the same unit of measure (though it may be an immeasurable).

There is not a single solution that fits all requirements. There are many companies with great processes and programs, but be sure to choose the solution that will best complement your plan, not the vendor's vision. Your assessment should outline the areas you need to improve, and in some cases, one vendor may have what it takes to solve all your issues, but this is rare. For example RCM could resolve your poor lubrication contamination exclusion practices, but there would be a quicker ROI (return on investment) in implementing good lubrication practices as a foundational program.

Regardless of how great a transition tool seems, if you do not fully understand your

LOCTITE®

WHERE'S *YOUR* LOCTITE®?

Keep your Loctite® products in hand and you'll always have the proper tools with you to get the job done right!

Call 1-800-LOCTITE to locate your local authorized distributor, to speak with a Loctite® adhesives and sealant specialist or to schedule in-plant training.

www.henkelna.com/mrotraining

Henkel

current state and define your desired state, it is unlikely you will obtain the desired state (see Figure 2, top).

If your organization fully understands its deficiencies and implements the correct solutions, in the correct sequence (Figure 2, bottom), the only barriers left will be the immeasurable human elements.

With a History of Failed Initiatives Why Should Anyone Buy Into The Next Solution?

Change? Great, What Flavor Is It This Week?

It doesn't work here. We tried improving, we now have the 3S program. That doesn't apply to this industry. Management never supports it. We are too busy to improve! We can't afford to save money! We make lots of money, we don't need to improve! Do any of these sound familiar?

Understanding the shop floor perception is a key, and in fact, an immeasurable concept to succeed with any reliability improvement initiative. There is a great deal of documentation on facilitating change, but as with improvement initiatives, you have to truly understand your starting point. On a shop floor level, within both operations and maintenance, the perception of how the organization is operating must be understood. Do the personnel feel that everything is fine, that there is no requirement for change? Is the general perception one that they are fighting an insurmountable death spiral of over-worked resources and continually shrinking budgets? Is there an internal power struggle between operations and maintenance? Just having a general perception of these dynamics is not sufficient. You need to understand specifics, such as what percentage of the people feel which way and how strongly they feel about the organization.

People seldom want to be inefficient. Most people want to do a good job. They may not have the education or training to understand the reliability implications of what they do, but they do not want to intentionally do a poor job. Even apathetic people do not want the publicity given when their actions cause unreliability.

Understanding perception and motivation are key elements in selling solutions to floor level employees. In order to motivate people to buy into a solution, you must address their perception of the situation and tailor your presentation to their perception. If you have to disprove their perception, do not get emotional and always utilize factual information to show the real situation. Show how your organization measures up in relation to other competitors, or how a particular solution is meant to guide your organization to the desired state. All people have a subconscious ability to recognize dishonesty, do not twist the truth, use too much 'spin' or manipulate the information.

If you are unsure of the solution you have chosen, educate yourself. If you are presenting and promoting it, you will be perceived as an expert. You have no choice but to become an expert on the subject if you want to implement it. If you are bringing in an outside resource, ensure they are experts on the solution. One downside to the rapid growth of the reliability industry is that some consulting companies provide under qualified consultants, which is a major disservice to customers. Check the qualifications and experience of the solution provider. You can be certain that the personnel within your organization will eat an under qualified consultant for lunch and spit out your unsuccessful solution.

We Manage by Measurements.... But What is the Unit of Measure for Leadership?

A President Is a Leader.... But So Is a Man With a Dog.

Does implementing change truly require a white knight waving a banner and yelling charge? Unlike what the reams of paper used in printing the plethora of change management books state, leadership is not an individual, it is a thing. A leader is

a person, but leadership is a thing.

So what is this thing "leadership", within the context of industrial evolution? Ironically, it is best described as a virus. It starts with a carrier that successfully communicates its value to stakeholders. If it is successfully transferred and survives its incubation period, then the first line of stakeholders becomes infected. The initial carrier may not show any symptoms, it may have just been one of many daily corporate decisions. If the decision was invalid or poorly communicated, then the organization's natural resistance will quickly eradicate it. Correctly chosen and sequenced, it will overcome the resistances of the first line of stakeholders.

There will now be a core group infected with leadership, transferring the virus to the next level of personnel. There now becomes a group that has heard in advance that there is a virus and has attempted to compile resistance by utilizing negative communication.

Here, we again hit the perception window. Do the masses think leadership is bringing a positive thing or a threat to their way of life? If the communication and incubation period are handled well and are bringing positive change, a percentage of the masses will become infected with leadership and the virus will have reached critical mass. Critical mass then forces the people with the highest natural resistance to accept the leadership.

Industrial evolution leadership is measured by the depth of penetration within an organization to which leaders have been created. If the personnel on the plant floor are promoting the initiative, rest assured that you will be successful.

As a Leader, How Do We Establish and Keep Our Credibility?

Wait For Me....
I Am Your Leader!

Education is a key factor in establishing credibility. If the leader of the implementation knows less then the resistors to the implementation, the perception will swing to the most credible sounding argument. The perception of anything must be supported by facts to have credibility...unless you are a politician. If you truly want to influence the immeasurable things like perception, you need to devote the time to educate both yourself and the people affected by the change.

Communication is mandatory for success with immeasurable qualities. If the solution has been properly selected and sequenced, it is the right solution. If it is the correct solution, it should be adver-

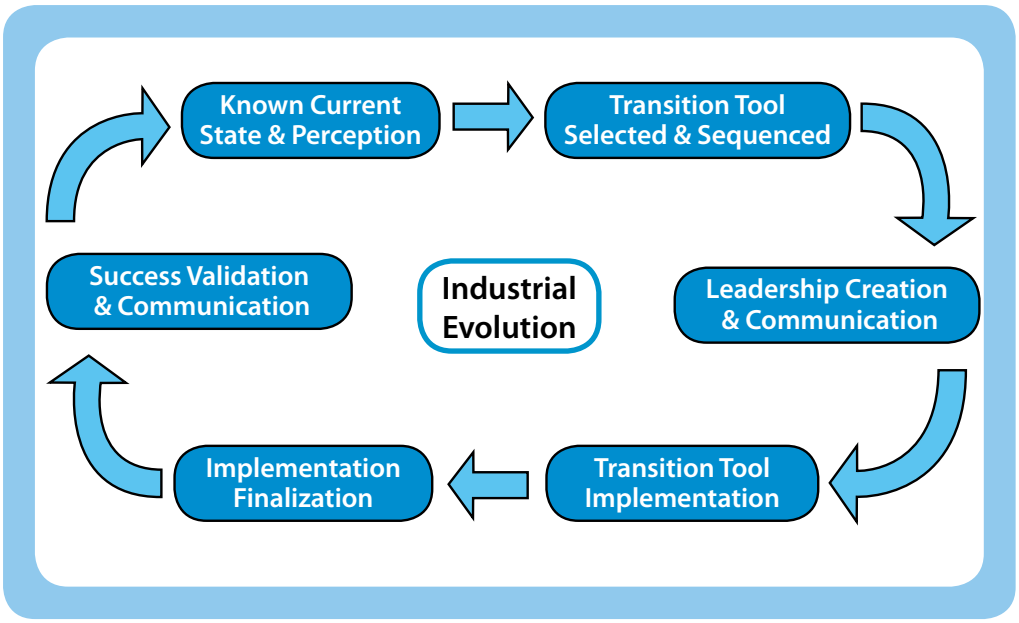


Figure 3 - Industrial Evolution Flowchart

tised, discussed, promoted and campaigned. Once you have fully educated change agents, debate should be encouraged early on in the initiative. Let people have their say and address their concerns. If people's concerns are addressed too late in the game, they will feel overlooked and this will only serve to increase the resistance to the solution.

Commitment is not just an internal perception. If you want to lead people through a change, you must be prepared to publicly state your commitment to the path. If you are not truly committed to the chosen path, then your people will see through anything you say. If you honestly believe the path is the required one, proclaim it, early and often. Utilize your education and communicate your commitment, and your followers will become leaders.

What Are The Common Traps Leaders Fall Into?

Mud Slinging Has Become Human Nature. Just Look at Political Advertising.

One potential trap that discredits leaders is when they give one message in public and another in perceived privacy. Do not try to convince people to commit to something you are not totally committed to. If you convey skepticism in private, it will become public and be used to derail your initiative. It is easy to promote something you believe in. This is exactly why choosing the correct and properly sequenced solution is imperative.

The time to learn is not as you are presenting a solution to the people affected. Know the solution you are developing. If it is TPM, for example, take the time to become an expert on the subject. Read, comprehend and retain information on whatever you are presenting. You may never know the subject completely, but if you understand the concepts, you will avoid uncertainty in your responses. If there is a question that you cannot answer, do not resort to elaboration. People will accept "I don't know, but I will get back to you" much easier than they will forgive something stated and later proven false.

Persevere! Many change initiatives fail in the last inning. If the leadership moves on to the next priority and is perceived to have stopped the initiative, then regression quickly slips in. Even if priorities have shifted, ensure that you have finalized the first implementation. This is the point that measurables (KPI's) are implemented and reinforced. Lead until you get there.

How Do We Ingrain Sustainability?

Did Things Change? How Did We Used To Do This?

In the cycle of change we reach a point where the objective has been met. In order to have reached that point, we have assessed our needs, chosen a solution, addressed and changed the perception of the people affected, created leaders throughout our organization and implemented the solution. So how do we keep the solution in place?

One of the fist priorities would be assessing the perception of the solution. Do people actually believe it has happened? Are they actually utilizing the new process/technology, and utilizing it correctly? Have the conditions of the defined state been met? If not, then the implementation is not finished.

Sustainability is only truly validated when the culture forgets there was another way. The current state must be ingrained into the day-to-day processes of the organization. This is the point where measurements come into play. The measurements must not only be tracked, but the required alarms must be developed. If a KPI is exceeded, then the required actions should be defined and initiated. Do not focus only on failure! If the numbers are surpassed, communicate and publicize it. Because, believe me, there is immeasurable success in being able to proclaim we are no longer trying to be world class! World class is trying to be us!

Jeff Smith, CMRP, is the president of Reliability Laboratory Ltd. (Rlab). Rlab was founded as a research facility to explore all facets of reliability optimization. Jeff has 25 years industrial experience in both technical and tactical reliability. He has implemented reliability improvements globally in a multitude of industries. Jeff has presented at several conferences and delivered numerous seminars on integrated condition monitoring. He can be reached at solutions@reliabilitylaboratory.com or (604) 823 2422.

Reaching 99.8% Reliability

Software Increases Confidence in Decision Making

by Amy Davidson

The vast amount of diagnostic information available today about the condition of critical production assets – information that can be of real value to decision makers -- can be confusing and even overwhelming. However, when information from hundreds or even thousands of separate sources is consolidated and organized on a single platform, a more complete picture of the health and operation of critical assets, or an entire process, emerges.

As a result, users can literally see into the future to prevent process slowdowns or unplanned stoppages. The ability to view the health of critical production assets from anywhere in the world may be just what a manager needs to recognize a developing problem and predict what will happen well before a serious breakdown threatens productivity, whether in a production unit or an entire plant. Equipment not performing up to full capability can be identified well in advance, making it easier to decide when to deploy maintenance resources in the most efficient and cost-effective manner.

Look at the results from a multi-plant petrochemical company in southern Africa. When data from various sources was consolidated, a previously unattainable view of the production assets became the basis for predictive maintenance:

- Equipment reliability improved from 97% to 99.8%
- Saved 11 days of production by minimizing downtime
- Saved $200,000 to $300,000 by selectively overhauling control valves

Johan Claassen, previously mechanical and instrument maintenance manager for seven petrochemical plants, said officials were looking for a good maintenance management tool at a newly commissioned plant. This facility had all the latest automation technologies, including HART and FOUNDATION fieldbus instrumentation and was the site of a comparative asset management systems trial conducted in 2005. After the six-month trial, the company selected Emerson's AMS Suite as its basic predictive maintenance software. This included AMS Suite: Asset Portal, a web-based application designed to aggregate diagnostic information from data sources within the plant.

Since that data can be accessed via Internet Explorer, authorized personnel in the plant, or half-way around the world, can view vital information on critical production assets. The information can be organized in a way that is most helpful to the user – by location, asset type, description, health index, or significance to plant reliability. The configurable dashboard instantly presents the highest priority assets. Users can consult appropriate documentation from a manufacturer's website or view internal records on a specific asset directly from the dashboard.

The combined data gives managers a broader view of the current operating condition of mechanical and process equipment as well as field instruments and valves throughout a plant or across an entire enterprise. This can have a strong impact on decision-making.

"After six months of intensive scrutiny," Claassen said, "we decided to standardize on these technologies for their ease of use, the amount of diagnostic information we could obtain from the field, the high level of information received, and the ability to drill down for more detail if required. This was

***Editors Note**: We published this article with specific references to Emerson's AMS Suite and Asset Portal software in order to tell more people about potential solutions as maintenance and reliability information management evolves. We did not want to make it generic. There are other unique software products that we will also be presenting to you in Uptime. In order to bring you the full impact of the capabilities of some of these new technologies - we have decided to allow product specificity - not as an endorsement - but to create an enhanced understanding of the rapidly changing landscape of Information Technology. Uptime is comfortable stepping out of the limited and traditional etiquette of magazine publishing and we hope you see the value in our decision. We certainly invite your feedback as we continue to move forward.*

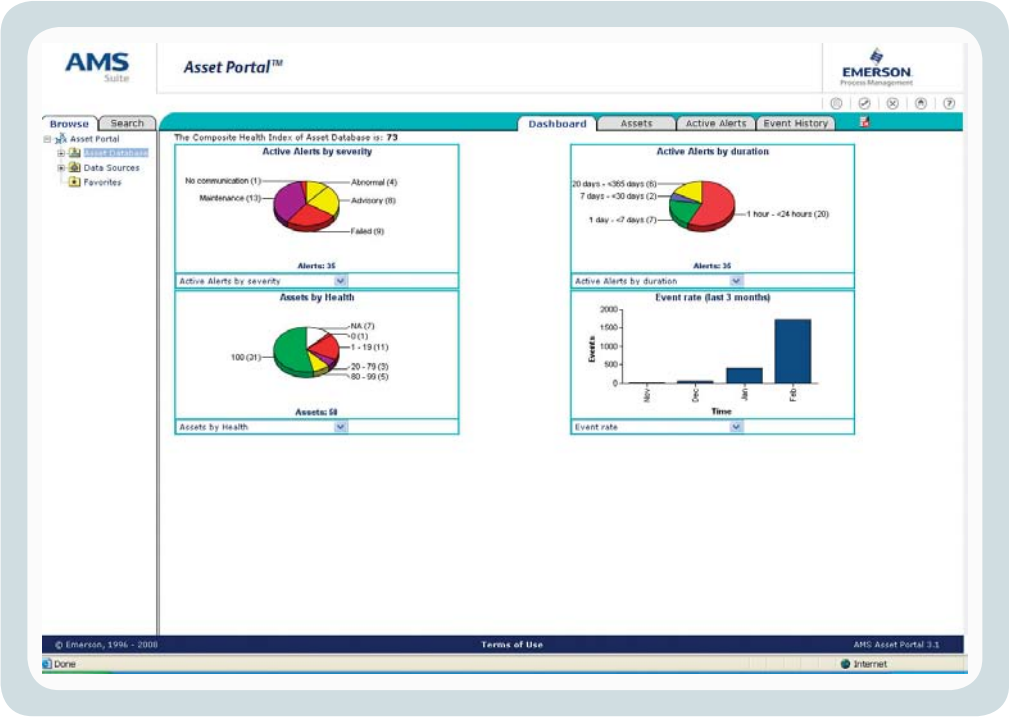


Figure 1 - A screen shot of the dashboard within Emerson's AMS Suite: Asset Portal, which gives you a view of Active Alerts by severity and by duration, a view of Assets by health and a score for the composite health index of you asset database.

a good choice; they proved their value in their first year of full operation in our plant."

The two major yardsticks used to evaluate the operational effectiveness of the AMS Suite products, Claassen said, were the impact on maintenance costs and plant reliability. In 2003, the first year of plant operation, instrument and valve reliability was 97 percent – not bad, he said, but of course everything was new. Following implementation of AMS Asset Portal, reliability increased to 99.8 percent.

There was also a direct financial benefit in the reduction of maintenance costs. Instrument and valve spending actually decreased in the years following start-up. This was largely due to a "big gain", Claassen said, on the control valve side where a program was implemented to use the predictive diagnostics produced by valves equipped with digital valve

controllers (DVCs), which provided feedback on valve function and condition.

In the past, control valves were generally removed from service and overhauled every two years. The new valve diagnostics proved that that repair frequency was not necessary.

"We actually changed our valve maintenance philosophy based on the new technology," Claassen said. "When production and maintenance personnel met prior to a shutdown, we would determine which valves had to be removed based on a preventive maintenance philosophy calling for maximum removals just to be on the safe side. When we started basing decisions on each valve's actual performance, by comparing original and current valve signatures, we found that far fewer valves had to be scheduled for overhaul.

"This represented a significant savings," he said, "because removing a control valve requires a huge amount of planning and coordination. For example, the wiring must be detached, and the lines must be drained and removed and the valve placed in a good space where the guys can work on it. It also may be necessary to arrange for scaffolding or get a crane to lift the valve, depending on its size and location in the plant. We saved between $200,000 and $300,000 per shutdown by greatly reducing the number of valves serviced each time."

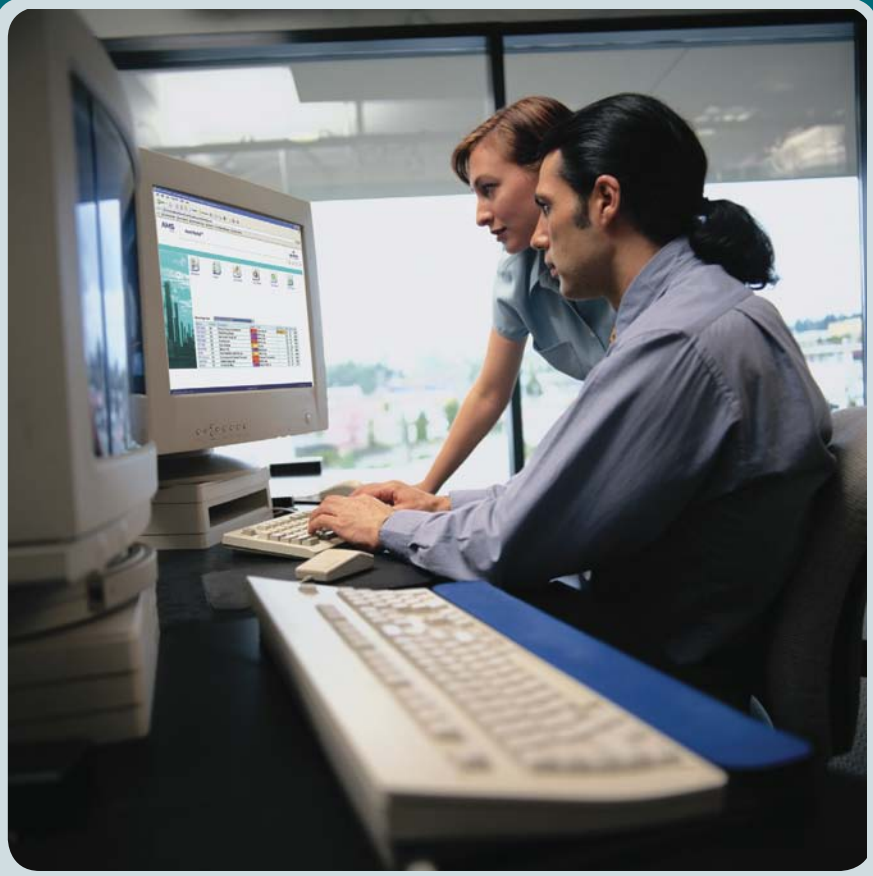
Claassen concluded, "Even with that impressive savings, the biggest financial impact resulted from increasing equipment reliability to 99.8 percent. The additional uptime was equal to about 11 full days of production per year." He cited still another benefit – faster plant startup following a shutdown. Claassen said, "The biggest concern an instrumentation and valve manager has after a shutdown is whether everything is physically connected in the same manner as it was before the shutdown. A lot of contaminants can get into the system during a shutdown, so we always try to make sure all the equipment is back to normal."

Claassen said, "AMS Asset Portal enabled me to actually see which devices were ready and which ones had problems. If it showed everything was connected and properly configured, it gave us the confidence to sign off on the startup."

Timely information provided by this software includes:

- Plant Health Home Page for a quick look at the health of all plants
- Asset Health Dashboard Report that organizes

Using AMS Suite



Each of the AMS Suite applications provides a unique window into a specific area of plant operations that can be observed in no other way. AMS Suite: Intelligent Device Manager gathers data generated by smart instruments and valves throughout a plant. This single application supports device configuration, documentation, calibration management, and diagnostics, making it possible for maintenance personnel to predict with great accuracy how long and how effectively a smart device or smart valve can be expected to continue performing reliably.

In much the same way, AMS Suite: Machinery Health Manager supports predictive maintenance of rotating mechanical equipment by analyzing vibration data from motors, pumps, fans, turbines, etc.

AMS Suite: Equipment Performance Monitor is another web-based service designed to increase the availability and throughput of turbo, rotating, and process equipment.

AMS Asset Portal aggregates data from all AMS Suite applications to provide a comprehensive picture of asset health across a plant.

and displays information on the condition of plant assets in a concise, yet understandable way (Figure 1)

- Enterprise-wide view of production assets, no matter where they are located
- Importing capabilities for data regarding production assets not connected to standard sources
- Exporting capabilities to send asset data to a third-party, such as an equipment vendor, for analysis and suggestions

Summary

By consolidating diagnostic information from many sources throughout a production unit, or an entire plant, on a single platform, the condition of all essential production assets can be observed. Plant personnel can quickly identify under-performing equipment long before it causes a slowdown or stoppage. They are essentially able to look into the future with the power to predict unexpected failures or off-spec product in time to take corrective action.

With these technologies in place, equipment reliability is raised to new levels, predictive maintenance can be practiced, and hundreds of thousands of dollars can be saved.

Amy Davidson is a Product Manager in the Asset Optimization Division of Emerson Process Management, located in Eden Prairie, Minnesota. An Emerson employee for the past five years focusing on asset management issues, Amy has more than 20 years of experience in project management and marketing in the automation industries. She is a graduate of South Dakota State University with a BS in Chemical Engineering.

Creating A Team of Experts

Improve Internal Connections For Enhanced Electrical Safety

by H. Landis Floyd II, PE, CSP, CMRP, Fellow IEEE

How does your organization's maintenance & reliability program link to its electrical safety program? Do you see strong evidence of synergy and collaboration? Exploring these questions may open the door to greater results in both worker safety and operations uptime. This article provides insight into how to asses this opportunity for your organization.

Modern industry and commerce are dependent on electrical technologies for energy, control, data management and communications. In celebrating the top 20 extraordinary engineering achievements of the 20th century, the US National Academy of Engineering selected electrification as #1, and acknowledged that the remaining nineteen all were dependent on electrical technology. This underscores the critical importance of electrical systems' uptime and reliability performance to business and commerce. Beginning in the late 19th century and continuing today, electrification, or the displacement of other technologies with electrical technology, has transformed all aspects of our modern society. Energy generation and distribution, heating, lighting, transportation, food production and storage, medical diagnostics, and financial transactions are just a few examples in which electrical technology has displaced previously used technologies to enable extraordinary advancements and conveniences. The implications of having such dependence on electrical technology, combined with increasing initiatives in pursuit of operational excellence, makes the elimination of errors and failures in electrical systems of paramount importance to both personnel safety as well as operations uptime. Optimizing the safety and uptime performance of critical electrical systems presents the opportunity for synergy and collaborations that some organizations have yet to recognize.

Many businesses and organizations today are pursuing performance goals that are defined in terms of operational excellence. In a broad sense, operational excellence is about improving business and operating processes that do one of the following; enhance the quality of product or services, achieve higher yields, use less energy, result in less waste, and increase uptime. Most organizations pursuing operational excellence understand that improving safety performance is also good for business. In addition to holding in high regard the moral and humanitarian duty to provide a safe workplace, most organizations regard safety performance as an integral element of business success. An effective electrical safety program has the potential to provide even more benefits for an organization pursuing operational excellence.

When mishaps occur in critical energy and control systems, a more likely consequence than injury is disruption of the operations served by the electrical systems. Whether it is a chemical plant, financial institution, medical facility, mass transportation or almost any other component of our modern society, an incident resulting in disruption to electrical systems critical to operations can have very significant financial losses. As examples, an incident resulting in disruption of electrical energy or control to a hazardous chemical process could result in a process safety event, waste of raw materials, loss of production, and damage to facilities and equipment. A similar incident in a credit card transaction processing center can impact millions of dollars in banking transactions. An incident in a hospital electric power system could jeopardize the welfare of critical care patients.

Effective application of maintenance & reliability management principles can have both a direct and indirect impact on electrical safety improvement. The mechanical integrity of grounding and bonding conductors is essential for the elimination of shock hazards associated with equipment enclosures, appliance cases, and tool housings. It is also necessary to assure protective devices work as designed during ground faults, and it eliminates sparks and arcs that can occur during fault conditions that could ignite flammable or explosive materials. Many organizations are investing in arc flash hazard analysis studies to establish the basis for arc flash hazard mitigation programs. The effectiveness of this investment is completely dependent on the reliability of circuit protective devices such as circuit breakers and fuses to perform as designed. Without an effective maintenance & reliability program for these critical devices, the arc flash hazards analysis investment is money unwisely spent.

One example of an indirect effect on electrical safety performance is the effort to improve motor mean time between failure. Every motor failure initiates a series of events that entail maintenance worker exposure to electric shock and arc flash hazards. This may include operating disconnect switches, opening electrical cabinets to perform troubleshooting, performing diagnostic

testing, disconnecting and reconnecting motor leads, and replacing fuses. Extending motor reliability reduces the frequency of these events, thus reducing the opportunity for serious electrical injuries. Effective application of predictive maintenance techniques, such as infrared thermography, serve to reduce unscheduled emergency repairs, which tend to have a higher frequency of safety incidents than work that is planned and scheduled.

In recent years, NFPA 70E, Standard for Electrical Safety in the Workplace has brought attention to improving electrical safety programs. Continuing its evolution since first published in 1979, the 2009 edition of NFPA 70E for the first time makes indirect reference to maintenance & reliability management systems through a direct reference to safety management systems standards. In 2008, the Canadian Standards Association published a fully harmonized version of NFPA 70E, CSA Z462, Workplace Electrical Safety, which includes a similar reference. The referenced management systems standards focus on the strategic levels of management policy and implementation processes to help establish management commitment and support necessary for planning, implementing and assuring sustainable and continuous improvement in safety performance. A key element of safety management systems is establishing the relevance of other business management systems, including maintenance & reliability, to the safety management process. The relationship to electrical safety program improvement may not be apparent unless safety professionals and maintenance & reliability professionals are engaged in a collaborative effort with electrical specialists. One of the most critical factors in the success of the electrical safety program, no matter what stage of implementation or its maturity, may be a better understanding of the safety management system's role in planning and implementing changes in an electrical safety program.

The design and implementation of the electrical safety program is often delegated to the electrical experts in the organization. While this may seem to make sense, this approach overlooks critical competencies that can lead to extraordinary results. The fundamental elements of safety management systems and maintenance & reliability systems may be overlooked if the electrical safety program is delegated solely to the electrical experts. It is my experience that electrical engineers, technicians, and specialists involved in designing and implementing improvements to a workplace electrical safety program tend to focus on the technical aspects, including safe work practices, electrical system design, hazard analysis, and the performance of personal protective equipment. These electrical experts may not be knowledgeable in safety management systems or in maintenance & reliability management systems. These competencies are essential to optimizing the electrical safety program's impact on operations excellence.

For someone with concern or responsibility for an organization's maintenance & reliability program, exploring the answers to these questions may hold the key to enabling success:

- Is the visibility of electrical systems in the maintenance & reliability program in alignment with the organization's dependence on uptime and reliability of critical electrical energy and control systems?
- Does the maintenance & reliability program involve participation of electrical experts familiar with critical electrical systems in proportion to the organization's dependency on the uptime and reliability of these electrical systems?
- How familiar are you with ANSI Z10, Occupational Health and Safety Management Systems, or CSA Z1000, Occupational Health and Safety Management, or other globally recognized safety management systems standards?
- How do these standards relate to the maintenance & reliability management systems for your organization?
- What role does your maintenance & reliability program currently play in your electrical safety program?
- How would you rate the collaboration and synergy among safety professionals, maintenance professionals, key members of management, and the electrical experts with respect to driving improvement in the electrical safety and the maintenance & reliability programs in your organization?

For those not fully comfortable with answers

to these questions, a pathway to improved synergy and collaboration may be found in the subtle, but significant, changes to NFPA 70E, a high profile standard driving change in workplace electrical safety in the US. NFPA 70E has long acknowledged that there is more to an effective electrical safety program than the safe work practices and other guidance contained in the standard. Previous editions provided this acknowledgement with a Fine Print Note in Section 110.7 Electrical Safety Program, which stated that, "Safety-related work practices are just one component of an overall electrical safety program". The 2009 edition includes a reference to ANSI Z10, and states "ANSI/AIHA Z10-2005, American National Standard for Occupational Health and Safety Management Systems, provides a framework for establishing a comprehensive electrical safety program as a component of an employer's occupational safety and health program". Better understanding the role of safety management systems in planning and implementing changes in an electrical safety program may be one of the most critical factors in the success of the electrical safety program, no matter what stage of implementation or its level of maturity. As noted in the beginning of this article, addressing the synergy with other business systems, including maintenance & reliability, is well recognized in safety management systems.

A safety management systems standard provides the blueprint, or framework, to help enable effective, robust and sustainable programs to manage occupational safety and health risks. Where industry standards did not provide consensus standards, some companies developed proprietary safety management standards that align with, or go beyond, industry standards that have since emerged. The first industry consensus standard addressing these needs appeared in 1995, with the publication of ISO 14001, Environmental Management Systems. In 1999, a collaboration of international safety organizations published OHSAS 18001, Occupational Safety and Health Management Standard. A similar standard, ILO Guidelines for Occupational Safety and Health Management Systems, was published by the International Labour Organization in 2001. Implementation of these standards includes rigorous certification processes, similar to the ISO 9000 quality certification process. More recently, ANSI Z10 Occupational Health and Safety Management Systems, and CSA Z1000, Occupational Health and Safety Management were first published in 2005 and 2006 respectively. These standards are well harmonized with each other and with the aforementioned safety management standards, but can be applied without rigorous certification requirements. These safety management systems standards are based on quality management principles popularized by W. Edwards Deming. The Deming quality improvement model Plan – Do – Check – Act as shown in Figure 1 is central to safety management systems and maintenance & reliability systems, as well as any quality continuous improvement process. These standards are also well harmonized on the comprehensive hazard control measures shown in Table I. In addition, they are harmonized in how these equally important measures are ranked in descending order of relative effectiveness in helping assure worker safety. The first three measures are well aligned with

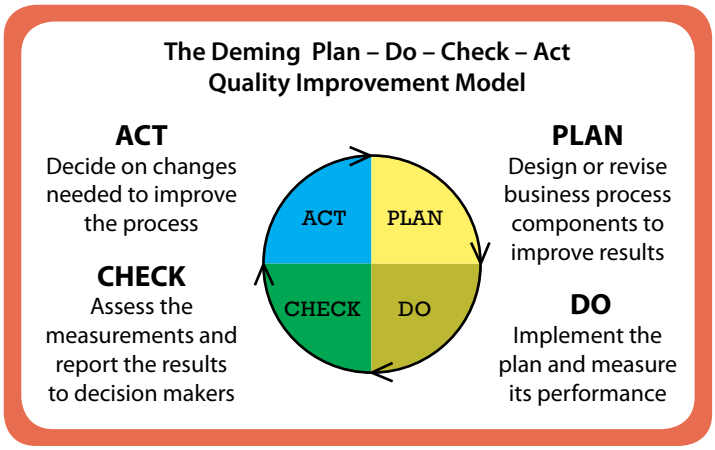


Figure 1 - Elements of the Deming Quality Improvement Model

Figure 2 - Illustrating the collaboration of maintenance & reliability experts, management, safety professionals, and electrical experts that can lead to mutual optimization of electrical safety and maintenance & reliability objectives

maintenance & reliability concepts of re-engineering systems and equipment to eliminate defects and causes of failure. Currently, NFPA 70E focuses on control measures 4, 5, and 6, and does not address the first three, except through its reference to safety management systems standards.

The safety management system standards are based on proven principles that are fundamental and essential for robust safety programs and sustainable safety performance. While strict implementation of requirements in NFPA 70E can enable an organization to realize performance improvement, optimum improvement is likely not achievable without integration with the proven strategies provided in the safety management systems standards – including the business integration with maintenance & reliability management systems.

Safety professionals are generally expert in safety management systems but not in the details of electrical safety, or in maintenance & reliability systems. Electrical professionals may be knowledgeable in electrical technology and how things work, but not expert in safety management systems and maintenance & reliability systems. Maintenance & reliability experts may not be familiar with the details of safety management or electrical systems. Senior and middle managers may not be expert in either of these competencies, but hold the keys to establishing goals and objectives for the organization, and providing financial and human resources to solve and manage issues of importance to the organization. The illustration in Fig. 2 depicts these competencies and skill sets as key elements of an effective collaboration aimed at linking maintenance & reliability to electrical safety. Management has the responsibility for managing priorities, resources, and setting business objectives. Safety professionals bring a skill set in safety management systems, risk management, and rapport with all levels of the line organization. Electrical engineers, electricians, and technicians bring a skill set spanning design, construction, maintenance, and operation of electrical equipment and systems. Maintenance & reliability professionals have expertise in failure analysis, quality improvement, and workforce development. Collectively, these skills, knowledge and responsibilities can create an extraordinary collaboration and synergy to assess and improve both the electrical safety program and electrical system's uptime.

Hierarchy of Hazard Control Measures	
1.	Elimination of the Hazard
2.	Substitution of Less Hazardous Equipment
3.	Engineering Controls to Replace Exposure or Severity
4.	Warnings, Signs and Other Communications
5.	Administrative Controls, Including Safe Work Practices
6.	Personal Protective Equipment

Table I - Hierarchy of Hazard Control Measures Described in ANSI Z10

Business and commerce are dependent on electrical technology for energy, control, data, and communications. In conducting the critical analysis described in this article, you can develop a better understanding that an organization which manages its electrical safety program closely coupled with its maintenance & reliability program will likely derive benefits across a broad set of business performance parameters, especially when they depend on defect free operation of electrical energy control and communications systems critical to operations. The performance parameters that will improve from an effective electrical safety program include improved energy utilization, improved on time delivery, fewer environmental releases, optimum employee safety, improved raw material utilization, improved first pass yield, and increased operational uptime.

H. Landis "Lanny" Floyd II has been with DuPont since 1973. For the past 25 years, his responsibilities have largely focused on electrical safety in the construction, operation and maintenance of DuPont facilities worldwide. He is currently Principal Consultant, Electrical Safety & Technology and is responsible for improving management systems, competency renewal, work practices, and the application of technologies critical to electrical safety performance in all DuPont operations; and the application of this knowledge and experience to electrical safety products DuPont brings to the marketplace. He is an IEEE Fellow, a professional member of American Society of Safety Engineers, a Certified Safety Professional, a Certified Maintenance & Reliability Professional, and a registered professional engineer in Delaware.

Protecting Precision

Understanding Bearing Housing Protection and Reliable Lubricant Application

by Heinz P. Bloch, P.E.and Chris Rehmann

Bearings are precision components; they require clean lubricants in adequate amounts to survive, and even seemingly small amounts of contamination can greatly reduce equipment reliability and uptime. A new generation of bearing protectors is now available that can help maintain lubricant cleanliness, prevent loss of lubricants, and prolong the life of your rotating equipment.

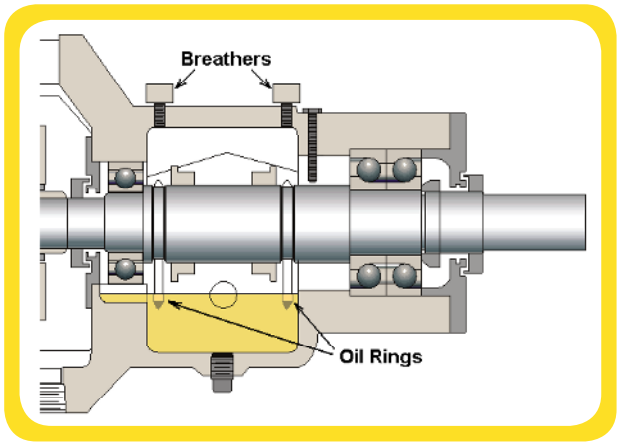


Figure 1 - A typical bearing housing, shown here without modern bearing protector seals

Where Contaminants Come From

Moisture and dust often enter bearing housings (Fig. 1) through old-style labyrinth seals or lip seals as airborne water vapor, or via a stream of water from hose-down operations. Contaminants can also enter through a breather vent, or from the widely used non-pressure balanced constant level lubricators (Fig. 2 and Ref.1). An often-overlooked source of oil contamination is abraded oil ring material, which will be discussed later in this article.

How to Stop the Contamination

Unless the rotating equipment is provided with suitable bearing housing seals, an interchange of internal and external air (called "breathing") takes place during alternating periods of operation and shutdown. Bearing housings "breathe" because rising temperatures during operation cause gas volume expansion, and dropping temperatures at night or after shutdown cause gas volume contraction (Ref. 2). Open or inadequately sealed bearing housings promote this back-and-forth movement of moisture-laden, contaminated air.

To stop this breathing and resulting contamination, there should be no interchange between the housing interior air and the surrounding ambient air. Breather vents (Fig. 1) should be removed and plugged.

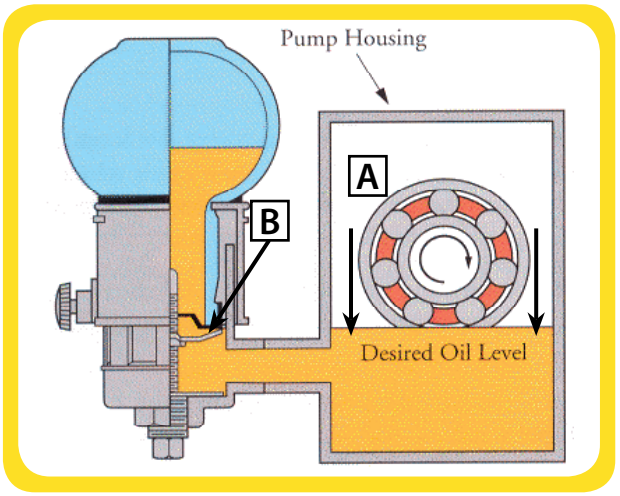


Figure 2 - Constant level (non-pressure-balanced) lubricator (graphic courtesy of TRICO Mfg)

Instead of the widely used (non-pressure-balanced) constant level lubricators (Fig. 2), which allow the oil to come in contact with dirty air, a pressure-compensated (or "balanced") constant level lubricator should be installed (Fig. 3 and Ref. 3). Both devices will be explained more fully a bit later.

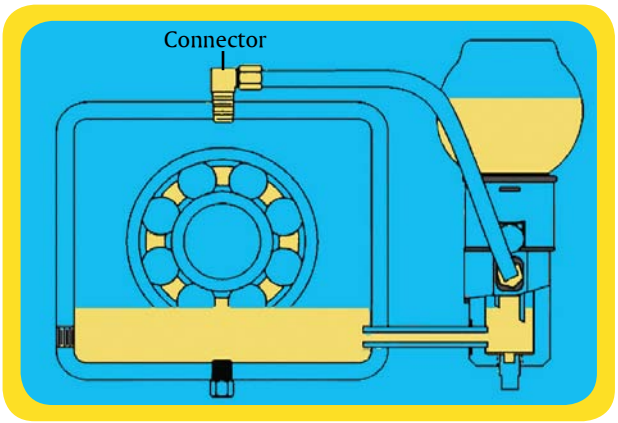


Figure 3 - Pressure-balanced constant level lubricator (graphic courtesy of TRICO Mfg)

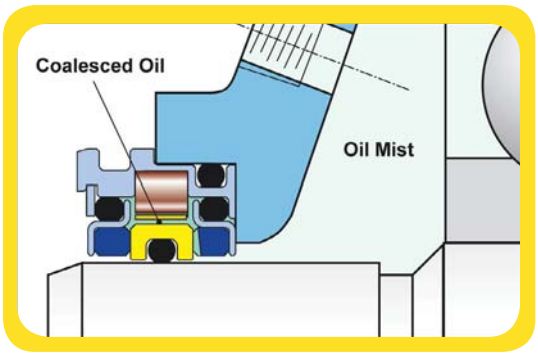


Figure 4 - Dual-face magnetic bearing protector seal in oil mist service

Finally, full sealing of the bearing housing requires the use of face seals. An API-610 compliant magnetically-activated dual-face seal used on oil mist-lubricated rolling element bearings is shown in Fig. 4; a similar device is used to seal conventional oil-splash lubricated bearings. The use of a face seal, along with the other recommendations above (plugging the vent and using balanced oilers), will prevent the entry of all EXTERNAL contamination into the housing.

Beware of Non-Obvious Sources of Contamination and Insufficient Lubrication

Regardless of whether the bearing housing is sealed or not, the serious limitations of the oil rings ("slinger rings") shown in Fig. 1 also need to be addressed, as they can be a source of INTERNAL contamination. Operating oil rings on rotating shaft systems that are not horizontal will cause the bronze slinger ring to spin and rub against the low side of the housing, resulting in severe wear on the ring. The resulting bronze particles can clearly damage the bearings.

Beware of oil sumps with incorrect oil viscosity, or with varying depths of oil ring immersion, or incorrect roundness or rough surface finish of the slinger ring. All of these conditions can result in insufficient lubrication from the oil ring.

Not all versions of "constant level" oilers will serve the reliability-focused user well. The oil level below the reservoir bottle of most constant level lubricators is contacted by ambient air (Fig. 2). In these devices, a wing nut adjustment sets the height of the transparent bottle. The oil level near the tip of the wing nut (Point "B" in Fig. 2) is contacted by the surrounding (ambient) air. An increasing gas temperature (usually air, or an air-oil mixture) in the bearing housing ("A" in Fig. 2) tends to elevate pressure in the bearing housing. This elevated pressure drives down the oil level in the housing (arrows in Fig. 2), increases the oil level in the narrow annular space above the tip of the wing nut, and can result in overflow of oil from the annular space onto the ground. When this happens, bearings starve for oil and will be quickly and permanently damaged.

Pressure-balanced oilers (Fig. 3) decrease downtime risk (Ref. 3). They differ from the non-balanced type by incorporating an external pressure balance pipe so as to make sure that the pressure inside the bearing housing and the pressure at the tip of the wing nut in the constant level lubricator are always identical. Consequently, the oil in the bearing housing is pushed downward by the hot gas (air) with the SAME pressure that is pushing downward on the oil in the oiler, and there is no change in the oil level.

Bearing protector seals can greatly improve the cleanliness of the lubricating oil and extend the life and reliability of the rotating equipment. However, bearing protector seals serve no purpose if oil contamination originates with oil ring inadequacies or if used with unbalanced oilers, or if the oil is not kept at the proper oil level.

On the other hand, bearing protector seals clearly WOULD have helped prevent the large amount of water ingress into the oil of the bearing housing being drained below in Fig. 5.

Figure 5 - Without bearing protector seals, large amounts of water are often found in bearing housings

Lip Seals vs. Rotating Labyrinth Seals

In today's economy, many people ask "How can you justify spending $150 on a rotating labyrinth seal, when a lip seal costs only $5?" The answer to this question requires us to look at the Total Cost of Ownership, not just the cost of the seal.

Lip seals will seal only while the elastomer material (the lip) makes full sliding contact with the shaft (Fig. 6, upper portion). Operating at typical shaft speeds on process pumps, lip seals show leakage after about 2,000 operating hours (Ref. 4). To prevent contaminant intrusion, one would have to replace lip seals just before they fail --- four times per year, to be safe. In sharp contrast, modern rotating labyrinth seals incorporating the features seen in the lower portion of Fig. 6 (and also in Fig. 8) have been available and operating since 2004. As of this publication date, not one of the many thousands now running has been reported to have failed in operation. Comprehensive statistical and probabilistic assessments using Weibull and WeiBayes analyses have been conducted. One analysis included the few "failures" that occurred during installation, yet still predicted a component life in excess of ten years. It would thus be very conservative to assume a four-year life before opting for an early and purely precautionary change-out of the various O-rings in the labyrinth seal. It should be noted that, in modern bearing protector seals, these O-rings are field-replaceable, whereas in the old-style seals of Fig. 7 they cannot be replaced by the user.

A comparison of the Total Cost of Ownership between a lip seal and a labyrinth seal will prove revealing. Our comparison assumes a cost of $10 for two lip seals (with 4 changes per year) vs. $300 for two rotating labyrinth seals (with one change every 4 years); in each case, the cost of maintenance labor would be $500 per event. Lip seal replacements would cost ($10+$500)*4 =$2,040 per year, or $8,160 over 4 years. Rotating labyrinth seals would cost ($300+$500)/4=$200 per year, or $800 over 4 years. The cost of ownership of the rotating equipment with lip seals is about TEN TIMES the cost of ownership with modern rotating labyrinth seals! By using the available O-ring replacement kit (about $30 each), the cost of ownership of the labyrinth seals can be reduced even further.

Rotating Labyrinth Seals: How They Work and How They Differ

Findings of rapid payback and quantifiable failure reductions are supported both by industry statistics and the failure rate plots issued by several lip seal manufacturers. For decades, lip seals have been out of compliance with the minimum requirements stated in the widely accepted API-610 industry standard for centrifugal process pumps (Ref. 5). Indeed, most rotating labyrinth seals are a good choice for bearing protection and will generally outperform lip seals by wide margins.


IT TAKES A TEAM TO
WIN A RACE
GASOLINE
uptime magazine
2.0
MRO Zone
PdMCity
VIBRATION SCHOOL
RELIABILITY WEB.COM
Maintenance Conference
Visit the Reliabilityweb.com Network Team Sites:
Reliabilityweb.com • MRO-Zone.com • MaintenanceConference.com
VibrationSchool.com • MaintenanceForums.com • Maintenance.org
UptimeMagazine.com

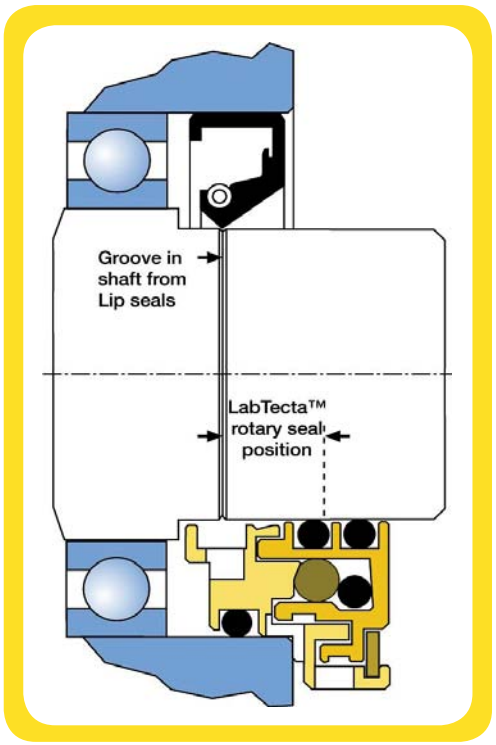


Figure 6 - Lip Seal (Upper Illustration) and Modern Rotating Labyrinth Seal (Lower Illustration)

It must be realized, however, that there are many types and designs of rotating labyrinth seals. Different configurations will allow anything from a minimal amount of "breathing" and virtually zero oil leakage, to a rather significant amount of breathing and worrisome leakage. The amounts of breathing and leakage depend very much on the design and construction features of a given brand and must be compared against the construction features of another design or brand.

Before deciding on a brand, a value-focused buyer will require potential vendors to provide test data and cross-sectional views that disclose the operating principles of different versions of bearing protector seals. Reliability professionals are not asking for the disclosure of proprietary manufacturing drawings; however, they are entitled to see exactly what they are about to purchase. Some vendors may refuse or are unable to provide data other than marketing claims and anecdotal references, and they deserve neither one's time nor active consideration.

When looking at different labyrinth seal designs, note that certain old-style designs incorporate specially contoured rotating lip seals which slide on a stationary component (Fig. 7, right).

Other seal designs are fitted with an O-ring

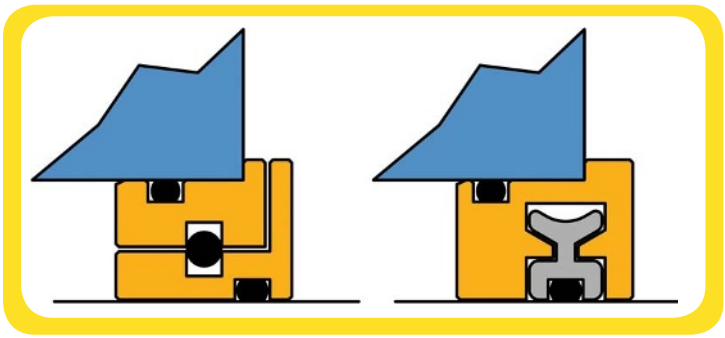


Figure 7 - Rotating labyrinth seals with (left) dynamic O-ring opposite sharp-edged groove and (right) a sealing lip engaging a tapered groove

that moves radially in and out of a groove (Fig. 7, left). Some manufacturers use these O-rings only to make the seal into a cartridge-style assembly and have ignored the consequences of an O-ring contacting simultaneously the sharp edges of the rotating and the stationary elements of the seal.

Available area of contact is important in O-ring devices; basic engineering principles tell us that pressure equals force divided by area of contact. When we apply a given force to a large area vs. applying the same force to a small area, the resulting contact pressures will differ in proportion to the ratio of the contact areas. Sliding one's finger over the sharp edge (small contact area) of a knife will have more pressure (and do more damage!) than sliding one's finger over the dull back of the knife (large contact area). The sharp area of contact of the old-style labyrinth protector design shown above in Fig. 7 (left diagram) is much more likely to damage the O-ring seal than the large, smooth area of contact shown in the design in Fig. 8

The rotating labyrinth bearing protector seal of Fig. 8 uses two O-rings to clamp the rotor to the shaft. This makes it considerably more stable than seal designs that use a single O-ring as a clamp for the rotor (Fig. 7). There is more stability with two clamping O-rings and the risk of rotor skewing or "walking" is reduced. If the dynamic O-ring of Fig. 7 were to make contact with the grooves in the stator, undesirable frictional heat would be generated, and O-ring degradation would take place. O-ring degradation (wear) is sometimes observed as "black oil."

Certain modern bearing protector seals are engineered hybrids (Fig. 9) that incorporate both the face-contacting features of a lip seal with the generous wide-contact and shut-off valve features of the modern rotating labyrinth seal in the lower portion of Fig. 6. The lip seal shown in Fig. 9 provides excellent oil retention while sealing on an internal shaft sleeve to prevent damage (fretting) to the equipment shaft. Meanwhile, the outboard labyrinth and shut-off valve keep out water and airborne particulates, which are a lip seal's worst enemies. This design gives the user the "best of both worlds".

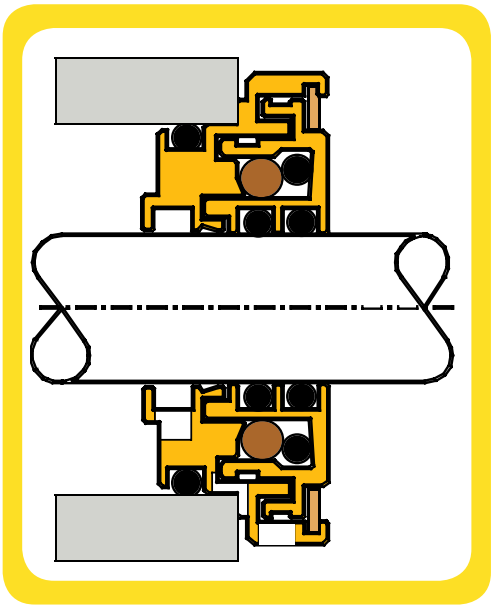


Figure 8 - Modern Bearing Housing Protector Seal.

Note how rotor is clamped to shaft with two O-rings for stability, and how the large cross-section dynamic O-ring (brown color) contacts a large, smooth surface area for effective sealing.

Best Lube Application Practices Examined

Plant-wide oil mist lubrication systems have proven their superiority since the late 1960's (Fig. 10 and Ref. 6), with demonstrated reductions of pump bearing failures from 80 to 90% (Ref. 7). The advantages and disadvantages of oil-mist lubrication as compared to wet sump lubrication may be summarized as follows:

Advantages:

- Reduced bearing failures of 80 to 90%.
- Lower bearing operating temperatures of 10 to 20 F.
- Flushing-off bearing wear particles.
- Slight positive system pressure eliminates contaminant entry.
- Reduced Energy costs of 3 to 5%.
- Reduced oil consumption of about 40%.
- No moving parts

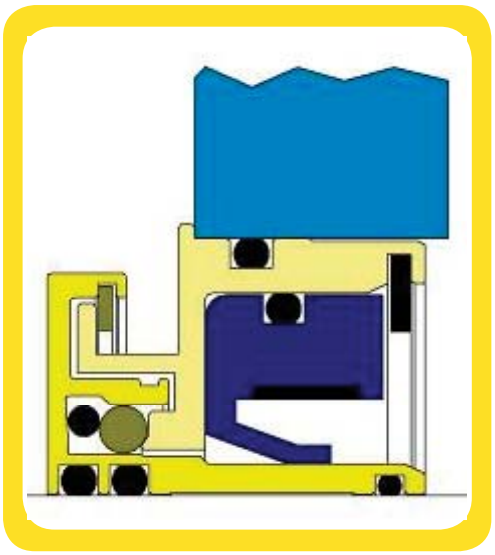


Figure 9 - Example of a Hybrid Labyrinth Seal and Lip Seal

Disadvantages:

- Capital investment
- Cost of compressed air

We had earlier commented on the demonstrated vulnerabilities of oil application methods that depend on oil rings. While it is acknowledged that oil rings are satisfactory as long as shaft peripheral speeds are neither too slow nor too fast (Ref. 3) and as long as shaft horizontality, ring immersion, ring eccentricity, bore surface finish and lube oil viscosity are well controlled, reliability-focused thinking has led to a re-examination of the vulnerabilities of oil rings.

Elastomeric oil slinger DISKS (Fig. 11) are being used by many equipment owners to replace the oil slinger RINGS. The disk is attached to the shaft with set screws, and eliminates ALL of the previously discussed problems with oil rings involving the shaft being out-of-level, too much or too little oil in the sump, oil viscosity, out-of-roundness, and surface finish roughness.

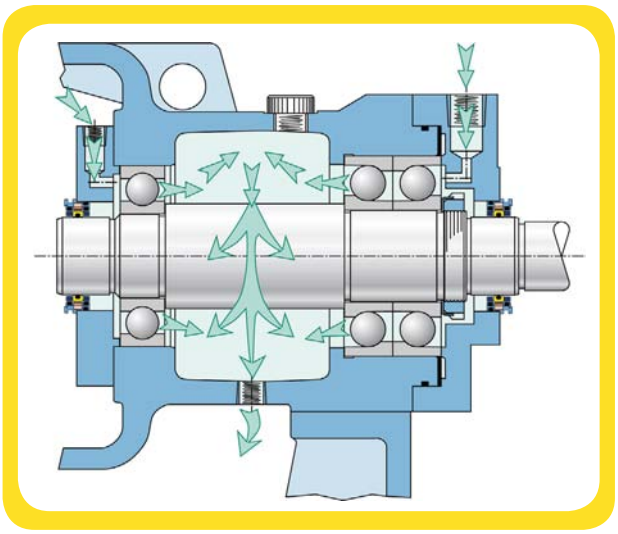


Figure 10 - Oil mist lubrication applied to a pump housing in accordance with API 610, 10th ed. Note dual mist injection points and use of face seals to prevent mist from escaping to atmosphere.

Summary

Rolling element bearings are precision components which require a very clean film of lubricant in the appropriate amount (neither too much nor too little) in order to provide rotating equipment reliability and long life. Modern bearing protectors can both prevent the entry of contaminants, as well as the loss of lubricant. Two types of modern bearing protectors are now available: contacting face-seals, and rotating labyrinth seals. The payback period for a modern bearing protector, as compared to a lip seal, can be as fast as 4 or 5 weeks, after which it begins saving the equipment owner as

Figure 11 - Elastomeric flinger disk used for lubricant application (2008)

much as $1,000 to $2,000 per year in avoided maintenance costs.

References

1. TRICO Manufacturing Corporation, Pewaukee, WI, Commercial Literature Also, see Ref. 3, pp. 118, 144, 232, 234
2. Charles, Jacques; Les Ancient Papiers de l'Academie Francaise, ~1787
3. Bloch, Heinz P. and Allen Budris; "Pump User's Handbook—Life Extension," 2006, Fairmont Press, Lilburn, GA 30047; ISBN 088173-517-5
4. Brink, R. V., Gernik, D. E. and Horve, L. A. "Handbook of Fluid Sealing, "1993 (McGraw-Hill, New York).
5. American Petroleum Institute, Alexandria, VA, API-610, "Centrifugal Pumps", 10th Edition, 2009
6. Bloch, Heinz P.; "Practical Lubrication for Industrial Facilities," 2nd Edition (2009), Fairmont Press, Lilburn, GA, 30047 (ISBN 088173-579-5)
7. Bloch, Heinz P. and Abdus Shamim; "Oil Mist Lubrication--Practical Applications" (1998), Fairmont Press, Lilburn, GA, 30047 (ISBN 088173-256-7)
8. TRICO Manufacturing Corporation, Pewaukee, WI, Commercial Literature, Also, see Ref. 3, pp. 126, 232, 238

Heinz P. Bloch (hpbloch@mchsi.com) is a professional engineer with offices in West Des Moines, Iowa. He advises process and power plants worldwide on reliability improvement and maintenance cost reduction opportunities. Heinz is the author of 17 full-length texts and over 400 papers and technical articles. His most recent texts include "A Practical Guide to Compressor Technology" (2006, John Wiley & Sons, NY, ISBN 0-471-727930-8); "Pump User's Handbook: Life Extension," (2006, Fairmont Publishing Company, Lilburn, ISBN 0-88173-517-5) and "Machinery Uptime Improvement," (2006, Elsevier-Butterworth-Heinemann, Stoneham, MA, ISBN 0-7506-7725-2)

Chris Rehmann is Marketing Manager for AESSEAL's North American operations. He holds a BS in Electrical Engineering from the University of Notre Dame. Prior to that, Chris worked for Schlumberger, an oilfield engineering firm, for 15 years, holding positions in field engineering, technical sales, and management in the USA, Middle East, and Asia-Pacific. He joined AESSEAL in 2002, moving his family from Saudi Arabia to Knoxville, Tennessee. Chris has taught several courses and authored a number of technical papers dealing with bearing protection on pumps, electric motors, oil mist, and gear boxes. He can be reached at: AESSEAL, Inc., 355 Dunavant Dr., Rockford, TN, 37853, chris.rehmann@aesseal.com or 865-531-0192.

Establishing Proactive Maintenance

Effective Maintenance Structuring - Do It Now

by John Ross

I'm hoping that this is an original quote, "you are where you are by doing exactly what it is that you've been doing"? Said another way, "how can you expect to be better than you are, based on what you've been doing?" It really is a definition of insanity to believe that you would accomplish more by merely doing more of the same. In regards to equipment reliability, and the driving need to continually improve; the status quo just isn't getting the job done.

More of the same has only served to bring us back to where we are. Now that we've entered the 21st century, we maintenance professionals have got to get serious about moving in a different direction, specifically in improving our core services. One issue we must work on is getting fanatical about moving from reactive to proactive. Interestingly, one approach to our reactive vs. proactive battle might be found in an early 20th century concept. Now there's juxtaposition, solving an epidemic problem in the 21st century with good ol' fashion 20th century thinking. Consider it the maintenance equivalent of blood letting, or leech application.

Consider this too, we might in fact be passively contributing to the cause of our reactive nature without being aware. For example, I have noticed in American manufacturing that there is an overwhelming ignorance in establishing a proper maintenance structure. We have by default, structured ourselves to be wholly reactive. Take this simple test. Is your maintenance structure designed to simultaneously address these three activities?

- Preventive Maintenance
- Corrective Maintenance
- Emergency Maintenance

Now up the ante. Same questions, but this time, raise the bar. Can your organization simultaneously:

- Complete 100% of the preventive maintenance activities, on time, every time?
- Plan and Schedule 100% of all corrective maintenance?
  - ~ Commencing priority 1s within 24 hours
  - ~ Commencing priority 2s within 7 days
  - ~ Commencing priority 3s within 14 days
- Complete 100% of all emergency work, and not sacrifice preventive or corrective maintenance?

Most maintenance leaders cannot provide objective evidence that their organizations can respond to these issues, in force and with earnest. What is keeping us from being successful? It may be that we are structured wrong; in fact we are not even giving ourselves a chance to support the mission correctly.

Why are these three maintenance services important? The importance of preventive and planned corrective maintenance is that these two systems are primarily responsible for moving organizations from a reactive mode to a proactive mode. In order to address preventive maintenance, though, we have to spend time focusing on preventive maintenance. In order to address corrective maintenance, we likewise have to focus our attention on corrective maintenance. At the same time, we must also respond to emergency work. Preventive, planned corrective and emergency work has an egalitarian relationship; they pull equally against our resources and we act in kind by trying to cover all the bases while in a crisis mode. We must, however, be prepared to and structured to address all three at the same time.

We can't, in direct contrast to this notion, address any of these needs simultaneously because of our maintenance structure. In fact, we operate and manage as if there is a hierarchical relationship. Emergency work takes precedence over corrective; taking priority over preventive. Don't believe me? Do you know of a time when a mechanic working on a corrective maintenance work order was 'pulled' from that job to work on an emergency job? Do you know of a time that a PM was not completed because operations would not shut down the machine, or the technician was needed to work on a priority job?

Our own ignorance and failure to see what is plainly in front of us has literally kept us from moving from reactive to proactive. We aren't guilty of malfeasance; but we are guilty of applying rigid thinking to a malleable problem. It is the totality of our inability to identify our structure and act accordingly that makes this a root cause.

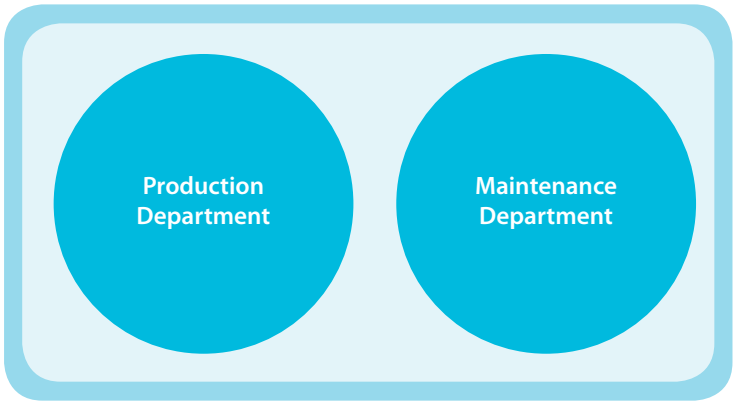


Figure 1 - Centralized Maintenance Organization

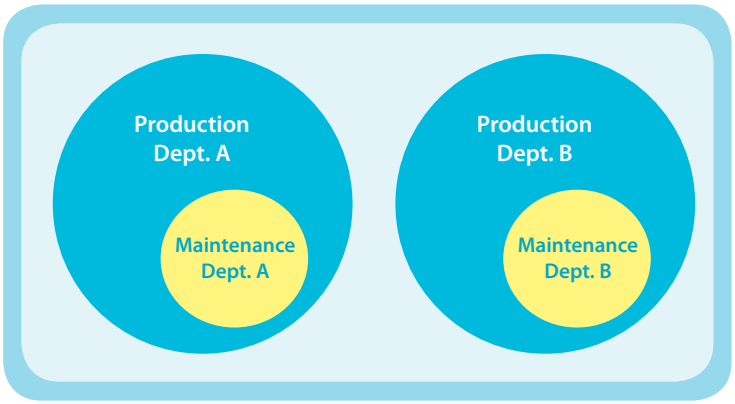


Figure 2 - Decentralized Maintenance Organization

Traditionally, a maintenance organization takes on a centralized or decentralized structure. A centralized organization places the maintenance department outside the functional center of production, where all needs are met from a separate and common base (see Figure 1). At least in a decentralized structure (Figure 2) there is an attempt to divide up the elephant and give each section of the plant a focused effort. Neither is as effective in the 21st century as they could be, and as a result, we sometimes morph versions of these traditional structures; each providing segmented service and response, seeking out that magic 'sweet' structure that will satisfy all our needs; often in vain.

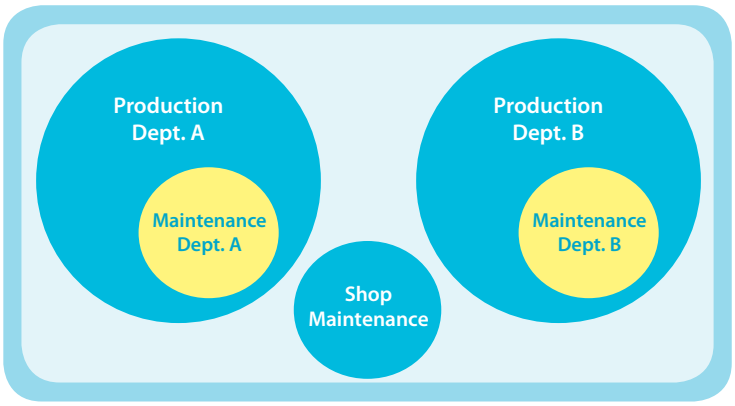


Figure 3 - Example of a Morphed Maintenance Sructure

To be certain, there is nothing wrong with a hybrid maintenance structure. What is a common pitfall, though, is a continuously changing maintenance organization, moving in an effort to find what fits best, to find a home, never really arriving at that final evolution. Our maintenance organizations become the Lost Patrol of fable, always looking, but never finding their way home – or their rightful place.

An absolute 'tell-tale' sign that your structure does not fit your needs resides at the bottom of your computerized maintenance management system work order file. If you have a low priority work order (or several) that have been in the 'system' for over 1 year; your structure is not working. If operators classify every work request 'urgent', ''safety', or 'priority 1'; your structure is not working. These are symptoms of a loss of trust in the work order flow. Loss of trust because we've failed to establish a maintenance structure that can cover all needs at the same time.

The rubric for a successfully responsive organization is to design a structure that can equally handle PMs, corrective, and emergency work; each without hesitation and without sacrifice to the other.

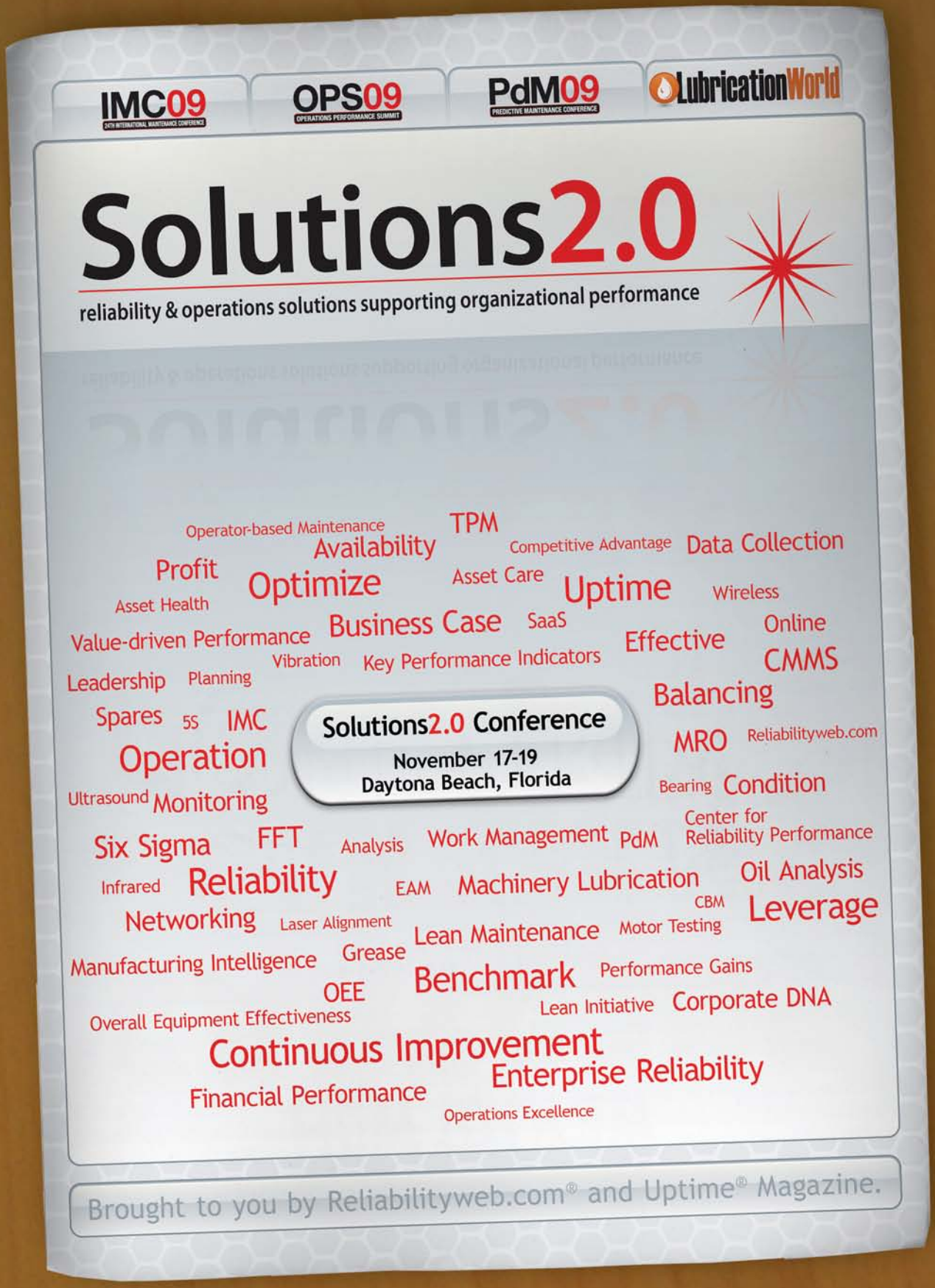
My introduction to this concept occurred in 1995 as the maintenance department manager of a major cookware manufacturer. I had just separated from the U.S. Air Force as a senior aircraft maintenance officer, and I was keenly aware of the value of a well-organized, well-staffed, well-disciplined, and well-funded maintenance operation. None of these adjectives matched what I found in my first 'civilian' job. Quite honestly, I was shocked at the poor level of maintenance organization.

This particular company had been in business since 1776; and it was now 1995. They were quite literally the poster-children for reactive maintenance. They had no preventive maintenance, no CMMS, no storeroom, no predictive maintenance, and absolutely no idea that it could be different. I was about to rock their world in terms of structure and give them a working definition of proactive maintenance.

There are two practices, I told them, that will move you from reactive to proactive, and you have to be committed to them in order to make the transition. The first is a disciplined preventive maintenance program; and the second is a planning and scheduling process. Preventive maintenance has to be done with 100% commitment from maintenance and operations. The resistance to compromise should be sacredly guarded. If we believe that preventive maintenance helps us to identify tomorrow's breakdowns, why would we sacrifice 100% compliance?

Planning and scheduling brings in the corrective concept of catching little issues before they become tomorrow's headline failures. There is slightly more flexibility in planning and scheduling than in preventive maintenance. A 90% compliant planning and scheduling effort is most noteworthy and would be a great benchmarking achievement. Planning and scheduling allows us to address the corrective maintenance work orders identified earlier, many coming from the PM process.

Emergency work, quite honestly, is self-explanatory. Performing dedicated and absolute PM compliance and maintaining a great deal of truth and integrity in our



FOUR EVENTS IN ONE ALL GEARED TO DELIVER!

	Mids	Days	Afternoons
Hit Crew *2 Mechanics* *1 Electrician*	X	X	X
Line Crew *(1, 2, 3, 4)*		X	
PM Crew *2 Mechanics* *1 Electrician*		X	

Figure 4 - Revamped Maintenance Structure

corrective maintenance activities will ultimately net less emergency work.

I told my maintenance team that we had to get out of our reactive mode. So, what was my plan to move this 219 year old company from heavily reactive to heavily proactive? The answer, quite simply was in the structure!

Our first move was to create a dedicated preventive maintenance crew. This team literally created the preventive maintenance program from absolutely nothing. They researched what technical manuals we did have, interviewed more seasoned maintenance technicians, and performed a lot of trial and error. They became, in time, a very dedicated and a very well informed PM crew. These technicians worked on day shift and performed preventive maintenance; 40 hours a week and nothing else.

We developed our off-shift (midnights and afternoon) maintenance personnel into what we called at the time, "hit crews". My logic was simple; between 3:00 p.m. and 7:00 a.m., I only needed a workforce staffed and equipped to keep the plant running. There were no heavy corrective repairs or projects on the off shifts. Hit crews were well equipped and very knowledgeable cross functional teams charged with responding to equipment breakdowns. Using any means necessary (legal and safe), they were commissioned to keep the equipment running until the cavalry arrived (day shift). I have since heard this concept referred to as "Do It Now", or DIN squads.

We also created a team of line mechanics on day shift. There were four production lines in the plant, and each was assigned their very own maintenance mechanic. The primary role of this millwright was to walk the line, all day, make small adjustments, repairs, and any scheduled corrective repairs as needed. On day shift, emergency repairs were handled by the line mechanics and hit crews as required; otherwise line mechanics performed scheduled work. PM crews continued their PM duties, uninterrupted.

Organizationally, we took on the structure: shown in Figure 4.

This structure gave me an ability to complete 100% of my preventive maintenance, on time, every time. We had the simultaneous ability to address any emergency work, and to work closely with our operational partners to schedule and repair corrective work with our line mechanics. The collaborative nature of the operations/line mechanic structure put the scheduling monkey squarely on the back of those holding the reins to equipment access. Our operational partners had to make equipment available, or risk permanent shutdowns. For our part, we never scheduled work we were not ready to perform. Our results were stunning: a move from 95% reactive to 5% reactive in only 18 months.

I have since come to learn that some organizations have capitalized on this approach and have added priority 3 (low priority) work orders to the tasks for the Hit Crew, or Do It Now Crew. When there are no emergency calls, this dedicated team can work on those work orders that seem to congregate and clog the backlog with older and "overdue" work-orders. Thus, the priorities are handled as in Figure 5.

Consider your structure. Complete this simple paper-work exercise with your maintenance supervisors; answer these three questions:

- Are we completing all PMs on time, every time?
- Are we responding to all emergency work requests WITHOUT pulling someone from scheduled maintenance or deferring preventive maintenance?
- Are we completing every corrective maintenance or routine maintenance work order within 6 months?

If you cannot answer yes to each of these questions, maybe you need to re-organize to bring your reactive, preventive, and corrective work under control through a different maintenance structure. If so, I suggest that you Do It Now!

	Priority 1 (Emergency)	Priority 2	Priority 3	Preventive Maintenance
Hit Crew	X		X	
Line Crew		X	X	
PM Crew				X

Figure 5 - By adding Priority 3 work orders to the Hit Crew's duties, they can then clear the backlog of Priority 3 work orders when there are no Priority 1 work orders.

John L. Ross, Jr, Ph.D., is a Sr. Consultant with Marshall Institute Inc., an international maintenance and reliability consulting and training company based in Raleigh, NC (www.marshallinstitute.com). John has over twenty-two years of experience in maintenance and manufacturing, including the Air Force, consumer goods manufacturing, and steel manufacturing. He can be reached at jross@marshallinstitute.com

A Cradle to Grave Approach

Motor Management at Its Best

by Noah Bethel, CMRP

Ask a motor manufacturer how long one of its motors is expected to live, and the response will be something like, "20-plus years in the right environment." Ask the same question in a facility that uses such a motor and the answer is more likely to be, "If we get five years out of it, we'll be happy!" Why does this discrepancy exist? Why do motors die of an infant mortality instead of living to the ripe old age for which they are designed and built? The answer has to do with the failure to optimize motor management and maintenance.

Fortunately, in recent years, there has been a shift in philosophy with regard to motor management and maintenance. Companies no longer regard it as a cost center or a necessary evil. Rather, optimizing the lifespan of motor assets is now considered an opportunity. Business owners have come to recognize motor reliability as a decisive variable in overall profitability and competitiveness. Previously, they purchased information systems and software programs to attack the challenge from different vantage points, but until now, technology has not provided a turnkey solution for optimizing the motor management and maintenance processes.

Four Levels of Software: A Puzzle With Pieces Missing

Now companies recognize that optimal motor management and maintenance brings greater reliability. Greater reliability, in turn, ensures the best return on asset values, as well as less downtime and therefore more cost-effective manufacturing. This recognition led to the birth of reliability centered maintenance (RCM), a coordinated approach to maintenance, communicated through a centralized base and directed toward the overall reliability of assets and machinery. There are four levels of technology that facilitate this coordinated approach. They are:

Level 1: Technology-level software.

The software in this category has been limited to identifying health concerns with motors. It is designed around widely accepted standards for motor reliability and delivers alerts and alarms recommended by IEEE (Institute of Electrical and Electronic Engineers) or NEMA (National Electric Manufacturers Association). These serve as a first level of notice that something is wrong with the motor or with the system in which it is installed.

Level 2: Information management software.

A handful of software tools are available that are designed to organize information about a specific asset so that a supervisor, planner or technician can rapidly identify trends or indications of problems related to that asset. Much of this information amounts to historical data on a motor allowing personnel to track which systems the motor has been installed in and what kinds of problems it has encountered in the past.

Level 3: CMMS, centralized maintenance management software.

Best-of-breed CMMS packages provide centralized information management on a company's motor assets in a variety of technologies – electrical, mechanical, vibration, and others. It is the central location where work requests are initiated and work orders submitted and authorized. The software tracks each asset's work request and work order history so that personnel can look up the status and type of maintenance or repair work currently being performed on an asset.

Level 4: EAM, enterprise asset management.

Top-level recognition of maintenance as a critical portion of business decisions is the driver behind popular business-level software programs such as those produced by SAP. CMMS software is often linked directly to a company's EAM platform so that reliability and return on investment (ROI) of assets can be monitored directly at the highest levels to ensure cost-effective and competitive manufacturing. Some EAM programs include their

own CMMS modules, which are, however, not usually best-of-breed software.

While each of these technology levels is critical to the overall picture, they only present partial pieces of the puzzle. What has been missing is a turnkey approach to tracking motor management and maintenance cradle-to-grave.

Cradle-to-Grave Approach

The ideal technology supports the entire motor management and maintenance effort from cradle-to-grave, without the need to purchase and integrate several software packages. The process of assuring motor reliability begins with specification. It continues on to quality control upon receipt of the asset, then to proper storage, to pre- and post-installation verification, and to monitoring the asset while operational. The final stage of the process is having the right information to recognize when a motor has become afflicted with a terminal disease or is nearing the end of its life for other reasons. Then the process begins again with a replacement motor.

1. Precision Specification

Cradle-to-grave management software includes a tool for precision specification, a growing trend in motor management. When forward-thinking companies buy a motor today, they begin with stringent specifications to make sure it is the highest quality motor available in the marketplace. They know that it is more cost-effective in the long run to purchase a superior, highly reliable motor than to pay a low price up front and then waste resources on frequent repairs. A cradle-to-grave approach to motor management includes technology that allows motors to be pre-qualified at purchase to "design out" potential problems from the start.

2. Quality Control

Quality control is a paramount, but often overlooked, component of reliability. Motors are sometimes defective upon arrival. As such, much testing, troubleshooting and repair down the road could be avoided with solid quality control at the time of receipt. The old adage is, don't buy a car that was built on a Friday. In other words, don't buy a motor and count on its warranty, hoping for the best. Starting with a new motor that is 100 percent perfect will increase its long-term life expectancy and decrease reliability concerns with its installed application.

3. Scheduling and tracking.

Scheduling and tracking are important to the efficient use of a motor in any industrial environment. For example, just like a human body, a motor needs regular check-ups and maintenance so that any trends pointing toward a health problem can be identified and corrected or reversed before they become terminal illnesses. Because problems directly or indirectly related to a motor can be very subtle, thorough tracking of a motor's history can identify negative trends. Such tracking must be automated because people are generally too busy with other tasks to keep notes on the history of motors. While everyone has good intentions about maintenance, it is generally eclipsed by other priorities. Further, the population of workers available to perform testing and analysis on motor assets is dwindling, making the need for automated scheduling and tracking that much more vital.

Another important reason for tracking a motor's reliability and maintenance history is to be able to recognize the point of diminishing return. If a motor's problems and repairs are not tracked, investments may be made in maintaining and repairing it when it is no longer cost-effective to do so. For instance, if a motor has been rewound 13 times, another rewinding is inadvisable because the motor will be very inefficient despite this maintenance effort.

The fact is, if maintenance activities are not scheduled and tracked, they probably will not occur. Furthermore, in the absence of automated scheduling, analysis and trending of data to identify conditions leading to lower reliability, potential problems will be overlooked, and the plant's competitiveness will suffer.

4. Predictive Testing and Trending

Testing and trending needs to be predictive rather than just preventive or reactive. Let's clarify that important distinction with a medical analogy. Regular medical checkups are predictive in that the findings may predict illnesses. A preventive measure would be taking vitamins on a regular basis to minimize the risk of unhealthy conditions. However, since the body eliminates excess vitamins, it is not necessary to be predictive about taking vitamins, which would amount to taking a blood test every day. Being reactive about one's health would mean to stop eating junk food once diagnosed with a serious medical condition. Like medical checkups, software-enabled predictive maintenance is designed to identify conditions that are conducive to failure or lower reliability, so that they can be corrected to increase the life expectancy of an asset or motor.

Cradle-to-grave reliability software tracks the history of repairs, or mean time between failures, to show faults so that their source can be identified and remedied. Without such historical information, repeated repairs or continual cleaning of a motor may waste a company's resources on correcting symptoms while missing the real disease.

5. Tracking Installation History

Tracking the history of a motor itself is not enough. Turnkey reliability software also tracks the history of the systems in which the motor is installed. This is particularly important when a motor is used in a number of different systems, from fans to pumps to compressors. If a motor fails as part of a pump, is sent to repair, installed in a fan, fails again, is repaired again, installed in a compressor, and fails yet again, it's important to be aware that the motor has failed every time and to know why it failed. Knowing whether it failed for the same or a completely different reason each time is critical to making a decision about its future. If analysis

shows that none of the failings are related, the motor may still have 10 years of life and is therefore worth maintaining.

Here's an example. Let's say a motor's application history shows that its last failure was due to a ground fault when it was installed in a ventilation fan. A review of the fan's history reveals that all of the last three motors installed in it failed due to insulation to ground. A common fault mechanism has now been identified and can be further investigated. A technician is dispatched to the site and discovers that the motor above the fan is leaking grease into the fan's motor. If the history of the fan and its motors had not been tracked, several more motors might have failed, wasting resources on repeated repairs. Again, it is critical to automate the tracking of where a motor has been and what problems it has encountered so that personnel can focus on making the right decision rather than spending valuable time on analysis.

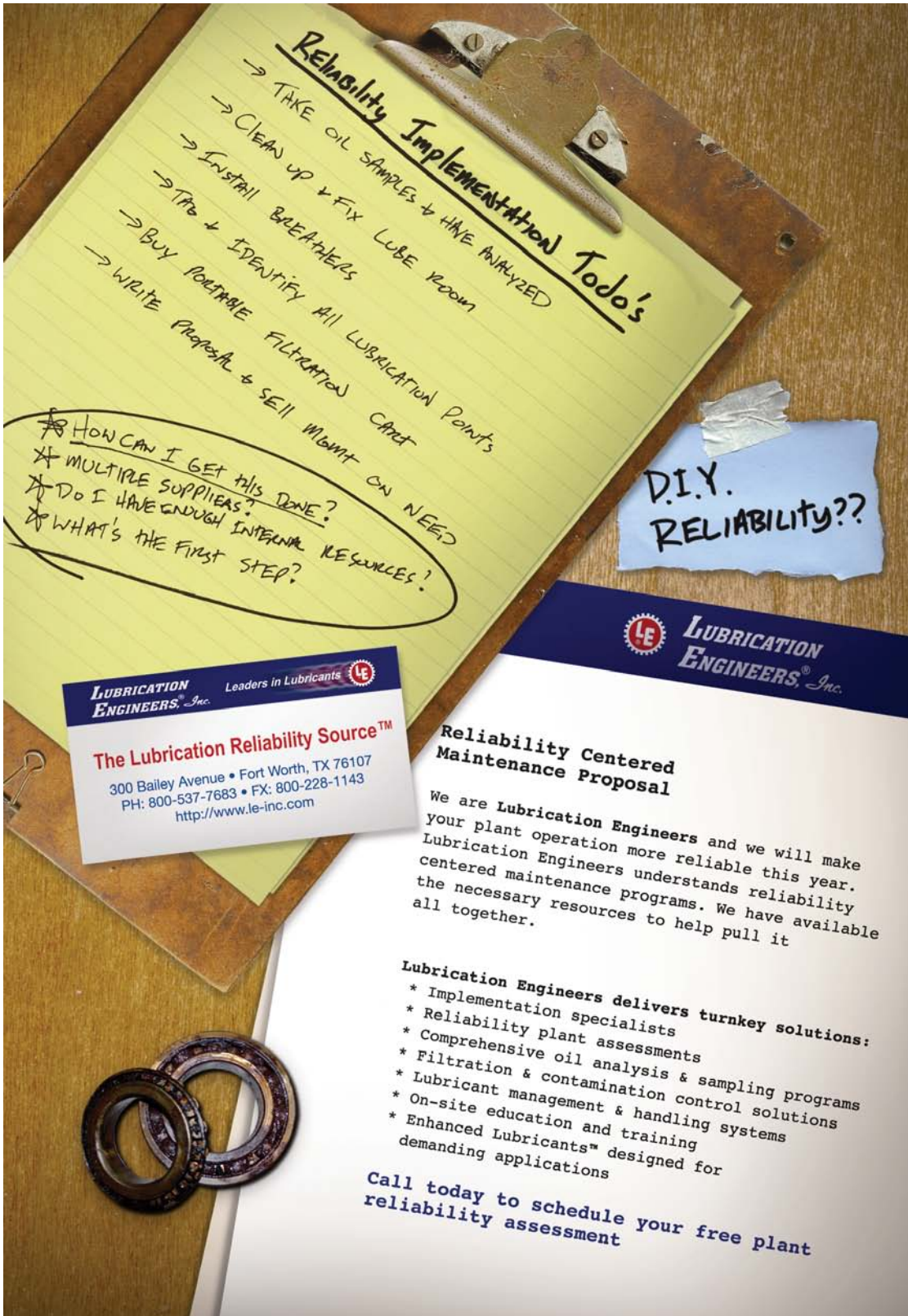
New turnkey software at the technology level now enables the comprehensive management and maintenance of motors through all these important stages of an asset's life, from precision specification to recognizing when the motor must be replaced – in short, from cradle-to-grave. The software also delivers that information to asset management platforms so that senior management can make decisions that will continue to increase the company's competitive edge.

A Solution to Last a Lifetime

As one of the most critical factors in reducing manufacturing costs, motor reliability has to be taken very seriously if a company wants to increase its return on investment in motor assets.

Keeping around several spare motors is not a profitable solution to reliability issues. Rather, the answer is a cradle-to-grave approach to motor management and maintenance that begins with thorough specification and qualification and tracks assets and the systems in which they are installed throughout their lifetime. A company that wants to be world class has no choice but to be world class in its motor management and maintenance efforts. Thanks to new turnkey, best-of-breed software at the technology level, the motor reliability effort has just become a whole lot easier.

Noah Bethel is Vice President of Product Development with PdMA Corporation. PdMA, based in Tampa, Florida, is a leader in the field of predictive maintenance, condition monitoring applications, and the development of electric motor test equipment for motor circuit analysis. For further information, visit www.PdMA.com or call 800 476-6463.



The Dough Is In MRO

Optimizing the MRO Storeroom

by Tracy Smith

Are you tired of maintenance having to do the "crib crawl" to find the parts they need? Are you searching for ways to reduce maintenance material costs while improving asset performance? Is your storeroom looking more like a war zone than a place for conducting business? Look no further, the answer to these challenges lies in MRO Storeroom Best Practices.

A key component in supporting effective and efficient asset management activities is the MRO Inventory Storeroom.

Figure 1 – Storeroom before Optimization

The Storeroom's primary roles are to secure, store and properly manage high usage and production critical materials. An effective MRO Storeroom Operation helps get the right material, in the right quantity, in the right condition, to the right place, at the right time while minimizing total inventory cost. The Storeroom plays a critical and value added role in helping to increase productivity, improve asset performance and reduce overall MRO materials costs. As the saying goes "the dough is in MRO." More specifically, an effective and efficient MRO storeroom operation can…

- Increase maintenance productivity by 12 to 15%
- Reduce MRO material costs by 20 to 30%
- Reduce equipment downtime by 3 to 7%

Applying these ranges to your own values will show you just how significant these improvements can be. Maintenance, Operations, Purchasing and Stores are all beneficiaries of a properly run MRO Storeroom Operation. The key to unlocking this value lies in MRO Storeroom Best Practices.

What are MRO Storeroom Best Practices?

Best Practices are the backbone of an efficient and effective MRO Storeroom Operation. However, too many times MRO storerooms are neglected, improperly designed, poorly operated, lacking documented processes, not staffed appropriately and working with corrupted data. Historically, MRO inventories are one of the most inefficiently and ineffectively managed units of an organization.

This has a significant impact on productivity and reliability. A 1970's article in Duns' Review entitled "The High Cost of Bad Maintenance" identified the single biggest reason of high maintenance costs as problems related to MRO materials management. On average, a maintenance technician will spend 1½ to 2½ hours per day trying to find the parts they need to get their work done. If the right materials had been available, this time could have been reallocated to improving asset uptime and reliability.

To be fair, it is not always the storeroom's fault. If maintenance does not respect Stores' policies and/or submit "timely" and "accurate" job plans identifying material requirements, then it can be difficult for Stores and Purchasing to adequately service, in a cost effective manner, every maintenance material need.

MRO Storeroom Best Practices are defined as the most efficient and effective means to managing, storing and handling MRO inventory materials. For example, clean, standardized and enriched MRO inventory data, separation of receiving and buying activities, inventory cycle counting, trained and skilled storeroom personnel, clean and well organized storeroom , automated requisitioning, reorder point optimization and key performance indicators are just a few of the critical MRO Storeroom Best Practices that create value and support asset reliability efforts and operational needs.

How do we improve MRO Storeroom Operations?

The first place to start the MRO improvement process is in the storeroom itself. Once stable storeroom operations have been established, maintenance and operations can work to improve their pre-planning efforts.
At first glance, this appears to be a daunting task. Trying to organize, store, identify and properly manage thou-

sands of disparate inventory items, with different and seemingly unpredictable demand patterns, creates an environment in which it is difficult to succeed.

Creating an implementation strategy that is simple, straight forward and thorough, is critical to a successful MRO Storeroom Operation. There are seven key elements to implementing MRO Storeroom Best Practices.

Analyze The first step in this implementation process is to perform an assessment of the existing (or non-existent) storeroom operation. The purpose is to identify gaps between the current environment and the best practice environment. An output of this assessment process is the development of a Project Implementation Plan that guides the facility and Stores operation from its present state towards its future or "model" state.

This initial assessment should address all elements of storeroom operation and its integration to its partners. And those partners, maintenance, operations and purchasing, must be included in the analysis and re-design efforts. The assessment should be designed to answer questions such as:

- How are materials stored?
- What does the inventory data look like?
- Is the storeroom adequately designed?
- How is the storeroom staffed?
- What kind of savings can be expected by implementing MRO Storeroom Best Practices?

Once the assessment is complete, a formal presentation to management should follow. This will help expedite the "buy-in" process and serve to excite and educate management on the opportunities that are available by controlling and properly managing MRO inventory materials.

Design Improving MRO Storeroom Operations begins with understanding exactly what items will be maintained in the Storeroom A physical inventory will identify not only obsolete and unusable parts, but also highlight any duplication of items. Once the universe of parts to be stored is identified, the physical redesign may proceed.

MRO items must be properly sheltered, organized, identified, and labeled in order to be effectively and efficiently managed. Additionally, a professional-looking storeroom fosters organizational respect and discipline, something that many MRO storerooms sorely need. The design of a storeroom should include:

- Definition of material storage and square footage requirements
- Identification of storage media requirements and suggested layouts
- Development of an inventory location scheme
- Identification of office, issue, receipt, kitting, and staging areas
- Recommendations on material handling equipment

Mobilize Once the storeroom has been designed and built, it must be properly setup. Storage media must be moved in, parts relocated, databases developed and/or updated. There are two key steps to mobilization: Data Setup and Storeroom Setup.

Data Setup — Developing and maintaining a clean, standardized and enhanced inventory database is the "brick and mortar" of an EAM (Enterprise Asset Management) inventory module and every MRO Storeroom Excellence Initiative. Poor descriptive information can reduce maintenance productivity and decrease asset uptime.

Data integrity is a must. Integrity requires that the data is clean, consistent, complete, and accurate. Data must be attribute-rich, classified, and satisfy all inventory record field requirements.

Developing rich and meaningful MRO inventory source data speeds up part sourcing and retrieval activities and facilitates detail reporting and analysis.

Item numbers should be sequential and non-intelligent. Leave the intelligence for the other fields in the database. Item descriptions should be developed in a noun, modifier, attribute and value format utilizing a Standard Modifier Dictionary (SMD) approach.

Storeroom Setup — Correctly organizing, binning, and labeling inventory materials and locations is critical to easily finding and sourcing inventory items. Additionally, properly storing MRO inventories can extend parts life. Materials should be organized by usage and available cubic space, (with high usage items near issue points) and not by commodity.

Operate Operating an effective and efficient MRO storeroom operation is comprised of two parts. First, standard operating procedures in the form of a Best Practice Model must be developed to guide implementation and process activities. Second, personnel must be trained and coached on Model practices and procedures.

MRO Materials Model Development

The MRO Materials Model forms the basis for how the Storeroom is going to operate and conduct business with its partners: maintenance, operations, and purchasing. An MRO Materials Model establishes the ideal or best practice state for all storeroom materials management activities, and should contain information such as:

- Key performance indicators
- Detailed procedures, process flow charts
- Storeroom roles and responsibilities;

A corporate-wide MRO Materials Model establishes the business rules and sets the "World Class" standards throughout the corporation. You can then move on to storeroom start-up.

MRO Materials Model Training

Once the storeroom and database are properly setup and "Best Practices" have been defined and documented, the next steps are to provide new training, have the "ribbon cutting" ceremony and go-live!!

Training should focus around both the tactical and strategic aspects of operating a storeroom.

Training for Storeroom Personnel – Training for storeroom personnel is tailored to those performing the day-to-day activities of managing the inventory. These individuals are primarily responsible for managing the movement of materials, processing system transactions, and performing housekeeping activities. Some of the suggested training topics are listed below:

- Performing receiving activities (opening boxes, checking packing slips, noting discrepancies, etc.);
- Stocking inventories (storeroom returns, receipts, and new items);
- Managing outgoing shipments (vendor returns and repairable spares);
- Performing parts picking, issuing, kitting,

staging and delivery activities;
- Performing cycle counting;
- Preparing materials for maintenance equipment shutdowns;
- Maintaining target service levels.

Training for Storeroom Supervisor – Training is also tailored to the Storeroom Supervisor, who has the primary authority and responsibility for overseeing the management of storeroom inventories. Some of the suggested training topics are listed below:

- Storeroom operations
- Key Performance Measurement
- Leading MRO materials team
- ABC Analysis
- Min / Max Modeling
- Maintenance and Operations Coordination

Once training is complete, it's time to celebrate and go-live!! Have a cookout. Don't forget to involve your "customers" (maintenance and operations) and your partners (purchasing).

Measure Once the new storeroom is up and running, the focus should be on delivering and measuring performance.

Figure 2 - Storeroom after Optimization

The implementation of a storeroom performance management program helps ensure the practices are tied to the organization's objectives and are achieving the intended results. Performance measurement involves tracking specific performance criteria:

- Comparing results to benchmarks and historical values
- Identifying needed improvements and potential solutions to the problem.

There are several possible performance measures for MRO Storeroom Operations. The following are the most useful:

- Storeroom service levels
- Internal lead times
- Inventory accuracy

A hierarchy of indicators is utilized to prevent small problems from becoming larger ones. Performance measures must also carry some clout. There must be accountability and consequences for poor performance as well as recognition and praise for good performance. As an old football coach once said, "If you aren't keeping score, you are just practicing."

Optimize After sound processes are in place and we are generating good historical data, it is time to optimize inventory levels. This is where the rubber meets the road. The right level of inventory minimizes the total cost of inventory. What is desired is the optimal level of inventory to maintain.

Right sizing the inventory is just that. It is the process of analyzing operational risk and materials management transactional data and identifying the optimal reorder points and maximum level of inventory to maintain.

The optimization process helps to achieve

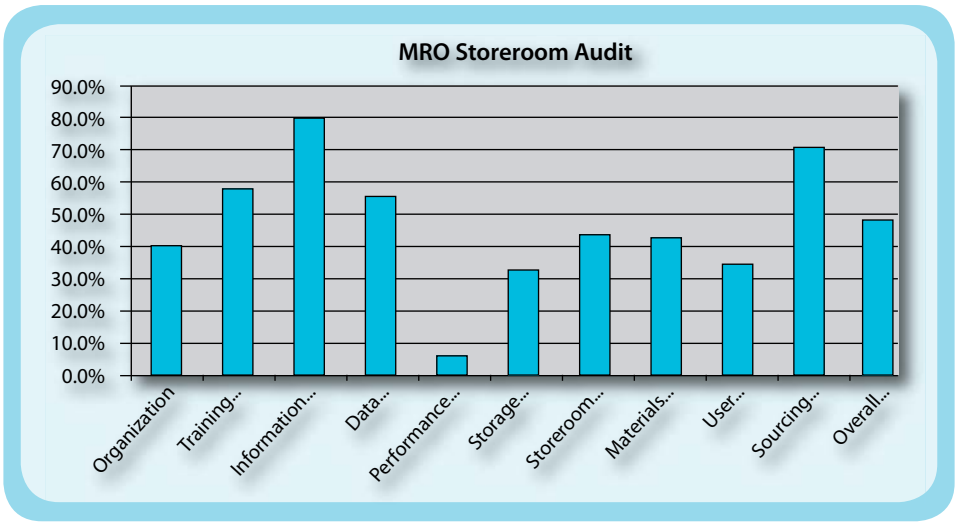


Figure 3 - Example of Results from Storeroom Audit

the correct balance between costs and accessibility.

Sustain Staying on track, sustaining progress and continuing to improve can be a challenge. There will be a point where the shine might wear off. The key is to stick to the fundamentals and established standards and not wander off course even in times of revolt.

A good way to stay on the straight and narrow is to implement periodic MRO Storeroom "Best Practice" Sustainability Audits to ensure all plant implementation teams are on track and continuing to close Best Practice gaps. A formal ranking system based on the implementation of best practices will allow internal benchmarks to be established and progress to be measured.

Summary

Implementing MRO Storeroom Best Practices is critical to optimizing MRO spend and inventory investment while supporting asset reliability needs.

What is equally as important is how these philosophies and measurement programs are implemented. The identification of best practices coupled with a simple but thorough implementation methodology shortens implementation time, accelerates organizational buy-in and facilitates the realization of long term and significant value within the plant and across the organization.

Tracy Smith is the Director of MRO Services for Performance Consulting Associates in Duluth, Georgia. PCA is an asset reliability consulting firm that designs, develops, and implements best practices for maintenance, stores, inventory, and supply chain operations. PCA has also developed a comprehensive Business Process and Procedures Model for stores, purchasing, and the entire supply chain process. Tracy Smith can be reached at 770-717-2737 or smith@pcaconsulting.com

Reliability Centered Maintenance

An Introduction for the New Reliability Engineer

by Umeet Bhachu, E.I.T.

What is RCM? By definition "Reliability is the ability of a person or system to perform and maintain its function under routine circumstances, as well as hostile or un-expected circumstances". When we apply this to accommodate and optimize the maintenance requirements of physical assets such as pumps, compressors, turbines and various other pieces of machinery typically found in an industrial set-up in a continuous improvement framework, that is what constitutes the process of Reliability Centered Maintenance (RCM).

The correct approach is in understanding RCM as a process rather than a set of specific rules that guide us in determining the predictive, preventative and corrective actions that must be taken in order to ensure that a physical asset performs to its required expectations. The basis of such actions and strategies takes into account the economics, environmental, safety and operational criteria for the asset in the given operating circumstances. The set of maintenance decisions made to ensure that such conditions are met within justifiable cost budgets, and causing minimal impact to operations, are developed by carefully applying the RCM process. One of the key motivations of applying RCM is its ability to optimize operational expenditures by rationalizing the maintenance decision making process. This is achieved by shifting the maintenance approach from a reactive model to a proactive model, performing on-going maintenance and monitoring of assets during their operation (proactive) as opposed to performing maintenance only at failure (reactive). It is important to realize that keeping the RCM process live during the service life of equipment helps to increase its effectiveness because it maintains a constant review of the maintenance routines performed on a particular asset and allows the maintenance decision making process to change as new experience is gained during its operational life. Think of this as a feedback loop to correct and improvise on past errors.

In my opinion, a person applying the RCM process needs to ask the question, "Is RCM truly needed in this particular situation?" It is very important to first assess if implementing an RCM would be the cost effective way to fine tune the maintenance requirements or if exploring other options, such as replacing failed parts or perhaps up-grading to a better design, might better serve the purpose. There are many factors that contribute to equipment failure and its frequency, and an RCM effort requires a lot of due-diligence, experience, effort and motivation on the part of maintenance and operation personnel involved in making it a success. Implementing RCM in a larger organization such as a refinery is a very involved and laborious task and would do more harm than good if not properly planned and implemented.

Fundamental Principles of RCM

The RCM process emphasizes the use of both predictive and the more traditional preventative maintenance strategies. From an operational point of view RCM must take into account the consequences of equipment functions and functional failures. Every failure mode needs to be considered in a logical manner to determine if maintenance is required and what action needs to be taken. Predictive maintenance is performed while the equipment is in operation to determine the future trend of the equipment and the probability of failure in the future. Predictive maintenance is a cost effective approach since, in most cases, it does not disrupt the normal functioning of the equipment. The goal of predictive maintenance is to either continuously or intermittently monitor equipment so that you can identify defects before functional failure occurs. Maintenance can then be planned and scheduled to occur at a cost efficient time based on the data gathered by the monitoring process and the operation schedule. Hence, it is often also referred to as condition monitoring.

In contrast, preventative maintenance is a complete overhauling of equipment, whether or not it is warranted at a given point in time. As an analogy, it can be thought of as the routine maintenance performed on cars after a regular interval of time, irrespective of the condition. While this approach was useful in many industrial settings in the not so distant past, the complexity, size and scope of modern machinery makes carrying out such a strategy, in many cases, costly and inefficient.

Prior to and while implementing the RCM, it is important to answer a series of questions that were initially developed by John Moubray, and which still form a crucial groundwork for developing the RCM plan.

1. What are the functions and associated performance standards of the asset in its present operating context?
2. In what ways does it fail to fulfill its functions?
3. What causes each functional failure?

4. What happens when each failure occurs?
5. In what way does each failure matter?
6. What can be done to predict or prevent each failure?
7. What should be done if a suitable proactive task cannot be found?

These questions should provide a good guideline and framework to follow during setting up and directing the process. However, along with answering these questions, the RCM analyst should bear in mind that the purpose of implementing the RCM in the first place is to reduce maintenance cost and increase asset efficiency. Merely addressing the above questions in a narrow context will lead to an unsuccessful RCM program and higher maintenance costs, which would do the organization more harm than good. For instance, both long term and short term failure consequences should be examined. Careful note should be made of the cross discipline issues involved with the various functional failures, i.e. instrumentation, electrical failure modes, etc. We could have a failing in-board mechanical seal because the pressure gauge mounted on the in-board seal malfunctioned, leading to an incorrect assessment of the condition of the seal, leading to its eventual failure. It would also be wise to take into consideration the size of implementation, and if enough experienced staff could be made available without tying up the other functions of the organization.

In the past, a number of world class organizations have come to the realization that RCM is costing them a lot of money and was increasing year after year. Having introduced all the requirements of RCM, the conclusion was that while a company was profitable, the maintenance department was not and it fell below the expected standards.

The Decision to Apply and Implement the RCM Process – A Practical Look

Arriving at the decision to implement and carry through with the RCM process is the most difficult stage of the process. Making this decision requires efficient planning and resourcefulness on the part of management and the rest of the teams. I will walk through a practical example that highlights the various questions that are encountered during implementation.

In contrast to failures encountered in some of the other industries, the failures encountered in process plants are random. An aircraft hydraulic pump operates under predictable circumstances, where as a crude pump in a refinery application has many constraints and probabilities of failures, such as operator error, alignment issues, lube oil contamination, etc. One might argue the fact that it would be more appropriate to fully investigate such issues at the pre-design stage, which would prove to be much more economical then spending the money, and tying up entire teams of people, to perform a Failure Modes and Effects Analysis (FMEA).

From a practical standpoint, I have noticed a lot of pumps in many refineries failing as a result of bearing failures. These bearing failures, among other things, are a result of lube oil contamination by water and various other particulates. If one were to replace all the bearings on the 600 plus pumps in a refinery, that would translate into a great deal of money. Applying an RCM/FMEA process on such an application would, again, be very costly, time consuming and might not justify the cost of implementing the modification changes identified by FMEA. On the other hand, tackling this issue at the pre-design stage by taking into account the cause of such failures and designing better bearing protectors would be an efficient and economical approach.

A great deal of complexity comes into play when trying to decide and implement RCM on failures that are random in nature and have multiple constraints as seen above. Usually a good approach in such circumstances is to emphasize predictive or condition based maintenance in order to prevent and reliably recognize such failure prior to their occurrences.

The challenges involved in implementing RCM can lead to certain important questions that one should ask during the planning stage to explore other, possibly more efficient avenues than RCM. These would include:

1. What is the weakest component in an equipment failure and can we equate it to the equipment lifecycle?
2. Is it better to implement RCM in-house or hire an external consultant?
3. What is the cost outcome of implementing various decisions with and without RCM?

Answers to the above questions would help us make the process more productive and profitable.

Tools Used in Implementing RCM

There are various tools that are used in performing the RCM analysis and establishing a cause-effect relationship between system failures and performance. Some of the analytical tools used are:

- Failure modes, Effects and Criticality Analysis (FMECA)
- Root Cause Analysis (RCA) & Fault Tree Analysis (FTA)
- Risk Based Analysis (Using a control matrix)
- Weibull Analysis (Statistical modeling of failures)

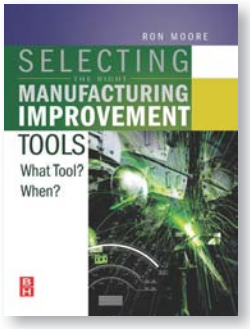
Every tool plays an important part in the analysis process, and in determining the possible causes and effects of failures. Failure modes, Effects and Criticality Analysis is a frequently used tool that helps to prioritize causes of failures based on their potential consequences and probabilities of occurrence, and to classify actions that could be taken to mitigate their harmful affects on the process. A simple FMECA analysis can be performed on paper or using Excel. There are also many software packages on the market today that are used for more complex analysis performed at larger sites such as manufacturing plants and petroleum refineries.

On the statistical end, Weibull Analysis is an excellent tool that can be used to study and relate the effects of performing maintenance on particular assets and their failure rates. Excel can be used in performing this simple, yet very useful, analysis to study if certain maintenance decisions implemented as a result of the RCM process were successful in reaching their target. Like FMECA and other tools, various software packages can also be used to perform advanced Weibull Analysis which takes into account complex parameters. It is well known that the 'Bathtub Curve' in reliability engineering helps to categorize the various failure rates versus time. A product batch that follows the classic bathtub curve will have a higher failure rate at the beginning of the product's life (labeled as Infant Mortality, which might be due to poor design of the product). The curve decreases over time into a relatively constant failure rate, with the failures occurring as a result of random circumstances, which are hard to prevent. However, these failures can be mitigated through accurate condition monitoring and predictive techniques. The final phase of the curve takes an up-ward slope of increasing failures, which happen as a result of age and normal wear and tear of the product. Weibull analysis helps us in understanding these failures by plotting

CHOOSE YOUR RELIABILITY DESTINATION WITH A RELIABILITY ROADMAP WEB WORKSHOP

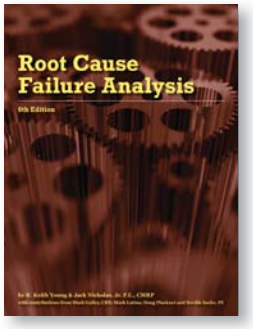
Reliabilityweb.com® and Uptime® Magazine know times are tough with travel and training budget reductions, less personnel and being asked to produce more with less resources. Now you can stay close to home and get information to help your company create a reliable operation.

The 2009 series of Reliability Roadmap Web Workshops includes sessions for executives, managers, supervisors, and technical level inspectors with topics and leading subject matter experts and Authors.



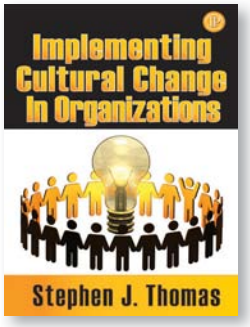
Selecting the Right Manufacturing Improvement Tools by Ron Moore, Author of Selecting the Right Manufacturing Improvement Tools

This 9 part workshop series provides an excellent review of the most popular improvement tools and strategies - Lean Manufacturing, Kaizen, including 5S, Kanban, Quick Changeover, and Standardization, Total Productive Maintenance, Six Sigma, Supply Chain Management, Reliability Centered Maintenance, Predictive Maintenance (or Condition Monitoring), and Root Cause Analysis.



Root Cause Failure Analysis by Jack Nicholas Jr., Coauthor and editor of Root Cause Failure Analysis

This 12 part workshop series provides an outline presentation of fundamentals of root cause failure analysis (RCFA) theory and practice. Special guest presenters include Neville Sachs, Mark Galley, Robert Latino and more. Two motor failure case studies are also included.



Creating Cultural Change for Maintenance & Reliability Professionals by Steve Thomas, Author of Implementing Cultural Change In Organizations

This 3 part web workshop series de mystifies the concept of organizational culture and links it with the eight elements of change: leadership, work process, structure, group learning, technology, communication, interrelationships, and rewards. If you want to break the cycle of failed improvement programs and instead use cultural change to help make significant and lasting improvements in plant performance, this book will show you how.

Reliability-Centered Lubrication by Mike Johnson, Independent Machinery Lubrication Expert

This 12 part workshop series based on a Society for Tribologists and Lubrication Engineers (STLE) series of papers provides a technically precise machine re-lubrication plan which is one of the more important functions that plant management can provide to protect plant productivity.

Electrical Reliability & Arc Flash Web Workshops led by Independent Experts

Please join us for a 10 part Reliability Roadmap Web Workshop series designed to enhance electrical safety. There is a fair amount of confusion and misunderstanding in terms of Arc Flash, NFPA 70E, CSA Z462 and other issues surrounding electrical safety. This series brings together a series of leading experts to provide a clear understanding of today's standards and what constitutes best practice.

Infrared Thermography Level 1 by Wayne Ruddock, Independent Infrared Expert

This 23 part course follows the recommended training requirements of ASNT for Level I Thermal/Infrared Certification. The hands-on workshops ensure that the participants should have mastered the skills necessary to not only operate their infrared system but to perform various inspections and report on their findings.

These web workshops are not to be confused with typical webinars and are non-commercial educational learning events. Reliabilityweb.com® and Uptime® are proud to be able to leverage our technology and deliver COST FREE – TRAVEL FREE workshops from the convenience of your desktop. Train alone or in groups.

Cost: FREE
Where: Your PC or MAC
When: Throughout 2009 - Check the schedule online at www.reliabilityweb.com
How: You can connect using our FREE VoIP audio system (requires headphones or speakers) or you can dial in using a standard telephone.

them against 'Median Rank' which is an estimate of the proportion of the population that will fail by a certain number of operational cycles. The plot gives us the Weibull shape parameter called Beta (ß) among other things. When ß is less than 1, we know that the failure rate of the population is decreasing, which could suggest that the maintenance or design changes implemented as a result of RCM have been successful. When ß is equal to 1, the population will have a constant or random failure rate, in which case one should stress condition monitoring methodologies. Finally if ß is greater than 1, the population has an increasing failure rate and options such as run to failure or design changes need to be exploited. As a note, it's worth mentioning that Weibull Analysis constitutes an important tool in determining warranty requirements. Since it is capable of determining, at the very least, the probability of failure associated with an asset or design after a given number of cycles or time frame, it is capable of generating important analytical data in determining how much warranty a particular asset should be given based on its design to failure, thereby improving odds against competition.

There are other tools such as Risk Based Inspection (RBI) to determine and develop reliability and maintenance routines. The RBI process takes into account economic impact, danger to environment and safety, probability of occurrences and classifies actions based on a Risk Matrix to develop a maintenance program to tackle higher risks task first, followed by the ones lower in priority. This helps reduce costs and equipment downtime during plant shutdowns. It is a particularly useful tool used in the pulp and paper industry as part of the asset management program.

Concluding RCM and its Advantages

Implementing RCM can provide potential benefits to specific organizations if it is selectively chosen and planned. It is a process that should be slowly and progressively implemented in larger organizations to avoid confusion or making it a too cumbersome for maintenance management.

First and foremost, it helps to increase asset efficiency, which translates into better productivity and cost savings for organizations seeking to cut maintenance vis-à-vis operating costs. Some of the other benefits derived can include:

- Better public and environmental safety
- Better view of resource requirements that help implement efficient Enterprise Resource Planning (ERP) strategies.
- Motivation to perform in a team environment and better team building
- Development of a concise and comprehensive database of information

Reliability Centered Maintenance is not a quick fix solution for maintenance problems, and it requires planning and management support for successful implementation. The approach requires a team effort at the management and technical level to accomplish its directives. It is an active approach in that it requires active participation and live implementation by operating, maintenance and design personnel. Since its introduction in the aircraft industry during the early 80's, RCM has helped a multitude of companies across the spectrum of industries to increase uptime and become more competitive in the marketplace. It would advantageous for engineers new to this field to explore, plan and, if found viable, to implement best practices within the RCM framework to help their organizations reduce costs, prioritize safety and dramatically cut down-time and equipment failure rates.

References

1. Moubray, John. Reliability-Centered Maintenance. Industrial Press. New York, NY. 1997

Umeet Bhachu, EIT, is an On-site Reliability Engineer for Suncor Refinery/Flowserve Canada Corp, and is an ISO category II vibration certified analyst. He earned a degree in Mechanical Engineering from the British Columbia Institute of Technology, and then graduated with a B.S. in Chemical Engineering from the Univ. of British Columbia in 2005. After graduation, he worked with Canfor Pulp as Reliability EIT, managing pulp and paper assets to prioritize and plan maintenance work. He then moved onto design/project engineering with a multinational EPC firm before moving to Flowserve in 2008. Umeet currently works at the Suncor Refinery in Ft. McMurray, Canada, where his work involves design and technical assessments of various pumps and mechanical seals to improve the present MTBR at the plant. He enjoys playing the guitar and travelling. Umeet can be reached at (780)405-5162 or ubhachu@flowserve.com

There's Something in the Air

What Problems an Airborne Ultrasound Program Can Help Identify

by Thomas J Murphy, Eng

The use of ultrasound as a predictive tool has been with us for over 35 years. Despite this vintage, the use – and indeed, the understanding – of this technology is still not widespread. The purpose of this article is to explore the vast range of application of airborne technology from simple to sophisticated. A "Part 2" article in the November edition will explore contact ultrasound applications.

The Basics

Ultrasound can be very simply defined as any sound with a frequency above 20kHz, that is above the highest frequency a young adult can detect. This is a big, big frequency range. Medical ultrasound instruments can often be using ultrasound in the megahertz range. The typical frequency range used by predictive maintenance ultrasound systems is much lower – normally in the 30-40kHz region.

Ultrasound is inaudible. Traditionally, ultrasound systems use heterodyning or mixing techniques to present a signal to a headset, which would typically have an audible 2kHz frequency range. Once you get past the "cheap and cheerful" ultrasound system (which merely click or whirr to represent the presence of an ultrasound signal) to one which uses this mixer technology, you have an instrument which actually allows you to listen in on what is going on far beyond our human range of hearing. In fact, some instruments on the market allow you to change the mixer frequency so that you can listen to frequencies up to almost 200kHz. This is fascinating when you think about it – you can actually listen in on what is happening far beyond the capability of our ears. If there is a click, knock, rattle, whirr or hiss at 40kHz, that's just what you hear when you set your instrument to be within 2kHz of that frequency.

Measuring Ultrasound

Ultrasound is treated, quite rightly, as a sound, which means that when we quantify the level of ultrasound signal we are listening to, we use a decibel scale. Unfortunately, the arrival of the electronic calculator in the '70s meant that complex arithmetic could be performed without the aid of log tables. Because of that technology, very few people understand decibels anymore.

Log tables helped in all manner of engineering feats. Two key features of this relatively simple arithmetic are that:

1. Any number can be represented as a power of 10. For example, we all know that 10,000 = 10^4. The log of 10,000 is 4. The log of 20,000 would be 4.3.

2. When we want to multiply two numbers together, we add their logs. When we want to divide, we subtract their logs. This means that any multiplication or division of numbers could be reduced to simpler addition and subtraction just by using log tables.

The depth of the misunderstanding of the decibel scale has even spread to the pages of this and similar learned publications, so let's review a few points about dBs as they are known. For example, dBs are never multiplied or divided.

The dB is a logarithmic ratio scale and you cannot have a ratio without a reference value. In itself, it is not a unit of measurement. The measurement unit is the bit on the end: dB(A), dBm, dBV or dBμV could be termed units of measurement, but dB on its own is meaningless. For example, the equation which defines the dBμV used in SDT's ultrasound is:

$$20\log10\ (V1/V0)$$

Where V0 is the reference voltage of the ultrasound detector, namely 1μV. Simply quoting a dB and not quoting a reference is highly misleading since, without a reference value, you might be comparing apples with bananas.

Using this scale, an increase in ultrasound by a factor of 2 would increase the ultrasound level by 6dBμV. The increase from 20 to 26dBμV is the same as the increase from 50 to 56dBμV, since it is an increase of 6dBμV which corresponds to a doubling in the amplitude of the ultrasound measured.

Right. Well, now that the boring (but important) explanation is over, what can I do with ultrasound?

The Applications

Compressed Air Leak Detection – An ultrasound system allows me to hear in a different part of the audio spectrum from my normal hearing. If you turn that statement around, you understand that an ultrasound instrument does not hear what is in the audible range of human hearing. This means that I can take an ultrasound system into the loudest of factories, into the loudest of audible sound fields, and it doesn't make any difference in the ultrasound detector's ability to detect ultrasound sources.

There are many common applications for airborne ultrasound. Perhaps the most common is compressed gas leak detection. The gas is normally air, but in many cases it is also Nitrogen, Oxygen, Hydrogen, Carbon Dioxide, Argon and many others.

Skeptics often say that they can hear air leaks. Within a very small range of controls this is quite true. If there is no background noise, a relatively large leak will be audible. However, if you look at the frequency range of the noise generated by an air leak, only about 10% of the energy produced is in the audible range. The peak frequency range is 30-40kHz. So, those same skeptics wandering around a shut down factory will hear some, but far from all, of their air leaks.

There is a parallel between air leaks and the profile of machinery breakdowns – and both of these carry a passing resemblance to the ancient Japanese technique of death by a thousand cuts.

In the world of reliability, we know that it is not the big high profile, once in a lifetime, failures which ruin a business's reliability, it is rather the multiple high frequency, low impact, chronic failures.

So it is in the world of air leaks. Finding and fixing the few big air leaks is all well and good, but it is equally important to find and fix the dozens (or maybe hundreds) of small, inaudible, air leaks as well. These small, chronic leaks soon add up to being a major drain on your compressed air system. This statement, which I have often heard, "We saved our money and didn't buy an ultrasound system. We just listen for our leaks on the weekend." should now be seen for the absurdity that it is.

An air leak has quite a distinctive ultrasonic signature. You can hear a rushing or roaring noise similar to an aircraft engine. What we are effectively listening to is flow, we are also basically listening to friction. Finding air leaks is very simple. In fact, it is easy. Anybody can do it with only a nominal amount of training. Since it is not a specialist function, it is an inclusive technology. A comprehensive program of leak detection can turn a company around by increasing profitability and, therefore, competitiveness. Compressed air is expensive – frequently the most expensive energy resource used in the business. It is sometimes an interesting exercise to refer the cost of your air leaks to the input of your manufacturing process.

Consider a producer of potato chips making millions of packs per year which are sold for a profit of 5 cents per pack. Now consider that you have an annual cost of producing (and leaking) compressed air of $100,000. That means that you will have to sell, produce, package, ship, invoice and case the money for 2 million packs of chips just to pay for the air leaks!

If you reduce your air leaks to an annual cost of $10,000, you could use the savings to fund a promotion to give away 1,800,000 bags of chips and still have the same income! What's the value of that competitive edge?

Vacuum Leaks – If you have a vacuum system, you will know just how difficult it is to find a vacuum leak without ultrasonic assistance. The mechanism of sound generation is similar to that of a positive pressure leak, but in the case of a vacuum the sound is not travelling towards you but instead is being drawn back into the pipe.

The sound of a vacuum leak is similar to that of an air leak, but inherently, the vacuum leak is quieter. If you have to find a vacuum leak then, in the presence of air leaks, you could have a problem. Training helps out here and a Level 1 ultrasound certification would be a good investment if you may potentially run into this kind of problem.

To accurately identify a vacuum leak you must work hard to increase the sensitivity of your detector, block out competing ultrasound sources or both. For this reason many of the ultrasound equipment manufacturers produce an acoustic horn, which is a wonderfully useful device in the world of acoustics – and one which is still used extensively in the loudspeaker industry today. The beauty of an acoustic horn is that by controlling the relative dimensions of the throat, the mouth, and the length and profile of a horn, you can tune it to quite a narrow range of frequency – effectively it resonates.

The beauty of such a horn is that you could produce an amplification of more than 26dBμV which is a factor of 20x higher sensitivity. However, you do so at a price – the horn will have a very narrow frequency range over which this amplification will be present. Move outside this range and the horn could even reduce your sensitivity to a level below what you would have without the horn.

Vacuum systems are quite widespread – chemical and pharmaceutical processes frequently require vacuum to initiate a chemical reaction. No vacuum, no reaction, no production. This tends to sharpen the interest of these industries in ultrasonics. In this energy-poor environment we must now work in, it must surely be unacceptable to simply buy another vac pump if you don't have sufficient vacuum.

Steam Leaks – High pressure steam leaks are potentially deadly. If you are using superheaters, for example, you could be operating at a temperature over 300°C, perhaps up to nearly 600°F. A high pressure leak could, therefore, be generating an invisible lance which can easily cut through a human.

"Something so important must have an important detection system in operation," I hear you cry. Not so, it is still quite commonplace to find people using long poles or even broom handles with rags tied on the end to find such leaks – when the rag twitches you have a steam leak. A few years ago in the UK there were two near fatalities using this procedure, which finally resulted in it being banned and replaced with ultrasonic inspection.

As noisy as a compressed air leak is, the turbulence generated by a steam leak is even greater, which means that there is even more ultrasonic noise.

Electrical Inspection

Ultrasound can be used to find three common electrical problems: corona, tracking and arcing.

Corona is ionization of air molecules and a surface partial discharge. Ionization of the air is not likely to take place at voltages below 4kV. The presence of corona indicates that there is a problem and that this problem requires attention to prevent the problem from getting worse. Corona is particularly problematic in high voltage switchgear and transmission components. Sadly for thermographers, corona does not generate heat, so it is not detectable using an infrared camera.

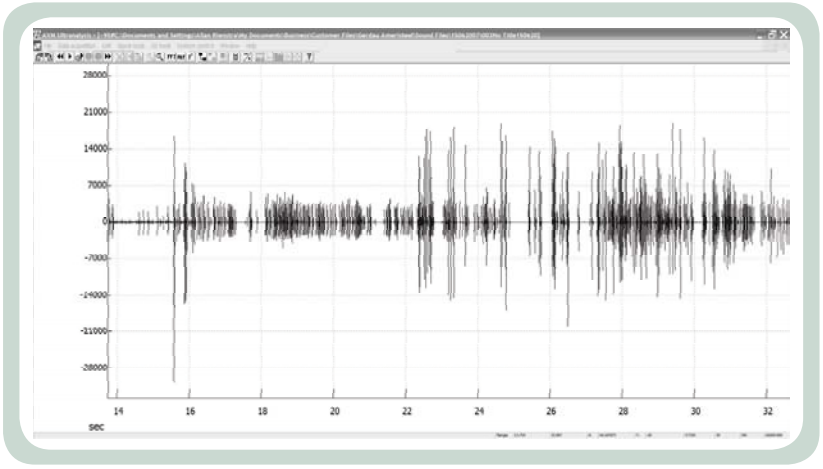


Figure 1- Insulator on 13.8kV step-down transformer before cleaning

In recent years, arcing and tracking have become major topics in the world of infrared inspection of electrical cabinets. An ultrasonic inspection of a panel prior to opening it is now considered to be best practice - with good reason. Ultrasound is sound, and sound travels through gaps in doors and door frames and bounces around inside a cabinet. Using an airborne ultrasound sensor on a door which is not watertight would therefore identify any crackling sounds inside the cabinet which might be coming from arcing or tracking events.

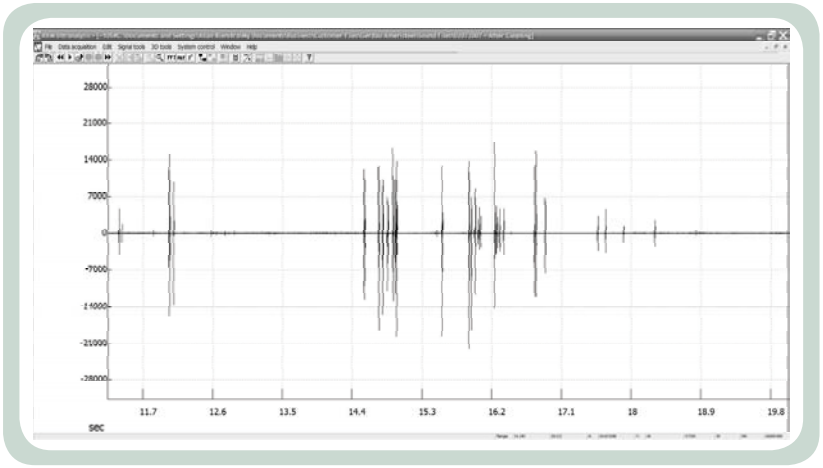


Figure 2 - The same insulator after cleaning still shows problems.

Figure 1 is an example taken from a 13.8kV step-down transformer showing an insulator with a tracking problem before and after cleaning. As seen in Figure 2, the presence of activity after cleaning shows that there is a residual problem which will require more detailed repair action.

Tightness

Mentioning watertight electrical cabinets brings me to another major use for airborne ultrasound – tightness testing.

Now, instead of using a physical source of ultrasound like those discussed previously, we are going to generate ultrasound with a transmitter (loudspeaker) and listen to that sound. If I place a transmitter inside a sealed box, the sound of the transmitter will not be able to get past the seals of the box, so it can only be heard on the outside, like in the case of a car with a powerful sound system, by vibrating the panels of the box.

This simple idea opens up almost unlimited applications for airborne ultrasound. But, as with all simple ideas, there are some catches. The transmitter you rely upon to provide the source of your ultrasound must be stable and give a repeatable amplitude of signal source. Otherwise you could be in a situation where the combination of transmitter instability and poor detector sensitivity would make a leak inaudible.

This is actually the globally recognized and preferred method for inspecting hatch covers of cargo ships for tightness, an ultrasound transmitter and airborne detector.

Put a transmitter inside a car, close all the doors and windows and you can find where all the gaps are – in some cars you can find a pinhole gap and that gap will make an audible difference to the owner of that car.

This same test method is used to inspect heat exchangers, tractor cabs, buses, trains, trucks, vans, vacuum chambers, autoclaves, windows and roofs on buildings, watertight bulkhead doors and more applications are being added to the list every month.

Mechanical

Surely it is a contradiction in terms to contemplate using airborne ultrasound for mechanical applications. Not so. In fact, there are many mechanical applications where the ability to inspect without making physical contact can be highly beneficial.

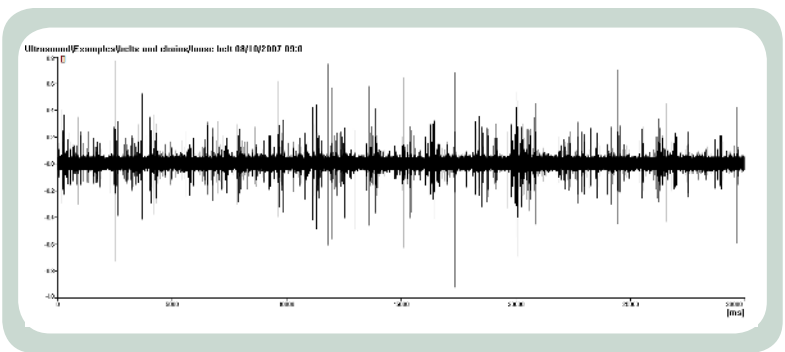


Figure 3- Time signal of slapping drive belts.

I mentioned before that we could listen to friction. I can perform an FMEA (Failure Modes and Effects Analysis) exercise to identify failure modes which are associated with friction. If I have instances where the ultrasound generated by that friction can become airborne then I can use airborne ultrasound detection to isolate the problem. The only thing that I need is an air path between the sound source and my sensor.

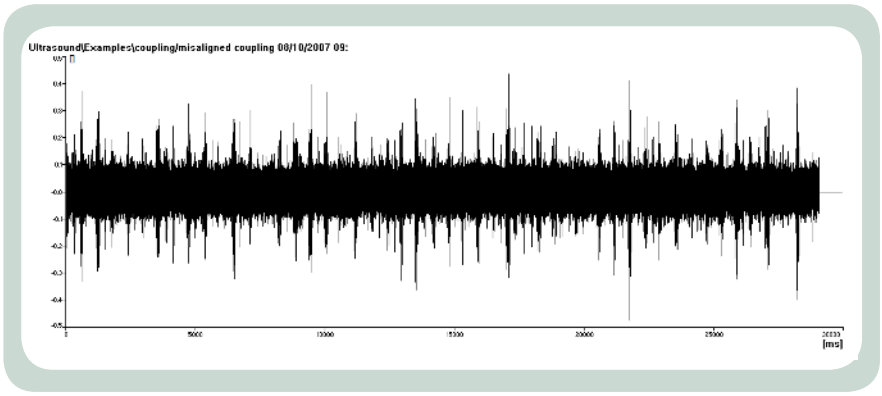


Figure 4 - Ultrasonic signal from a misaligned coupling.

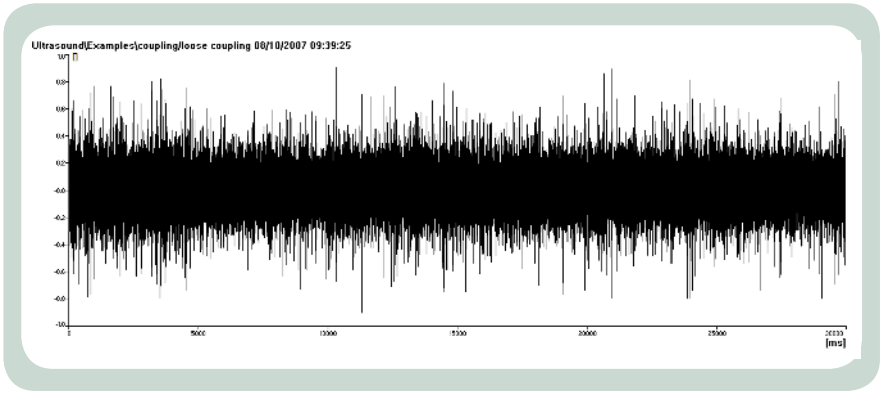


Figure 5 - Loose couplings generate a harsher and less periodic ultrasonic signature than misaligned couplings.

Some examples include:

Drive belts

Belts can be loose, belts can be tight, and belts can be running on misaligned pulleys. Loose belts will slap and produce a noise similar to a whiplash. Tight belts and misaligned belts will generate additional friction which will again be audible ultrasonically. Figure 3 is a sample time signal of some slapping belts.

Couplings

Couplings can be misaligned, and couplings can be loose. Infrared training tells us that a misaligned coupling generates heat. This heat is generated by the periodic friction caused by the coupling being squeezed with each revolution. Remember, friction we can hear. So, a misaligned coupling will generate periodic friction and, therefore, a periodic ultrasound signal like the one shown in Figure 4.

A loose coupling will generate an ultrasound signal caused by the fretting of the coupling halves rattling. This fretting will be more harsh and less periodic (see Figure 5) in nature than misalignment.

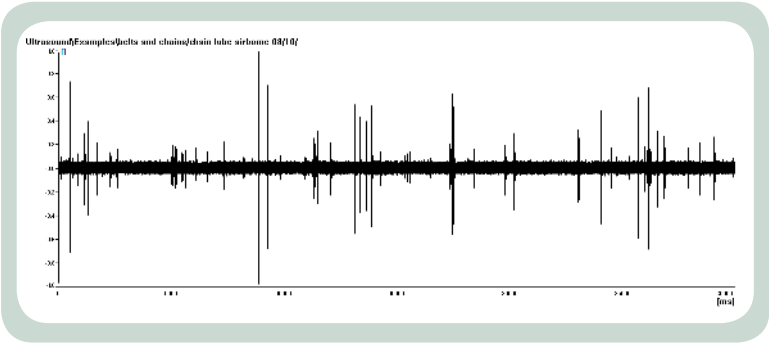


Figure 6 - Time signal of a chain drive.

Chains

Very few people with chain drives have any predictive or even non-intrusive inspection programs for chains. This is a shame since it is so easy to inspect a chain using ultrasound.

As a chain link moves over a sprocket, two things happen. Firstly, the chain link bends and secondly a tooth of the sprocket must slip though the link and make contact with the pin. This is all going to introduce friction and, therefore, ultrasound, which will show impulses corresponding to each of these movements, with a degree of periodicity as the chain repeats its circuits (Figure 6, previous page).

Bearings

Certain bearing defects generate ultrasound. Bearings which are open to the environment will generate ultrasound which will be transmitted into the same environment. What sort of sounds can be expected? The most obvious one is, of course, friction. An incorrectly lubricated bearing will generate friction. The sound of poor lubrication is a constant crackling sound like something in a frying pan, and it looks like Figure 7.

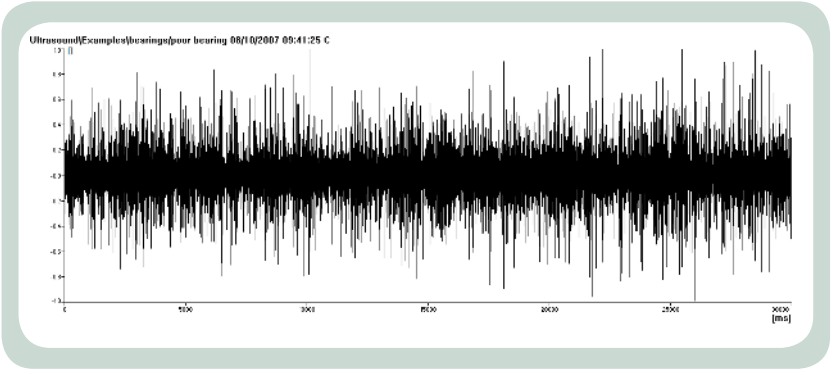


Figure 7 - Ultrasonic record of a poorly lubricated bearing.

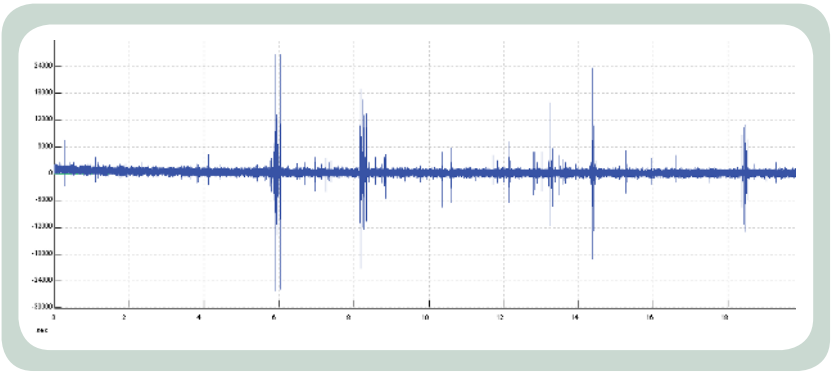


Figure 8 - Note the impacts of an object inside the bearing.

If a bearing has something worn or loose inside which is generating impacts internally, it is possible that these impacts will be audible in airborne ultrasound mode, and will look like Figure 8.

A loose bearing housing (or, similarly, soft foot on a motor) will generate a periodic impact as the foot lifts and falls. This impact will produce an audible airborne ultrasound signal. Figure 9 is an example where a loose bearing foot was identified by airborne ultrasound. The bearing was tightened up and an additional measurement was taken to prove the efficacy of the repair (Figure 10).

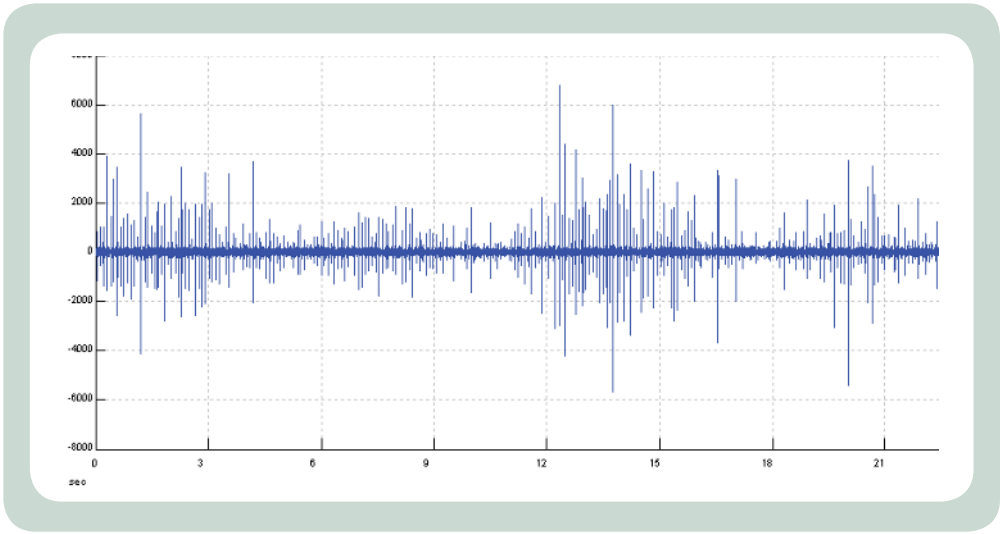


Figure 9 - Ultrasonic inspection confirmed a loose bearing foot.

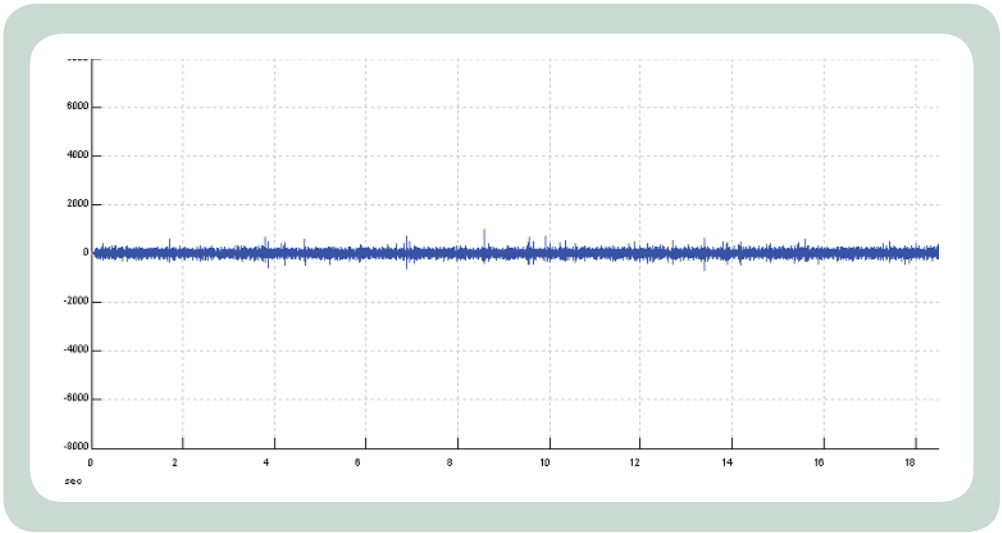


Figure 10 - Ultrasonic reading that validated the repair procedure.

The Future

One common misconception of ultrasound is that you need a 40kHz recording system – "normal vibration data collectors don't have the bandwidth" is a typical comment. Of course, this is incorrect because it a misunderstanding of the fact that the output to the headset of an ultrasound system is typically a signal of just 2kHz.

The last couple of years have seen a marked increase in the desire to record ultrasound signals for the purpose of more detailed, and advanced failure analysis. Previous articles in this publication have highlighted the need to capture a signal using a high quality device. For instance, one that captures high quality wave signals, not compressed MP3, and one that does not apply an autogain to the signal, thus corrupting the dynamics of the data for the purpose of analysis.

It is this ability to properly record and process the audio signals which has allowed me to show the time signal graphs in this article.

Great care must still be taken if comparative work is to be undertaken using recording methods. Apart from the obvious need to maintain the same distance from the test subject, it should also be clear that there is a need to control the output level from the ultrasound instrument and the input gain of the recorder in order to produce comparative data.

The future of ultrasound technology? Well, normally we would go with smaller, lighter, faster, or perhaps, more powerful, more sensitive. These are all, to some extent, useful – especially the more sensitive idea when dealing with ever smaller leaks. But what about more objective? Is there a need for systems which measure? Which measure more precisely, with traceability? Systems which capture dynamic data as well as the dBμV value and process that signal as a signal rather than as a sound? If ultrasound is to more fully deserve its rightful position as "the third technology" we must follow the lead of infrared and move from viewers, or hearers, to measurement devices.

Conclusions

The wide range of applications of airborne ultrasound reviewed above should have provoked some thoughts. Hopefully you will now realize that walking around any plant with an airborne ultrasound detector will uncover lots of problems.

Furthermore it should have raised the perhaps disturbing realization that it is not necessary to trend all defects. It is possible to find problems as part of an inspection, but not as part of a point-by-point measurement procedure.

Part 2 of this article will be in November's issue and will deal with contact ultrasound applications – and there are plenty of those too!

Acknowledgements
Grateful thanks to Allan Rienstra of SDT North America for providing some of the time signals used in this article and more significantly for the benefit of his editorial skills.

Tom Murphy is an Acoustics graduate from Salford University and has 25 years experience in the world of industrial ultrasound and vibration measurement – 15 of those years have been involved with the use of Operating Deflection Shape techniques in the paper, printing, petrochemical, power generation, pharmaceutical and food industries. Tom is the Managing Director of Adash 3TP Limited, based in Manchester England, a Company specializing in the application of vibration, infrared and ultrasonic technologies to improve maintenance. More info can be found at www.reliabilityteam.com and Tom can be contacted at +044 161 788 9927 or at tom@adash3tp.co.uk

The 3 Dimensional Timesaver

A Triax Accelerometer for Route Based Vibration Analysis

by Dr. James C Robinson and Stan Sparkman

A new triax accelerometer has been developed specifically for route-based vibration data acquisition for industrial machinery condition monitoring. The sensor incorporates a two-pole (two feet) integral magnet, so it can be placed on a curved surface. When the new triax sensor is mounted on the curved surface of a machine, the bandwidths of all three sensors are sufficient to capture the mechanical vibration and limited stress wave activity taking place. If the sensor is placed on a flat surface (mounting pad), the bandwidth of the z axis is sufficient to capture the stress wave activity that accompanies impact, fatigue and friction.

When a two-channel data collector is employed, simultaneous two-channel data acquisition can be executed, such as z-axis mechanical vibration paired with z-axis stress wave analysis followed by x-axis paired with y-axis mechanical vibration. Being able to acquire this amount of data simultaneously results in significant time savings for instrument technicians engaged in route-based vibration data collection and analysis.

The triax sensor has reached all design goals, as demonstrated in the laboratory. Data has been acquired in the field with the triax sensor in the normal route mode of data acquisition and shown to be essentially the same as the same data acquired employing the single axis sensor. However, the field experience has verified a time savings of around 30 percent.

Limitations of a Single Axis

A single axis accelerometer mounted to a two-pole (two feet) magnet is the most common sensor employed in route-based collection of vibration data for condition monitoring of industrial machinery. The magnet is easily attached to a curved surface (providing two-line contact), so minimal surface preparation is required at the measurement point. This means of collecting vibration data provides meaningful results for the detection and trending of many mechanical faults occurring in the industrial environment.

It is desirable to obtain machinery vibration data for the sensor oriented in the horizontal, vertical, and axial directions. Additionally, the capture of the higher frequency stress wave activity (in at least one direction) is beneficial for detecting impacts, fatigue, and friction. Mounting the sensor via a two-pole magnet on a curved surface limits the ability of the sensor to detect the higher frequency stress wave activity introduced by friction due to the limited bandwidth (~5 kHz) of the two-pole magnet.

If it is important to reliably detect friction at an early stage, the two-pole magnet should be replaced by a flat rare earth magnet requiring a smooth flat space, or a mounting pad. However, this could mean three mounting pads at each bearing in order to make horizontal, vertical, and axial measurements. The inconvenience of providing three mounting pads on each bearing, as well as time restraints, discourage the acquisition of broadband (up to 15 20 kHz) data in the three directions.

For those cases where it is important to reliably detect friction activity (requiring broadband detection capability), data acquisition is generally restricted to one direction using a single axis sensor. An alternative to the single axis sensor with flat magnet is the use of a conventional triaxial accelerometer, which also requires a special mounting pad or other surface preparation. This method lacks the versatility of a two-pole or flat magnet, and, hence, is not widely used in route-based data acquisition programs.

The triaxial accelerometer developed by Emerson specifically for route-based data acquisition has the versatility of the single axis accelerometer, without the limitations. When the triaxial accelerometer is placed on a curved surface, the performance of the sensor in the z direction is approximately equivalent to the single axis accelerometer attached to a two-pole magnet placed on the curved surface. When the triaxial accelerometer is placed on a flat surface (such as a mounting pad), the performance of the sensor in the z direction is approximately equivalent to the single axis accelerometer attached to a flat surface (mounting pad).

Development of the Emerson Triaxial Accelerometer

The design criteria for the triaxial accelerometer were:

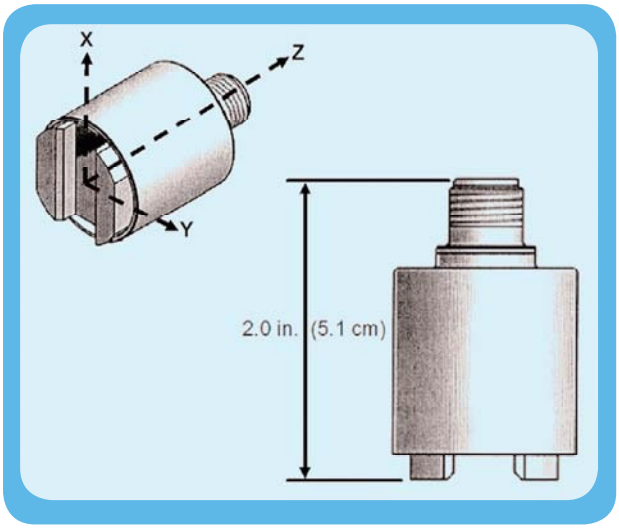


Figure 1 - Plan view of the triax accelerometer with x-axis direction always parallel to two-pole magnet feet.

1. Versatility of two-pole magnet maintained.
2. Magnet be integral to sensor, thereby avoiding sensor/magnet interface.
3. Sensing in the z (x-y is plane parallel to feet) direction be flat within 3 dB up to 10 kHz.
4. Sensing in the z direction be responsive up to 25 kHz for stress wave activity with sensor mounted on flat surface, such as a mounting pad.
5. Sensing in horizontal (x-y) plane be flat within 3 dB up to 4 kHz.

A plan view of the triaxial sensor is presented in Figure 1. The sensing element for the x direction is always parallel to the feet as shown along with the y-z sensing direction. The two feet are broader than normal for a two-pole magnet used with a single axis sensor. When placed on a mounting pad, the increased area (relative to typical two-pole magnet) of the feet on mounting pad provides sufficient holding force to provide the desired sensor bandwidth in the z-direction.

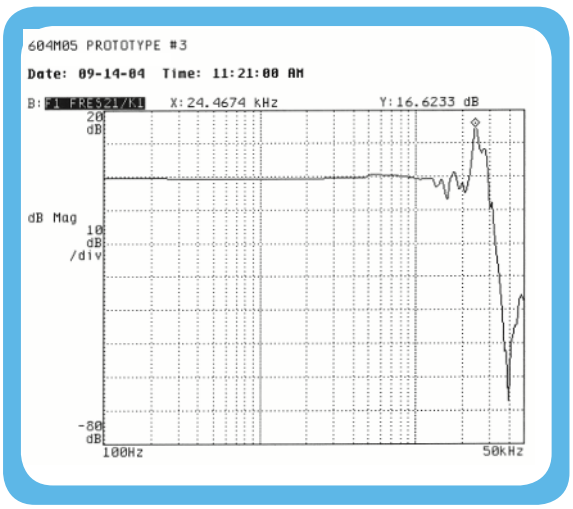


Figure 2 - Frequency response sweep between 100 and 50,000 Hz for z-direction sensor in triax accelerometer

The frequency response sweep between 100 Hz and 50, 000 Hz for the triaxial accelerometer is presented in Figure 2. The resonance for this sensor is around 24 kHz showing a peak around 10 dB at resonance. There is a decrease in response in the proximity of 15 kHz. The activity around the resonance varies somewhat between sensors, but the z-axis sensor is within 3 dB at 10 kHz and remains responsive to 30 or so kHz. This is a key point.

A reference 50 kHz frequency response sweep for a single axis sensor on flat surface is presented in Figure 3. The response is similar to the z-direction sensor of the triaxial accelerometer in the 10 kHz to 30 kHz range.

To further evaluate the response of the triaxial accelerometer to stress wave activity over a frequency range of 6 to 25 kHz (where some impacting and most friction generated stress wave activity are expected), a stack of piezo electric discs was attached to the end of a massive steel table. The piezo electric disc stack was excited by a reasonably high voltage periodic signal. The driving periodic signal consisted of a sinusoidal signal gated on for 2 msec and then off for the remaining duration of the driving signal period (the repetition rate was about 13 times per second).

Sensors were placed on the top surface of the metal table. Two high

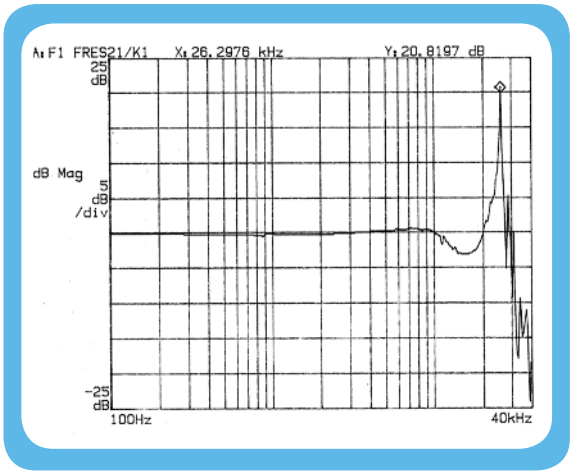


Figure 3 - Frequency response between 100 Hz and 50,000 Hz for a single axis accelerometer mounted on flat surface

frequency sensors were used as the reference sensors. The single axis sensor was mounted to the table surface with a flat rare earth magnet. Three integral magnet triaxial sensors to be evaluated were also attached to the table.

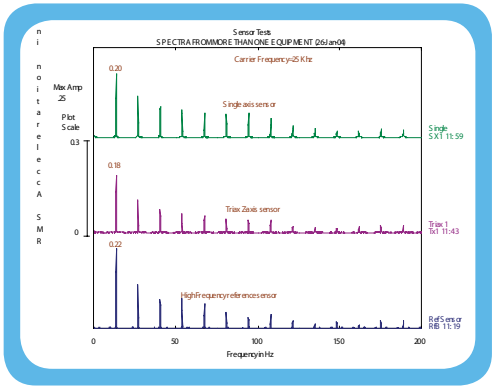


Figure 4 - PeakVue response of high frequency accelerometer, z-axis of triax accelerometer, and single axis accelerometer/flat rare earth magnet to an impulse excitation of 25 kHz carrier gated on 2 msec with a periodic rate of 13 per second.

The PeakVue™ spectral data acquired from the reference sensor, single axis sensor, and a triaxial (z direction) sensor for the case when the excitation frequency was 25 kHz are presented in Figure 4. The PeakVue spectral response of these three sensors with a second triaxial sensor at multiple carrier frequencies is tabulated in Table 1 (following page). The key observation is the z axis triaxial sensor. This sensor is capable of detecting stress wave

Carrier Frequency (kHz)	Reference Sensor (g's RMS)	Triax 1 z-axis (g's RMS)	Triax 2 z-axis (g's RMS)	Single axis (g's RMS)
6	0.025	0.01	0.01	0.01
10	0.034	0.03	0.02	0.015
15	0.054	0.05	0.04	0.02
20	0.15	0.20	0.08	0.05
25	0.22	0.20	0.18	0.20

Table 1 - PeakVue Spectral g's for multiple sensors with multiple carrier frequencies.

activity beyond the 25 kHz range, which is sufficient to capture stress waves generated by impact, fatigue, and friction when mounted on a flat surface.

Route Based Vibration Data Acquisition Using the Triaxial Sensor

This section presents comparative data which were acquired from a single axis accelerometer and from the triax accelerometer. The first set of data is for trending parameters for single axis accelerometers mounted in the horizontal, vertical, and axial directions compared to the x-y-z sensors in the triax accelerometer. The second set of data is for the z-direction sensor in axial direction over a six-month time span covering the detection of a BPFI fault in velocity spectral data and subsequent propagation of fault until bearing was replaced. The third set of data is for an outer race defect (BPFO) detected employing PeakVue and single axis accelerometer. The final set of data is for an outer race fault (fluting) on an exhaust fan using PeakVue data from the triax accelerometer.

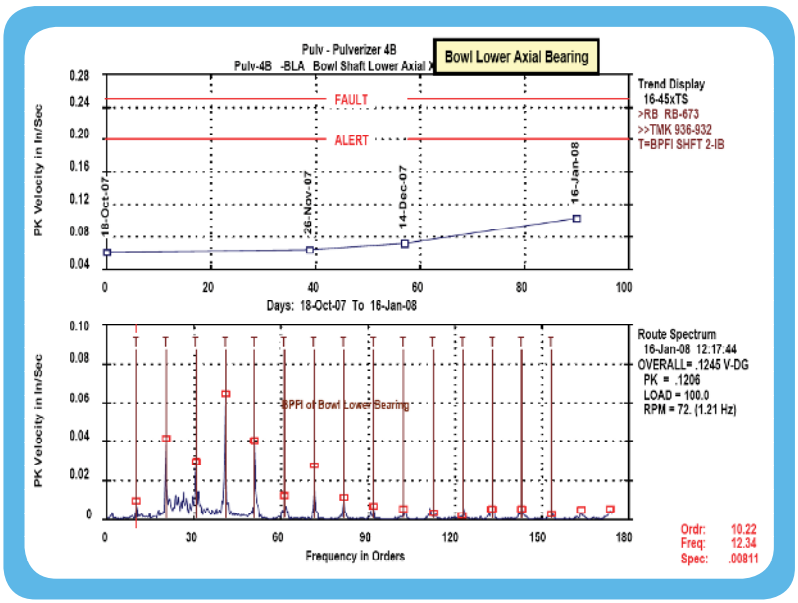


Figure 5 - Velocity spectra data from z-axis sensor on pulverizer gearbox clearly indicating inner race bearing fault.

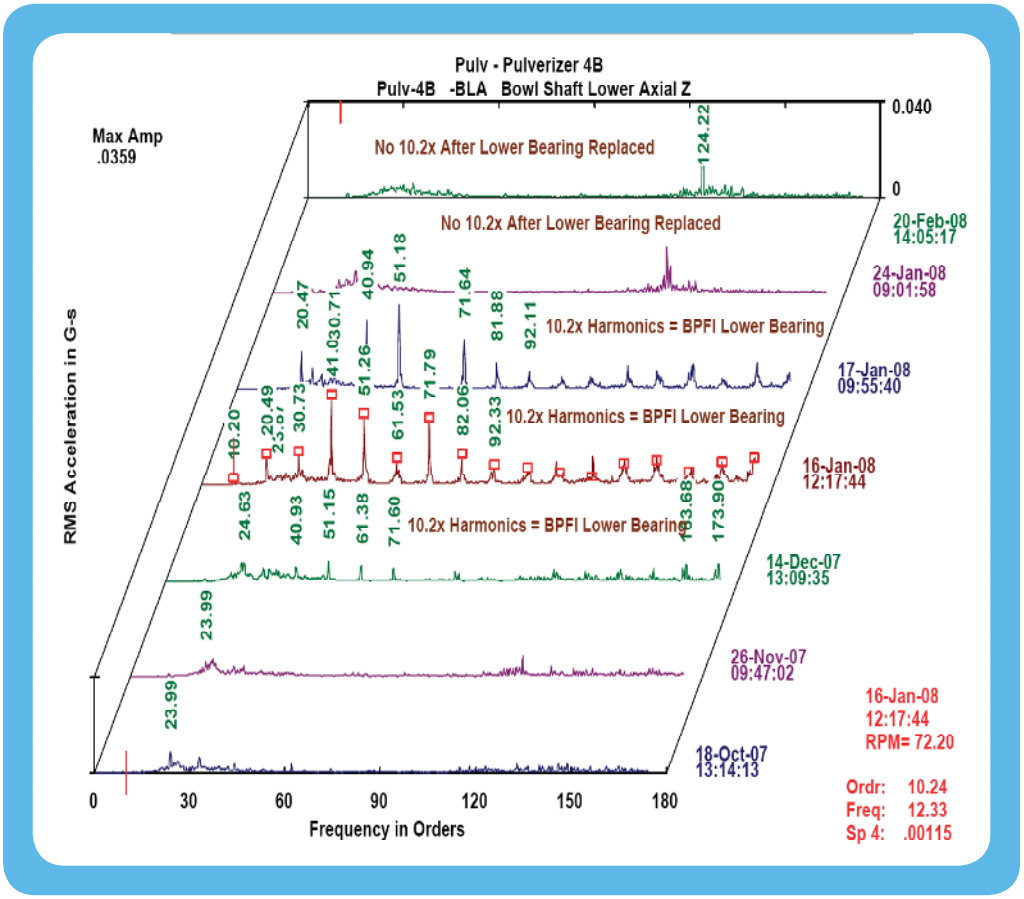


Figure 6 – Water fall velocity spectral data from z-axis sensor on pulverizer gearbox over 6-month period with inner race fault present between Dec 14, 2007 and Jan 17, 2008, when bearing was replaced.

all, 1x, 2x and 3-8x RMS values. The single axis data acquisition required sensor placement at three different spots, whereas the triax required sensor placement at a single location. The single axis data was acquired on June 8, 2007, and the triax data was acquired on July 7, 2007. Both sensors were placed on curved surfaces for data acquisition. The acquired trend parameters are tabulated in Table 1. There is very little difference in the two data sets.

Inner Race Detected and Trended with Triax

The velocity spectral data from the z sensor of the triax sensor placed on a curved surface of a pulverizer gearbox are presented in Figure 5, clearly showing an inner race fault. The velocity spectral data acquired over a six-month period from the same triax sensor mounted on the curved surface are presented in Figure 6. The defect, which was first observed in the December 14, 2007 data, increased in severity through the January 17, 2008 data set, after which the bearing was replaced. Figure 7 is a photo of the inner race from the removed bearing, showing significant damage.

Figure 7 - The defective inner race from bearing removed from pulverizer gearbox following January 17, 2008 data set in Figure 6.

Comparison of Trending Parameters

A motor/pump machine was chosen for the enclosed trending parameter comparison (single axis versus triax accelerometer). The parameter trended is the velocity over-

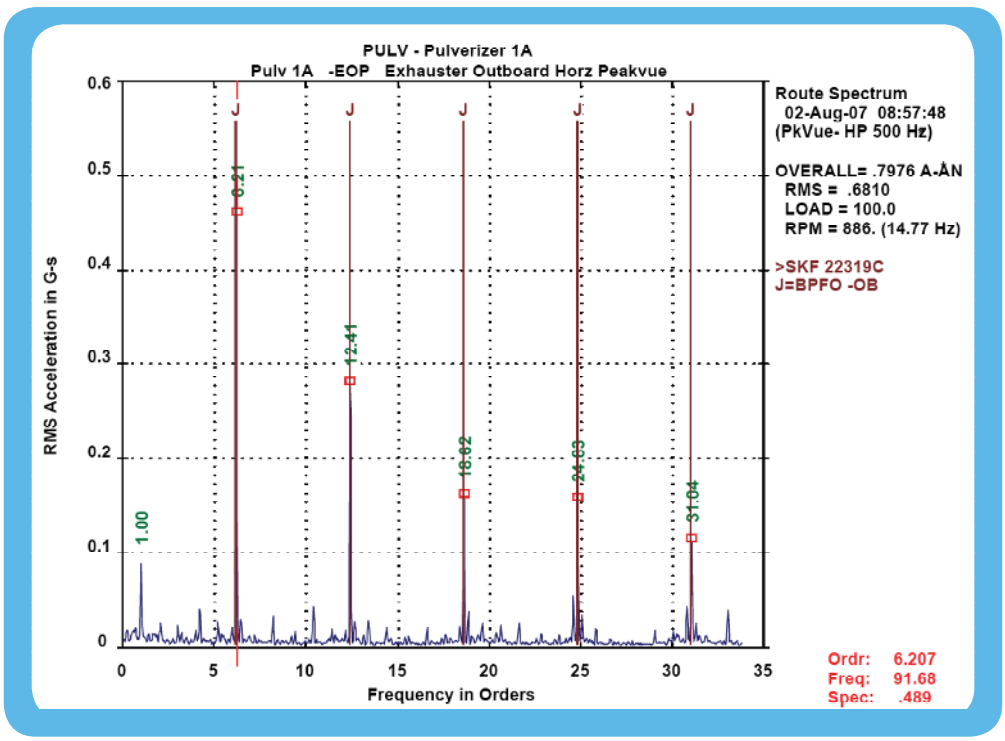


Figure 8 - BPFO fault detected Aug 2, 2007 with PeakVue from a single axis accelerometer.
Note slight amplitude modulation at tuning speed.

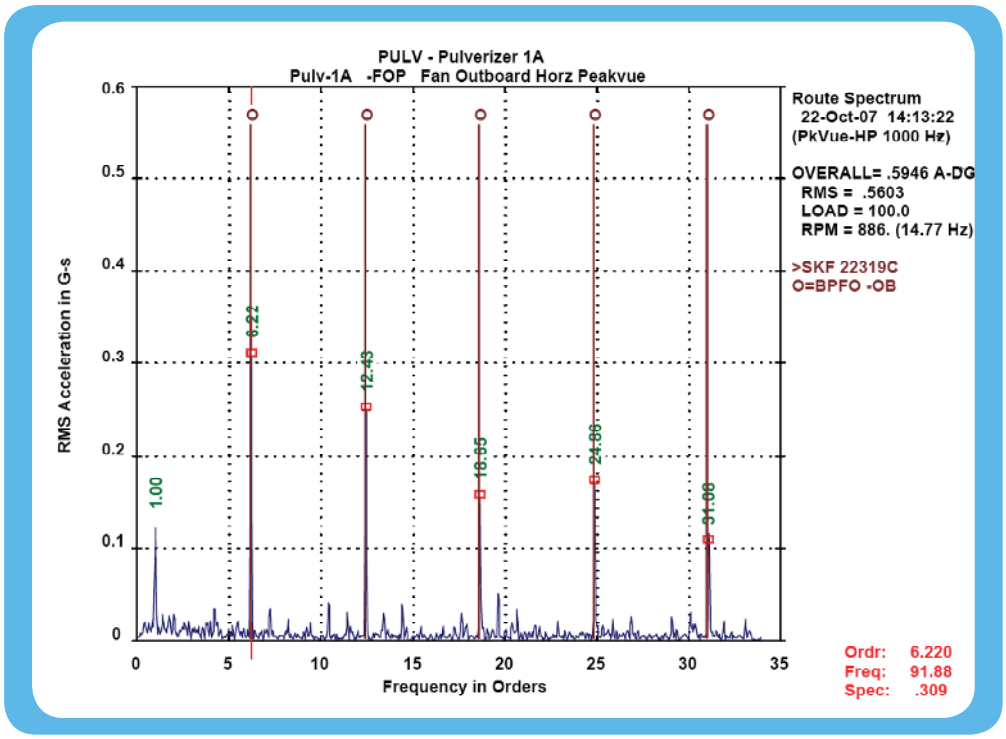


Figure 9 - BPFO at same acquisition point of Figure 8 using the triax z-axis accelerometer on October 22, 2007. Note amplitude modulation has increased slightly relative to data in Figure 8.

Outer Race Defect and PeakVue

An outer race defect detected on August 2, 2007 employing PeakVue from a single axis accelerometer mounted on the pulverizer exhaust fan is presented in Figure 8 (previous page). On October 22, 2007, PeakVue spectra from a triax sensor on this same exhaust fan (Figure 9) indicate the outer race defect, but with less amplitude at the defect frequency. The 1-x component has grown slightly, and there is obvious side banding (amplitude modulation) of the BPFO fault activity with the running speed, suggesting that possible unbalance may be increasing.

PeakVue Trend and Spectra around Bearing Replacement

PeakVue spectra from the z sensor in the triax accelerometer from the pulverizer exhaust fan clearly shows the BPFO fault (Figure 10). The peak g level trend data from the PeakVue waveform over a five+ month period is presented in Figure 11.

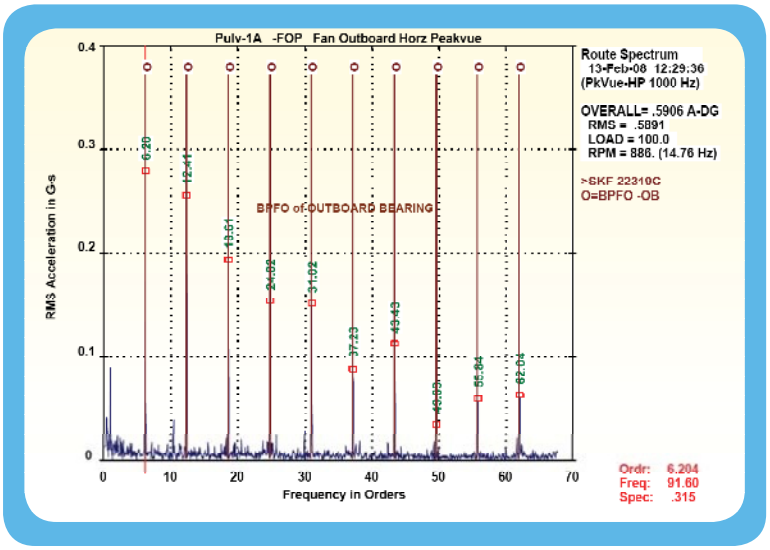


Figure 10 - z-axis PeakVue data from pulverizer exhaust fan on February 13, 2008 showing an outer race defect.

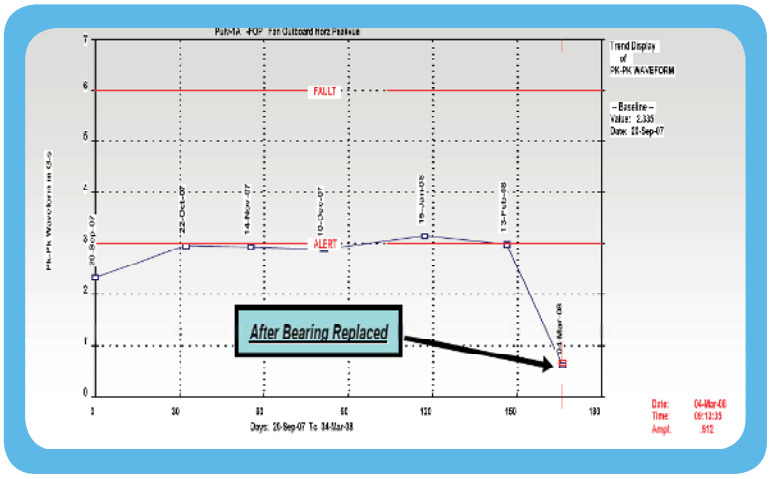


Figure 11 - Peak g-level PeakVue trend data from z-axis sensor over 5.5 month period from same measurement point from which PeakVue spectra data in Figure 10 acquired.

Figure 12- Defective bearing (fluting) from pulverizer exhaust fan where data presented in Figs. 10 and 11 were acquired.

After the bearing was replaced about March 4, 2008, a significant decrease in the peak g-level amplitude is apparent. A photo of the defective bearing (showing fluting) is presented in Figure 12.

Conclusions

The primary objective in the development of the triax sensor was to have an equivalent sensor in the z (typically in vertical) direction to the commonly used single axis accelerometer when on a curved surface. Additionally, the x-y sensors can be used where x generally is axial and y is horizontal (assuming z is vertical). The triax sensor proved to meet the design objectives in the laboratory followed by successful application in the field. If the triax sensor is placed on a smooth flat magnetic surface, the bandwidth of the z sensor is increased to the 25 30 kHz range, which is adequate for high frequency stress wave activity accompanying friction, fatigue, and fluting. Use of the triax sensor in the route mode of data collection in the field has reduced collection times by an average of 30 percent.

	Overall		1X		2X		3-8X	
	Triax*	Single Axis	Triax*	Single Axis‡	Triax*	Single Axis‡	Triax*	Single Axis‡
MOH (z)	0.102	0.107	0.077	0.077	0.063	0.069	0.024	0.024
MOV (x)	0.030	0.029	0.028	0.026	0.007	0.0090	0.0076	0.0076
MOA (y)	0.065	0.060	0.056	0.045	0.032	0.027	0.0030	0.0036
MIH (z)	0.112	0.126	0.091	0.103	0.056	0.061	0.035	0.038
MIV (x)	0.054	0.052	0.047	0.046	0.024	0.022	0.011	0.011
MIA (y)	0.072	0.070	0.047	0.047	0.054	0.039	0.0047	0.021
PIH (z)	0.207	0.200	0.200	0.193	0.0073	0.010	0.054	0.043
PIV (x)	0.112	0.097	0.063	0.080	0.013	0.010	0.091	0.038
PIA (y)	0.121	0.093	0.104	0.064	0.0072	0.013	0.042	0.042
POH (z)	0.123	0.153	0.120	0.148	0.012	0.013	0.022	0.021
POV (x)	0.128	0.153	0.124	0.130	0.013	0.012	0.028	0.024
POA (y)	0.083	0.096	0.078	0.086	0.0059	0.0065	0.025	0.015

* - Triax data acquired on 7/17/07. Units (ips) ‡ - Singular data acquired on 6/8/07. Units (ips)

Table 2 - Comparative trend data between three single axis readings and triax readings.

Disclaimer: TVA's participation in this study does not imply TVA endorsement of the product.

James C Robinson is Senior Technical Advisor in the Engineering Group for Emerson Process Management in Knoxville, TN. He has had many years experience in the design and development of vibration monitoring equipment and analysis methodologies used for condition monitoring.

Stan Sparkman is a Predictive Maintenance Technician (Level III) with the Tennessee Valley Authority's Electric Utility at the Gallatin Power Plant in Gallatin, Tennessee. He is responsible for the periodic vibration data collection, database management and equipment analysis of the essential and critical equipment at Gallatin.

Simple is always better. And solutions really don't come any simpler than this one. Imagine eliminating virtually any chance of cross contamination in all of your grease applications. The solution is as simple as switching the type of grease gun you use. That's it.

Clearing the Confusion

A clear grease gun. Wow! It makes perfect sense once you think about it. So why didn't somebody think about it until now? Nobody really knows, but now that they are here, companies can experience the simple solution to grease worries. These patented clear grease tubes allow users to have 100% visual grease identification, therefore avoiding costly grease cross contamination errors. Other grease guns on the market do not allow the grease to be seen, which means that proper grease identification is not possible. The clear grease tubes provide a simple, cost effective reliability solution to eliminating grease misapplication mistakes.

Lubrication Engineers is the global distributor of Clear Grease Guns. We talked to their Marketing Manager, Paul Grimes, who as an 18-year veteran of the industry, and former Six Sigma Black Belt & Continuous Improvement Leader, knows a thing or two about improving industrial processes. Here is what Paul had to say...

The clear tubes and colored end caps allow for 100% visual identification of what grease is being applied.

A clear grease gun? It sounds so simple, why didn't anyone think of it sooner?

Some of the simplest ideas are always overlooked. Some of the best ideas are ahead of their time in the market place. Today we have a product that is simple and provides immediate value to an organization by virtually allowing the elimination of misapplication of greases. Why, because you can see what you are putting into the machine and verify that the grease is correct for the application. Almost makes the old stand by grease gun obsolete.

There is no question that cross contamination during grease application is a major problem across industries. It leads to unnecessary failures and downtime, both of which cost companies money.

Who came up with the idea, and how fast was the process of going form idea to a finished product?

LE was introduced to the patent holder of the clear grease tubes (Kany Innovations, Mike Cline) in December of 2008. Our alignment of our joint business perspectives happened immediately from the first phone call. Lubrication Engineers and Kany both saw this as an exciting opportunity to solve a real problem for customers, especially those investing in the lubricant reliability journey. From our initial business alignment to product launch we were able to release to the market in only three months.

What are the advantages of using a clear grease gun vs the old-school metal gun?

Again the concept is simple! Today's grease guns have barrels that an operator cannot see through. Someone may load the gun with a particular grease but once they put the gun down and another operator takes it to the floor, do they assume or do they verify what grease is inside? The clear grease gun allows any operator to see the grease whether it is a tube of grease in the packaging or grease that has been bulked filled. Seeing the grease means visual identification for the operator, but that is not the end to the story. LE wanted customers to not only visual identify but to positively verify. Positive verification takes the product to another a whole new level.

Each Clear Grease Gun Tube comes with colored end caps already assembled onto each tube. The colored end caps come in a variety of colors. The color end caps allow the end user to create an additional positive form of identification.

Customers purchasing the clear grease tube and grease gun kit will also get an additional form of color identification. Included in each box will be a sheet of colored marking decals. The decals will allow the operator to mark the tube with yet another form of positive color identification.

We wanted to allow customers the opportunity to establish and follow best lubricant reliability practices by providing them flexibility in how the tubes are colored mapped throughout the lubricant management process.

OK, but how can a clear grease gun be tough enough to stand up to a tough industrial environment?

The product is made of high impact polycarbonate, drop it and it bounces. The end caps are made out of T 6061 aircraft aluminum. The polycarbonate tubes were specifically designed to withstand the day-to-day abuse standard grease guns are subject to in the industrial market.

What are the three top reasons a company should consider switching to clear grease guns?

Clear Grease Guns are made of high impact polycarbonate and aircraft aluminum.

1. Eliminate cross contamination of greases in normal and critical bearing applications.

2. Eliminate the opportunities for staff to apply the wrong grease in any of the equipment.

3. Eliminate costly equipment failures due to the wrong grease being applied or mixed.

4. Eliminate unscheduled downtime due to the wrong grease being applied or mixed.

I know....that was four, but I couldn't stop at three. They are all very important, and quite simple to accomplish.

Please give us a success story or two from companies that are currently using clear grease guns.

Easy, this product is already in use with the U.S. Naval Center and, of course, several companies that have implemented the clear grease gun solution as well. All of them are very happy with it. Two that immediately come to mind are Cargill Regional Beef in Milwaukee which says that they had quite a significant drop in cross contamination incidents after introducing the clear grease guns. The other facility that really stands out is the APS Redhawk power plant in Arlington, AZ. The reason they come to mind is because of the way they made the conversion to our grease guns. The maintenance foreman actually saw one of our ads and brought it to the attention of the mechanics as part of their continuous improvement process. They all agreed the guns could completely eliminate the opportunities for cross contamination, and after implementing are even more convinced of their usefulness. They think that anyone using more than one kind of grease should use this product.

Have you met any resistance from lubricators that would be using the clear grease guns?

The early response has been phenomenal! Customers see this product as an easy way to truly solve a problem. It is cost affordable and an easy first step on the road to long term lubrication reliability. Customers can modernize older grease guns by purchasing just the colored grease gun tubes or customers can replace these older grease guns and upgrade by purchasing the entire LE grease gun kit, which includes both the gun and the clear grease gun tube. The cost of the product far outweighs the negative cost implications that grease misapplication provides in an operational setting.

How can interested people get more information about your clear grease guns?

We are easy to contact by either calling us toll free at (800) 537-7683, e-mailing us at webleads@LE-INC.COM or visiting our website at www.cleargreaseguns.com

And I would just like to add that at Lubrication Engineers, we are focused on providing lubrication reliability solutions. The clear grease gun is one tool in our reliability arsenal that helps our customers create and capture value with reliability based benefits.

Rotalign ULTRA – Highest standards in machinery laser alignment

ROTALIGN® ULTRA now features a larger full color TFT display readable in sunlight with a faster processor, new user interface and enhanced graphics. As always, achieve alignment results in 3 easy steps: Dimensions - Measure - Results. Enjoy wireless communication, standard, vector and user-editable tolerances, Soft Foot Wizard, Standard Deviation and much more!

http://www.ludeca.com

LUDECA, INC. **305-591-8935**
ALIGNMENT * VIBRATION * BALANCING **info@ludeca.com**

Ultrasound Training

2009 Schedule

Atlanta, Feb 17-19
San Diego, Feb 24-26
Charlotte, March 10-12
Louisville, March 24-26
Chicago, April 21-23
Hamilton, ON, May 6-8
Winnipeg, May 11-13
Cincinnati, June 2-4
Milwaukee, June 23-25
Minneapolis, July 7-9
Nashville, August 25-27
Pittsburgh, Sept 15-17
Birmingham, Oct 6-8
Indianapolis, Nov 3-5
Atlanta, December 1-3

General Motors Trains with SDT

Register early, seats fill quickly

Call 1-800-667-5325 to reserve your seat or,

Visit www.sdtnorthamerica.com/training/learn

Training Menu

Level 1&2 ASNT Public
Level 1&2 ASNT Onsite
Onsite Implementation
1 Day Leak Surveyor
1 Day Lube Tech
Complete Program Mgmt
PdM Super Course (IR,Vib,US)

Onsite Courses

We can save you $$ in travel by coming to your plant. Call about our onsite certification and implementation

"Training is the cornerstone of an effective ultrasound program"

Walgreens is the nation's largest drugstore chain in sales and technology use. The company's strategy is to be the most convenient healthcare provider in the U.S. Sales for fiscal 2008 reached $59 billion, from more than 6,500 stores located in 49 states and Puerto Rico. With 500 store openings this year, Walgreens plans to have 7,000 stores by 2010.

Walgreens Distribution Centers has developed a reputation for finding the newest, most efficient and innovative ways to move merchandise, and we are currently seeking dynamic, qualified **MAINTENANCE MANAGERS and MAINTENANCE TECHNICIANS** for 19 locations in our state-of-the-art Distribution Centers across the country.

For more information, visit: www.walgreens.jobs, and click on the "Distribution Centers" link.

HOUSTON CHAPTER OF SMRP 2009 MAINTENANCE & RELIABILITY SYMPOSIUM

Improving Productivity
The Road to Recovery

August 27—28, 2009
Moody Gardens Hotel Galveston, TX

- Technical Presentations by speakers from major industries following the 5 pillars of SMRP
- Great opportunities for learning & networking
- Nearby for the TX, LA industrial areas
- Low cost

For information or to register visit: www.smrphouston.org

Panasonic Computer Solutions Company has announced its fully-rugged ultra-mobile PC, Toughbook U1, has been recognized by Frost & Sullivan as recipient of the 2009 Global Market Engineering Award for Product Innovation. This award is presented each year to the company that has demonstrated excellence in new products and technologies within their industry.

The Toughbook U1 is the first ultra mobile PC to integrate the low power Intel Atom processor in a rugged handheld computer, making it an ideal device for mobile workers. Field workers are now able to connect to critical information and applications in real time, thus improving organizational efficiency, increasing information accuracy and enabling field-based decision-making. The Toughbook U1 is a 2.3-pound ultra-mobile computer with a 5.6" daylight viewable touch screen display, 32GB SSD and 9 hours of battery life.

For more info on mobile computing solutions, www.panasonic.com/toughbook.

The Economic Report Features SMRP

As an M & R professional, you already know that a solid M&R plan saves companies money and downtime, but to some people, this is a novel idea. SMRP is working for you to help get the word out and promote the M & R profession. The Economic Report is a five-minute segment in which SMRP leaders explain how a maintenance plan is good for business. This report will air across the nation this summer.

Visit our website to read the full story, watch the five-minute segment, and download a schedule of viewing times.

The schedule be updated as SMRP receives information, so don't forget to check back in regularly. You will be notified when it airs in your region.

Cooper Crouse-Hinds Announces EV LED Lighting Technology
New product provides superior energy efficiency & product life

Cooper Crouse-Hinds introduces its EV LED luminaire, the industry's first bright white, Class I, Division 1 factory-sealed LED luminaire for general illumination. Light Emitting Diodes (LEDs) are solid-state semi-conductor devices that convert nearly all the electrical energy directly into visible light. Expected operating life on an LED typically ranges from 50,000 hours to more than 100,000 hours, which is a significant upgrade over traditional light sources. LEDs also offer better lumen maintenance and optical efficiency, which leads to greater energy efficiency. Additionally, LED lighting has an advantage over conventional light sources because it dramatically reduces the overall cost of ownership. For more info, visit www.crouse-hinds.com.

FluidScan Monitor Wins 2008 Great Ideas Competition Award at DoD Maintenance Symposium

QinetiQ North America announced that its FluidScan™ monitor has won the 2008 Great Ideas Competition Award presented annually by the Society of Automotive Engineers (SAE) at the Department of Defense (DoD) Maintenance Symposium. The FluidScan monitor can be used to quickly check the condition of lubricants such as hydraulic fluid, engine oil, turbine engine oil for contamination. Current practices require maintenance crews to extract fluid samples and send them to remote or centralized laboratories for testing to determine whether or not maintenance is required.

Spectro, Inc. 978-486-0123
info@spectroinc.com www.spectroinc.com

NC State University announces simulation classes in Lean Six Sigma training program that include new software by Simio. Attendees learn process simulation without the burden of low-level programming.

"The class is designed for those who want to learn process simulation for making decisions or conducting process improvement projects, without being burdened with low-level programming," says Jeffrey A. Joines, Associate Professor in the Textile Engineering, Chemistry, and Science Department at NC State University. Dr. Joines continues, "The idea is that Simio software is easy for non-experienced simulation users to use to build process simulation models that aid in process improvement projects."

Classes will be of interest to operations managers in industries such as health care, defense, national security, mining, shipping, airports, supply chain and manufacturing. Simulation software is used to help minimize the risk of capital investments and clarify lean operation initiatives. This class is part of the North Carolina State University Lean Six Sigma Master Black Belt program, but attendees are not required to be part of the Six Sigma program, nor will it impact students' ability in the class.

NC State University, voted one the top five universities for its value, offers continuing education credits (CES) for attendance. Instruction is provided by Steve Roberts (Professor of Industrial and Systems Engineering) and Jeff Joines (Associate Professor of Textile Engineering). According to Dr. Roberts, "We have world class facilities and instructors with years of experience in building simulation models for various industries."

For more info JeffJoines@ncsu.edu

Individuals interested in attending are invited to evaluate the Simio software in advance by visiting: http://hs.simio.biz/free-software-registration/?source=sim103

Emerson Expands Smart Wireless Field Starter Kit to Increase Range of Applications for Plant Improvement

Emerson Process Management has added discrete switches as well as vibration and pH transmitters to the already wide range of components available in its Smart Wireless field starter kit. Currently deployed in hundreds of installations across industries and world regions, the kit enables users to choose from a wide range of functions, to realize fast and easy operations improvement, while experiencing wireless technology as a basis for future innovation and advantages. Complete use of standard WirelessHART™ technology further enhances user flexibility.

For reference and application info - www.EmersonProcess.com/smartwireless
For brief wireless product videos - www.EmersonSmartWireless.com/Videos
Orderable online - www.EmersonSmartWireless.com/FieldKit

New True UV-A LED Flashlight for NDT!

Spectronics Corporation has unveiled the powerful Spectroline® OPTIMAX™ 365 — a cordless, rechargeable true UV-A (365 nm) LED flashlight that is ideal for nondestructive testing applications such as MPI, FPI and general fluorescent inspection. The OPTIMAX 365 utilizes ultra-hi-flux LED technology to produce a nominal steady-state UV-A intensity of 18,000 µW/cm² at a distance of 15" (38 cm). Powered by a rechargeable NiMH battery, it provides 90 minutes of continuous use between charges. The LED lifetime is 30,000 hours. It comes with UV-absorbing spectacles, a belt holster and smart AC and DC battery chargers, all conveniently packed in a padded carrying case.

Spectroline® OPTIMAX™ 365 www.spectroline.com
In U.S./Canada 800-274-8888 Outside U.S./Canada, call 516-333-4840

New Low-Foaming Multan Bio-Resistant Metal Removal Lubricants

Henkel Corporation has introduced two new water-soluble Multan metal removal lubricants formulated to generate minimal foam and be used continuously for years with minimal biological degradation. Excessive foam, common when traditional metal cutting fluids are used, causes lubricant overflow and waste while bacteria growth generates odors, degrades the lubricant, and can cause operator health and safety concerns. Both Multan B 236 and B 414 are semi-synthetic metal removal fluids for machining and grinding ferrous and non-ferrous alloys. These lubricants are designed for applications where soft water or process requirements make foam control difficult.

More Info: 248-583-9300 henkel.metalworking@us.henkel.com
http://www.henkelna.com/multan.

Toolmex Stocks New Charlotte, NC Warehouse

Toolmex Corporation has expanded its motor warehouse facilities in the southern United States to include a new Charlotte, NC location. This latest expansion from Toolmex will support local customers with the full line of Elektrim® and Elektrimax® AC TEFC motors. The new centrally located facility is easily accessed from I-85 near the I-77 juncture, and local customers will now have access to same day service for pickups, 8:00AM - 4:30PM EST Monday thru Friday, or next day delivery on all in-stock Elektrim and Elektrimax motors.

The Elektrim line includes 1-500HP High Performance Design "C" & "B" motors, 25-500HP Crusher Series motors, 0.08-150 HP Metric (IEC) motors, 1-30 HP Brake motors and 1-30HP JM/JP Pump motors. The Elektrimax line includes 1-250HP General Purpose motors, 1/3-3 HP 56C Frame motors, 1/3-30 HP Stainless Steel motors, 1-300 HP Explosion Proof motors and 3-100 HP Design D motors.

For more info www.toolmex.com 800-992-4766

Uptime + MRO-Zone.com = Reliability Solutions

New! Uptime® Magazine has teamed with MRO-Zone.com to make it even easier to find the products, software, training and services you want.

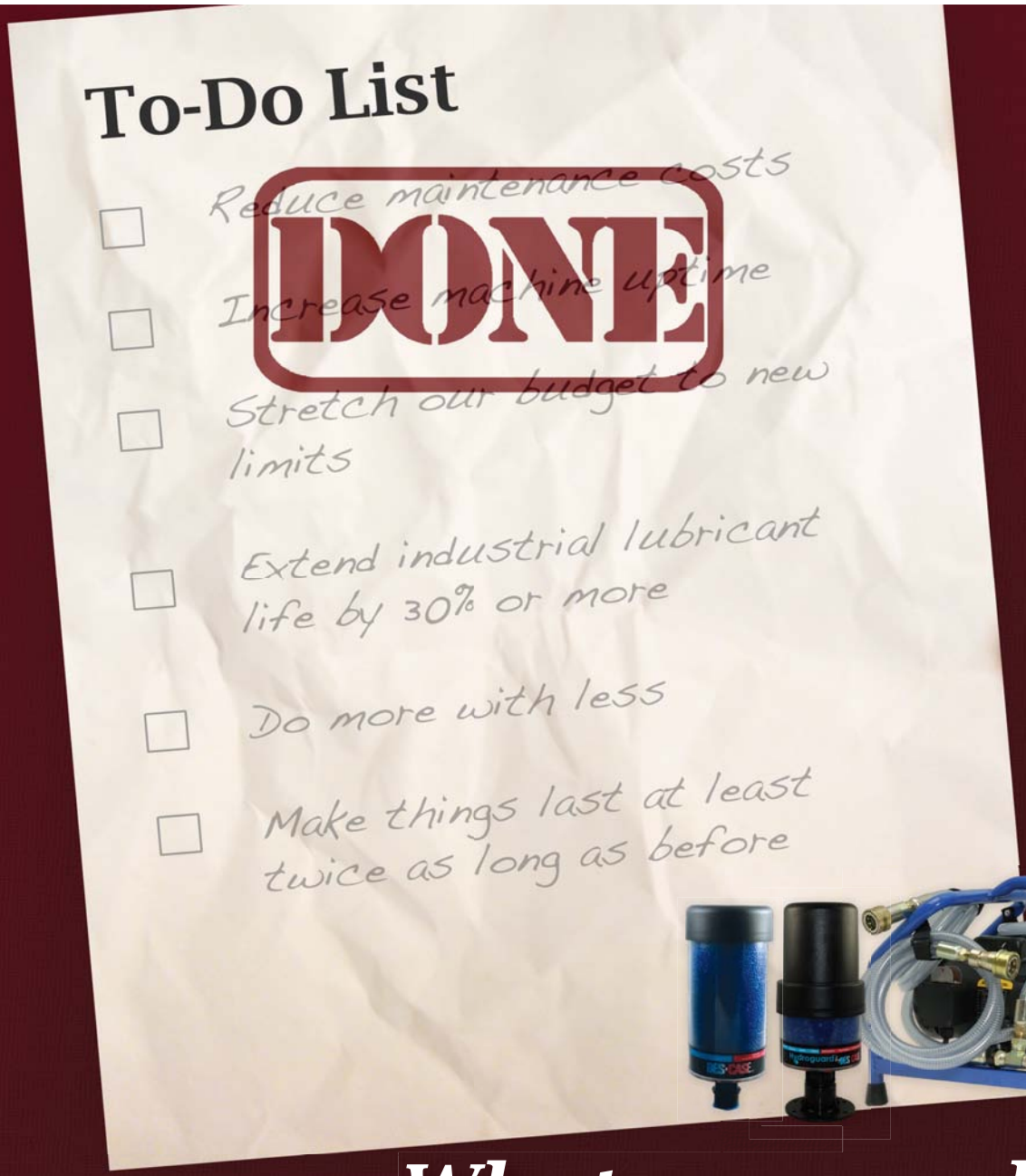
Simply visit

http://shopper.mro-zone.com

to request information about all the great strategies, techniques and technologies featured in each issue of Uptime Magazine.

You can also find a comprehensive maintenance and reliability community calendar of conferences, training courses, workshop and seminars aswell.

It's the newest and easiest way to find what exactly you need. Try It Today!



What you need to get reliability done.

DES-CASE®
CORPORATION

(615) 672-8800

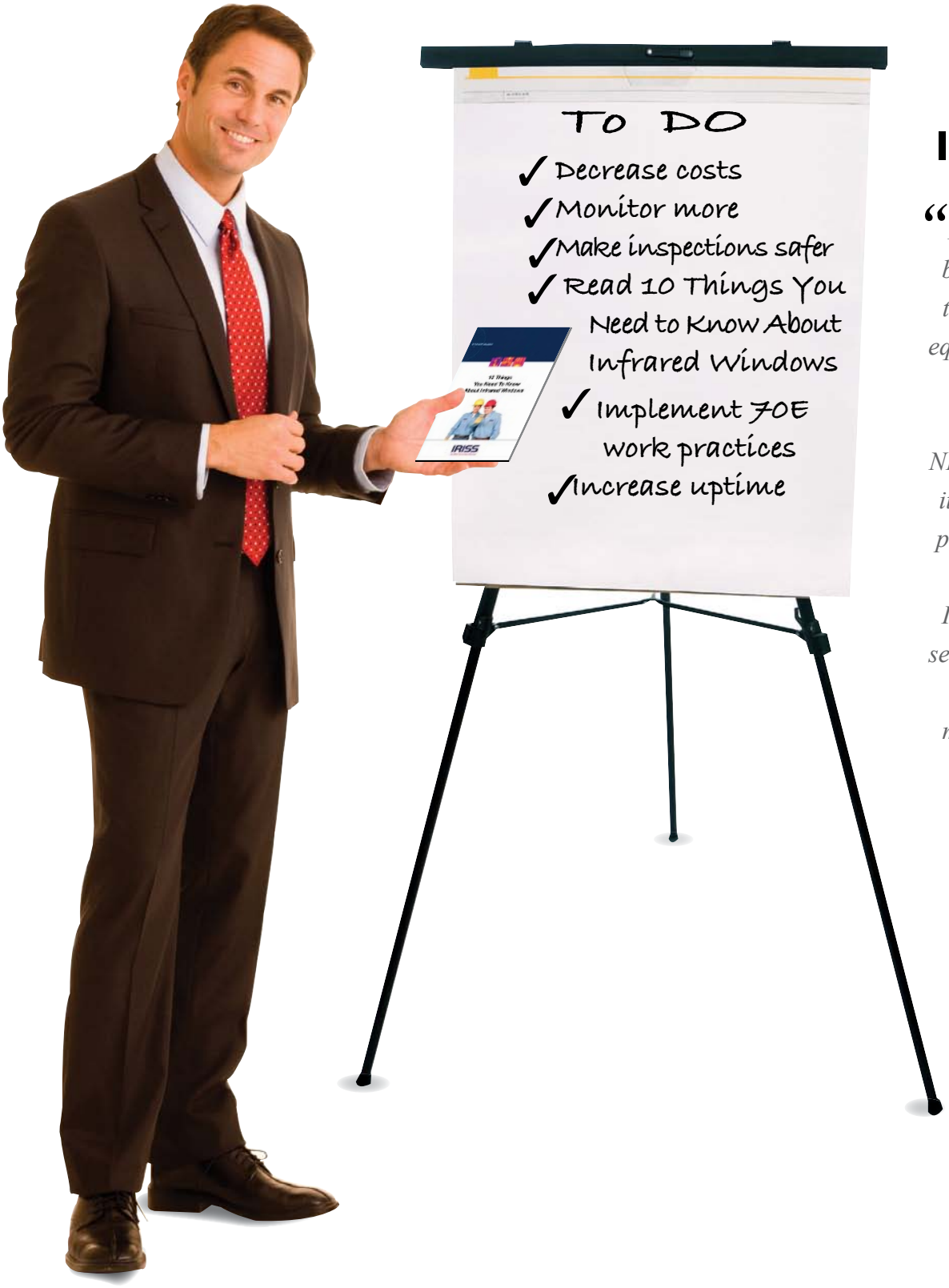
done@descase.com

www.descase.com

You have more on your to-do list than ever … and probably have less to do it with. Des-Case products get it done – without a big investment.

Our breathers and fluid handling products will help you stretch your budget, lengthen the life of your oil, and protect your equipment.

Want to see for yourself? To get started with a free breather, visit www.descase.com/done.



IRISS Industrial Grade Infrared Windows

"I was asked to do more, with less budget dollars. My solution is one that will allow us to monitor more equipment, even equipment we could never inspect previously. The inspections will be safer, make NFPA70E compliance easier, and do it all while driving efficiencies into programs and reducing costs to the point where the IRISS Infrared Inspection Windows pay for themselves almost instantly. I am actually saving budget dollars while monitoring more equipment, more efficiently, and more accurately than ever before!
In short, doing more with less."

Call **IRISS**
+1 941-907-9128
US 877-404-7477

Save time, save money, stay safe with IRISS!

www.iriss.com

Visit our website to get your copy of the "10 Things You Need to Know About Infrared Windows" www.iriss.com/10Things-IRwindows

IRISS®
See What You've Been Missing!