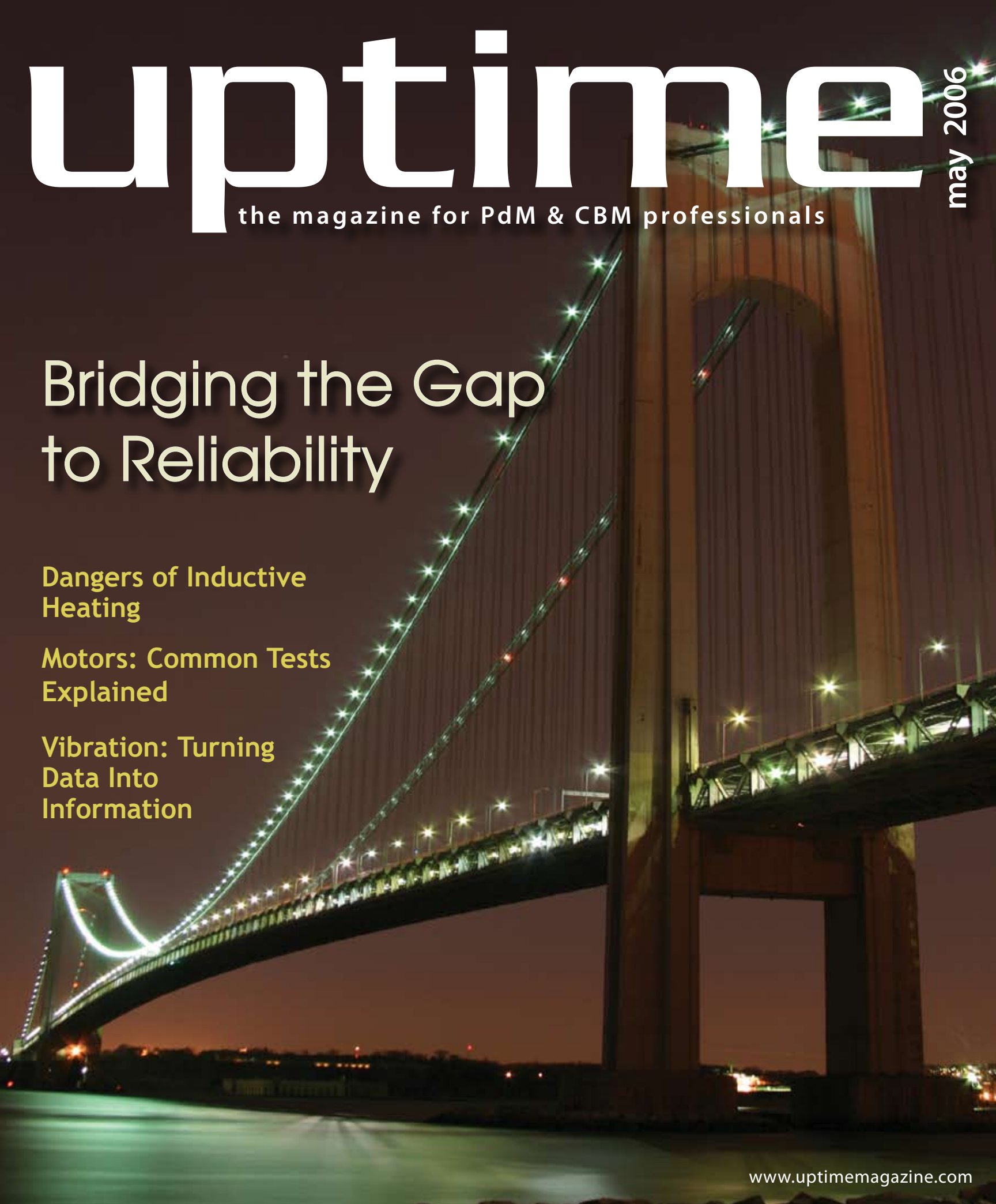
uptime

the magazine for PdM & CBM professionals

may 2006



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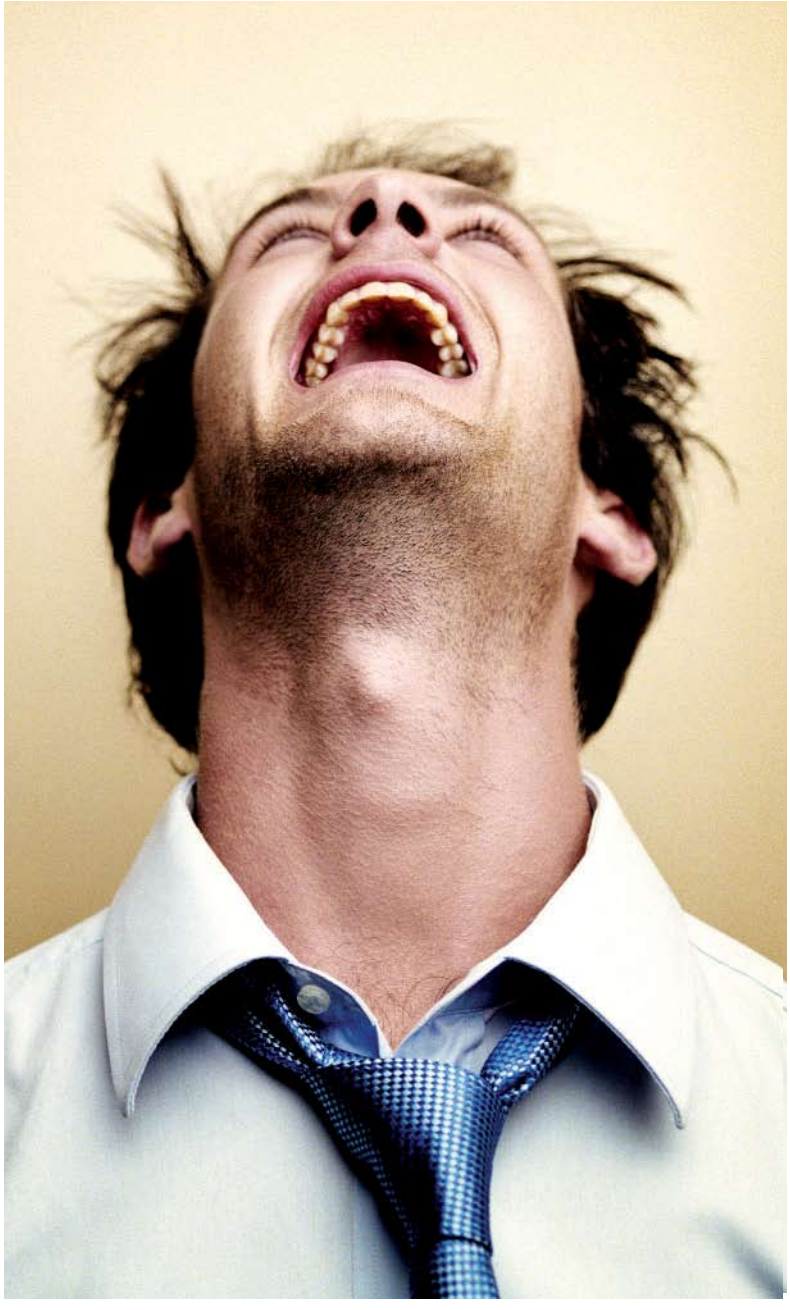

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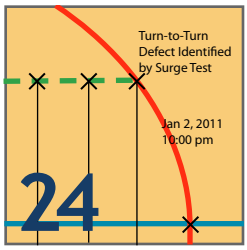

Stepping PdM Up

Predictive maintenance (PdM) is important. In order for companies to maximize their efficiency, and their competitiveness in the marketplace, they need a healthy predictive maintenance program. Studies have shown that somewhere north of 50% of all maintenance activities should be driven by predictive technology or condition based monitoring. Achieving this pulls a company out of the reactive - putting out fires - mode, and into the proactive mode of maintenance. Proactive-type maintenance activities cost somewhere around one third the cost of reactive maintenance activities. You can see that a high-quality PdM program truly makes its company stronger, more efficient and increases its bottom line.

We think it is high time that PdM professionals get more recognition - both inside and outside the maintenance world - for their significant contributions to the success of their companies. That is exactly why we created the Uptime PdM Program of the Year Awards. I urge you to take a look at the Publisher's Special Feature (pages 12-14) highlighting the awards.

I want to emphasize that this is not a commercial venture. There is no cost to enter and there are no other strings attached. This is simply our way of recognizing the PdM profession as a whole, and the individuals who dedicate themselves everyday to making their equipment more reliable so their companies can be more successful.

I hope you will enter your program in the PdM Program of the Year awards. If you win, you will receive two complimentary passes to PdM-2006 conference in September, you'll know that your program is at the top of the PdM field and you'll have a handsome trophy to prove it.

Even If you don't win an award this year, you'll still benefit from the experience. You will see how your program stacks up, and, perhaps, it will give you a goal to shoot for next year.

In either case, you will have made a significant contribution to the PdM world just by entering. It is our hope that this award program will increase recognition of the entire maintenance universe. Let's take PdM to the next level, and, together, make this great profession even better.

Thank you for reading. We appreciate your support and hope you find something of value within these pages. If you have any questions, comments or ideas that would make Uptime more useful for you, please let us know.

All the best,

Jeff Shuler
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Introducing the Reliability Roadmap™ - a new series of free web workshops hosted by Uptime® Magazine and Reliability-web.com™. The Reliability Roadmap goes beyond the typical "webinar", taking participants on a learning expedition. The destination: Understanding the value of a holistic and integrated approach to maintenance programs. Your journey will include six web workshops in 2006- one every other month - with industry leading professionals However, your experience goes far beyond those six days. In addition to the actual workshop, attendees will have access to audio "PodCasts", white papers, case studies, and many more resources that will allow them to have a deeper learning experience.

Each workshop will feature two presentations - one covering management aspects and one covering technical aspects. Each presentation will be followed by a Q & A session, and you can choose to continue the discussion with other participants via the web for days, weeks or months. Our goal is to create a community of shared knowledge that will lead maintenance & reliability professionals to a better understanding of reliability principles.

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Spanning the

Many companies have recently implemented Reliability initiatives geared toward optimizing the maintenance function at their plants. Some are very successful. However, most will admit they did not realize the expected benefits. While there are many approaches to successfully implementing a Reliability program, I will discuss a proven model for improving a company's Reliability-based maintenance program through maintenance task optimization focused on failure elimination.

Let's begin by assuming we are dealing with a large plant with many programs already implemented as they attempt to move toward Reliability-based maintenance. A CMMS is utilized to manage the operation; a large inspection-based preventive maintenance (PM) program has been built; and a relatively large predictive maintenance (PdM) program is in place to monitor asset condition. Many of the pieces of the Reliability puzzle exist but improved cost and Reliability results have not been realized because integration of the separate systems has not been considered, leaving each system sub-optimized.

Space Between

Applying the Correct Maintenance Strategies to Your Assets & Intergrating PdM Programs Improves Reliability

by Timothy White

Often programs like those listed above are viewed by organizations as "stand alone" programs. Yet if there is a concerted effort to refine and integrate all the programs already in place, we will typically see increases in Overall Equipment Effectiveness (OEE) with a significant reduction in maintenance spend.

The Starting Point

Success is typically measured by the improvement to the company's bottom line. To achieve the financial success of any project the key cost drivers addressed by the project have to be understood. For example, a plant may measure types of work (preventive, predictive, failure and modifications), labor and materials.

Let us assume we are looking at a plant where about 15% of the work is predictive, 35% is preventive, 25% is unexpected failure, and approximately 15% of the PM tasks are delinquent each month. In addition, the organization may have a gross overlap between preventive and predictive maintenance activities. Overlap costs money and overlap occurs for a specific reason. It is important to understand the reason before developing a maintenance strategy.

Plants can spend many years building PM programs and they are encouraged to do so because they are rewarded for reduced failure when a PM process is implemented. Over time, these PM systems will grow to include inspections for all manner of failures. There can be a

negative experience related to a failure requiring the addition of a PM. The frequency will be set and the PM applied to every piece of equipment that is similar to the one that failed. The consequences or the nature of the failure are usually ignored because they have no bearing on meetings with superiors explaining the failure. The machine failed, the boss is unhappy, and PM makes the boss less unhappy. Over time, the number of PMs increase to the point that many aren't being completed; even with an extensive PM program there are still failures that can't be eliminated.

A plant would begin a PdM program by monitoring a few pieces of highly critical equipment with vibration analysis (where there usually is some success). Of course, success is a positive reward and to increase that success the program would grow. If the organization has a lot of support corporately for implementation of PdM they would typically apply the technology to 50% of their known assets and use all available technologies. To determine how many assets to monitor, the plant should determine how many technologists it can support and then buy the equipment needed to perform the work.

In neither case, PM nor PdM implementation, were the failure modes, effects or consequences of failure evaluated to determine the cost effectiveness or even the feasibility of the maintenance task to truly predict or eliminate failures.

As an example, a plant may use a predictive technology to monitor bearings, but frequently send a mechanic to tear down an asset and inspect the same bearings. The ridiculousness of this may seem fundamental. However, it is common in industry. Because of this, we must first discuss the methodology before describing the implementation steps.

The principles used to correct such inefficiencies are:

- All maintenance tasks must address a specific failure mode
- Use the least expensive and most effective task to maintain the asset
- The maintenance task interval will be such that it addresses the failure at the optimal point in that asset's failure cycle
- The total cost of the failure must exceed the cost of the tasks to maintain the asset
- PM should ultimately be a time-based refurbishment, not an inspection
- Failures created by operating an asset outside of capability cannot be maintained. The asset must be redesigned.

To illustrate this approach let's take a quick look at the P-F Curve shown in Figure 1. John Moubray uses the P-F curve in his book, RCM II, to demonstrate the timeliness and effectiveness of PdM tasks. Points have been placed along the curve to represent a period of time (P-F) from defect detection point P to functional failure point F. Logic tells us that the longer the warning period, the easier it is to support the planning and scheduling effort necessary for an efficient, Reliability-based maintenance organization. What we can readily see by studying this curve is that PdM tasks have the ability to identify failure-creating conditions at a longer P-F interval than PM tasks. In addition, the PdM task may be more suited to identifying the failure mode.

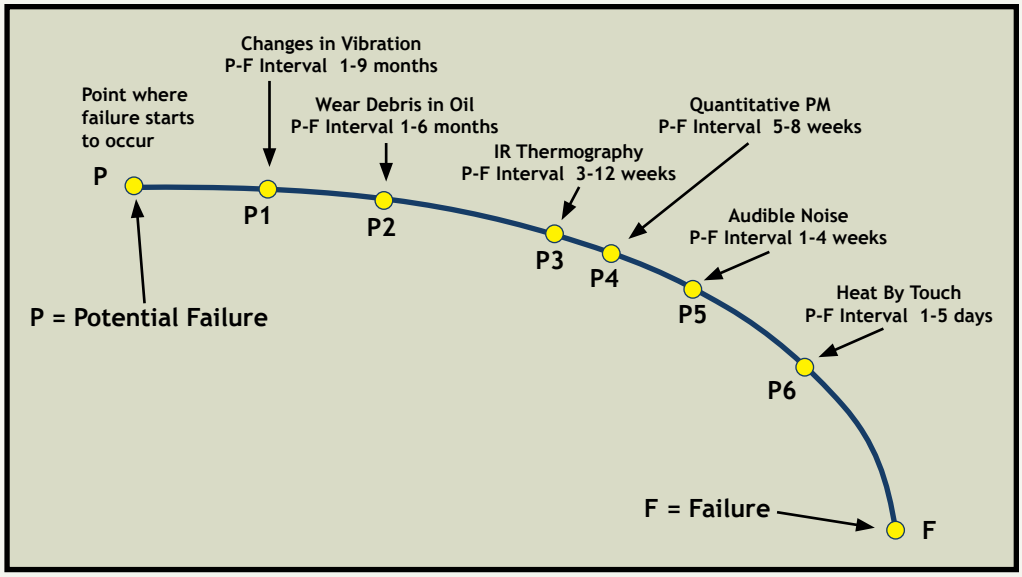

Figure 1 - The Potential Failure to Failure (P-F) Curve (John Moubray: Reliability Centered Maintenance II)

Further analysis of the labor required to perform the work shows us that from a financial standpoint, PdM tasks, on average, are a quarter of the cost of a PM task used to detect the same failure mode. In addition, PM is proven to introduce failure that otherwise would not happen. This early failure is often referred to as infant mortality.

An additional, and often the greatest financial impact is production downtime. PdM tasks are usually performed while the equipment is running and the corrective work identified by the PdM technology is scheduled concurrently with other high value corrective tasks. PM inspections normally require the equipment to be shut down.

As you can see, the most economical decision, and the one that makes the most technical sense, is to maintain the asset by using the following resources, in order, as they apply: Process Monitoring, PdM Technologies, Time/Meter based directed tasks (PM).

Aligning Maintenance Tasks to Failures

Failures can be grouped into the following three categories. Understanding these categories is critical when assigning maintenance tasks.

1. Induced
2. Intermittent
3. Wear Out

Induced failures are a result of an outside force causing the failure mode. For instance, a plant may run the production process in such a way that the assets are prematurely forced into a potential failure situation, or a soft foot condition on an equipment train causing coupling misalignment eventually leads to an inboard bearing failure. While Process and PdM Monitoring may help detect these potential failures (thereby eliminating an unscheduled stoppage), it is important to understand that induced failure must be recognized and analysis performed to determine the root cause. Only then are we acting proactively and making the transition into a Reliability-based maintenance organization.

Intermittent failures can happen at any time. Some may actually use the term "random". However, the implication is that the Mean Time Between Failure (MTBF) cannot be determined. These differ from induced failure because they typically happen far enough up the P-F curve that the repair can be effectively planned and scheduled. A plant can best detect these failure modes through Process and PdM Monitoring when possible.

Many plants also find that PMs are not effective in determining the onset of failure in either induced or intermittent failures and therefore a waste of capital. Too often a plant may then choose to increase PM frequencies, or worse, write and schedule new procedures to attempt to mitigate these failures. This reaction is what ultimately leads to an ineffective, costly and out-of-control maintenance program.

Wear Out failures have a known MTBF and they occur when the useful life of a component is expended. These types of failure modes are often detectable through Process and PdM Monitoring. However, time-based refurbishment usually proves to be the most effective maintenance strategy.

The Definition of PM

A PM, by definition, is a repair/replace activity that will restore the functionality or useful life of an asset back to its original state. Other types of PM are Failure Finding or Condition Evaluation tasks. A plant would deploy a Failure Finding task when the consequences of failure or the risks associated with the failure are tolerable; these tasks are also helpful in finding hidden failures. One method of Failure Finding is to test-run standby plant equipment on some frequency to ensure it hasn't failed while sitting idle.

Condition Evaluation tasks are performed to determine a component's failure rate. When organizations choose to perform Condition Evaluation tasks, it is with the understanding that condition evaluation is used to try to determine the MTBF. Correctly applied, it should be quantitative in nature. In other words, a precision measurement is taken and compared to established criteria that define when replacement is necessary. There are two principle reasons a plant would establish quantitative measures.

1. Craft skill differences are minimized
2. Wear rate trending. Where possible, warning or alert levels (yellow condition) and critical or action levels (red condition) should be defined

The Implementation

A thorough understanding of potential failures of each piece of equipment can be developed through Failure Modes and Effects Analysis (FMEA) to each equipment type in the plant. FMEA templates can be developed at a class/subclass/qualifier level (i.e. Pump/Centrifugal/Coupled or Pump/Centrifugal/Belt Driven). Significant time savings can be realized by developing templates. With each equipment type, a plant should be able to answer the seven basic RCM questions.

1. What is its function?
2. What are the functional failures?
3. What are the failure modes?
4. What are the effects of those failures?

5. What are the consequences?
6. How can the failure be mitigated?
7. What if a suitable task cannot be found?

When answering question 6, consider a logical path to utilize the three resources, Process Monitoring, PdM Monitoring, and PM, in that order, as previously described.

Once the FMEAs are completed, they can be applied at the asset level. This more granular review ties in the Criticality Ranking Criteria to determine if the consequences of failure are great enough to perform the task. This is really an economic decision rule, "Is the cost of failure greater than the cost to mitigate?" This is extremely important to note since the goal of these programs is to reduce the cost of maintenance while maintaining high asset utilization.

Now a plant can define and communicate process parameters and rebuild and implement PdM routes. For example, a plant may employ: slow and high-speed vibration monitoring, electrical and mechanical thermography, motor circuit analysis, oil analysis and NDT thickness testing. Existing PM tasks that cover the same failure modes that are now being defined with the PdM tasks can then be removed from the system.

If a plant determines that a PM is the most effective way to mitigate failure, the worn component is replaced. For example, if a screw conveyor is shut down for a PM that addresses hanger bearings, the bearings would be replaced rather than inspected to determine if replacement is needed. This approach is often taken because the cost to shut down the line and the labor required to tear down the equipment for inspection is greater than the cost of a few hanger bearings. Once repairs are completed, the removed bearings could be inspected "at the bench" to help further define the MTBF and thereby "tweak" the task frequencies if warranted. This eliminates almost all condition evaluation type tasks.

PM frequency is determined by work order history and craft knowledge. If there is a

question about the MTBF, any given plant will choose the longer duration to set the PM frequency. Why should they choose the longer duration for failure rate? One might think this will cause some failure, but think of it this way: if every PM is entered conservatively and performed at a short and safe interval, it will take a long time to know if we right-sized the PM system. If each PM is set at an interval that, to the best of our knowledge is the true interval, there will be a few mistakes made but this will be evident relatively quickly. This may be an enormous leap for some plants. However, in order to make great strides in most Reliability efforts, this will prove to be the correct method. If some frequencies are missed, they will be able to temporarily accept failure and improve over time. Success will hinge upon whether the frequencies appear to have been set appropriately and if unexpected failure does not increase.

The Results

This approach typically results in the following:

- During the initial stages, maintenance costs will drop, and will continue to do so
- Total maintenance staffing will decrease significantly compared with pre-project levels and will continue to decrease (this is usually realized through the elimination of contractors)
- Significant return on the project investment (i.e. the first three months' performance paid back over half of the total project costs)
- Large shutdowns will be possible to enable the installation of new capital equipment while the Overall Equipment Effectiveness for the facility does not decline
- Equipment is taken out of service far less frequently due to PMs
- The number of predictive technologists increases as does the percentage of condition monitored assets. Because of the depth of the condition monitoring coverage, continued monitoring ensures that the Reliability of the plant is not compromised because of the project.

Many plants and managers identify tools and systems that claim to remedy the Reliability ills of a facility. Implemented independently the tools and systems are just added modules that increase costs without increasing plant Reliability. True Reliability is achieved when the most cost effective methods are applied to the assets in the plant, thereby maximizing the maintenance effort with the minimum total cost to the business. "Economy of Force" is a military term used to describe the technique of using only the force necessary to defeat the enemy. In the Reliability world, the enemy is downtime, labor, rework, and materials costs. To compete globally we must use the "Economy of Force" principle to ensure our plants run reliably at maximum output for minimum total costs. An integrated maintenance and Reliability strategy is a key part of accomplishing this objective.

Timothy White is the Services Delivery Manager for Management Resources Group, Inc. Tim has worked on Reliability initiatives worldwide for MRG and currently resides wherever in the world his work takes him. He is also an avid watercraft enthusiast and is happy to address your questions (boat-related or otherwise) at whitet@mrginc.net.

get proactive

Make the shift...

Your organization wants to stop putting out fires. You want your guys to take charge before things become costly. Making the shift from reactive to proactive is not straight forward but it needs to start somewhere. So why not start with the basics...Asset Basic Care?

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The Power of PdM

The Predictive Maintenance Program of the Year Awards

by Terrence O'Hanlon, CMRP

Are you looking for a way to energize your maintenance team? Do you want to improve your organizations' reliability? Are you interested in a no cost way to get an outside perspective on your Predictive Maintenance programs strengths as well as the opportunities for improvement? Do you want to generate a substantial Return on Investment (ROI) from your maintenance program?

Enter Uptime Magazine's PdM Program of the Year Competition to see how your program stacks up to dozens of other winning programs.

When Jeff Shuler and I made the decision to publish Uptime Magazine, we noticed that most industry magazines did not provide consistent focus on Predictive Maintenance (PdM) and Machinery Condition Monitoring. The people, technologies, techniques and software involved in a predictive maintenance program provide some of the best results of any maintenance activity; yet, many companies are still struggling with their condition monitoring programs. We want to change that. And we want to increase awareness among non-maintenance personnel of the benefits that PdM activities provide.

We strongly believe in PdM/CBM. We believe it has the power to transform... not only the maintenance department, but the entire company.

One way we can raise the visibility of the importance of Predictive Maintenance was by creating the PdM Program of the Year Awards.

Simply applying for the PdM Program of the Year will make you a winner because it will help elevate the status of PdM professionals just like yourself worldwide.

When implemented correctly, PdM/CBM can provide one of the highest returns on investment that a company will ever achieve. Why don't more people know this?

Entering the PdM Program of the Year Awards is a pretty simple process. We want to get enough information about your programs to judge them fairly, but also want to keep it short enough so it is not too burdensome to enter.

Here is how the PdM Program of the Year works:

1) Visit www.uptimemagazine.com and look for the PdM Award icon to download an application and a list of frequently asked questions.

2) The entry form is prepared with much of the criteria the panel of independent judges will be considering when selecting winners. However there is also an option to simply write an essay type story about why you think your program is a winner.

3) There is no cost to enter.

4) Uptime Magazine does not request or require any confidential information.

5) E-mail or fax the entry form by June 1.

6) Winners will be selected and notified between July 7 and July 15.

7) Awards will be presented at PdM-2006 on Sept 13, 2006 in Chattanooga, Tennessee.

8) Winners receive free passes to PdM-2006 The Predictive Maintenance Technology Conference.

There will be one award for Best Overall PdM Program as well as winning programs for each individual technology area including:

- Vibration Analysis
- Infrared Thermal Imaging
- Airborne Ultrasonics
- Motor Testing
- Oil Analysis/Lubrication
- Precision Maintenance (alignment and balancing)

Your PdM Award entry will be judged by several of Uptime Magazine's Editorial advisory board members depending upon the technology entered.

Information is requested in 10 areas. The questions are straightforward and include:

1) Your strategy for determining your PdM activities (i.e. RCM, Criticality rating, past experience etc…)

2) What percentage of important/critical equipment is monitored?

3) Are PdM Team Members certified?

4) Is ongoing training and skills development included?

5) Is Root Cause Analysis used?

6) How does the PdM information interact with the CMMS/EAM?

7) Are PdM program accomplishments communicated to management and other employees?

8) Has reliability/availability improved since PdM began in your plant?

9) What chronic problems did PdM eliminate?

10) How do you measure PdM effectiveness

No confidential information is requested or required.

If your program is selected as a winner – you will be notified in Mid July and invitations to the PdM Program of the Year Awards Banquet and the PdM Program of the Year Award presentations at PdM-2006 will be made.

The people responsible for PdM/CBM activities deserve to be seen as major contributors to the success of the organization.

Winning programs receive:

- Free Passes to PdM-2006 – The Predictive Maintenance Technology Conference
- Invitation to the PdM Award Banquet
- Public Recognition at Award Presentation
- Recognition and Team Photo in Uptime Magazine
- Handsome Award Trophy
- Peer Recognition
- $100 Donation in your name to Operation Uplink that provides calling cards to service members stationed overseas

All entrants will receive:

- Feedback on the current PdM program including strengths and opportunities
- Uptime Hat for each team member
- PdM-2006 Conference Proceedings CD

What are you waiting for? If you will not blow your own horn about your Predictive or Precision Maintenance program – who will?

Help us elevate the status and adoption of Predictive Maintenance by entering the PdM Program of the Year Award today!

PdM Program of the Year

PdM Award Details - www.uptimemagazine.com

PdM-2006 Details - www.maintenanceconference.com

Magnetism Not Always Positive

Unwanted Inductive Heating A Serious Negative

by David Sirmans

Let's face it, magnetism is pretty cool. If you're from the same generation as I am, your dad probably showed you how a magnet will bend the picture on an old black and white television picture tube. No? Maybe it only happened to us science geek kids. At any rate, after being shown that particular demonstration by my dad on an old black and white he kept in the garage, I tried to replicate it on his brand new Sylvania Super Set. It was a color model. Some ten or so years later, that TV still had a pink spot right in the middle of the picture, which greatly diminished the excitement associated with watching most anything. My dad complains about that incident to this day.

There are a myriad of everyday, positive uses of magnets, like holding an especially good report card on the fridge or retrieving dropped washers and nuts. However, in addition to my aforementioned tale of woe, there are also negative effects of the phenomenon of magnetism. Who among us has had the misfortune of exposing a credit card or ATM card to that device at most point-of-sale counters that is clearly labeled "Don't put your credit card here."? I distinctly remember one time during a service call, I stood next to a 125KVA transformer for about 5 hours. Of course, the magnetic card to my hotel room was in my trousers pocket. That evening I tried my room key 112 times in an attempt to avoid walking the 200 yards from my room to the front desk. And I still had to make the trek.

The dynamic transducer (which makes a microphone function), relays, electric motors and transformers all function due to magnetic energy. Those of us familiar with electricity know that electro-magnetic fields, or EMF's, exist around electrical conductors. Ampere's Law states that the magnetic field in space around a current carrying conductor is proportional to the electric current which serves as its source, just as the electric field in space is proportional to its source. Basically, the higher the amount of current through a wire, the greater the magnitude of the EMF surrounding it. The application of this law as it applies to industrial maintenance may not be clear at first, so I will refer you to Figure 1.

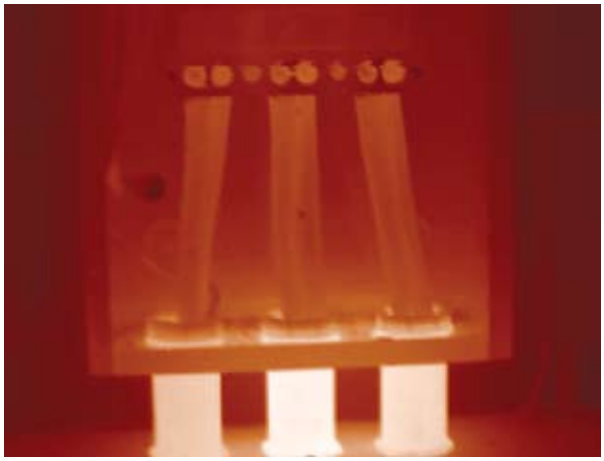

Figure 1 - Hot Conduit, Cool Connections

The thermographic image in Figure 1 was taken during our company's inspection of an industrial facility belonging to one of our larger customers. In this example, the phase conductors feeding a three phase distribution panel were routed in EMT conduit from the main distribution panel. However, rather than routing the three phases together, twisted together, in one piece of conduit, the wires were routed separately from each another, in individual runs. The result was three different pieces of conduit, each with several leads of each individual phase. Phase "A" wires all in one run of conduit, Phase "B" wires in another, and Phase "C" in yet another. Notice that the only "hot" items in the image are the runs of conduit themselves, not the mechanical connection between wire and lug, that we typically see.

Scratching your head? Magnetic lines of flux. The magnetic field surrounding the individual phase conductors are to blame. OK, quick review. Many years ago, there were a couple of guys who experimented with electricity, magnetism and few other things named Faraday and Ampere. Don't ask me their first names, that data was cleared from my mind long ago. But I have managed to retain the basics of the laws named for them.

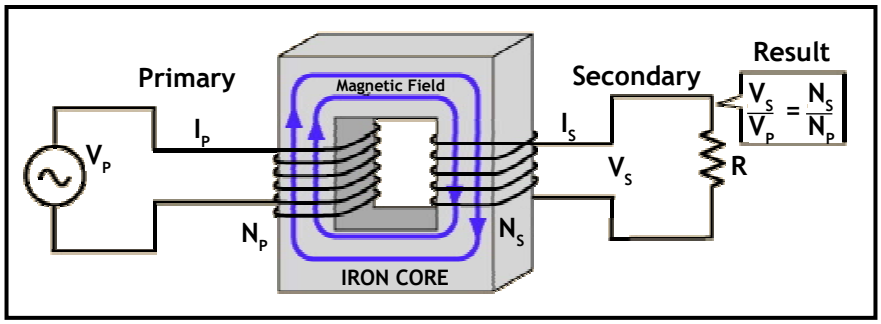

Figure 2 - Faraday, from Flashlight to Power Transformer

Faraday's Law states that any change in the magnetic environment of a coil of wire will induce a voltage on that coil. Mr. Faraday's name has more recently been attached to the $9.95 flashlight you can order from TV that lights when you shake it. Basically when you shake the light, a magnet moves back and forth through the center of a coil of wire, inducing voltage that is stored, then released to the bulb. Like you hadn't figured that out, right? Pretty simple. The same principle that makes this remarkably affordable item (which never requires batteries by the way) function is also responsible for the operation of a not-so-simple item, the power transformer. Figure 2 is a pretty nice image of this concept.

As mentioned earlier, Ampere's Law states that the magnetic field in space around an electric current is proportional to the electrical current that serves as its source. Simplified - which is how I prefer my physical laws - the higher the amount of current, the greater the size of the magnetic field surrounding it. Magnetic lines of flux emanate in a perpendicular fashion around a phase conductor. If they were routed together, these lines of flux would normally be cancelled out by the opposing lines of flux generated in the other two phases of electric power. In three phase power distribution, as some of you know, each phase is 120 degrees out of phase from the next. Phase A leads Phase B by 120 degrees, and B leads C by the same amount. This phase shift causes the EMF generated by the three phases to cancel one another out, assuming a relatively small differential in current from one phase to the next.

Maybe you have heard of the right hand rule? Do your best Fonzie imitation with your right hand. Your thumb represents the direction of current flow in a conductor, your fingers represent the direction the magnetic field rotates around the conductor. See Figure 3.

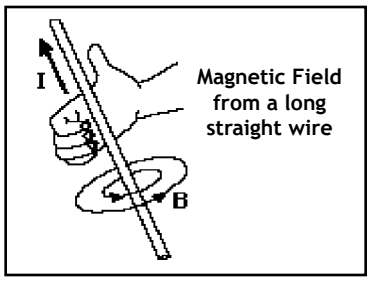

Figure 3 - Fonzie and Faraday, fun with magnetic fields

The magnetic lines of flux generated in the circuit in the thermographic image in Figure 1 are resonating through the conductive material from which the conduit is made. In much the same way that the macaroni and cheese or leftover slice of pizza you warm up in the breakroom is heated by microwave frequency RF waves resonating through the water molecules in them, the magnetic lines of flux resonate through the conduit. This resonation can heat it to a temperature sufficient to ignite a material of a relatively low flash point, such as dust or lint. Did I mention that one of the by-products of the manufacturing process at the aforementioned customer site is lint? The situation documented in the thermal image in Figure 1 was dangerous, possibly extremely so.

Another example is shown in Figure 4. The bracket holding these cables is showing a surface temperature close to 200 degrees Fahrenheit. This raises a few concerns. The insulation rating of the cable is not known, but could very well be below 200 degrees. If it begins to breakdown due to temperature, we could have a serious fault. Additionally, annealing of some metals can occur at temperatures as low as 200° over a moderate amount of time. If the bracket fails structurally, tension would be placed on the crimped connections, leading to higher resistance and ultimately, to failure.

Both the conduit in the first thermal image and the bracket in the second images were obviously made of ferrous metal. A ferrous metal is any metal that has Iron as one of its components. Due to the properties of ferrous metals, they are subject to heating when exposed to magnetic flux. Inductive heating has a number of uses within industry. I've even seen applications in cook top surfaces. When inductive heating is used, it is incredibly efficient, and has a very fast ramp up time. This efficiency can create serious problems when unwanted inductive heating takes place. The examples shown here are instances when we'd rather not have heating, so we need to take steps to avoid it.

The National Electric Code is very specific about the number of phase conductors allowed in conduit of a certain inside diameter. It also specifies the size wire required for circuits of a certain current rating. The reason for these specifications is to reduce the chance of electrical fire, since heat is one of the natural by-products of current flow. The problem is that NEC code standards are not always followed when adding equipment to an existing electrical service. The end result of this flawed practice could be a situation like the one illustrated here. If enough dust or lint had accumulated between the pieces of pipe feeding out of the above panel, the heat of the pipe could have ignited it. The worst part of that potential tragedy is that it would have been completely preventable.

Figure 4 - Brackets approaching 200°F - hot enough to ignite materials with a low flash point.

During your next Infrared scan, give some consideration to the possibility that this condition could exist in your facility. Take the extra few moments to scan outside and around the circuit breaker panels and control enclosures. Our thermographers routinely pan their trusty Mikron 7515's all over the electrical room or manufacturing space where they are performing electrical IR inspections. This practice is what yielded the image in Figure 4, and has also resulted in the discovery of potentially dangerous thermal issues within other systems that weren't part of our original inspection.

Diligence, attention to detail and working outside our comfort zone is what separates success from failure. Beware of the little known, often overlooked phenomenon of magnetic heating. The catastrophe you avoid could be much worse than a little pink spot on a TV screen.

This article was originally delivered as a presentation at ThermalSolutions, one of the premier learning events in the world for infrared thermographers. For more info on the conference go to www.thermalsolutions.org

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Keep Your Fluids Flowing

Next Generation Fluid Monitoring

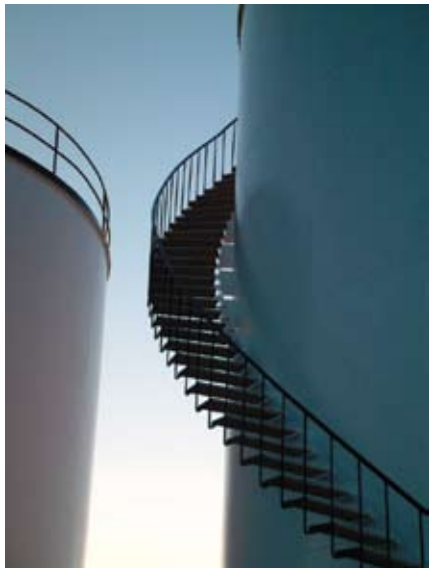
by John Malone

Reducing costs and increasing profits are always top performance objectives for businesses of all sizes. In today's highly dynamic, competitive marketplace, the search for tools to achieve these goals is even more intense. There is now a significant new capability that has direct impact on the bottom line for users of bulk lubricants: online fluid monitoring systems.

Online fluid monitoring is an innovative partnering of sophisticated technologies that delivers new business value and helps avoid costly risks. This article describes the vital components of an effective online fluid monitoring system and how these systems benefit industrial plants, companies with commercial transportation fleets, and other users of bulk lubricants.

Advances in Fluid Monitoring

While fluid monitoring technology has developed rapidly in recent years, the type and sophistication of fluid monitoring in use today varies widely across industries. Some users of bulk chemicals, fuels, and other fluids rely on advanced systems with automated data gathering and transmission. At the other extreme, some tank farms still rely on "sticking the tanks." As many as 95 percent of large industrial facilities have gauges and monitors on their tanks, but rely on a human being to read each one.



For users of bulk lubricants, advances in online fluid monitoring have resulted in innovative new systems that save time and costs. Chevron's EyeTank™, for example, is designed to efficiently and reliably maintain bulk lubricants at optimum levels.

By combining proven technologies from companies including Level Devil, FuelQuest, and SMARTLogix, this new approach to fluid monitoring safeguards lubricants and equipment, prevents costly mishaps, and benefits users' bottom lines.

Vital Functions and Benefits of Online Fluid Monitoring

To take advantage of the new online fluid monitoring capabilities, users need only a standard browser and an Internet connection. Sensors and monitors collect data at each tank at pre-determined intervals and transmit the data to a central location—where it is analyzed and placed in the user's confidential folder on an interactive web portal.

By checking their web portal periodically, users retain an accurate view of lubricant stock levels. They can schedule replenishment before run-out, eliminating the costs and stress associated with emergency orders and emergency deliveries. As needed, alerts can be designed to draw attention to unusual events such as sudden, unexpected changes in inventory levels.

The overall results of an online fluid monitoring system designed for lubricants include a reduction in the time and labor required to check tank levels, optimization of inventory and lower carrying costs, simplification of the fulfillment process, and the ability to validate and track deliveries with absolute accuracy.

In selecting a fluid monitoring system for bulk lubricants, users should look for specialized functionality such as forecasting and the ability for simultaneous viewing of information for multiple tanks. Being able to segment the data, customize it for the unique needs of the user, and incorporate it into larger business processes are vital. In addition, sophisticated new systems can connect tank monitoring signals to dealer and supplier order fulfillment systems, creating automatic e-mail purchase order requests, distributor replenishment requests and total order fulfillment.

Facilities of almost any size can benefit from on-line fluid management.

Proactive: The Power of Forecasting

Planning, data transparency, and forecasting are already familiar business tools for large industrial plants, but until now, these have not been applied to their full potential for supplies of bulk lubricants.

In the past, industrial facilities could derive some business data about their lubricant inventories through their cost accounting systems. One hurdle was that to roll this data across multiple plants took time and required that every reported transaction have consistent coding. Beyond the basic problems with assembling and analyzing the data, there was another issue that undermined its potential value: it was all after the fact.

With the new online fluid monitoring capabilities, one person or a team of decision-makers can get rapid access to accumulated knowledge—and data on precisely what is happening right now—at each of dozens or even hundreds of sites, no matter how geographically spread or remote. This data can be viewed for separate tanks, or aggregated for the overall inventory. Much more than indicating a re-order point, the new online fluid monitoring systems provide accurate forecasting for advance planning. This is proactive, not reactive. The user can see trends, compare performance, and take action before inventory problems occur or broader business process are impacted.

Centralization and Cost Savings

Efficiency and centralization are key drivers in the cost savings offered by online fluid monitoring systems. For plants with hundreds of tanks in multiple locations, the requirement to read gauges manually or to physically stick each tank takes time and generates labor costs. Even with sophisticated sensors and gauges, it can take several hours to gather data at a large industrial facility. The comparative efficiency of automatic data collection is obvious.

A major efficiency benefit of online fluid monitoring is data centralization. Online fluid monitoring enables businesses to centralize the information related to inventory and forecasting, and put it into the hands of one or a few individuals to review and act upon. This central oversight of hundreds of storage sites and plant locations is dramatically more efficient than one-by-one local monitoring and individual phone or email reporting.

Centralized data gathering also provides a measure of control, which will be discussed in more detail in the next section. With one person authorized to observe and review fluid inventory data, the potential for local problems—which could result in costly losses or fines—is mitigated.

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On-line fluid management can provide a seamless supply and replenishment process.

Controls and Compliance

Spillovers are another example of risks that can be minimized with online fluid monitoring systems. Knowing the precise level of each tank at all times can help the tank operator avoid not only potential fines but also clean-up charges associated with a spillover. An online fluid monitoring system can pay for itself in a few months to a year, depending on fluid usage and company business model. However, such a system will pay for itself immediately if it prevents a spillover.

Another incentive for tighter controls is the potential for theft and fraud. For example, with high-end industrial and synthetic lubricants stored at widely distributed locations, field supervision may be minimal, and an online fluid monitoring system can be a vital tool to track volumes and usage. Unexpected usage when production is usually shut down, such as over a holiday, can be detected by an online system and communicated immediately to alert the appropriate business manager.

Valuable Collaboration with Suppliers

New online fluid monitoring systems combine data collection and automation and deliver forecasting that is fine-tuned to the user's business requirements. In addition, the forecasting data can be shared automatically with suppliers.

This close collaboration with suppliers can ensure a seamless supply and replenishment process on a regular basis. And, if a weather disaster or other emergency were to cause a supply disruption, the accurate forecasting provided by an online fluid monitoring system enables lubricant users and their suppliers to determine precise needs and arrange delivery accordingly.

John V. Malone, Reliability Solutions Manager, has worked with Chevron for the past 5 years. John received his MBA from Northeastern University and BS in Civil Engineering from the State University of New York at Buffalo. His experience also includes working in the US Coast Guard. He lives with his family in Houston, TX.

Start Making Sense

Understanding PdM Tests for Electric Motors

by Curt Lanham

Most electrical failures are caused by a combination of the voltage spikes that occur at start up and normal deterioration. The problem often begins as a turn-to-turn short that will eventually go to ground. Without high voltage testing many of these problems will go undetected. So it's important to know your tests. Let's take a look at the insulation resistance test, polarization index test, DC hipot test, and the surge test and outline the types of problems they can and cannot find.

Introduction

Before making a logical decision about what kinds of testing should be done on motors to predict electrical failures, you must understand what makes these failures occur. It is important to understand the different insulation groups, the aging process of the insulation, and review typical failure scenarios. Only then can decisions be made as to which tests should be included.

The Insulation Groups

The insulation system of a motor consists of the groundwall insulation, the phase-to-phase insulation and the turn-to-turn insulation. In a typical induction motor the groundwall insulation is the slot liner paper that protects the insulated copper to ground. The Phase-to-Phase is often a sheet of insulation paper that is laid between the phases. The weakest link in the insulation system is often the turn-to-turn insulation. This is the enamel on the copper of a random wound motor or the enamel and tape found on form coils. This insulation's purpose is to protect from copper to copper failures.

To properly test the total insulation system several different tests must be performed. The groundwall insulation can be tested with a megohmmeter to determine insulation resistance values, a polarization index test to evaluate the elasticity of the insulation, and a DC hipot to test the dielectric strength of the insulation to some predetermined level. The phase-to-phase insulation can also be tested with some of the same tests previously mentioned if the motor is completely disconnected. In most predictive maintenance scenarios this will not be the case and the phase-to-phase insulation must be tested in the same manner as the turn-to-turn insulation. Surge testing is the only available test of the turn-to-turn insulation.

The Insulation Aging Process

The insulation aging process can be affected by one or more of these five factors:

Contamination: A chemical deposit on the windings that causes deterioration of the insulation.

Mechanical: Vibration or movement within the windings or the motor which wears the insulation system.

Normal thermal aging: The slow deterioration of the insulation over the windings natural life through normal operation.

Early thermal aging: Excessive winding temperatures causing premature failure.

Overvoltage spikes: High Voltage surges caused by switching, lighting, and VFD designs.

All five of these should be considered when designing a test program. We will look at the normal thermal ag-

ing process and how it is effected by Mechanical, Early thermal aging, and the Overvoltage spikes. We will concentrate on the non-contamination related problems.

What Makes Motors Fail?

Depending on which study you refer to, electrical failures are responsible for somewhere between 35% to 40% of all motor failures. These same studies, some dating back to 1936, often show that many of these winding failures begin as turn-to-turn shorts caused by steep-fronted surges due to switching[2]. Beginning as early as 1960, measurements of these surges show spikes of .5 micro-seconds at up to 5 per unit.

Note: When discussing dielectric strength and voltage spikes in this article the measurement of "pu" will be used. One per unit (pu) is the peak line to ground voltage.

These steep-fronted surges are caused by a variety of sources. The most common and main cause of breakdown of the inter-turn insulation is switching surges[3]. These switching surges can occur both when opening and closing the contacts. Restriking will create multiple surges.

Studies show that these surges will range from 1 to 5 pu with rise times of .1 to 1 micro second. A 4160V motor will see surges of up to 17,000V.

In normal operation, a typical coil will only see 10 to 100V turn-to turn. Pashens law states that a difference of 350V is required to initiate an arc. (see Figure 1). With this small of a potential difference a motor should not fail due to turn-to-turn shorts from normal operation. It is the combination of weak insulation and the steep-front surges that accelerate the natural deterioration of insulation - eventually leading to the motor's electrical failures.

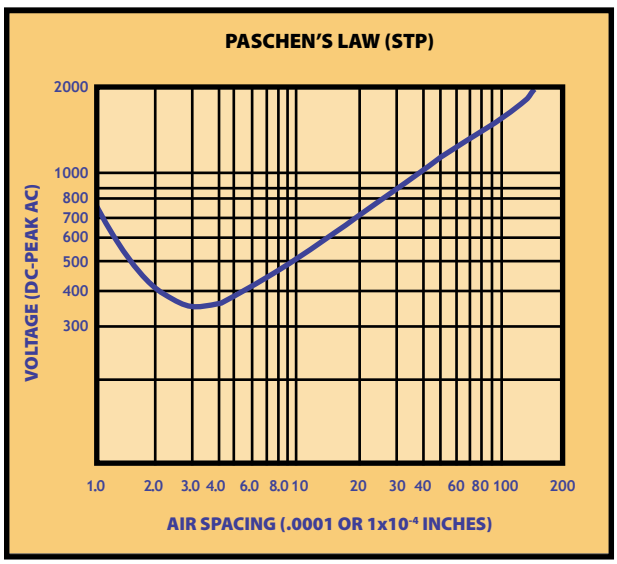

Figure 1- Paschen's Law

Mechanical abrasion within the winding is another deterioration mechanism operating on the motor's insulation. At start up a squeezing action caused by the magnetic forces will cause wear between the moving components[4]. The magnetic field changes 120 times a second causing this squeezing to occur each time. Even though wear does exist between the winding and the ground insulation, studies show that less than 17% of the ground insulation can be worn away due to this movement. It is the turn-to turn insulation that is most affected by this type of abrasion.

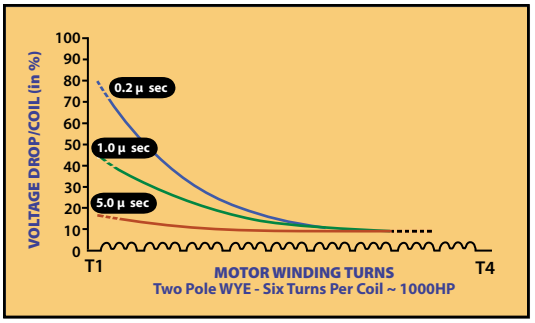

Figure 2- Faster Rise Time, Less Linear Voltage Divides

As stated above, the potential turn-to-turn difference during normal operation is not enough to cause a failure of the turn-to-turn insulation in a motor. Only the spikes will have a voltage level high enough to cause this kind of problem. Adding to this turn-to turn stress is the non-linear distribution of voltage across the phase. In a study conducted by Christiansen and Pedersen[5], it was concluded that the rise time of the spikes will determine how the voltage propagates over the windings. As shown in figure 2, the faster the rise time the less linear the voltage divides over the coil.

Typical Scenario of an Electrical Failure

When a motor is new the dielectric strength of the insulation system is very high. On a typical 4160V motor turn-to-turn insula-

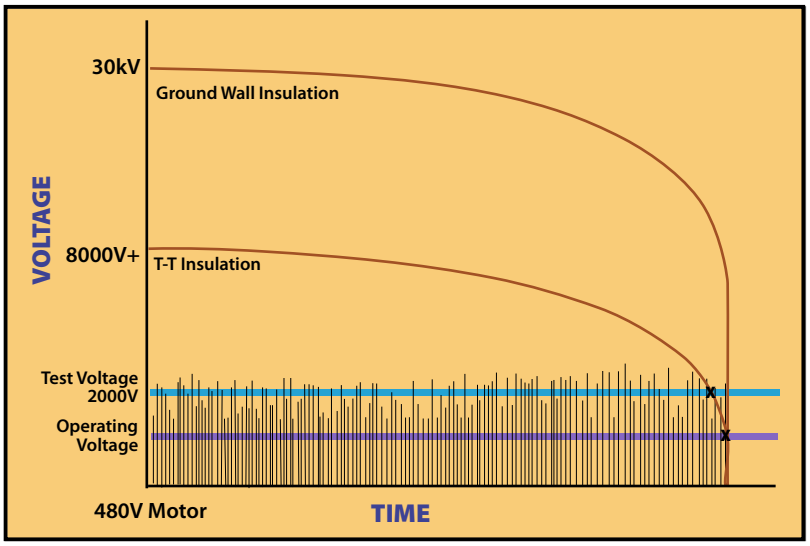

Figure 3- Insulation Deterioration

tion strength is over 34KV. Over time the insulation will deteriorate due to the normal thermal aging process. Excess contamination and mechanical stress will cause a more rapid deterioration. This will continue until finally the insulation has deteriorated to a level that is affected by the surges (see figure 3).

At this time each surge will result in an arc causing more deterioration of the insulation. When the turn-to-turn insulation erodes to a level close to the operating voltage, the conductors will weld together causing rapid failure due to the high induced current. (see figure 4).

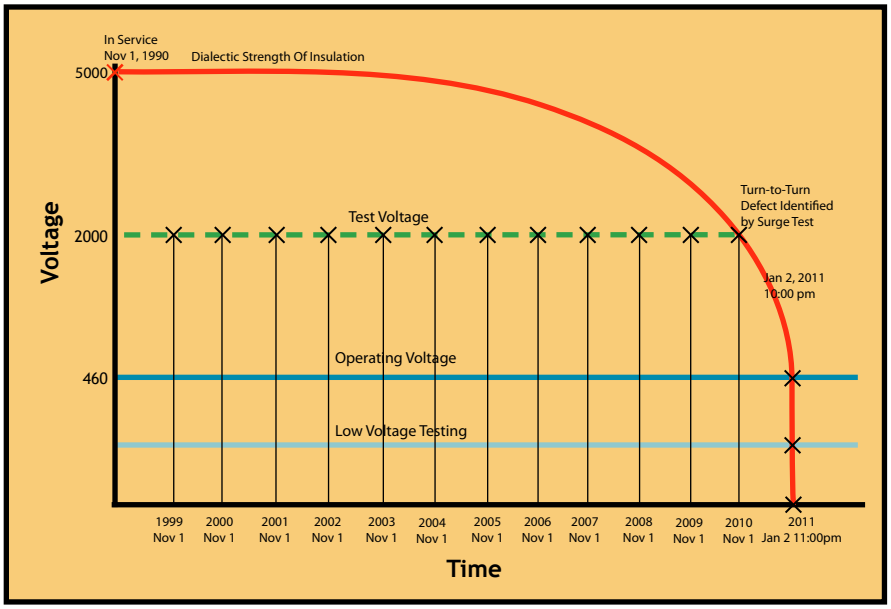

Figure 4 - Rapid Deterioration of Insulation Once Defect Identified

High Voltage Testing?

Of the four tests reviewed in this article, only two are considered to be "high voltage". It is important to understand what each of these tests can and cannot do. It is the combination of the right tests that will help meet the goal.

Insulation Resistance Test

Developed early in the 20th century, the insulation resistance (IR) test is the oldest and most widely used test for assessing the quality of insulation to ground. In this test, the motor frame is grounded, and the test instrument (megohmmeter) imposes a dc voltage on the motor windings. Instrument readout is provided in megohms.

A sound winding yields a readout in hundreds, or thousands, of megohms. For random wound & asphalt Mica insulation ANSI/IEEE Std 43 IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery prescribes 1 megohm plus 1 megohm per KV of the motors rated voltage as a minimum acceptable reading. 100$\mu\Omega$ for modern form wound windings is acceptable. For example, the minimum acceptable resistance for a 460V motor is 1.46 megohms. Prudence, however, dictates that the motor be removed from service for winding refurbishment while winding-to-ground resistance is still well above the minimum acceptable value.

IR test readings are highly sensitive to temperature and moisture. For accurate, meaningful readings, testing should be done when the motor has been out of service for a long enough time for it to have reached atmo-

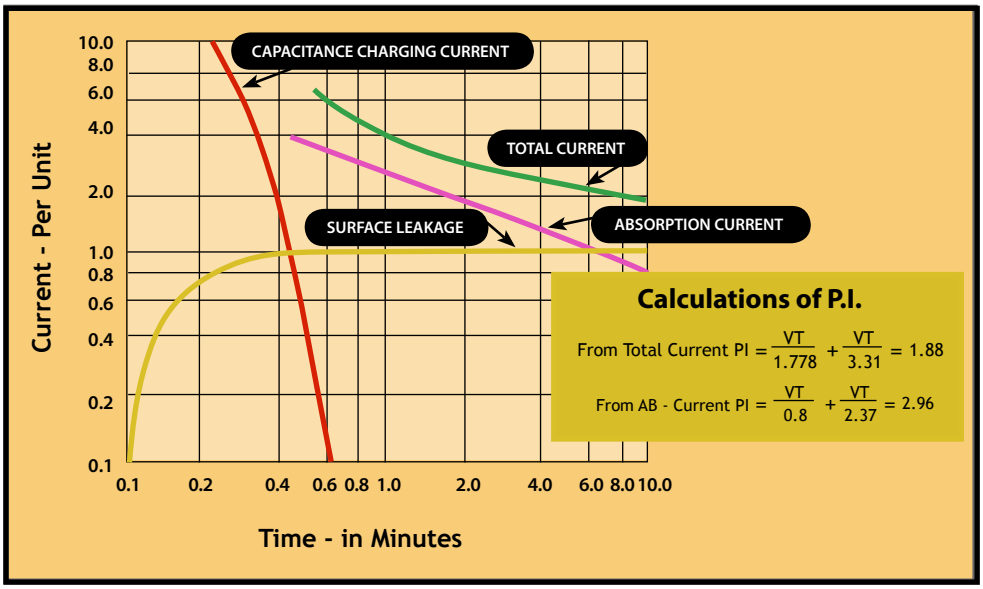

Figure 5 - Calculations Involved in the Polarization Index

spheric temperature. To preclude condensation, the temperature should be above the dew point. IR readings obtained must then be corrected to a standard temperature in accordance with tables provided in the IEEE 43 formulas. This test is a test of the ground insulation only and has no value in determining the quality of the turn-to-turn insulation.

Polarization Index Test

This ten-minute DC test is performed at a voltage lower than maximum testing voltage as per IEEE43. For more information of exact voltage levels see the table available in IEEE43. A megohm reading is taken at one minute and again at ten minutes to determine the elasticity of the ground insulation. When placed in an electric field, molecules of the ground insulation should align with that field. (see figure 5) If the insulation is aged, hard, and brittle, no polarization can occur.

The Polarization Index is the ratio of the ten-minute insulation resistance reading divided by the one-minute reading. Over the ten minute period this reading should increase by a factor of two or more giving a "PI" of two or more. If the insulation is very brittle the polarization index will be one or very slightly more than one, indicating no polarization took place (see figure 6). This test also looks only at the ground insulation and will not see problems in the turn-to-turn insulation.

DC High-Potential (HiPot) Test

The first of the two "high voltage" tests, the DC HiPot test can uncover insulation weaknesses that might not necessarily be detected in an IR or PI procedure. In addition to measuring overall insulation resistance to ground, it provides information on insulation dielectric strength. In this sense, it can detect insulation weaknesses that are likely to fault to ground if subjected to the high transient voltage surges that commonly occur on industrial power systems.

With this test, the motor frame is grounded, and a dc voltage is gradually applied in step increments up to the maximum recommended test voltage. IEEE Std 95 Recommended

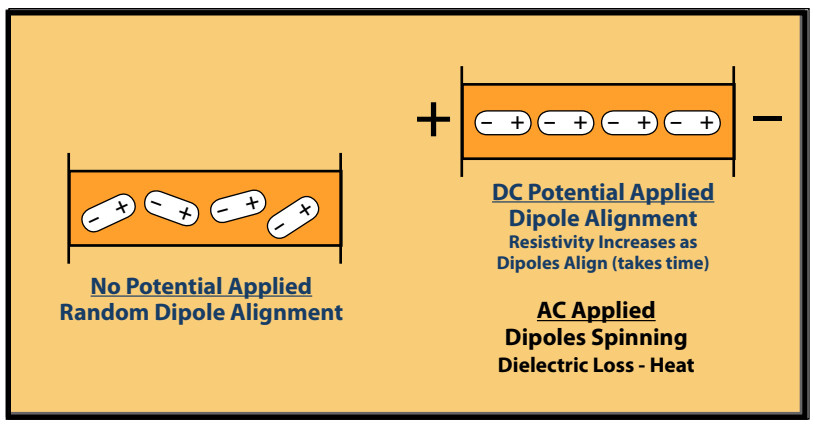

Figure 6 - How the Polarization Index Test Works

Practice for Insulation Testing of Large AC Rotating Machinery With High Direct Voltage recommends maximum test voltage at 1.5 x 1.7 x Vline. At each step up to this voltage, leakage current in microamperes is read and plotted against the corresponding dc test voltage.

The resulting plot should be a straight line. Magnitude of leakage current and resulting slope of the line is not the only consideration. The criterion of importance is that the plot be, in fact, a straight line. An abrupt upswing in the slope of the plot indicates an insulation flaw. The test should be immediately aborted to prevent the winding from failing under test. The motor can be returned to service, but winding reconditioning or replacement should be scheduled for the earliest convenient opportunity.

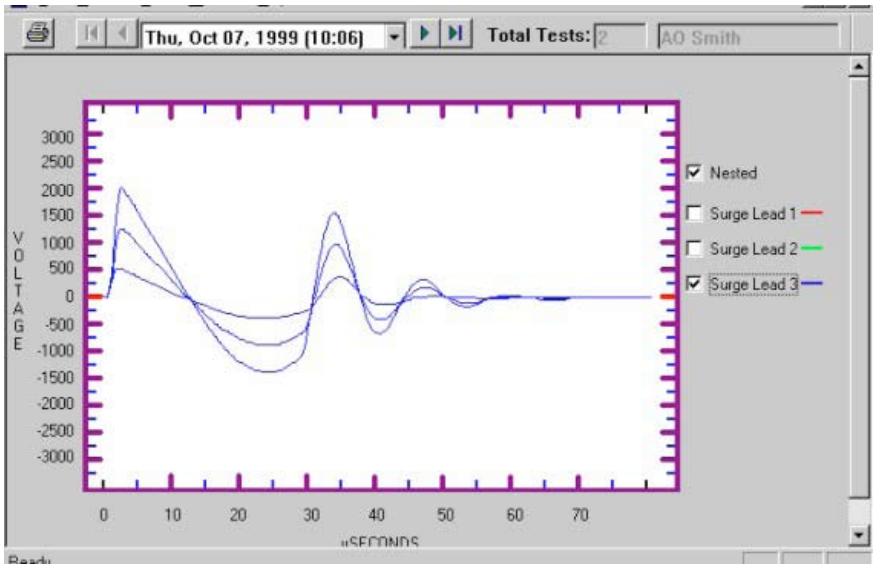

Figure 7 - Screen Shot - Surge Test with Nested Readings

The number of discrete steps in which the test is performed is optional. However, taking more steps in smaller voltage increments yields better results and minimizes the possibility of test voltage overshoot. Most dc high potential test sets incorporate overcurrent trips to protect the winding if a weakness is detected. The most sensitive of these overcurrent protective circuits can operate when leakage current is as low as one microamp. The DC HiPot is also a test that only looks at the ground wall and is of no value for the turn-to-turn insulation.

Surge Test

Although surge comparison testing was developed more than 80-years ago, it is the newest of the classic tests performed to determine winding insulation condition. This test detects turn-to-turn, coil-to-coil, and phase-to-phase insulation defects that cannot be discovered by other methods.

Surge comparison testing is premised on the principle that in a stator with no winding defects, all three-phase windings are identical. This is useful for form wound stators without rotors installed. Each phase is tested against the others – A-B, B-C, and A-C. The test instrument imposes a brief voltage pulse on the phase undergoing the test and reflected ringing pulses are displayed on the instrument's oscilloscope screen. If the two windings are identical (as they should be), reflected images are identical and appear as a single trace.

This comparison method has been used in the motor shops repairing motors for over 40 years. When using a surge tester as a predictive maintenance tool, the test does not require the comparison of two wave forms. A simpler test is performed that looks for a shift to the left by the waveform of the phase being tested. This shift indicates that the dielectric strength of the turn-to-turn insulation has deteriorated to a level below that of the switching surges. Once the insulation has weakened to this point, decisions need to be made concerning the future of the motor. With today's digital technology it is possible to acquire data of the phase under test at several voltage levels and nest them together. This technique is valuable in detecting and documenting this shift to the left.

Conclusion

When testing a motor's insulation system, it is important that the right tests are performed. Understanding that the motor sees voltages of up to 5pu, it is important that the insulation system be capable of handling

stress higher than its normal operating voltage. As shown in this article, if high voltage testing is not performed it is nearly impossible to detect the weak insulation in advance of it's failing.

Of the four tests discussed in this paper three concern themselves with the groundwall insulation with no regard for the turn-to-turn. The Surge test is the only test that looks at the turn-to-turn insulation. The turn-to-turn insulation is the root cause of a high number of the electrical failures. This test simulates characteristics of a surge at start up, making it an appropriate test for early detection of weak insulation.

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Curt Lanham is the president of Baker Instrument Company, a manufacturer of on-line monitoring and off line motor test equipment. An IEEE member and graduate of Missouri Western, Curt has worked in the predictive maintenance industry for the past 16 years. He has taught seminars on these subjects in more than 10 countries and throughout the United States. Curt can be contacted at clanham@bakerinst.com

Adventures in Alignment

Cooling Tower Assignment Tests Laser Alignment System

by Alan Luedeking

When an HVAC technician is called out to perform a shaft alignment on a cooling tower fan, it is always an adventure, and seldom a pleasant one. Numerous difficulties await, not the least of which include the long distance to be spanned, vibration from surrounding fans, hazardous wet conditions, and obstructions. Using dial indicators in the "face-face-distance" method, the job may take many hours, and very much longer if soft foot is found and must be corrected. The following application in a large hospital provides an illustration of a number of oft-encountered problems which must be overcome, and how they were handled with a laser alignment system.

The cooling tower in question had a 12-foot Marley fan whose gearbox was coupled to a Baldor 40 HP 1775 RPM motor via a 60-inch jackshaft with single-plane flex couplings at each end. The fan enclosure was located outdoors and consisted of a fiberglass shell constructed around a wooden framework. The alignment could not be measured by shooting the laser beam across both couplings simultaneously since the jackshaft went through an aperture in the fiberglass shell whose diameter was less than the coupling's outside diameter. This meant that the "two-step" procedure would have to be used to take alignment readings (just as with indicators). The "two-step" process involves bridging across each coupling individually, which is illustrated in Figure 1. The results of the readings from these individual setups are then combined to obtain the actual position of the machine to be moved. In this case this was the motor.

In order to simplify the task, a ROTALIGN® PRO laser alignment system was used. This permitted the cooling tower drive train to be configured as a three-machine train, with the middle machine configured as a "shaft", to represent the jackshaft. Configuring this particular setup makes it easy to take readings across the two couplings individually. The instrument then instantly calculates the necessary corrections for the motor without any need to manually combine results from the two setups. The first problem arose when the laser system revealed that in order to align the shafts, the motor would have to be lowered by 121.7 mils at the front feet and 202.0 mils at the back feet. We could not make this correction because there were not enough

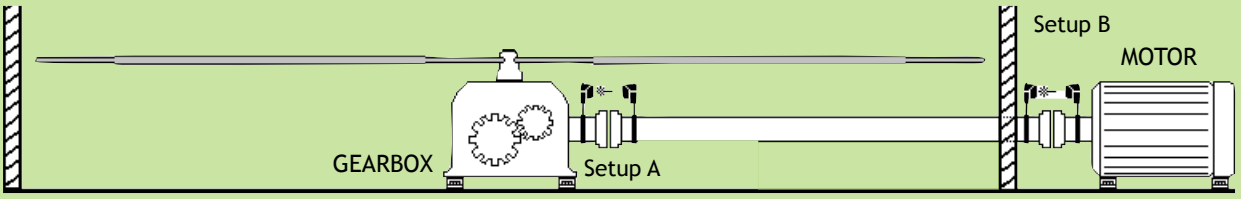


Figure 1 - The setup for the two-step alignment process.

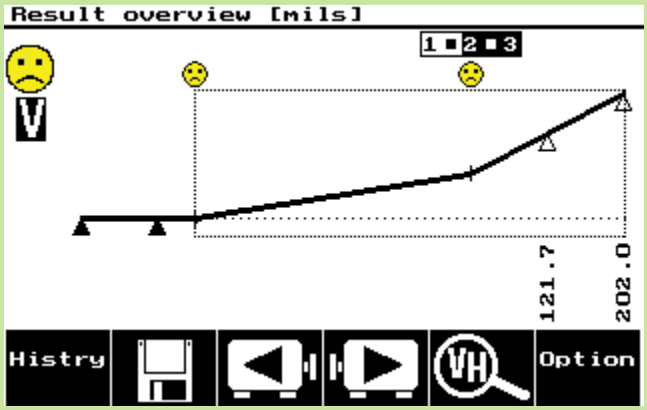


Figure 2 - Identification of Base Bound Machine

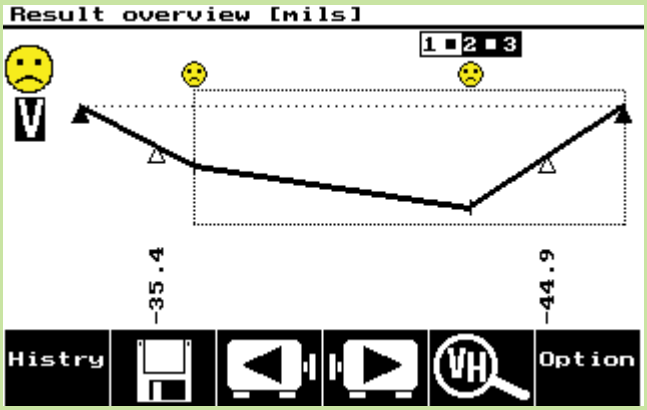


Figure 3 - Alternative Soution for Base Bound Machine

shims that could be removed from under the back feet of the motor. See Figure 2. This is the classic scenario where a machine is said to be "base-bound".

Since re-machining the feet or the base was out of the question both resource- and time wise, we had to find an alternative solution. This brought into play another feature of the ROTALIGN® PRO: the ability to fix specific pairs of feet as stationary for purposes of performing alignment corrections. We input information into the instrument to make the back feet of the motor stationary (since they could not be lowered) and to make the front feet of the gearbox movable. The tool then instantly calculated the following alternative solution shown in Figure 3.

As can be seen, both the front feet of the gearbox and front feet of the motor would now have to be raised by 35.4 mils and 44.9 mils respectively. The great advantage of this solution was that it required only positive shimming to be done (which is always easier than negative shimming), and minimized the magnitude of the necessary corrections. This solution is traditionally called "making an optimal move".

After the shimming corrections were performed, the instrument was reconfigured to make all of the motor feet movable again and new readings were taken to determine the final horizontal adjustment to be made. This move would also be monitored in real time with the laser system. Now another circumstance common to many cooling towers came into play. Since the fan enclosure blocked line of sight between the gearbox shaft and the motor shaft, the laser could not be mounted on the stationary gearbox shaft to monitor the horizontal move. Therefore, a different arrangement would have to be used. Since the laser serves only as a stationary reference line when monitoring moves, the laser emitter can be mounted to any fixed point, and does not have to be mounted to the stationary machine's shaft. This meant that the laser could be mounted to a fixed location on the motor side of the fan enclosure. In this case, a steel angle-iron attached to wooden bracing ran along the outside of the fiberglass wall of the fan enclosure (on the motor side), providing an ideal mounting location. The laser was mounted to this angle iron using magnetic brackets (Figure 4). With this convenient solution, no dial indicators would need to be mounted against the feet of the motor to control the motor's move. Furthermore, this laser setup also permitted checking for soft foot on the motor, which

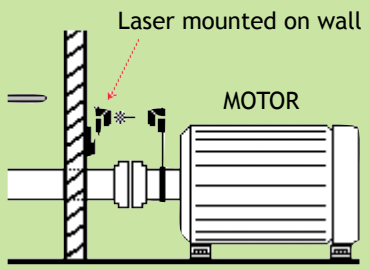


Figure 4 - Magnetic mounting

was done after the rough alignment but prior to the final alignment.

The final alignment ended up well within tolerance, as shown in the vertical and horizontal result screens in Figures 5 and 6. The entire job, including checking for and correcting soft foot took less than three hours, most of which was spent climbing up and down ladders and clambering carefully around the cooling tower structure. This resulted in greatly reduced downtime as well as labor savings.

Alan Luedeking is manager of training and tech support at Ludeca. He has a Bachelor's degree from the University of Colorado at Boulder and over 20 years of field experience in machinery shaft alignment and training. He enjoys technical writing and editing and speaks four languages. He is married with four young children and his principal hobby is numismatics. Alan can be reached at 305-591-8935 or by e-mail at alan@ludeca.com

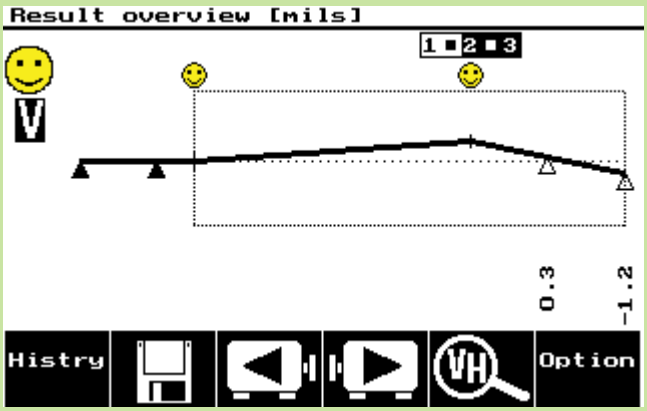


Figure 5 - Final Vertical Results

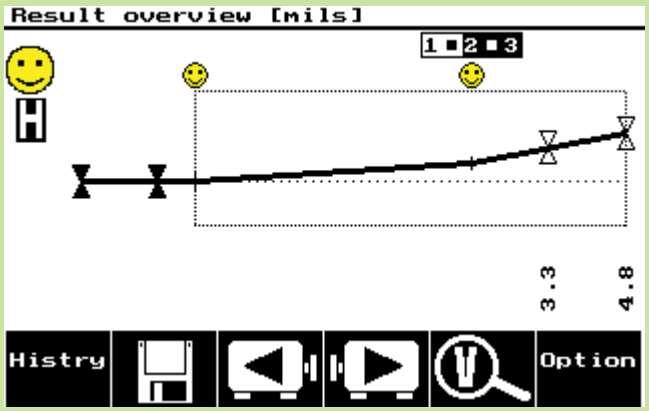


Figure 6 - Final Horizontal Results

Ultrasound Story Time

Storytelling A Great Way to Inform and Have Fun

by Jim Hall

Ultrasonic War Stories are those applications, techniques, or incidents where airborne ultrasound was used to diagnose, find, or remedy a problem. One of the most versatile instruments in the plant is your airborne ultrasound instrument. So, should it sit in your closet or tool crib waiting for an air leak or two?

Whether I am in a classroom or standing around talking to people, I try to use stories to break the ice, get someone's attention, and/or to get a point across. In any case it has to tie into the subject matter at hand. For instance, when I am discussing slow speed bearings, I may mention a short story about using ultrasound to find bugs in a company's kidney bean bags. I was really there to instruct the technicians on how to check slow-speed bearings on their ovens conveyors, but one thing led to another, and before I knew it I was listening for bugs in beans. It's now one of my favorite stories. More on that later.

Some of the greatest salesmen, mechanics, and engineers I have ever known, all have one thing in common. They tell a great story. Storytelling crosses all ethnic background and cultures. We all tell stories. Why, if it weren't for storytelling as a sailor at sea, I don't know how I would have kept my sanity. I had young men that had to be trained in a very short time to work on aircraft. Many of these men were replacements for the men who were allowed to go home towards the end of the Vietnam War. My shop was empty of senior people. Many of their replacements had no leadership and very little mechanical abilities. Storytelling, not yelling, got their attention.

Checking for steam leaking past a valve is only one of the many applications for which ultrasound can be used.

Over the past 17 years, I have seen many airborne ultrasound applications that the average technician will never see or hear about. For you, the seasoned airborne ultrasonic technician, you probably already have your own Ultrasonic War Stories. I encourage you to take notes, pictures, wave-files if applicable, and document your experience to share what you have learned with others. Here's are some examples;

Electrifying Retirement

A couple of mechanics performing predictive maintenance using their ultrasonic receiver were returning to the shop when one of them pointed the ultrasonic receiver at a lighting breaker panel.

Several months earlier, I had mentioned to these mechanics the importance of wearing the headphones and scanning for anomalies whenever using ultrasound in the plant. I continued to tell them to scan on the way out to a job and scan on the way back to the office. Electrical arcing, corona, tracking, noisy bearings, a loud gearbox and compressed air leaks are

just a few of the anomalies that you might hear that could possibly interrupt production or cause a shutdown.

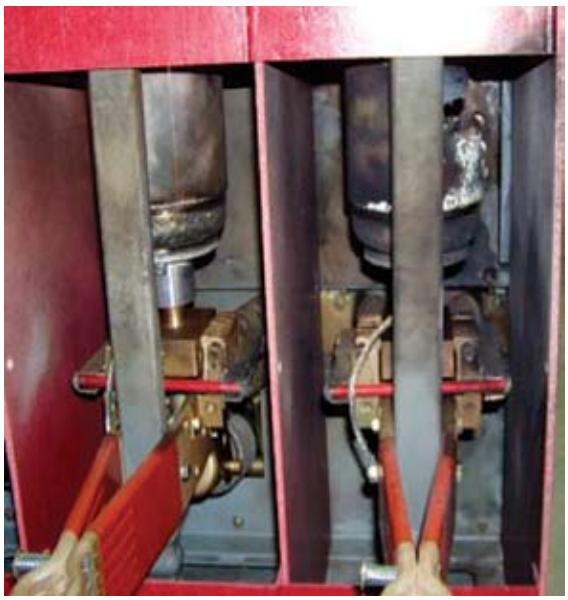
The second technician followed as the first technician honed in on the sound of arcing emitting from the lighting panel. After marking and tagging the area of suspicion, the technicians returned to their shop and alerted an electrical shop foreman about the panel. The electrical shop foreman said the panels had undergone an infrared inspection recently and he doubted that what they heard was arcing. The very next week the lighting panel had a catastrophic failure. People who witnessed the failure said it looked like the fourth of July in that part of the plant. A fourth of the plant had to be shut-down because of this breaker panel failure.

Scanning a breaker panel for anomalies (arcing, tracking or corona discharge).

The electrical shop foreman, who was just a year away from mandatory retirement, was not familiar with airborne ultrasound for electrical inspections. As with many others, he had come to believe that infrared alone is all that was needed for electrical inspection of breaker panels, switchgear and substations. Unfortunately for him, he was later asked to retire a few months early.

Vacuum Pump Leak and Hot Desert Rocks

One very hot summer day near the town of Mojave, California several years ago, I was instructing a technician on how to inspect bearings on his vacuum pump. This was mule train country, borax mining territory. In fact a similarly named company wasn't too far from this location. I remember the old westerns on TV, the cowboys wiping the sweat off their brow with their handkerchiefs and their eyes squinting from the bright sun. That's how I felt. Sweating, squinting and feet burning, I had bent over to touch the bearing housing with the contact probe when I noticed a white powdery substance near the shaft of the bearing. When I asked about the substance the technician told me that the second shift comes out with shaving cream and bright lights after dark to try to detect leaking bearing/shaft seals.



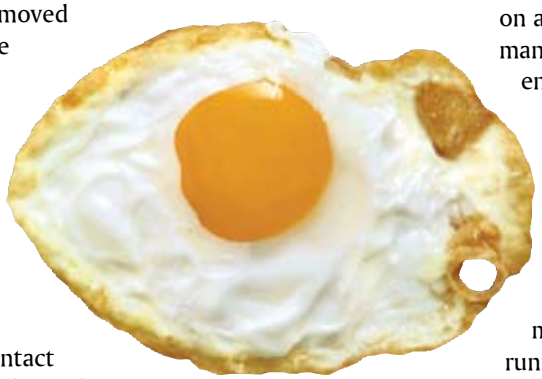
Carbon present on contacts from recent failure – No load on equipment during survey. Corona discharge was heard with an ultrasonic receiver.

Shaving cream is often used to look for leaks on vacuum systems - pump shafts, seals, casings, even condenser tube leaks. When applied liberally a small leak may be detected through the cream. This small hole is the "in-leakage source". Depending upon the product and/or process, in-leakage may cause cavitation.

Cavitation is the rapid formation and collapse of vapor pockets or air molecules in a flowing liquid in regions of very low pressure. It's a

violent implosion that can cause considerable damage to a pump or motor.

After instructing the technicians on how to detect bearing failures, I removed the contact probe and reinstalled an airborne scanning module and a rubber focusing cone in an effort to zero in on the leak. I was hesitating slightly because it was entirely possible that I would have to kneel down, and, in the process, burn my knees on some very large rocks that were hot enough to fry an egg on. Fortunately for me, this pump had a leak that was easily heard by the ultrasonic receiver from several inches away.



Using airborne ultrasound for leak detection is not limited to compressed air leak surveys. Leak detection for predictive maintenance is a perfectly valid application. Whenever I hold a training workshop I make a point to suggest that the technicians purchase a shoulder strap, holster or carry a small camera case with the ultrasonic instrument in the plant with them.

Bugs in my Refried Beans?

Once, I was training technicians on how to use ultrasound to detect bad bearings on an oven conveyor at a refried beans manufacturing facility. The maintenance engineer was suddenly called away to sign for the delivery of several bags of kidney beans that are used to make refried beans.

Testing slow speed bearings using airborne ultrasound is a preferred method by many companies with miles of conveyors or assembly lines running 300-350 rpm's or less. The sound of balls out of round, or an outer race can sometimes be heard distinctly. However, never go by sound alone. Remember, just as some ultrasound instruments will not read the same decibel between models, you and I may not hear the same either. There are a couple of methods - such as the "comparative method" which entails comparing alike bearings or the trending "historical method", in which you take readings over a period of time - that will increase your chances of a correct diagnosis. Diagnosing bearing failures by sound alone very seldom proves to be the correct way to diagnose a bearing for failure.

He returned shortly with a serious look on his face and asked if the instrument might hear bugs that may or may not have infested all the bags of beans on a truck waiting to be unloaded. I immediately answered, "I believe so," because I had once heard that the instrument had been used to hear termites. I thought, "why not, let's give it a try".

Ultrasound is high-frequency. Low-frequency sounds such as someone talking cannot be heard by the ultrasonic receiver. However, friction such as that of an eye lid opening and closing can be heard several feet away. The friction from rubbing your forefinger and thumb together can also be heard several feet away. Surely, the sound of bugs chomping on the beans could be heard.

We began scanning the bags using the same module or sensor used to locate air leaks. Scanning side to side and around the bags, a rather loud crunching or chomping sound could, in fact, be heard coming from several of the bags of beans. Having proved that bugs had infested some of his bags, he ordered those to be returned to the seller.

We then returned to the bearings on the oven conveyor and using the "comparative method" we located several bearings in a catastrophic failure mode that needed to be replaced immediately.

The Comparative Method is taking a reading of a bearing and comparing it to the readings of alike bearings. Several bearings on this conveyor were the same size and make. After documenting all bearing decibel

Over lubrication is a problem with serious consequences. Acoustic lubrication is another application for which ultrasound is used with positive results.

readings, use the lowest decibel reading as the baseline for the other alike bearings. Using 8-10 db's over the baseline as "incipient failure" or "lubrication", 12-15 db's as "failure", and 32 decibels over the baseline as a "catastrophic failure", a plan as to when to remove and replace the bearings can be implemented.

Remember, before you can teach people something, you have to get them to listen. What are your Ultrasonic War Stories? Share them with others. Maintenanceforums.com is a good forum to do this. When you combine the collective knowledge and experience of a group, you will see, as many others have before you, a tremendous benefit.

Ultrasonic War Stories is a bimonthly newsletter of stories from Jim Hall's personal library of ultrasonic applications. If you would like to read more, you can on-line to www.Ultra-SoundTech.com and sign-up.

Jim Hall is the president of Ultra-Sound Technologies, a "Vendor-Neutral" company providing on-site predictive maintenance consultation and training. UST provides an Associate Level, Level I & II Airborne Ultrasound Certification. Jim is also a regular provider of on-line presentations at ReliabilityWeb.com and is a contributing editor for UPTIME Magazine. Jim has provided airborne ultrasound training for several Fortune 500 Companies in electrical generation, pulp & paper, petrochemical and transportation (marine, automotive, aerospace). A 17 year civil service veteran, Jim served as an aerospace engineering technician for Naval Aviation Engineering Service Unit (NAESU) and with the Naval Aviation Depot Jacksonville Florida (NADEP). You can contact Jim at jim.hall@ultra-soundtech.com

Multiple Discriminant Analysis

Using Metrics for Bearing Condition Management

By John Judd

Trying to accurately predict the time of a bearing failure is like trying to predict the weather. "There is a 20% chance of showers today," you hear the weatherman say, only to have that 20% pour down on you on all day long. Just like the weather, classic rolling element bearing failures are random in nature. They conform to a Weibull exponential distribution, and are best predicted by statistical methods. When trying to make replacement decisions on a suspect bearing, don't ask: When will it fail? It is better to ask: What is the probability of failure before the next routine shutdown?

The BearingLifeguard™/MDA technology described in this article has been developed to provide an answer to that question - answers that will aid the decision making process. Like a TV remote control that requires little knowledge of video technology, the BearingLifeguard system requires minimal understanding of the underlying vibration analysis technology. It removes the complexity and provides useful actionable information.

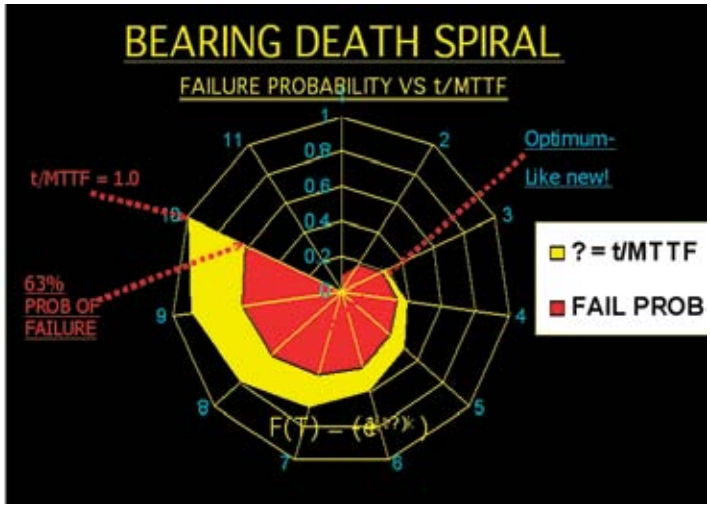


Figure 1 - The Life and Death of a Bearing

The MDA approach is based on sound logic: It addresses the four key elements in effective rolling element bearing monitoring: the level of life reducing forces, the condition of the bearing surfaces, the estimated probability of failure in a selected time period, and the financial risk of inaction. It applies proven diagnostic techniques to obtain these estimates. It measures and quantifies low frequency acceleration forces, surface roughness, defect impacts, ratios and envelope levels to provide meaningful estimates of the bearing condition and life expectancy. The technology is a simple, metrics-based, next generation smart system that is a powerful, easy to use, bearing monitoring tool.

Why Metrics?

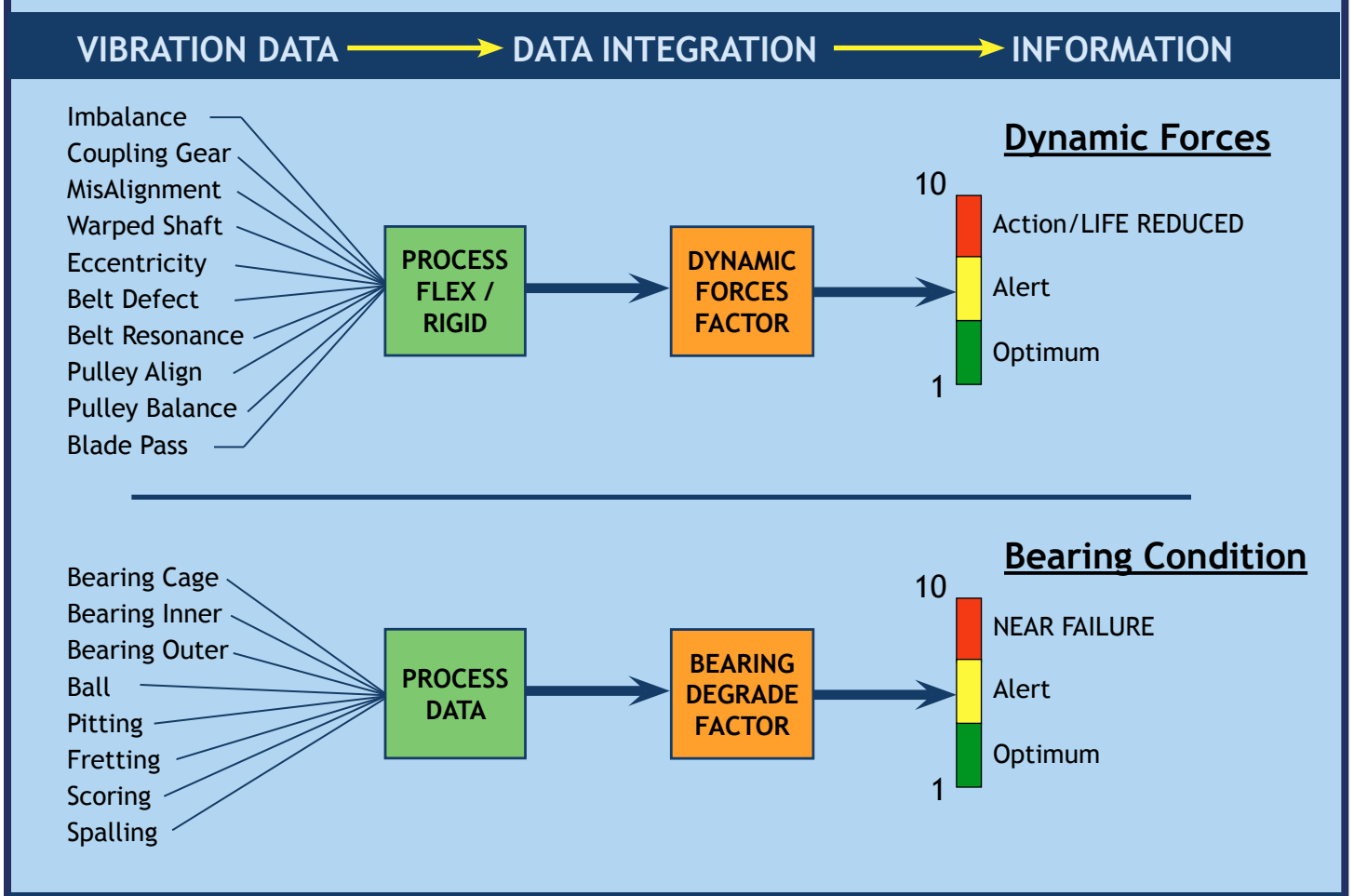
Reducing the data to simple metrics provides the end user clear, consistent information on a wide variety of areas such as bearing condition, remaining life, forces reducing life, near term failure, financial risk of inaction and the total cost of failure. Providing information in metric form reduces the clutter associated with information overload and simplifies the decision making process. This can lead to reduced training costs, reduced consulting costs, reduced mistakes, more effective communication, better benchmarking and, ultimately, better decision making.

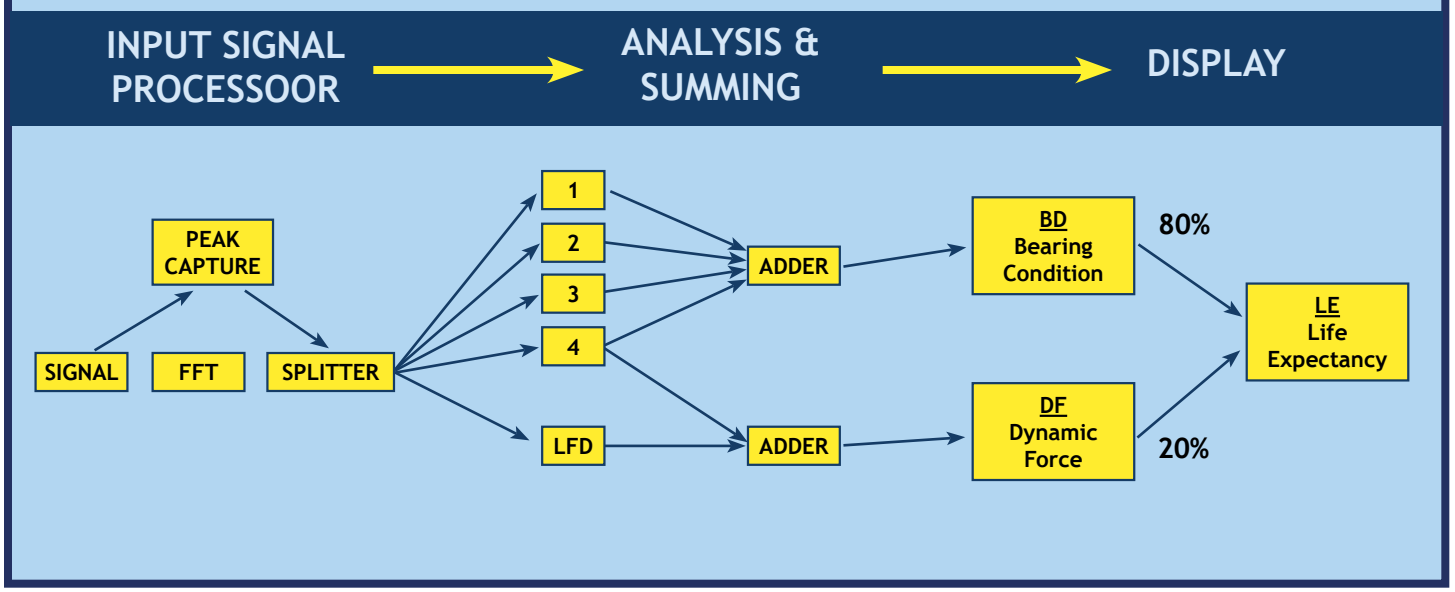
MDA Technology

MDA (Multiple Discriminant Analysis) is a patented[1] bearing condition assessment tool that provides information on four previously mentioned factors affecting machinery maintenance costs. As its name implies, the system utilizes multiple analytical techniques designed to assess a rolling element bearing's condition and reduces each of the process outcomes to a 1-10 Metric called a DISCRIMINANT. A metric value of <1 indicates a near optimum condition and a value near 10 indicates a worst case (near failure) condition.

How Multiple Discriminant Analysis Works

Multiple Discriminant Analysis is a process of converting raw vibration data into simple, usable metrics. The metrics provide the data in an easy to understand format that allows users to make informed decisions quickly.





When a bearing degrades, whether from lubrication film breakdown, or subsurface fatigue, a common pattern develops. Microscopic scoring or subsurface fatigue migration cracks begin to appear. A defined failure occurs when a surface defect reaches 10 mil inches square.[2] In this process, measurable acceleration impacts and high frequency energy with specific characteristics, begin to develop. The nature of these accelerations, carefully measured on the bearing housing, provides a useful indication of the ball/race interface surface condition and defect severity. While many diagnostic procedures have proven useful, none are without some element of uncertainty. To improve reliability the MDA system employs multiple procedures (six in the system described) that are all quantified and reduced to the 1-10 Metric. The results are further combined to produce three final Metrics reflecting bearing condition, life reduction forces and resulting expected life, and one to calculate failure probabilities.

The Discriminants

A discriminant is a diagnostic element that yields a quantifiable Metric related to a specific bearing related condition.

1) The Low Frequency (LF) Discriminant captures the RMS (root mean square value) of all the low frequency accelerations including those caused by misalignment and rotational imbalance, up to approximately four times the rotational frequency. Accelerations measured near the bearing load zone most accurately reflect the bearing ball/race/housing interface contact forces. Level corrections are made for rigid or flexibly mounted systems. This value is converted to a 1-10 metric.

2) The Crest Ratio (CF) Discriminant measures the average ratio between the peak value of high frequency acceleration spikes and the RMS value of the acceleration energy. The character of this measurement is such that it is very sensitive to micro cracks in the bearing/race surfaces. It may be high on a new bearing and often declines after run in and increases to higher values in the latter stages of failure.

3) The High Frequency (HF) Discriminant is a measure of high frequency accelerations indicating general surface irregularities, roughness and surface degradation. Microscopic impacts do not contribute significantly to this level because of their short duration and low energy.

Figure 2 - Information on Discriminants in easy to understand format.

4) The Kurtosis (KF) Discriminant provides an exponential measure of both the short duration peak impacts and the HF RMS energy. It will respond strongly to a bearing with rough surface spalling and micro surface fatigue crack degradation. It is a highly reliable indicator of a near failure condition.

5) The Envelope (ED) Discriminant is sensitive to shock impact ringing in the measurement system caused by impact durations near the accelerometer resonant period. It converts the RMS to a 1-10 Metric which typically increases dramatically in a near failure condition.

6) Peak accelerations are also converted to a metric which is factored into the Bearing Condition calculation. The value of P is not displayed as a distinct Discriminant.

The Discriminants are all displayed in a time stamped bar graph form as shown in Figure 2 and may be examined as the last five, last fourteen, last 24 or all, for purposes of observing changes or trends over time.

The Factors

A factor is a formulaic combination of discriminants designed to provide informational metrics on operational conditions such as dynamic forces, bearing condition, and life expectancy.

The Discriminant values are weighted and combined to produce a Bearing Condition (BC) Factor in which each analysis technique has a vote on the bearing surface condition. As mentioned earlier, a reading of 1 indicates

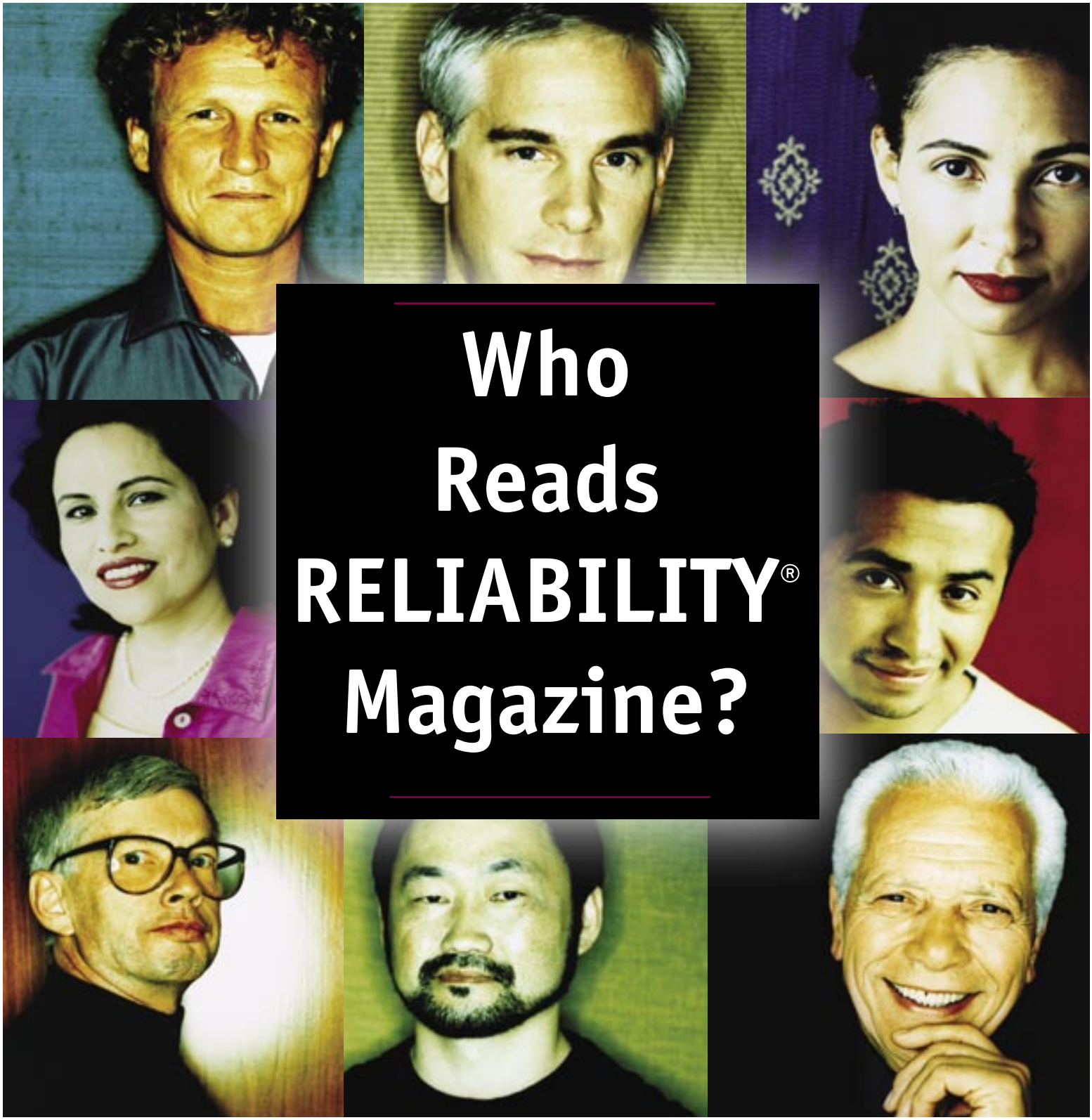


Figure 3 - Discriminant values combined to form Bearing Condition Factors

a like new, near optimum operating condition and a 10 reflects diagnostic agreement that the bearing is near failure. The Factor screen is shown in Figure 3.

The final 1-10 Life Expectancy Factor reflects the life shortening influence of the DF low frequency Dynamic Forces alerts the user to reduced bearing life. The uniform 1-10 metric system allows the user to quickly assess the system condition and puts all of the complex processing activity out of sight. The final step converts the factors to numbers displayed on an information screen.

The Bearing Information Screen (Figure 4) provides all key bearing informational estimates based on MDA measurements: bearing ID #, forecast period in days (adjustable, 45 to 270), Mean Time to Failure based on measured bearing condition data, Estimated Life based on the influence of dynamic forces acting on the bearing (user defined), probability of failure (POF) in the forecast period, POF short term (14 days), Risk Estimate -the financial risk of failure in the forecast period and the Actual (user defined) Cost of Failure. At the end of the collection sequence the information and raw data are stored for review.

System Configuration

The system is implemented in a three level password protected configuration in either planned, unplanned collection, or review sequence. Assembly ID and location are verified by barcode. Technician level is intended for data verification, collection and observational notes. At the analyst level all of the data collected may be reviewed in the Review mode. It allows examination of Factors, Discriminants for level and trends, as well as signal time history and frequency spectra. At the Supervisor level the assemblies, the system parameters, collection sequences and password assignments are defined in the database utility.

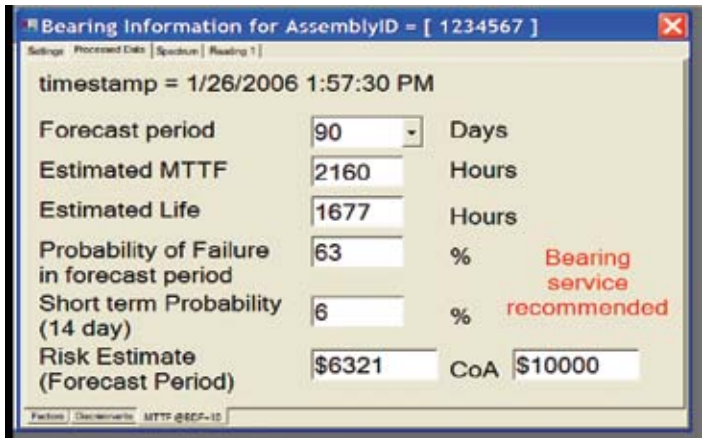


Figure 4 - Bearing Information Screen

At the Technician level, following a planned or unplanned sequence the technician selects a data point and mounts or connects to an existing industrial 100 mv/g accelerometer [Power supplied is 24 volt, 2 ma constant current.] If the sensitivity is not 100 mv/g the user may enter the correct value in the assembly point set up. If the sensor is not connected or is defective, a warning message is displayed. A 'signal test' screen appears which displays the raw data signal for confirmation by the technician. When confirmed as "real" the collector selects "use this data" to initiate the collection process.

The Analyst level allows more detailed analysis when required. It is assumed that in a well run facility most equipment is running properly and requires only routine service and periodic checks. On occasion problems occur that require more detailed examination. This is especially true if extraordinary costs or safety issues are involved. The Analyst level of BearingLifeguard provides additional information for the experienced practitioner. It allows access to all data Factors and Discriminants used in the system calculations, as well as acceleration time and spectrum data.

The Supervisor level provides access to all of the above plus control over schedule planning, defining the assembly details, rotational frequency, flexible or hard mounting, variable or fixed speed and locations as well as modifying system parameters and some processing coefficients.

More Analysis Detail

It is important to note that the Metrics provided in the BearingLifeguard/MDA system are statistical estimates based on measured diagnostic data. When the decision to schedule a bearing replacement may be critical to a process, safety or involve substantial cost, it is prudent to carefully examine the actual data used in the analysis to validate the conclusions. While the stored data may be uploaded and examined independently, the system provides convenient Tab selected data displays for the user. The Analyst Level may examine unfiltered or filtered acceleration data.

Time History Display

The acceleration verses time signal illustrated may be zoomed for close examination.

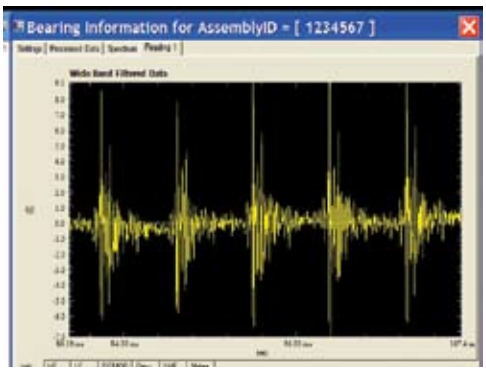


Figure 5 - Time History Display

Frequency Spectrum Display

The frequency spectrum may be Tab selected and displayed, zoomed and specific frequencies identified and amplitudes measured by the analyst.

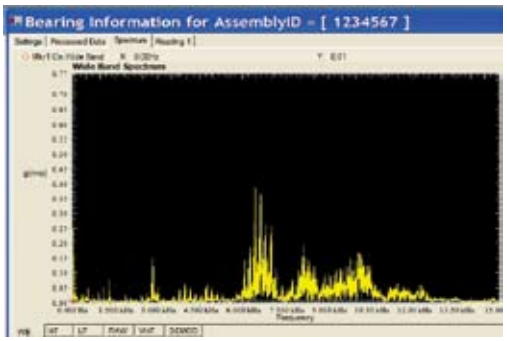


Figure 6 - Frequency Spectrum Display

Modulated Spectrum Display

The system allows Tab selected examination of low frequency impact envelopes. The impact frequencies are sometimes useful in recognizing inner, outer or ball defects.

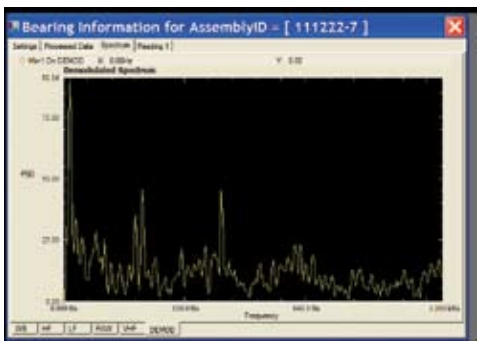


Figure 7 - Modulated Spectrum Display

Conclusion

The use of Metrics in rolling element bearing monitoring represents a new and unique approach. It is not meant to replace the need for analysis expertise, but rather to make the job of routine monitoring less complex and more useable by maintenance practitioners. It is designed to accommodate the vibration novice user as well as the expert. Good results with this system require a properly mounted conventional accelerometer, with a mounted resonance between 15 kHz and 24 kHz. The system may be used as a walk around data collector with a Windows XP laptop, or rugged tablet computer. A compact handheld terminal that provides data collection, waveform and information screen, will also be available. Information from this device maybe wireless linked or saved on Flash memory for uploading. The Metric approach lends itself nicely to 4-20 ma systems and provides all the analytic benefits of high frequency, ultrasonic analysis not possible in a 4-20 ma signal.

The system has been used effectively on belt driven, directly or flexibly coupled motors, pumps and compressors, at running speeds from 1750 to 7200 RPM with consistently good results. Provision is made to adjust the system for use with lower speed machines. A user may select a 90 day forecast period for 3600 RPM, or more aggressive or conservative 45, 60, 180, or 270 day period for any selected machine. Variable speed machines should be run at consistent speed when collecting data for best results. Caution must be observed in using the system on gear driven assemblies because of extraneous gear mesh noise not related to the bearing. However, provision can be made to reject selected gear mesh frequencies.

John Judd is the retired President and founder of Vibra-Metrics Inc. Active in vibration for fifty years with numerous patents, he is still learning by recently struggling through an MS degree at UNH. He loves new ideas, sailing, German Shepherds, his family and many friends. John is currently working with Rotarians and IDI/Sandata, Inc. in NY. to establish a national AMBER Alert Child ID database. He can be contacted at John@bearinglifeguard.com

1. Patent # 6 763 342 B1. Other patents applied for.
2. Ref: Torrington Bearing Serivce Manual

Lubrication is essential. Running clean oil in your machines is an important step to improving their reliability. Clean up your system with...

Thermojet

Lubrication is a great place to start when thinking about improving the reliability - and uptime - of machines. You already have oil in your machines. Why not keep it as clean as you can for as long as you can. That is the concept behind the Thermojet®. We talked with Keith Macaluso, who has been with Lubrication Systems Company, the maker of Thermojet, for 29 years. For the last 10 years he has been dedicated to Thermojet and its ability to make a real difference - in both machinery performance and in the bottom lines of company's that use it.

Can you briefly explain how Thermojet works?

The THERMOJet® Oil Purifier incorporates the principle of "Air Stripping." Air stripping is around us in our daily lives. The clothes dryer in your home, hair and hand dryers are examples of air stripping. In the THERMOJet®, we induce air into the flow of hot oil. This air now becomes the elevated temperature of the oil. Air at this elevated temperature has the capacity for dehydrating oil. In fact, doubling the air temperature over ambient will result in a 30 fold increase in moisture holding capacity of the air.

The THERMOJet® removes all forms of water. Not only free water, it also removes emulsified and dissolved water down to levels below 100 PPM. I recently spoke with a customer who was very surprised to see how dry his oil was after a few days on the THERMOJet®. His oil analysis report showed water content of 35 PPM. When oil is this dry, rust catalyzed by water stops, sludge and algae is eliminated and particulate is significantly reduced.

The THERMOJet's is a simple oil purifier. There is only one motor on the THERMOJet® that drives a dual spur gear pump. The THERMOJet® Oil Purifier is the most user-friendly of oil purifiers. Customers comment on how easy it is to move around from unit to unit with minimal training for plant personnel.

What sets THERMOJet® apart from other oil purifiers?

Degasification! The THERMOJet® not only can remove total water and particulate from oil, the THERMOJet® can remove light hydrocarbon gases such as H2S, hydrogen, propane, ammonia and other gases that can contaminate the oil. These gases enter the oil from the seals leaking into the compressor seal oil systems. This is an ideal application for refineries and petrochemical facilities. The contaminant can be safely removed, eliminating safety issues with handling these hazardous gases plus the gases can safely be disposed into the flare system. Flash point and oil viscosity are kept at the same levels as in new oil.

What kind of cost savings can a company expect from using Thermojet?

The cost savings from using the THERMOJet® Oil Purifier can be significant. The elimination of new oil purchases, cost for disposing of oil, labor for filling the oil reservoir with new oil and draining the contaminated oil all impact operational cost. There are also human error and safety considerations. Changing the oil in machinery has the risk of oil spills, as does the shipping of contaminated oil for disposal. Keeping the oil "like" new in the machine eliminates these costs.

What kind of impact can Thermojet have on overall plant and machinery reliability?

Numerous studies have shown that oil contamination has a direct impact on machinery reliability. Contaminated oil contributes to 50%-70% of lubricated related machinery failures. As I mentioned above, keeping the oil "like" new in the machine is the best practice. Oil is the lifeblood of machinery. If the oil is dirty, machinery reliability suffers because water in oil has a significant impact on the machinery reliability. A water content of 400 PPM in oil will reduce the relative bearing life by a factor of 12. Dedicating a THERMOJet® to a machine is one of the best practices a plant can make for improving machinery reliability and improving uptime.

What other benefits are there that a company that using a Thermojet might see?

The THERMOJet® removes water and gases from the oil without contaminating the environment. The water effluent discharged from the THERMOJet® is clean of any oil. Test shows trace amounts of hydrocarbon at <8 PPM. This effluent can safely be discharged into plant sewer systems.

In degassing applications, the THERMOJet® discharges the hazardous gases to the plant's flare system for safe, environmental friendly disposal of these gases. Safety is always an issue for plant personnel handling the hazardous contaminated oil. But the disposal of these contaminants into the flare eliminates these risks.

What industries are currently using THERMOJet®?

Water is a universal contaminant and is very vicious. Any reservoir will have water contamination. Reservoirs breathe in moisture from the cooling and heating of night to day. Refining, petrochemical, power, and pulp & paper are the primary industries that use the THERMOJet®, but it is truly universal.

What size of an operation does it take to justify purchasing the Thermojet?

Any facility that has a reservoir of oil can benefits from the THERMOJet®. We are now working with a customer that has only 45 gallons of oil in a small compressor. However, because of the daily problem of draining a small amount of the contaminated oil and freshening with new oil, it is easy to justify a dedicated THERMOJet® Oil Purifier on this application. There is no need to dispose of used oil and plant personnel can be proactive on other reliability issues!

Can you share a success story or two from Thermojet users?

We have many success stories with over 700 THERMOJets worldwide. A recent success was with a petrochemical customer that had over 1000 PPM water in oil. This customer had to add and drain oil on a daily basis because of a steam leak that he couldn't repair until a turnaround. Not only were water levels high but because of the water, rust generated by the water was causing high particulate levels. We installed a THERMOJet® on this turbine and within 2 days had the water down below 50 PPM and the particulate on a decline.

Today because of the strict rules and regulations with handling and disposing of oils with hydrocarbon contamination, the THERMOJet® is a success on many of these applications. Recently we went to a petrochemical facility that was spending $30K per month renting an incinerator to handle the hydrocarbon contamination from a refrigeration compressor. A THERMOJet® degassing unit was installed on both compressors, and the hydrocarbon effluent was configured to discharge to the plant's flare. The need for the incinerator was eliminated! Now that is a successful application.

How can people interested in Thermojet get more information?

There is a lot of good information on our website www.lsc.com and people can always contact me at mack@lsc.com

YellowJacket is a new free-standing safety device available from J.L. Geisler Corp. in Warren, Michigan. YellowJacket sets up in seconds and warns people away from hazards. It is an effective way to route traffic inside and outside a plant. Two Yellow Jackets fold flat for storage to only 9" thick. They are available in quantities from stock to form unlimited configurations. Each one folds flat to 4.5" thick. They are easily assembled or taken apart.

Tammy Kelly **586 574 1800**
J.L. Geisler Corp. **www.jlgeisler.com**

Onset Computer Corporation has introduced the HOBO® U-Shuttle, a new data transport device for use with HOBO® data loggers. The new Shuttle allows users to offload HOBO U-Series and FlexSmart data loggers at multiple locations in a facility and safely, transport the data back to a PC or Mac computer for analysis. Key features include a bright LCD display that provides current sensor readings, battery and logger status, memory capable of storing data from multiple data loggers, convenient, direct USB connection to host computer and easy and fast offload with Onset's HOBOware® software.

Onset Computer Corp **1-800-LOGGERS**
sales@onsetcomp.com **www.onsetcomp.com**

PCB Piezotronics (PCB®), a PCB Group Company, recently launched a series of recent upgrades to its homepage at www.pcb.com, developed to help customers find the best sensor and instrumentation products for their application. The PCB homepage includes varying images of typical applications, and a new, intuitive user search capability. This new interface allows the user to search by model number, product type and measurement type, from a database of more than 2,500 sensors, signal conditioners, cables and accessories, with up-to-the-minute, fully downloadable, specifications and drawings.

Andrea Mohn **716.684.0002, ext. 2216** **mktg@pcb.com**

LEDtronics introduces additions to its line of drop-in replacement MR 16-styled LED bulbs - the high-powered MR16 TrackLED's™. The new LED's are engineered to handle variations in voltages that may accompany "noisy"/"dirty" AC or DC power supplies, eliminating burnout from voltage that is higher than the lamp's capacity and the need to stock a variety of MR16 LED bulbs to coordinate with different voltages that may present with 12V-24V power supplies. LED lamps have an average lifespan of 50,000 hours (5 years), use only 10-20% of the energy consumed by incandescent lamps and are impervious to electrical & mechanical shock, vibration and frequent switching.

www.ledtronics.com **800-579-4875**

The Watchdog® EX Series Breathers for extreme humidity applications incorporate two check valves, one to control airflow into the protected reservoir and one to control airflow out. This prolongs the life of the desiccant by allowing the air to flow through the breather only when needed to protect the integrity of the tank. Unlike a membrane system, which does not allow internally generated gases and contaminants to exit the system, the Watchdog EX Breather offers all of the advantages of breathing air in and out of the tank while removing water vapor and solid particles before they contaminate the fluid.

Steve Southard **262-691-9471** **www.tricomfg.com**

Thermo Electron Corp. announced that its RadReachBack™ communications system is now available in its full line of radiation detection and identification instruments and systems. Open architecture enables users to integrate components to communicate wirelessly or through wired connections. The RadReachBack™ detection instruments contain a patented software capability that enables emergency personnel to get real-time, 24/7 technical analysis of radiation samples they find in the field. With the system, data from a personal radiation detector, mobile system or radiation portal can be sent directly to a command center, expert analysis facility, or even a next-level response agency.

Richard Oxford
440.945.2119 **www.thermo.com/rmp**

Larson Davis has introduced the Human Vibration Meter utility software, known as HVManager™, for Vibration Exposure Assessment and Management, designed to provide instantaneous tool assessments to all new standards, including the HSE recommended points system; EU physical agents directive 2002/44/EC; ISO 5349; and ISO 2631. With one click of a button, HVM 100 data can be downloaded directly from the instrument and saved to create databases of HVM100 Human Vibration Meter measurements for hand-arm and whole-body vibration. Daily vibration exposure for a worker using multiple tools for varying activities can then be generated in a single report.

Larson Davis **www.larsondavis.com**
888-258-3131 **sales@larsondavis.com**

With their capability to accommodate very heavy radial loads and compensate for misalignment, SKF CARB® toroidal roller bearings serve ideally as non-locating bearings in large electric motors (125 Hp and above). Their suitability for both coupled and belted loads provides users with a single bearing solution for motors, regardless of mounting method, and can help reduce motor inventory needs. These self-aligning roller bearings combine design features from several conventional bearing types to promote optimized performance, reliability, and longer service life.

SKF USA Inc. **800-440-4SKF**
skfusainfo@skf.com **www.skfusa.com**

Thermo Electron today introduced the Interceptor™, the first pager-sized instrument that enables anti-terrorism officials and other homeland security personnel to detect and identify possible nuclear threats. The Interceptor enables immediate identification of the radionuclide and electronically transmits the data, along with a digital picture and an audio description of the situation.

Richard Oxford
440.945.2119
www.thermo.com/rmp

The IMI Sensors Division of PCB® Piezotronics, Inc. launches the all new 686A Series two-wire electronic vibration switch. This groundbreaking switch technology is microprocessor controlled with no moving parts or mechanical adjustments required. The introduction of the new two-wire switch combines the reliability and dynamics of an electronic switch with the convenience of a mechanical switch, in one innovative compact design. The unique blueprint includes a U.S. patent pending feature that electronically adjusts the threshold value while the switch is installed on running equipment through a magnetically activated sensor.

IMI Sensors **imi@pcb.com**
800-959-4464 www.imi-sensors.com

Dytran Instrumented Impact Hammers provide a convenient way to excite machinery mounts, tanks, towers and other structures. When used with a multi-channel FFT analyzer and a response accelerometer, it is possible to measure transfer functions and develop mode shapes, find resonance frequencies and other dynamic characteristics of the structure. The hammers are available in three sizes providing head weights of 1lb., 3lbs., and 12lbs. to optimally excite most large structures. The hammers have a range of 5,000lbF and a sensitivity of 1mV/lbF. An assortment of tips is provided with the hammer kit to establish the width of the excitation pulse.

Bruce B. Lent
818.700.7818
Blent@dytran.com
www.dytran.com

GE Sensing's DewPro line of moisture and humidity transmitters gets a facelift. Updated to more closely respond to customers' needs, these flow-through and insertion transmitters now offer larger operational ranges, while providing a safe solution with certified packages rated for hazardous area requirements. Different versions of these compact, rugged, loop-powered transmitters can measure either dew point temperature from -90°C to 10°C or relative humidity from 0 to 100% in process temperatures up to 150°C.

Poupak Sepehri **978-437-1127** **Poupak.Sepehri@ge.com**

DIN Rail Universal Transmitter

The IMI Sensors Division of PCB® Piezotronics, Inc. introduces Model 682A06 DIN rail mountable universal transmitter. This module provides loop power for IMI's 4 to 20 mA vibration sensors, and is fully programmable using its detachable display. Once programmed, configurations are saved in the display unit for mirrored installation on subsequent modules.

The universal transmitter accepts input signals from all 640 Series 4 to 20 mA vibration transmitters; as well as VDC, ohm, RTD, TC, and potentiometer inputs. It provides output for current, voltage, and two Form A relays. Additional features include LED indicators for operation status and relay outputs, password protection for saved configurations, and error diagnostics.

IMI Sensors Division
800-959-4464 (US & Canada)
716-684-0003 (Intl)
imi@pcb.com
www.imi-sensors.com

Bernie DeWees
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3-D Service now offers complete service for electric power generating windmills throughout the country. To keep these windmills operating efficiently, 3-D Service provides regularly scheduled maintenance of all windmill equipment including couplings, gearboxes, generators and service hoists. The company also provides predictive maintenance services which track equipment vibration and electrical levels and lubricant contamination to forewarn of an impending equipment failure.

New MRC® "R Series" small inch-size ball bearings can serve as premium-quality "miniature" solutions to fit the smallest shaft diameters. Their availability in stainless broadens potential applications for these bearings by providing the capability to resist corrosion typically encountered in demanding or harsh operating environments. The design of these single-row deep-groove radial conrad-type bearings contributes to their capability to carry significant radial loads and substantial thrust loads in either direction, even at very high speeds.

Jay Carlson
716-661-2727
www.mrcbearingservices.com

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