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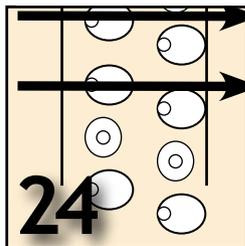
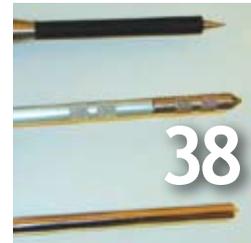
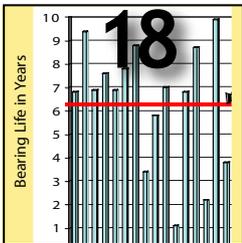
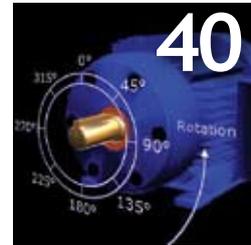
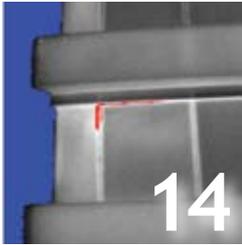


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Reliability Doing Its Part

I am proud to be involved in the maintenance and reliability community, in which predictive maintenance plays a major role, for a number of reasons. This is one of them...

You don't have to look very far these days to understand that the environment in general, and global warming in particular, is a major concern worldwide.

As part of its Fourth Assessment Report, The Working Group of the United Nations Intergovernmental Panel on Climate Change just published its Summary for Policymakers in February, and it contained this statement:

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

The science is clear on this... global warming is a fact. Since global warming is a fact, doesn't it make sense for each of us, at the very least, to do our best not to further contribute to it?

This means using our resources, both on a personal and corporate level, in the most efficient ways possible. In the end, isn't that what maintenance & reliability professionals do everyday? When you properly align the shafts, you increase efficiency. When you identify and eliminate a source of vibration, you increase efficiency. When you find and eliminate that compressed air leak, you increase efficiency.

We increase efficiency to decrease downtime which ultimately increases productivity and profits. We can hold our heads high because the work that we do everyday not only makes the companies that we work for stronger but also reduces the impact of our footprint on the earth. I'm proud of that.

Thank you for reading. Please don't hesitate to contact me with any questions, comments or suggestions that will help Uptime be more useful to you.



All the best,

Jeff Shuler
Editor In Chief

jshuler@uptimemagazine.com

1. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE,
Climate Change 2007: The Physical Science Basis, Summary for Policymakers
http://ipcc-wg1.ucar.edu/wg1/docs/WG1AR4_SPM_Approved_05Feb.pdf

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PUBLISHER
Terrence O'Hanlon

EDITOR IN CHIEF
Jeffrey C Shuler

EDITORIAL ADVISORS/
CONTRIBUTING EDITORS

Ron Eshleman	James Hall
Joseph Petersen	Alan Johnston
Greg Stockton	Jay Lee, PhD
Ray Thibault	John Mitchell
Jack Nicholas, Jr.	Jason Tranter
Howard Penrose, PhD	

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

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

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

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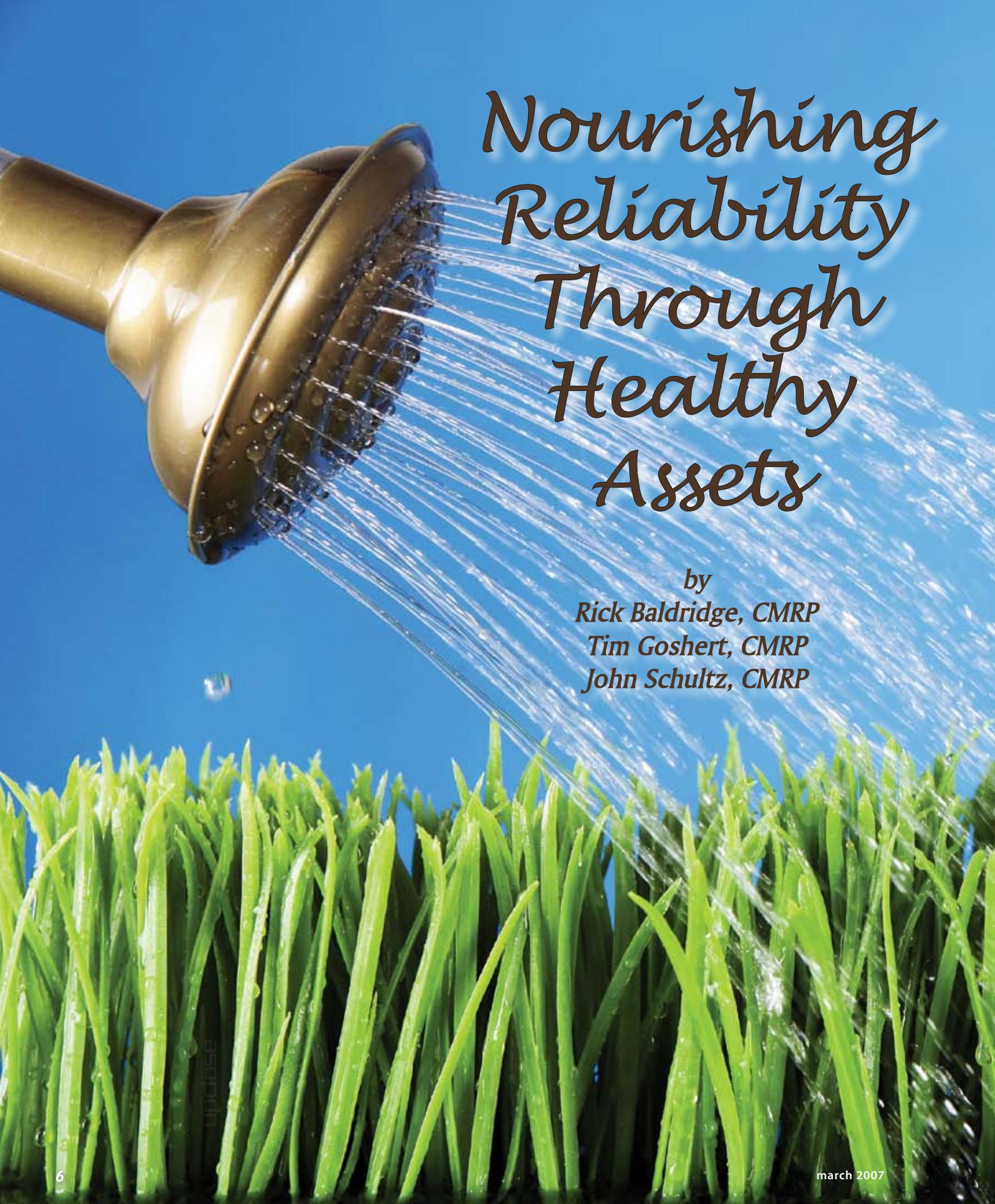
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Nourishing Reliability Through Healthy Assets

by
Rick Baldrige, CMRP
Tim Goshert, CMRP
John Schultz, CMRP

For about the last fifteen to twenty years, the maintenance and reliability industry has been talking about Asset Health. Software companies have helped enable this thinking by making simple Red – Yellow – Green score carding simple. What do the colors mean? Well, the easiest way to explain it might be with an analogy...

Analogy To Personal Health

Analogies are always being drawn between a facility's asset health and a person's health. If you have been in the maintenance business for any length of time, you have certainly heard this correlation. To help illustrate the connection, the following is a true story as told by one of the authors - Rick Baldrige...

My last name is Baldrige. Every single male as far back as we could go on the Baldrige family tree, with the exception of my father, my brother and me, has died of massive heart attacks. On my mother's side of the family, every single person, male and female, including my mother has fought a long, arduous battle with cancer. What does that say about my future? Let's just say it doesn't look too bright. In fact, I better finish my input to this article pretty quickly.

When my father turned 42 he really began thinking about this. His brother, father, all of his uncles, grandfather, as far as he could go back had passed away due to massive heart attacks. He gathered up all of the family history he could find and took it to his doctor. The doctor reviewed his history and said to my dad, 'This does not look good for you'. The doctor scheduled several exams, one of them being a blood chemistry analysis. One of several specific tests was for cholesterol. Cholesterol is like dirt and is the biggest enemy to the heart. The overall alarm band should not exceed 200, and most doctors have adjusted the alarm band to 180. My father's cholesterol was over 700. The doctor believed my dad was a walking heart

attack and wanted to put him into an ambulance and immediately check him in to the hospital. Of course, I had very similar concerns when I turned about 38. I went to the doctor and discovered that my cholesterol was 441. So why were all of the Baldriges dying of heart attacks? Without a quantitative assessment of my personal health would I have known that I had a circulatory problem?

This is the likely scenario. I enjoy and do a lot of hunting and fishing. I would have been walking across the prairie, up a hill or through the woods. I would become winded and have to stop to rest. Soon, my upper arms and shoulders would begin to ache. I would then feel like my 1996 Chevrolet 4-wheel drive pickup was parked on the middle of my chest. What happens next? Someone would be throwing dirt on top of me.

Do you happen to know what the first symptom is for 60% of all heart attack victims? I sure do. It turns out that the first symptom for those 60% of victims is death. What does that P-F curve look like? The subsequent collateral damage associated with point F is an unacceptable consequence of failure.

My father turned 72 on October 28 and in November we went deer hunting together in North Dakota. Chemically treated, his cholesterol is 117. My non-chemically treated cholesterol level is 177. In addition, we have researched all of the predominant male associated cancer failure modes on my mother's side of the family. Through research and quantitative assessment, I now know my current overall level of health and the failure modes that pose the biggest risk to me in the future. My mantra is "Early detection and elimination of defects".

Oddly enough, that sounds like a pretty good mantra for a proactive maintenance program as well.

What's the Difference?

What is the difference between understanding defects within our industrial physical assets and our personal body systems? Basically, the only difference is the consequence of failure. If we want to eliminate as many failure modes as possible, we need to gain an understanding of the health of our facilities.

Running a battery of tests to determine if an asset is healthy is an easy correlation to draw.

Unfortunately for the machinery condition monitoring community, few organizations have focused sufficient engineering forethought into putting all of the foundational elements necessary for meaningful asset health into place.

How difficult can it be to go do a bunch of condition monitoring (CM) and assign RED – YELLOW – GREEN. It's really not very difficult...unless, of course, you want it to mean something. Let's say we want to compare the percentage of healthy (GREEN) assets in a corn milling operation in the Netherlands to the percentage of healthy assets in a Corn Milling operation in Iowa. To make that comparison, we need for key foundational elements and standards to be in place. If standards aren't in place within an organization, there will most likely be a long debate on the definitions of RED – YELLOW – GREEN.

In the medical health monitoring community, there is a clear and consistent understanding of what the possible failure modes are, what

battery of tests should be run to detect those failure modes, and what "healthy" looks like for each test.

For asset health to be taken seriously by senior leadership, it must be standardized, meaningful, and repeatable. An asset health standard must be created. This year Cargill had their fifth internal Worldwide Maintenance & Reliability Conference. This conference had over 300 attendees and Cargill announced that next fiscal Year, they would begin to report asset health as a key balanced scorecard metric to their leadership team. This is a big step forward by a major worldwide organization and its implications should not be underestimated.

Nourishing Reliability Through Healthy Assets

Cargill is one of the world's largest privately held corporations. Cargill also holds other distinctions such as a having a passionate vision statement of "Nourishing the World" and having more Certified Maintenance and Reliability Professionals (CMRP) than any other corporation in the world. Cargill believes that their approach to maintenance and reliability is a competitive advantage and, to most organizations' surprise, it is not all about "maintenance costs".

As Ron Christenson, Cargill's Chief Technology Officer, points out:

"A key element of Cargill's strategic intent is to be the "partner of choice" to worlds we serve. Underlying being a partner of choice is trust. Cargill's COO, Greg Page, defines trust as promises made and promises kept over time. The most fundamental promise we make to our partners is to deliver our products and services on time, every time. That can only be achieved with world class plant reliability. Cargill has been on the journey to

world class reliability for more than 10 years and our partners are benefiting from our improved reliability. Reliability is an important factor in Cargill being chosen by our customers."

Like many other corporations, Cargill adopted the concept of creating corporate Centers of Excellence (COE). One of the COEs is set up for Maintenance and Reliability, and its mission is to:

"Define and establish direction and leadership to the corporation's business units to promote and champion the implementation of maintenance & reliability concepts for increased reliability, lower costs and improved asset health of facilities worldwide."

It's important to notice that maintenance costs is an outcome of focusing on increasing asset reliability. At the base of improving asset reliability is Cargill's initiative to measure, manage, and improve the health of the assets.

With regard to the often utilized P-F Curve (Figure 1), most "maintenance initiatives" focus on Point F and try to "manage the event". When your focus is on asset health, your focus is on Point P – "early identification and elimination of the defect". So, as soon as an inspection (though either a PM or condition monitoring) can identify that a defect is present (Point P - "Early Signal"), that asset is RED!

This early identification of the defect can enable the proactive workflow model (Figure 2). This is in marked contrast to merely utilizing the technologies to optimize a run to failure maintenance strategy. If you have an optimized PM/condition monitoring process that is failure mode driven, that process (including inspections and follow-up work) drives 75-85% of your workflow. If you plan and schedule your work, execute the work with precision, and have a continuous improvement process – you will be a pace setter – period.

Asset Health Standard

The steering committee was convinced that asset health needed to be a balanced score card metric, but it was also convinced that for it to be meaningful, a standardized approach had to be applied. As with any

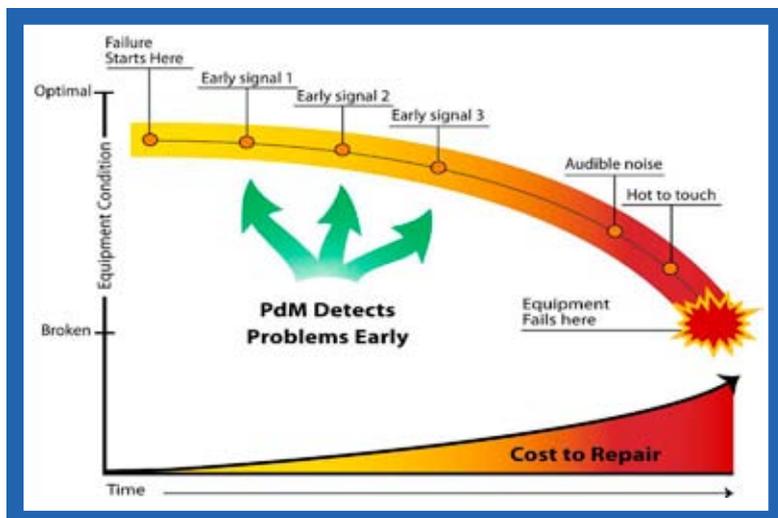


Figure 1 - P-F Curve

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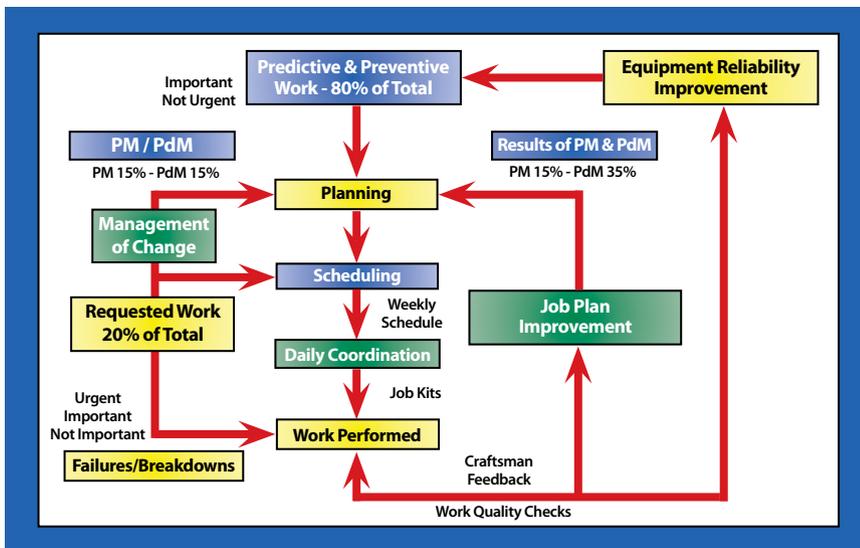


Figure 2 - Proactive Workflow Model

important metric in any corporation, if there was no standardization, the metric would approach and exceed expectations regardless of what was really happening. Cargill and Allied Reliability jointly developed an Asset Health Standard (Figure 3) to address this need.

The Challenge

There were two concerns expressed by Cargill leadership that had to be addressed – How Much and How Well.

How Much - how do we know that a facility reporting Asset Health is applying the standard to a high enough percentage of

their assets to be representative? In other words, many facilities only apply condition monitoring technologies to 10% of their most critical assets, or only supply a couple of technologies. This approach will not enable the Proactive Workflow Model, will not drive bottom line results, and will not give you a representative picture of your Asset Health. Figure 4 is an example from a plant where the “Grey” represents how many assets the given technology could be applied to, the “Green” represents “Best Practice Performance” based on benchmarking, and the “Orange” represents a plant’s given level of coverage. An organization must identify what the MINIMUM level of coverage

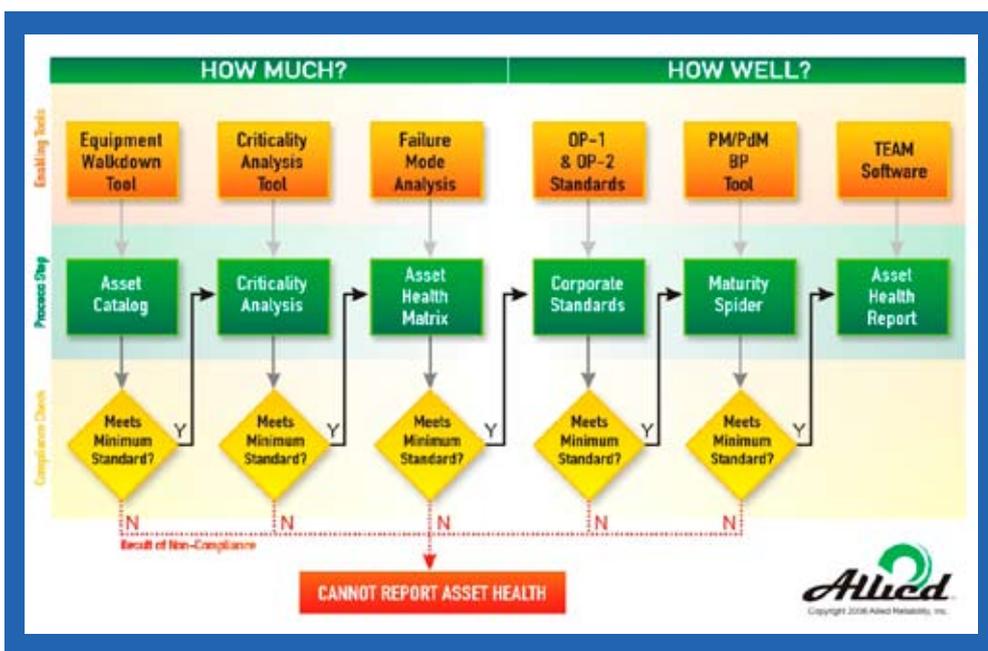


Figure 3 - Asset Health Standard Flow

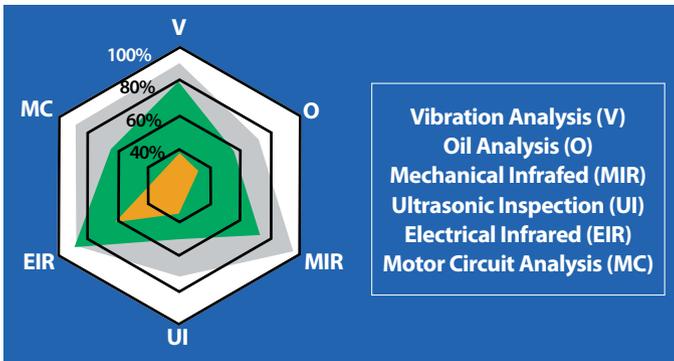


Figure 4 - How Much Condition Monitoring Coverage?

required is before a site has earned the right to report Asset Health.

How Well – how do we know that everyone is applying the same standards, in the comparable way, and with a comparable level of rigor? It has been found that many organizations will try to take short cuts and apply less effective Condition Monitoring technologies, lulling themselves into a false sense of security. While many of these techniques (overall vibration pens, point radiometers, etc.) are great “additions” to the Condition Monitoring process to drive additional engage-

ment, they should not be a substitute. Every technology needs to have a written standard for personnel and for technology execution. Compliance to those standards must be periodically audited or it is likely that standards will slip. Figure 5 is an example of a scoring table that is used to assign level of maturity. However, detailed data sheets and qualified assessors must also

be utilized to guarantee consistent application of the scoring process.

Once each technology has been scored and the supporting work process has been evaluated against the standard, an overall Maturity score is assigned (Figure 6). The standard must include the minimum standard for “How Well” that is required before a site can report Asset Health.

As shown in Figure 3, we identified that the Asset Health Standard must address both How Much and How Well.

The Process – The Required Elements

The process is broken down into three distinct elements that are all required for successful and consistent application of Asset Health – Enabling Tools, Process Steps, and Compliance Checks.

Enabling Tools – Cargill has over 1,200 operating locations in over 60 countries and is engaged in over 80 businesses globally. It was determined early on that enabling tools are absolutely necessary to ensure effective and efficient application of Asset Health. These tools enable the process steps and identify the compliance criteria that must be met to go to the next toll gate. For instance a walkdown tool was developed that ensures the correct data for the development of an Accurate Asset Catalogue. If you use and are task qualified on the tool, it is highly likely that you will meet the acceptance criteria. The focus was on the process steps and the tools were developed to enable those steps.

Process Steps – There are five prerequisite process steps that must be in place before a site is allowed to report Asset Health:

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Element	Level 1	Level 2	Level 3	Level 4	Level 5
Quartile Coverage	Spot Checks	4th	3rd	2nd	1st
Expectation	Trouble Shoot	Optimize Run to Failure Strategy	Do More PdM	Enable Proactive Workflow Model	Early Elimination of Defects & Root Causes
Employee Certification & Qualification	Nothing Formal	Level I - Supplier	Level II with Written Practice	Level III to International Standards	Certification plus Task Qualification
Standards & Controls	Nothing Formal	Based on Individual motivation skills, multiple people inputting data	Some basic database standards created with controlled input	Standards created with controls to monitor, formal workflows exist	Advanced standards created and MOC process used for changes

Figure 5 - Sample Scoring Table

1. The site must have an Accurate Asset Catalogue
2. The site must have completed a cross-functional Criticality Analysis
3. The site must have utilized an Asset Health Matrix (Figure 7, page 13)
4. The site must have met both the personnel certification and technology application standards established by the COE.
5. The site must be applying all of this to the required Level of Maturity

Compliance Checks – For each process step, detailed compliance criteria had to be developed and rigorously applied for the Asset Health Metric to have any meaning.

Process Steps Highlighted

Asset Catalog – questions such as what level of hierarchy granularity and what equipment data fields must be populated are just a few

examples of criteria that must be identified and satisfied.

Criticality – what functional areas must participate and what level of granularity must be incorporated are examples of criteria that must be defined and met for compliance with this process step.

Asset Health Matrix – what percentage of your mechanical, electrical and stationary assets must be on the program and what are the minimum failure modes that must be monitored for inclusion?

Corporate Standards – Do the site personnel meet the certification requirements outlined in the corporate written practice (training, testing, experience, oversight) and are the technology databases/inspection procedures compliant with the corporate standards?

Maturity Level – An annual audit by qualified

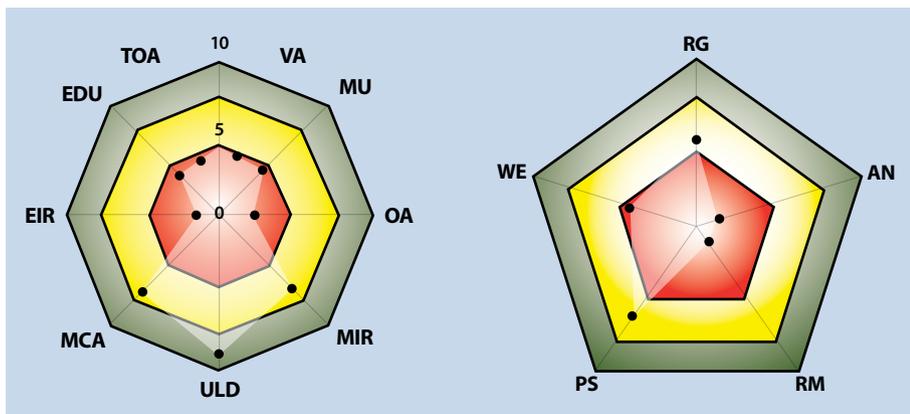


Figure 6 - How Well?

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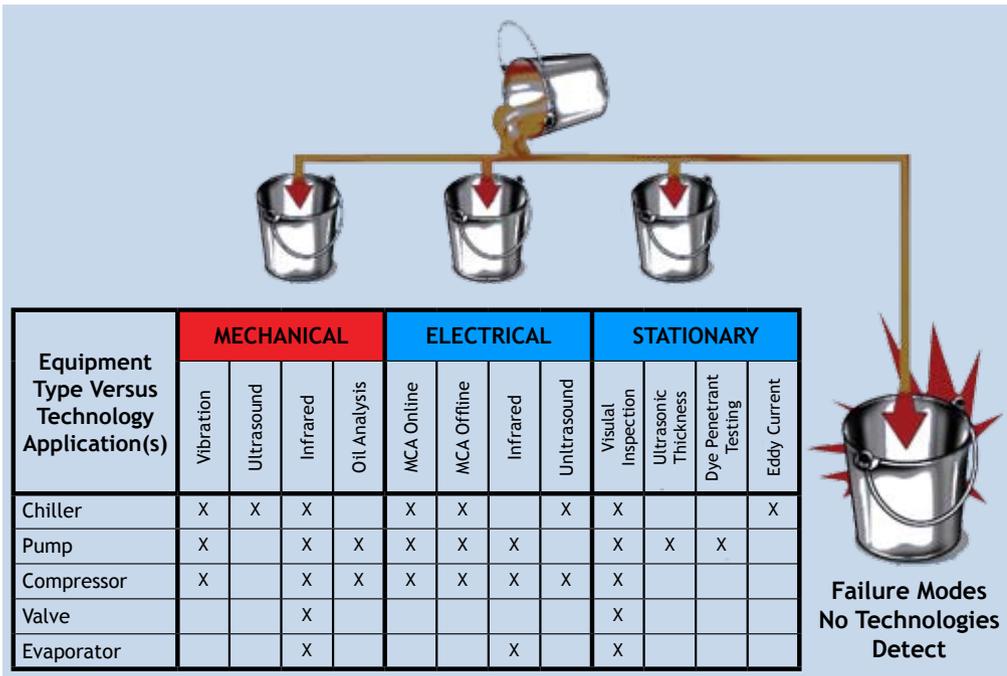


Figure 7 - Asset Health Matrix

personnel to ensure that the other elements are in place and that the supporting work processes meet the minimal level of maturity. Subjectivity must be minimized by providing high quality assessment questions; this will include well defined answers, a definition of question purpose, a definition of what best practice within that question looks like, how to validate data, and the targeted KPIs.

Conclusion

Like any other metric, for Asset Health to have any meaning, it must be defined. The definition must include "How Much" and "How Well". If the criteria are not met, a site must not be allowed to report the metric. To date, Asset Health has been a philosophy, but today with standard definitions, it is a Key Performance Indicator that the Cargill leadership team needs to use to drive our reliability improvement.

Rick Baldrige, CMRP, has 26 years of experience working in the agriculture and food processing industry. Rick is currently the Reliability Leader for the North American Grain and Oilseeds Export and Processing business units within Cargill, Incorporated. He holds a Bachelor of Science degree in Animal Science and an associate degree in business and psychology from North Dakota State University. Contact Rick at rickb2@charter.net or rick_baldrige@cargill.com

Timothy Goshert has 28 years of experience working in the food processing industry. Tim's current role is the Worldwide Reliability and Maintenance Manager with Cargill, a position held since 2000. In his current role, he is responsible for the company's worldwide reliability and maintenance initiatives and is chairman of the company's Worldwide Reliability and Maintenance Steering Committee. Tim holds a B.S. in Chemical Engineering from Penn State University. Tim earned his CMRP (Certified Maintenance & Reliability Professional) designation from SMRP in 2001. Contact Tim at tgoshert@hotmail.com or Timothy_Goshert@cargill.com

During the last 16 years, John Schultz has helped over 200 manufacturing locations save millions in direct costs, while increasing production, improving quality and reducing inventories. After helping Eli Lilly & Company develop one of the best reliability programs in North America, John founded Allied Services Group in 1997 – now called Allied Reliability, which is a consulting firm and service provider to some of the biggest names in American manufacturing, such as Cargill, Pfizer and Alcoa. A native of Terre Haute, Indiana, John holds bachelor's degrees in Mechanical Engineering and Economics from Rose-Hulman Institute of Technology. He lives in Charleston, SC with his wife and two children, and can be reached at (812) 841-9252 or schultzj@alliedreliability.com

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Seeing Green with Infrared

Infrared Thermography for Building Managers

by Gregory R. Stockton

Think back to the 1990s. How important was building energy efficiency, building moisture or building quality? Now think about the past 6 months....has your boss asked you to study your energy usage? If not, (s)he soon will. Thinking “green” has become in vogue. Why? Is it because your boss recently watched “An Inconvenient Truth” and became convinced that your company must do its part to stop global warming? Could be, but that’s probably not the reason most companies are thinking green today. Green thinking is about green-backs.

Building costs and energy costs are on the rise and by inspecting a building with IR and other techniques, the owner can determine what needs to be done to manage the building asset better, use less energy and save money.

There are four types of buildings by use:

- Residential--houses and apartments/dwellings of all types
- Commercial--office buildings, retail stores, malls
- Industrial--manufacturing facilities and factories
- Institutional--college and universities, hospitals, government buildings

From a building manager’s point of view, infrared thermography can be a very useful tool. Some of the many applications are: predictive maintenance of electrical and mechanical systems, manufacturing process quality assurance, product research and development, non-destructive testing and building thermography. This article focuses on building infrared; specifically construction quality assurance, building thermal and moisture envelopes. Building IR survey applications can be divided into categories such as heat loss, moisture intrusion, insulation quality assurance, structural and pest surveys.

Building Thermography...It’s Not That Easy

To be an effective tool, an infrared thermographer must know the limitations of the imager, the way that buildings absorb, retain and radiate heat energy and the best time to perform a given survey. He/she must have an imager capable of finding and documenting problems (or lack thereof) and more importantly, a working knowledge of building physics and an understanding of the thermal dynamics that are in play.

Building IR applications can be some of the most demanding work in terms of on thermal imager sensitivity and spatial resolution, two of the most important factors in an imager’s ability to focus on what can be physically small and/or thermally miniscule problems on a giant object. Coming up with effective techniques and good timing to perform these surveys also presents a challenge. For example, there is a different methodology for surveying the framing, missing insulation, heat loss, air leakage and moisture intrusion in the same building. IR can only detect surface temperature differences, but the patterns that these differences leave (IR signatures) can often indicate what is going on within the building to a very high degree of confidence.

Construction Defects

Liability is a real issue for sellers, buyers and insurers. The costs of construction, repairs and renovation are increasing dramatically as owners bring construction lawsuits against the contractors. “Getting what you paid for” is not a new concept, but perspective building owners are increasingly concerned about the costs and quality and efficiency of their investments. Infrared thermography can be used as a building quality assurance tool during construction, so that repairs can be made without destroying the building or delaying the building process. Since all building materials will absorb, retain and radiate heat energy at a different rate, building components can be checked for the quality of installation using IR. For instance, “cinderblock” or

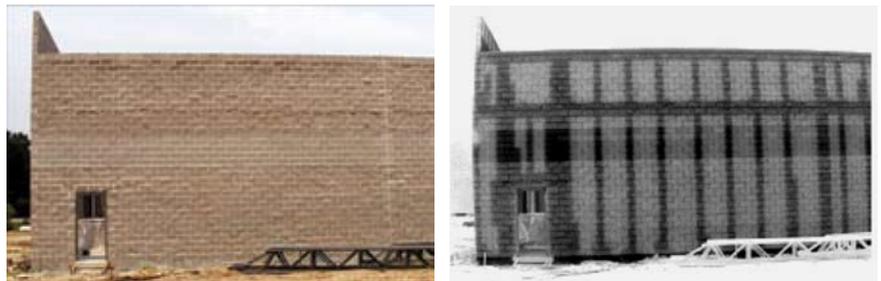


Figure 1- Visual and infrared image of a CMU wall.

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CMU (concrete masonry unit) walls are erected on nearly every street corner as malls, schools, warehouses, retail, convenience stores and more. CMU walls often have rebar and grout-filled cells as a structural component. By allowing the wall to absorb energy during the day and watching the heat energy dissipate at night, the building infrared thermographer can use the "picture" of the heat from the wall, to define exactly where the grouted cells are

and where they are missing (See Figure 1).

Don't Get Soaked

Design flaws, entrained moisture in roofs and walls and water leaks cause billions of dollars worth of damage to buildings every year. In very hot and very cold climates, poorly installed insulation and vapor barriers can lead to condensation problems and the degrada-

tion of the building itself. This can cause rot, mold and mildew, all of which lead to the building being devalued. In warm climates, as more "fresh" moist outside air is mechanically introduced into buildings in an attempt to make the building healthier, condensation and its side effects --mold and mildew-- become a real threat to the building owner and manager. Mold is a microscopic fungus known to destroy building materials and cause health problems for many individuals (See Figure 2).

Occupants are asking for more "healthy" buildings in which to work and live. Now, infrared thermography cannot be used to detect mold itself, because mold does not exhibit an exothermic reaction strong enough to be seen by an infrared camera walking around a building. But building infrared thermographers can help find moisture and without moisture, mold grow is limited. Roof moisture detection can be accomplished on almost any type of system either by looking up at the roof or down onto the roof. In roofs with attics, the thermographer looks for the evaporative cooling effect of water. In flat or low-sloped roofs



Figure 2 - Mold found inside a wall by finding moisture indications with IR.

(See Figure 3), IR imagery can pinpoint areas that contain moisture. By marking up the CAD drawings with the wet areas, surgical repairs are made, extending the roof's useful life.

Building Inspection Motivation Factoids

Even though using infrared thermography to examine a building can often pinpoint problems, owners may have different reasons for wanting to know [or not wanting to know] about the condition of a given building. Here are some examples:

- Buildings are often owned by one company

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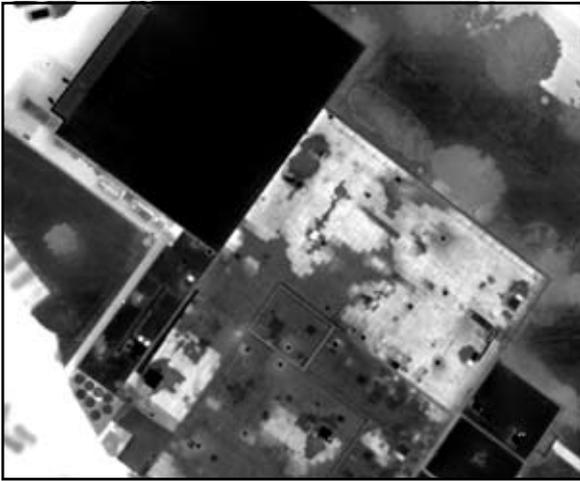


Figure 3 - IR image of a flat roof. (Light areas are entrained moisture.)

and leased to another. If the tenant is paying the utility bills, he/she wants the building to be energy efficient, but the lease may not be long enough for the tenant to enjoy an appreciable return on the investment from re-insulating the building or plugging up the air leaks. The owner has no financial motivation to make the building more energy efficient unless he/she is paying the heating/cooling bills or can use the fact that the building energy costs are low to his/her advantage in a sales negotiation.

- There is nothing remedial about infrared thermography itself, or any other type of testing for that matter. I have been looking at buildings with infrared cameras for 17 years and not once has a building that I scanned ever repaired itself. IR can pinpoint and document problems, but often the repair costs are more than the owner can afford, or the payback is too long.
- Sometimes, finding out that there is a major problem with a building opens a “can of worms” that the owner would rather not



Figure 4. Visual and IR image of an air leak on a window.

have opened. Also, some building owners may not be willing to pay the cost of repairs if they move every few years, because they figure that if they can live with problems for a while, then the problems will eventually become someone else's.

- Industrial building owners [manufacturers] care about one thing...how many of their widgets go out the loading dock door that day. Unless it affects the bottom line (like a refrigerated warehouse or a building that needs to maintain exact temperature control), most are not concerned about energy loss until it starts to: a) damage the building from condensation, b) affect the operation, or c) make the people inside so uncomfortable that they revolt. In a factory where 85% of the kilowatts are consumed by machinery, the heating/cooling bills are not the issue. But as energy costs go up, the manufacturing companies will be looking for ways to save on heating and cooling costs and reduce energy costs for machines that heat. What a perfect application for infrared!

Going Forward

Inspecting buildings for heat loss was one of the first uses for infrared thermography. As we decide to become less dependent on fossil fuels, IR thermography will again be used as it was in the 1980s to monitor the energy efficiency of buildings. Now, with the new IR cameras and more thermographers, more buildings will become energy efficient and better built. Volumes can be written on thermography for buildings and building subsystems. I'll just leave you with this thought -- Think green and the greenbacks will follow.

Gregory R. Stockton is the founder of Stockton Infrared Thermographic Services, Inc. The North Carolina-based corporation operates eight divisions performing many different infrared services in the US, Canada, Central and South America. Mr. Stockton has been an infrared thermographer since 1989 and has published numerous white papers and articles on the uses for infrared thermography over the past 15 years.



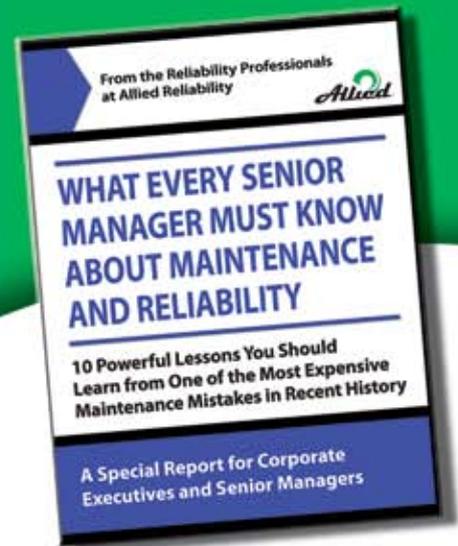
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Basics of Bearings

What You Don't Know Could Kill Your Uptime

by Ricky Smith, CMRP

This may come as a shock to many people. In the majority of cases, bearing failures can be predicted far enough in advance to order a replacement bearing, plan the job properly, and schedule the replacement months before failure. Many companies are successful in predicting the failure of bearings, yet fail in their work process due to a very short window of time that occurs between diagnosing the failure and the actual failure of the bearing. Even though the failure was predicted, this process is still known as reactive maintenance, which many companies know quite well.

To transition from that reactive maintenance environment, a serious culture shift may have to occur not only at the maintenance level but also at the operations and plant level as well. Remember this quote from Albert Einstein, "We can't solve problems by using the same kind of thinking we used when we created them."

One study shows that the motor component with the highest failure rate is the motor bearings. Of all the motor failure types surveyed, 51% of those failures were due to the bearings. To help eliminate bearing failures, you must understand the problem before you can understand the solution. Understanding the problem begins first with understanding bearing life.

Understand Bearing Life (L₁₀ Life)

Understanding the basics of bearings reliability is important and one of the first steps to predicting bearing failure. Anti friction (typically thought of as ball and roller type) bearing life is measured in terms of the Basic Rating Life, L₁₀ or B₁₀. The L₁₀ life is the more commonly accepted identifier in today's world and is simply stated, that "90% of a group of identical bearings should provide a specific minimum life in hours when operating under conventional conditions". This conversely means that 10% are expected to fail within the same time frame. Bearing manufacturers also refer to the L₁₀ life as the "minimum expected life". Bearing life is calculated based on bearing revolutions which can be correlated into expected life of the bearing as seen in Figure 1. This chart is based on identical bearings on identical

RPM's	Average Running Hours Per Day		
	8	16	24
60,000	23.2 years	11.7 years	6.4 years
80,000	30.7 years	15.6 years	9.3 years
200,000	61.4 years	31.2 years	18.6 years

Figure 1 - L₁₀ Bearing Life under Various Conditions.

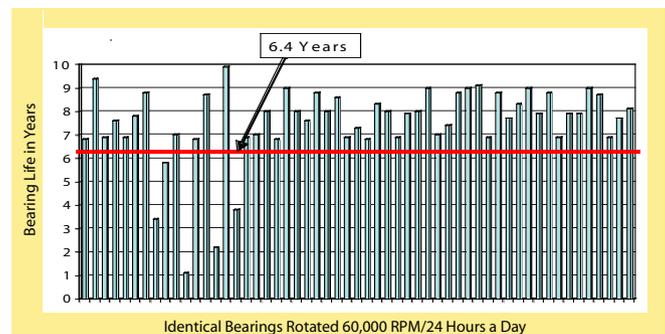


Figure 2 - 5 of 50 Bearings Will Fail Before Expected Life.

equipment operating 365 days a year. For example, if we were to look at 50 identical bearings operating at 60,000 RPM, 24 hours a day, five of these bearings (10%) will be expected to fail before they reach their expected life of 6.4 years.

Predicting Bearing Failure

Statistics have shown that as much as 60% of the equipment reliability is determined when the equipment is in the design phase and still on the drawing board. Proper design should take into consideration the proper type of bearing for the application, the bearing loads, equipment speeds, and environmental factors such as temperature, moisture, and chemical agents. Proper equipment design utilizes the L₁₀ life to build bearing reliability by choosing the correct bearing based on that "minimum expected life". However, the success of the bearing design also relies on other factors, such as proper manufacturing of the bearing, proper storage before use, the correct installation procedures, the operating context, and precision maintenance. These factors lead to the real world of reliability basics. Reliability studies over the last 30 years say that roughly 80% of asset failures are random. This is quite a departure from what we would expect, yet research has proven that for the majority of components (including bearings), there is no correlation between age and how likely they are to fail. To help us predict bearing failure at an early enough

stage so that we can properly procure replacement bearings, plan the job, and schedule the replacement; we must utilize proactive tools. In simplest form, this can be an inspection of the equipment by operations personnel listening to the equipment, feeling the temperature, smelling abnormalities, and seeing items like an oil leak. For more advanced prediction, utilize technologies such as vibration analysis, infrared thermography, and ultrasound. The goal is to detect early signs of random failure by monitoring the health indicators to determine when the bearing will fail using the P-F interval. The P-F interval is the time between the detection of a potential failure (P) and when the bearing has functionally failed (F), as demonstrated in Figure 3.

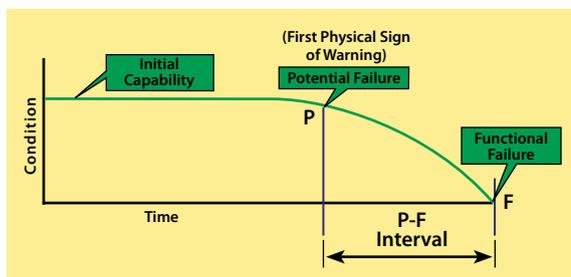


Figure 3 - P-F Curve. Many times for Bearings Functional Failure is equal to Total Failure.

With bearings, a functional failure is typically found to be a total functional failure which means the bearing has been degraded to the point it no longer rotates or performs the function required of it. It has broken and maintenance is then called because you have a breakdown. This breakdown is what you do not want to see. Using the P-F interval you want to identify the first sign of failure. This is “P” on the graph in Fig 3, and this interval is typically time based. At first you may or may not know this interval and, thus, may have to take the best estimate from maintenance personnel, operators, or reliability engineers.

Once you use the best method of identifying bearing failure and the P-F interval is known, then failures can be mitigated and controlled. Once bearing failure has been detected, the bearing replacement can be planned and scheduled based on the P-F interval. The point from which a bearing failure is detected “P” and actually fails “F” can be months or years. This allows for scheduling far enough in advance as not to interrupt production schedules and, thus, reduce losses due to unscheduled downtime. When you follow this process you can see many years with minimal unexpected bearing failure.

So far, I have talked about understanding

bearing life, designing bearing applications, and predicting failures. Earlier in the article, I mentioned making the culture change to move away from a reactive environment. This means implementing the requirements of proper storage, installation, maintenance, inspection and job planning procedures in a disciplined and precise manner. If not willing to follow these requirements, you are wasting time reading any further in this article.

The “Requirements”

In order for bearings to meet the required L_{10} life, there are a few requirements. First, the bearings must be handled properly in the storeroom and installation. Second, the bearings must be installed properly. This means the installation should be in accordance with manufacturer’s specifications and directions. After the correct storeroom and installation procedures have been followed, the bearing must be maintained with the correct type and amount of lubricant, and the equipment operated to a standard. These are requirements, not just recommendations.

Remember this fact, 70-80% of equipment failures are self induced. In order to mitigate bearing failure you must ensure the bearing has the chance to live a long life. Let’s look at these areas in more depth.

Storeroom Requirements - Bearing manufacturers can provide specific procedures as to how to store bearings and obtaining these procedures is highly recommended. An assessment by a bearing supplier of your bearing storage area is often free and a good idea to maximize bearing life. In general terms, bearings have specific requirements which must be met in the storeroom that include the following:

- Vibration – bearings (especially large bearings) should be stored in a location where vibration is kept to a minimum. If you cannot store these bearings in a low vibration environment, then they should be stored on vibration mats.
- Bearings are manufactured to extremely tight tolerances and require care when storing and moving. Consider them as fragile items. Store them at the correct angles. For example, a tapered roller bearing should be stored taper down and never stacked.
- Heat - Bearings should not be stored in high temperatures. The storage temperature should be kept between 68-72° F (+20-25° C) with low humidity. One problem in a hot environment is the

base oil separates from the thickener used to grease the bearing when it was manufactured. In addition to rust, this removal of the thin lubricating film on the bearing elements allows for metal to metal contact.

- Storeroom should issue bearings as first in, first out basis. This rotation of stock allows each bearing to spend the maximum portion of its life on the equipment and not on the stockroom shelf. Mark the original packaging with the date received using a soft permanent marker.
- Ideally, the bearing storage area should be a clean and sterile environment. Eliminate moisture, dust, and chemicals. No products such as acids, ammonia, salt, cleaning solutions, or gases should be stored in the same room.
- Always leave a bearing in its original package unless advised otherwise by the bearing manufacturer.
- Never allow personnel to handle a bearing in the storeroom and leave the bearing open to the environment.
- For larger bearings and longer term storage, a preventive maintenance program might be required to ensure proper bearing health.

Installation Requirements - This requirement is quite simple. Always follow the equipment and bearing manufacturers recommendation for handling and installation. Improper bearing installation practices cause a large amount of bearing failures. Make sure bearings are not hammered onto a shaft or installed without setting the proper clearance (if required).

- Properly remove old bearings and seals ensuring that damage does not occur to the shafts and surfaces.
- Effectively clean and inspect the shafts, keyways, and bearing surfaces for damage. A primary goal is the prevention of contamination.
- Inspect the new bearing. Ensure all of the elements are there such as rollers and balls. Look for rust and pitting. Check for lubrication.
- Ensure proper alignment of bearings, shafts, and other components.
- Again, use only manufacturer approved installation procedures.

Before I break out some of the requirements, I want to share more about lubrication. Proper lubrication is one of the most overlooked methods for ensuring bearing life. Studies from bearing manufacturers show that over half of all bearing failures can be attributed to poor or inadequate lubrication conditions.

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This can be as simple as selecting the correct grease or oil type for the operating context or conditions, not mixing incompatible grease or oil types, avoiding contamination, not over-greasing, and proper lubrication intervals. The purpose of lubrication is to prevent direct metal to metal contact with elements within the bearing. For roller-type bearings, lubrication also reduces friction and heat wear, helps to dissipate the heat from friction, prolongs the bearing life, prevents rust, and provides protection from contamination. Select proper sealing systems to ensure that contamination (moisture, dust, chemicals) does not become entrained in the lubricant, and to ensure the lubricant stays inside.

Regarding the selection of the appropriate grease and not mixing incompatible greases, realize that greases typically consist of the base oil (either natural mineral oils or synthetic oils), thickening agents (metallic soaps and non-soaps), and additives (added to improve certain properties like anti-oxidants, rust prevention) that are combined to form a certain consistency. This consistency can be measured using the NLGI Consistency Index that determines the “softness” of the grease. The index reflects grease penetration, so the larger the number, the stiffer the grease. For most

roller bearing applications, greases with NLGI index numbers of 1-3 are typically utilized. The general rule for mixing greases, even similar grease with different brands is simple, “Don’t Do It”. Often when different kinds of greases are mixed, the consistency becomes “softer” and the operating temperature range will be lowered. Mixing between brands can be problematic due to the additives used. For obvious reasons, don’t mix food-grade greases with their non-food grade counterparts. Unfortunately, this is not uncommon in surveys of food manufacturing facilities.

Prevent contamination by utilizing the correct storage and transfer containers. Keep the containers sealed to prevent contaminant intrusion. Use desiccant or hygroscopic breathers where appropriate to eliminate moisture. For grease guns, the worst method for filling them due to the contamination concern is to scoop or spoon grease into the gun cylinder and pack it to remove the air bubbles. Care must be used with grease tubes and pumping from a bulk container to ensure proper contamination control.

Lubrication of the bearing with the correct lubricant at the correct time is so important because if metal to metal contact occurs only

once, bearing failure will begin. Adding too much grease can cause an abnormal load on the bearing also causing premature failure. To prevent over or under-lubrication, determine the correct amount and interval for re-lubrication of the bearings based on the operating context (running hours, operating & storage temperature, equipment loading, etc.). Calibrate and label your grease guns. Every grease gun is different in respect to the volume of grease dispensed with one shot or stroke of the handle. Know that 3 shots on a particular gun equates to a set volume (i.e. one ounce) of grease. Color code the grease guns and lubrication points, and label the points with the lubrication amount required and frequency. Colored zerk fittings are available to match the grease gun color code. Set up all lubrication points on a PM-type route with a checklist. Since improper or lack of lubrication can provide upwards of 50% of failures, get people trained in the correct methods.

As a general rule, bearings and their housings should only be filled to 30-60% of their lubricant capacities. If equipment speeds are high and the need to reduce the rise in temperatures is present, less lubrication is required. Roller bearings require a more frequent lu-

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brication schedule than ball bearings due to the high radial loading present. Lubrication intervals and amounts can be determined several different ways. Bearing manufacturers provide calculation methods based on bearing dimensions. Predictive technologies can be utilized as well. For example, ultrasound or vibration can be employed as grease is slowly pumped into the bearings while running. The amplitude or sound decreases and additional shots are singularly added that cause a slight increase in amplitude or sound until each shot is carried away by the rolling elements. This process continues until the calculated amount of grease is added. Work with your bearing manufacturer to ensure you are applying the correct volume of grease at the correct frequencies to sustain bearing life.

Maintenance Requirements - Due to the discipline required, the maintenance requirements are often the most difficult requirements to follow. Remember that our goal is precision maintenance.

- Work with operations partners to keep the equipment clean to help prevent bearing contamination or wear on surfaces. Avoid using pressure devices like air nozzles and pressure washers that can

bypass bearing seal systems and introduce contamination.

- Perform preventive maintenance inspections using sight, smell, hearing, etc. with operations and maintenance personnel.
- Operate equipment within equipment manufacturer's specifications. Abnormal stops and starts can cause abnormal loads to bearings.
- Validate precision alignments when other components are replaced.
- Use belt tension devices to ensure proper bearing loads. Set chain tensions by manufacturer recommendations as well.
- Tighten mountings using torque wrenches to ensure correct fastening levels.
- Technical maintenance requires proper job planning to provide task specifications, installation procedures, kitted parts required based on the Bill of Materials, tools required, estimated time to complete, etc.

It is my hope that you recognize proper bearing maintenance requires more than just maintenance; it requires the participation of operations and the storeroom, among others, in established "best practices". For many organizations, this is the culture change that

must occur to move from a reactive program to a proactive program, which may be the difference between your plant closing or staying open.

The items mentioned in this article are not recommendations but requirements in order to stop bearing failures in their tracks. Stopping your bearing problems does not require any magic, just knowing what to do and the discipline to execute the right way every time.

Ricky Smith has more than 30 years of experience working in over 400 plants world wide providing increased reliability and maintainability in asset management. Ricky has worked for such companies as Exxon, Hercules Chemical, and Alumax Mt Holly (recognized for over 18 years as the best maintained plant in the world) in all levels of maintenance and maintenance management. Ricky holds designations as a CMRP and CPMM. Ricky has written a number of books and his latestst books, "Rules of Thumb in Reliability Engineering" and "Best Practices in Maintenance and Reliability" are due out in mid year 2007. Ricky can be contacted at ricky-smith@comcast.net

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Variations in Hi-Pot

Electric Motor Insulation to Ground Testing

by Howard W. Penrose, PhD, CMRP

We have been covering back to basic discussion and tricks related to electric motor testing over the past several months. This month, we will discuss High-Potential (Hi-Pot) testing and its variety of types and uses for the evaluation of electric motor insulation to ground systems. The use of Hi-Pot testing has been around for over a century, much like insulation to ground testing, except that the Hi-Pot is a stress test.

The Different Hi-Pot Test Methods

There are three basic types of Hi-Pot tests used for testing electrical insulation systems, including the rotating machine itself and the cable providing power. These include the AC Hi-Pot, the DC Hi-Pot and the Very Low Frequency Hi-Pot. Each of these has its specific uses, strengths and potential dangers to the operator and equipment being tested.

The AC Hi-Pot test is strictly a pass/fail test performed at a value of twice the nameplate voltage plus 1,000 Volts for new machines applied for one minute. For used insulation systems, the value that is applied should be 125% to 135% of the nameplate value for one minute. Because of the high voltages applied, and the difficulty in controlling the charging current, if an insulation defect is discovered, it will generate carbon tracking through the defect and other weak areas of the insulation system, destroying it. The high voltages, and potential high currents, also generate a possible personnel hazard to those performing the testing.

The DC Hi-Pot test is performed using DC power at a value of twice the nameplate voltage plus 1,000 Volts with the total multiplied by the square root of three for new insulation systems. The new insulation system value multiplied by 65% to 75% for the value tested on used insulation systems. The charging current and leakage current can be monitored during this type of test. This test can also be dangerous to the condition of the insulation system, so an alternate method can be applied referred to as the step-voltage test. In the step voltage test, the voltage is brought up 500 or 1,000 Vdc at a time. The current will briefly spike, then decrease, which relates to the charging current. The current that the value settles on is referred to as the leakage current.

The Very Low Frequency (VLF) DC Hi-Pot was originally used in cable testing to detect 'treeing' insulation systems (tiny fractures). The VLF Hi-Pot applies a 0.1 Hz frequency to the insulation system which 'excites'

the insulation system. This presents an opportunity for rotating machine testing with the power of an AC Hi-Pot and the safeguard of the DC Hi-Pot.

Basic Electrical Insulation Theory

The electrical insulation circuit is modeled as a series of parallel RC circuits between conductors and ground. As changes occur to the insulation system, the values of R and C change. The values of the insulation in each phase are the sum of the turn to turn and coil to coil RC values of each phase. Insulation to ground values are the sum of the insulation between conductors and conductors and ground for the complete circuit.

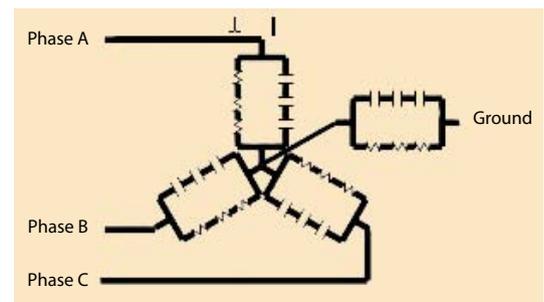


Figure 1 - Insulation Model of Motor Winding System

The capacitance of the electrical insulation is a direct function of the generation of dipoles within the insulation system. As a field is generated across an atom, or molecule, of a dielectric, it will polarize, meaning that the electron orbit of an atom will shift slightly, making one side of the atom more positive and one more negative.

As current passes through conductors near electrical insulation, the insulation reacts by polarizing the atoms (dipoles) within the insulation, as shown in Figure 2. As the dipoles polarize, there is less leakage (capacitance) between the conductors and ground. This also occurs in the insulation system between conductors when there is a difference in potential. In a good insulation system,

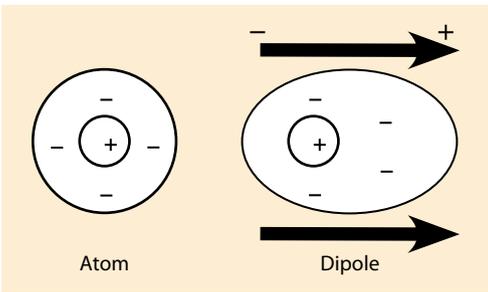


Figure 2 - Generation of a Dipole

the polarization of the insulation system occurs in a larger number of atoms. Once the potential is removed, the atoms return to their original state (dipoles randomize).

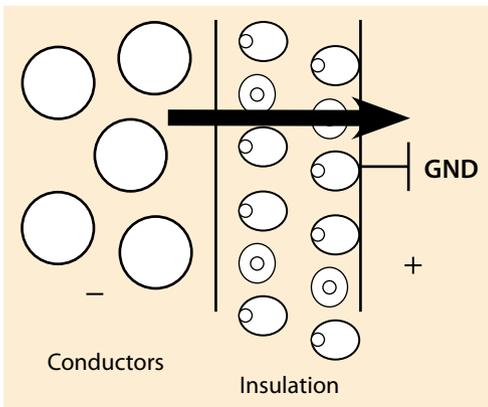


Figure 3 - Dipolar Effect of Insulation

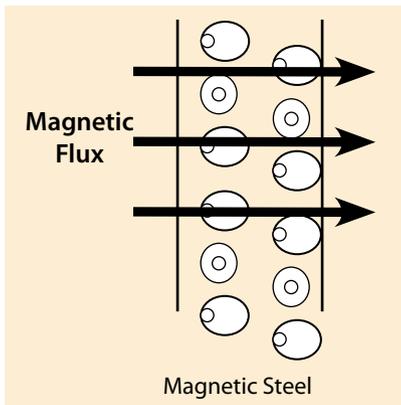


Figure 4 - Magnetic Dipoles

The same effect occurs in a magnetic field. The magnetic dipoles of the backiron and teeth of the stator core line up in the direction of the magnetic field. This helps direct the magnetic flux and adds to the strength of the fields within the airgap. The reluctance of the steel to change polarity shows up as hysteresis loss from the field. Once the field is removed, the magnetic dipoles of the steel quickly randomize.

The above descriptions for the polarization of electrical insulation and core steel represent the steady-state application of an applied voltage potential. In an operating three phase system, the effects get far more exciting. As each sinusoidal phase of voltage is impressed across the windings:

- As the voltage starts from zero, the beginning of the coil energizes, the insulating dipoles between the insulation to ground and the conductors within the coil are forced to polarize.
- As the voltage continues to rise, the potential at the beginning of the coil is higher than the end of the coil, insulating dipoles continue to polarize and the magnetic dipoles begin to polarize in the direction of the magnetic flux generated by the coils.
- As the voltage hits its peak at the beginning of the coil, a majority of the magnetic and insulating dipoles associated with the start of the coil have polarized and the ones at the end of the coil continue to polarize. There is a lag in the fields between the beginning and the end of the coil, which causes a potential between conductors to exist.
- As the voltage begins to decrease, the insulating and magnetic dipoles begin to randomize (move to neutral) at the beginning of the coil and release energy back into the system as the fields collapse. The fields at the end of the coil hit their peak then start to decrease.
- The voltage approaches zero, then passes into the negative sequence of the sine wave. The dipoles and fields continue to react, but align in the opposite direction (as in a piston action). We will define this action as 'dipolar spin' of both the electrical insulation and magnetic steel dipoles.

The high potential of most electric motors force the changes to the fields and dipoles to happen quickly. As a result, work is performed and heat is generated.

The Capacitance of each portion of the circuit is given, at any time, as:

$$[1] \quad C = \frac{Q}{Q - q} \frac{\epsilon^{\circ} S}{l}$$

Where an insulator exists between the conductors and conductors and ground. The

induced charge, q , increases the capacitance by the ratio $Q/(Q-q)$. The dimensionless ratio $q/(Q-q)$ is a property of the polarizability of the material and is referred to as the electric susceptibility, X_e . At the boundary of each insulation system (conductors, slot, phase, etc.), the boundary conditions are such that:

$$[2] \quad \tan \theta_2 = \epsilon r \tan \theta_1$$

Where ϵr represents the relative permittivity of the boundary of the insulation surface.

By dividing each phase into tubes and slices, the total capacitance for m slices and n tubes through the system would be:

$$[3] \quad C = \sum_{\tau}^n \left(\sum_{\tau}^m \frac{\delta l}{\epsilon \delta S} \right)^{-1}$$

The inductance of the circuit can be figured as the flux linkage per unit of current, and is represented by the unit Henry (H):

$$[4] \quad L = \frac{N \phi}{i}$$

For a motor with n coils, the inductance may be defined:

$$[5] \quad L_{pq} = \frac{N_p (K_{pq} \phi_q)}{i_q}$$

Where K_{pq} is referred to as the coupling coefficient between two coils (p and q). When p and q are equal, the inductance is termed as self-inductance, when unequal, it is termed mutual inductance.

The total impedance per phase as viewed from the stator input terminals is given as [6] where X refers to the leakage reactance (capacitive).

$$[6] \quad Z_t = R_1 + jX_{l1} + \frac{jX_M \left(\frac{R'_2}{s} + jX'_{l2} \right)}{\frac{R'_2}{s} + j(X_M + X'_{l2})}$$

In simpler form, impedance can also be viewed as:

$$[7] \quad X_L = 2\pi f L = \text{Inductive Reactance}$$

$$[8] \quad X_C = \frac{1}{2\pi f C} = \text{Capacitive Reactance}$$

$$[9] \quad Z = \sqrt{R^2 + (X_L - X_C)^2}$$

When looking at a balanced system, a wye circuit should appear as in Figure 5. The circuit impedance would appear:

$$[10] \quad Z_{AB} = \frac{V_{AB}}{I_{AB}}$$

For example:

$$32.9 \angle 45^\circ \Omega = \frac{650.5 \angle 120^\circ \text{V}}{19.8 \angle 75^\circ \text{A}}$$

Armed with this information, we can now review the effects of winding related faults on the operation of the motor.

Winding Faults

When a defect occurs in a winding due to a developing short, winding contamination or severely damaged core steel, it effects the electrical properties of the insulation system. In the case of a winding defect, changes to either capacitance or resistance within the insulation system will cause a reactive problem due to changes to the makeup of the insulation system. For instance, in a developing short, the changes to the insulation system cause changes to the capacitance due to

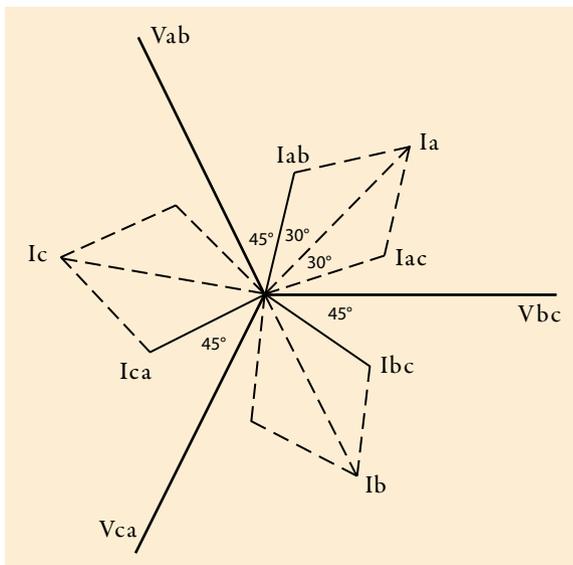


Figure 5 - Balanced Wye System

changes in how the dipoles are excited (dipole spin). As a result, there are changes to how the insulation reacts in that area, causing a leakage reactance variance and heating due to forcing the insulation to polarize with high applied potential (operating voltage). Winding contamination causes changes to the resistive and capacitive reactance between insulating surfaces, as well.

At design voltage, most defects do not become apparent until a distinct change occurs, which may be represented by a severe current unbalance, nuisance tripping or a direct short circuit. In the case of winding contamination, the end result is the same as a winding short: Either a short between conductors or across the insulation system to ground.

As a result, as faults occur due to thermal deterioration, contamination, moisture absorption or other reactive faults, the circuit impedance will change, slightly, at first, then more dramatically as the fault progresses.

Utilizing Hi-Pot Testing for Insulation To Ground Stress Testing

The type of testing performed by Hi-Pot testing only evaluates that plane between the conductors and the slot wall of the stator core, or the slot cell wall. They do not detect inter-turn winding faults or developing winding shorts. An additional important requirement in all high voltage testing is ensuring that the winding is clean and dry prior to testing.

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These conditions, of course, limits the abilities of this type of testing. However, there are a few tricks that can expand their test capability.

All Hi-Pot testing is set up in a similar fashion: If possible, each phase is separated with each phase not being tested, RTD's and other coils in the system are shorted to ground. This allows the insulation system between the coils being tested and the other insulation systems to be tested while also ensuring that there are no circulating currents and the leads are away from operators.

While AC Hi-Pot testing is the most dangerous form of testing, the AC applied voltage and current generate some excitation of the insulation dipoles. This gives a more complete pass/fail analysis of the condition of the system. The operator must also ensure that the lead is held rigidly against the conductor prior to applying voltage otherwise the arc that is generated will cause spikes that may cause latent damage to the insulation system. When testing an electric motor in place, the danger to the equipment is even more severe because of the additional surface area of the cabling. Any additional components such as capacitors, variable frequency drives, etc. including current and potential transformers, must be disconnected and grounded to reduce the chance for damage.

With the DC Hi-Pot, the safest approach is the step voltage test. If evaluating an electric motor rated under 600 Volts, step increments at 500 Volts, if above 600 Volts, step the voltage at 1,000 Volts. This reduces the charging current stresses on the insulation system. With the leads of other windings connected to ground (only if you can break the connections between phases) and components, you are also evaluating the condition of the insulation system between those phases as well as the phase being tested to ground. Just as with the AC Hi-Pot, everything should be disconnected if you are testing through the cable system to the motor. In both cases, the leakage current should be trended, this is the current that the meter stabilizes on after the voltage is increased. The trend should be a steady increase and any sharp increase in leakage current before the test reaches the calculated voltage indicates an insulation defect that should be corrected.

The VLF DC Hi-Pot provides a slightly more inclusive test which is handled in the same

way as the DC Hi-Pot. The primary difference between the two is that the VLF provides some level of excitation of the insulation system dipoles. This will more closely identify insulation to ground defects.

Conclusion

Electrical insulation systems are, primarily, dielectric systems. The purpose of high voltage testing of the ground insulation system is to identify if the system can withstand higher than normal stresses. This type of testing requires the insulation system to be clean and dry, otherwise there is potential for insulation failure directly as a result of the test.

Of the three types of Hi-Pot tests, the AC Hi-Pot provides the greatest danger to the insulation system and personnel, but provides the greatest opportunity to identify defects. The DC Hi-Pot allows the operator to trend the condition of the insulation leakage current when the step voltage test is performed. The VLF Hi-Pot provides many of the strengths of both the AC and DC Hi-Pot tests with less danger to the insulation system.

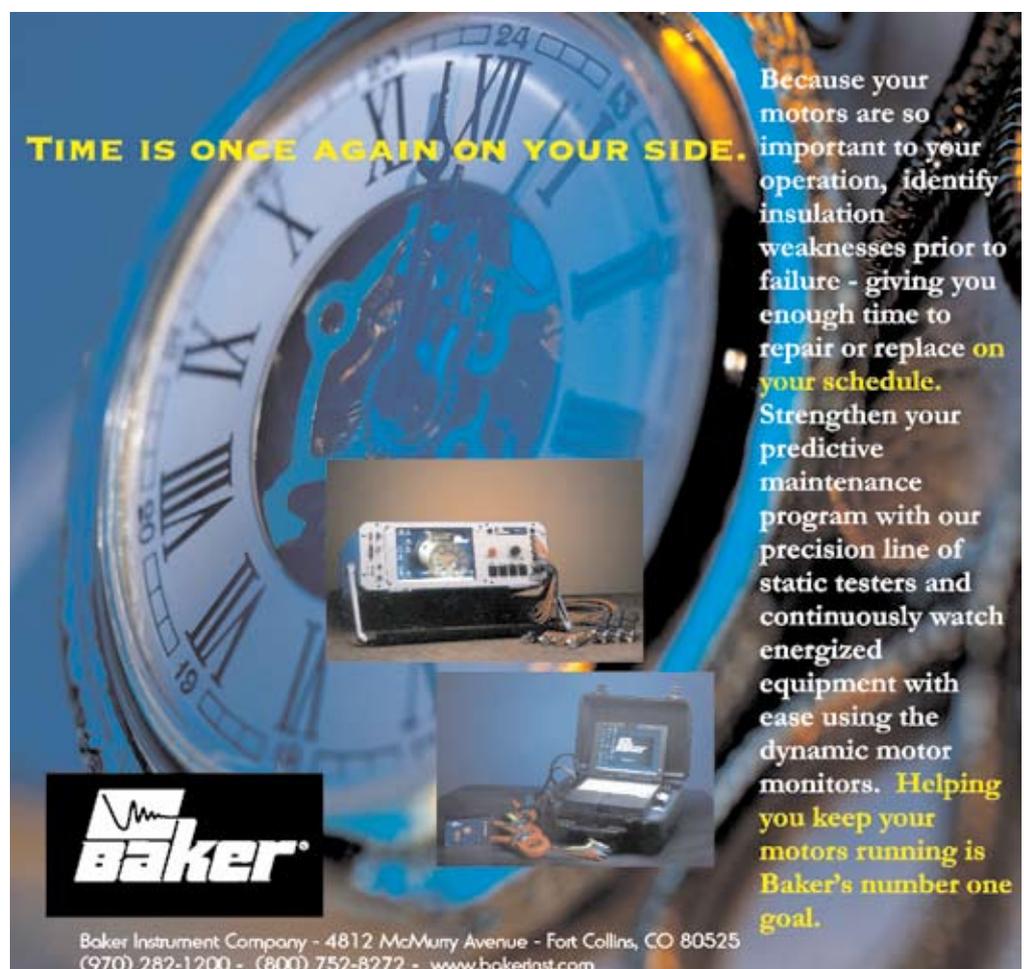
Bibliography

IEEE Std 1068-1996, IEEE Recommended Practice for the Repair and Rewinding of Motors for the Petroleum and Chemical Industry, IEEE Standards, 1996.

IEEE P1415/D15, Draft Guide for Induction Machinery Maintenance Testing and Failure Analysis, IEEE Standards, July, 2006.

ANSI/EASA AR100-2006, Recommended Practice for the Repair of Rotating Electrical Apparatus, EASA, 2006.

Howard W. Penrose, Ph.D., CMRP, is the President of SUCCESS by DESIGN, a reliability and maintenance services consultant and publisher. He has over 20 years in the reliability and maintenance industry with experience from the shop floor to academia and manufacturing to military. Dr. Penrose is a past Chair of the Chicago Section of the Institute of Electrical and Electronic Engineers, Inc. and is presently the Founding Executive Director of the Institute of Electrical Motor Diagnostics. For more information, or questions, related to this article or SUCCESS by DESIGN services, please contact Dr. Penrose at howard@motordoc.net.



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Diagnosis Unkown

A Mysterious Off-line to Running Alignment Problem

by John Piotrowski

A few years ago, our company was contracted by a company (which shall remain nameless) to diagnose a recurring problem they were having at one of their electric generating stations. The problem was occurring in a system that had an AC motor flexibly coupled to a fluid drive which was flexibly coupled to a multi-stage boiler feedwater pump. Frequent replacements of the motor bearings and flexible couplings on the boiler feed pumps indicated a possible shaft misalignment problem. Several pump shaft failures had also occurred and the exact cause had not yet been determined.

Historically, the fluid drive was aligned 10 mils lower than the motor and pump shafts based on alignment recommendations by the manufacturer (because the fluid drive shafts would “thermally expand” upward 0.010” from off-line to normal running conditions). No information on the amount of movement was ever received from the manufacturers of the motor or the pump and, therefore, it was assumed that no movement would occur. Plant personnel began to wonder if the bearing failures could be attributed to excessive loading of the motor and pump bearings. They also wondered if, by placing the fluid drive lower than the motor and pump shafts during off-line/cold alignment procedures, they were causing rapid wear in the gear type flexible couplings due to misalignment.



Figure 1 - 4A boiler feedwater pump drive system looking northwest.

Objectives

Our objectives were to determine how the motor - fluid drive - boiler feedwater pump shafts move from off-line to running conditions (aka hot and cold alignment or ‘thermal’ movement) in order to properly position shafts when aligning this machinery.

How the Measurements were Taken

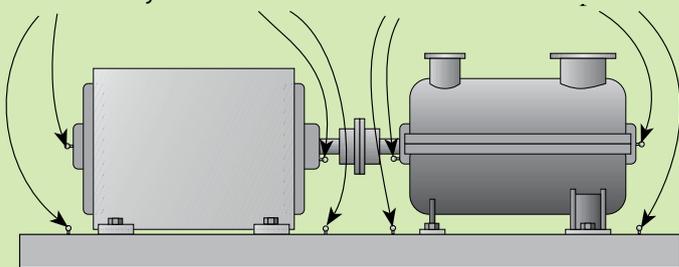
We decided to use two different techniques to conduct the off-line to running (abbreviated as OL2R) machinery movement measurements. The Inside Micrometer - Tooling Ball method (abbreviated as IMTB) and the Ball-Rod-Tubing Connector System (abbreviated as BRTC) were selected as the two methods. Figure 1 shows the motor - fluid drive - pump drive system at the electric generating station. Figure 2 shows the basic operating principles of the IMTB method and figure 3 shows the basic operating principles of the BRTC System.

Work Performed

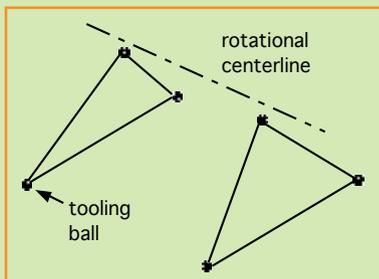
Support framing was designed, fabricated, and installed to hold the BRTC systems in place. The bearing housing bolts were used as anchor points for the support frames. The BRTC systems were set up to span across the motor to fluid drive and fluid drive to pump couplings as shown in figures 4 and 5. Tooling balls were attached to the motor, fluid drive, and pump casings just below the centerlines of rotation at the inboard and outboard ends using epoxy glue to fasten them to the frames. Tooling balls were also attached to the baseplate and floor in a pyramid arrangement to capture movement in all three axes (X, Y, Z) as shown in figures 6 and 7 on page 30. Note however that four of the tooling balls mounted on the base (west end of motor, under both couplings, and east end of pump) were not in exactly the same plane as the others. When using this Y axis offset, you must compensate for it when calculating the movement of the tooling balls under each bearing. After several days of setting up the systems, off-line data

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Tooling ball arrangements are placed at both ends of both machines. The tooling balls attached to the machinery case should be as close to the centerline of rotation as possible.



Triangular Tooling Ball Set-up



Pyramid Tooling Ball Set-up

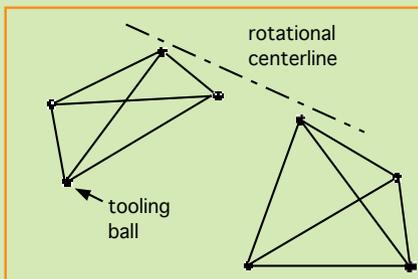


Figure 2 - Basic operating principle of the Inside micrometer - Tooling Ball method.

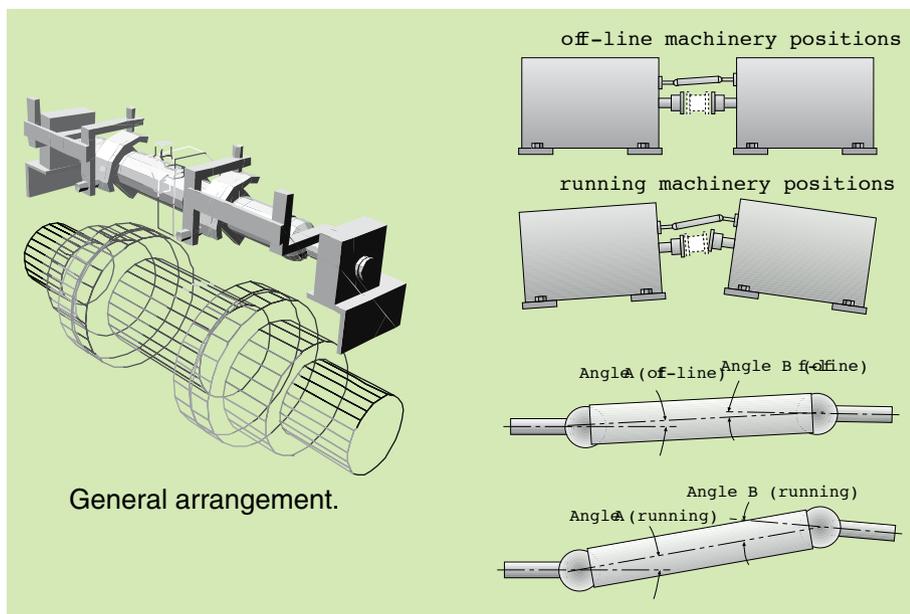


Figure 3 - Basic operating principle of the Ball-Rod-Tubing-Connector System.



Figure 4 (above) and 5 (right) - Side view and top view of BRTC system installed between the motor and fluid drive.



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Figure 6 - Tooling balls between motor and fluid drive.



Figure 7 - Tooling balls at outboard (east) end of pump.

was first captured through both systems on March 9th.

We experienced several glitches during the start up and operation of the drive system. The coupling between the motor and fluid drive was low on grease, a loose connection on one of the BRTC systems was discovered, the pump ran backwards due to a bad check valve, and a fire occurred when weld slag from above fell on the pump. After the inferno mishap, the BRTC systems were swapped and the unit started. It didn't take too long for us to realize that, ironically, the BRTC system between the motor and fluid drive had a resonant frequency that matched the operating speed of the machine. After using parts from the BRTC system to fashion resonance "de-tuning" mechanisms, we attached them to the extension bars to alter the natural frequency (shown in figure 9). The power supply on the BRTC system between the motor and fluid drive varied considerably during the data collection. We also discovered that the Essinger bar inside micrometer would thermally expand during the measurement process particularly when measurements were taken between the motor and fluid drive requiring frequent "recalibrations".



Figure 8 - Capturing a reading with the Essinger Bar inside micrometer between two tooling balls at the outboard end of the pump.

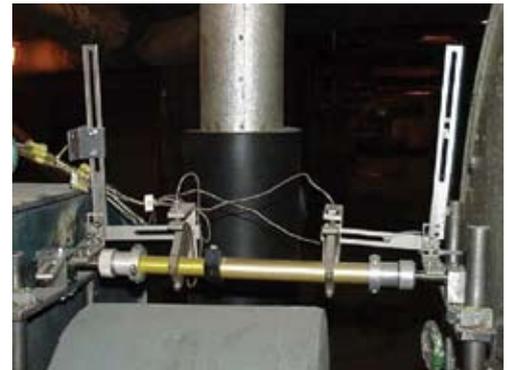


Figure 9 - Resonance de-tuning vibration absorbers installed on BRTC system between the motor and fluid drive.

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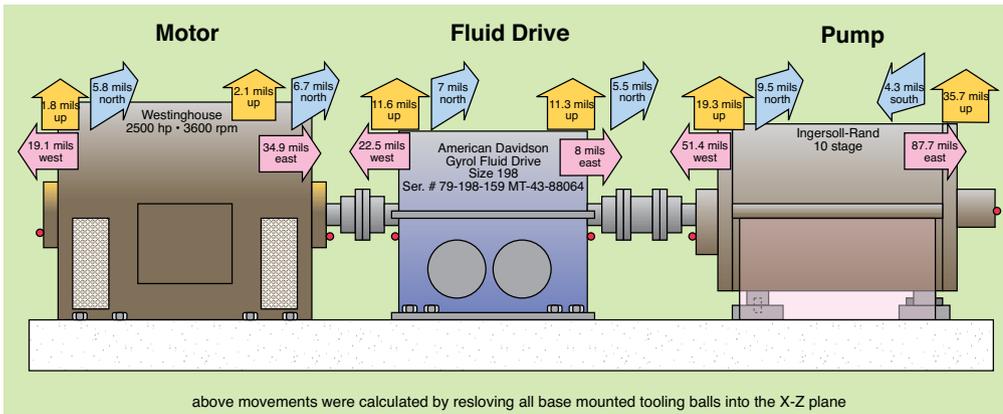


Figure 10 - Observed Movement of Inside Micrometer Tooling Ball method.

To give you an idea of the amount of time spent to obtain all of this data, it would take about an hour to capture each set of measurements on both the IMTB and BRTC systems and 98 datum sets were taken from March 9th through May 3rd. Needless to say this was quite a time consuming investigation and a tough challenge to diagnose.

Measurement Results and Analysis

Figure 10 shows the movement that was observed with the IMTB system. Examination of the IMTB data shows why we had to set

Ball Rod Tubing Connector System		Offline-2-Running Measurement Study Summary				
Operation Type	Fluid Drive IB Vert (volts DC)	Fluid Drive IB Horiz (volts DC)	Motor IB Vert (volts DC)	Motor IB Horiz (volts DC)	Power Supply (volts DC)	
off-line	8.29	8.09	8.08	8.09	Averaged OFF-LINE	
running	9.74	9.80	10.09	9.04	Averaged RUNNING	
Voltage Change OL2R	1.45	1.71	2.01	0.95		
OL2R Gap Change Mils	7.25	8.55	10.05	4.75		
Operation Type	Fluid Drive OB Vert (volts DC)	Fluid Drive OB Horiz (volts DC)	Motor OB Vert (volts DC)	Motor OB Horiz (volts DC)	Power Supply (volts DC)	
off-line	8.14	8.23	7.94	7.88	Averaged OFF-LINE	
running	8.00	8.50	8.73	7.89	Averaged RUNNING	
Voltage Change OL2R	-0.14	0.27	0.79	0.01		
OL2R Gap Change Mils	-0.70	1.35	3.95	0.05		

Figure 11 - BRTC system data summary.

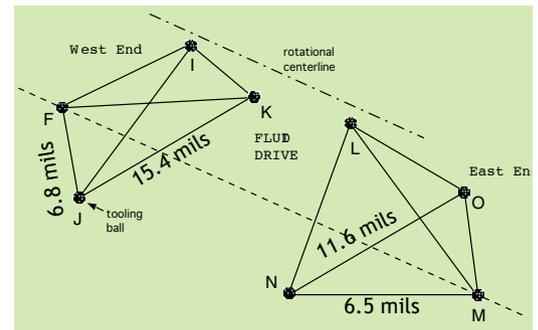


Figure 12 - Tooling ball diagram and distance changes on the fluid system.

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up the tooling balls in a pyramid arrangement rather than a simple triangular arrangement. The assumption in a triangular tooling ball arrangement is that there will be no movement in the axial (Z) direction. Notice the amount of movement at both ends of all machines in the axial direction. The motor moved 19.1 mils to the west at the outboard (west) end and 34.9 mils to the east at the in-board (east) end. Therefore, at the centerline of rotation there was a 54 mil increase in the length of the motor case. Did the entire motor expand this much or was it just at the centerline of rotation? If the motor is bolted to the baseplate at eight points, and the baseplate did not expand that much but the motor did, then could there have been some slippage between the foot bolts and the motor case?

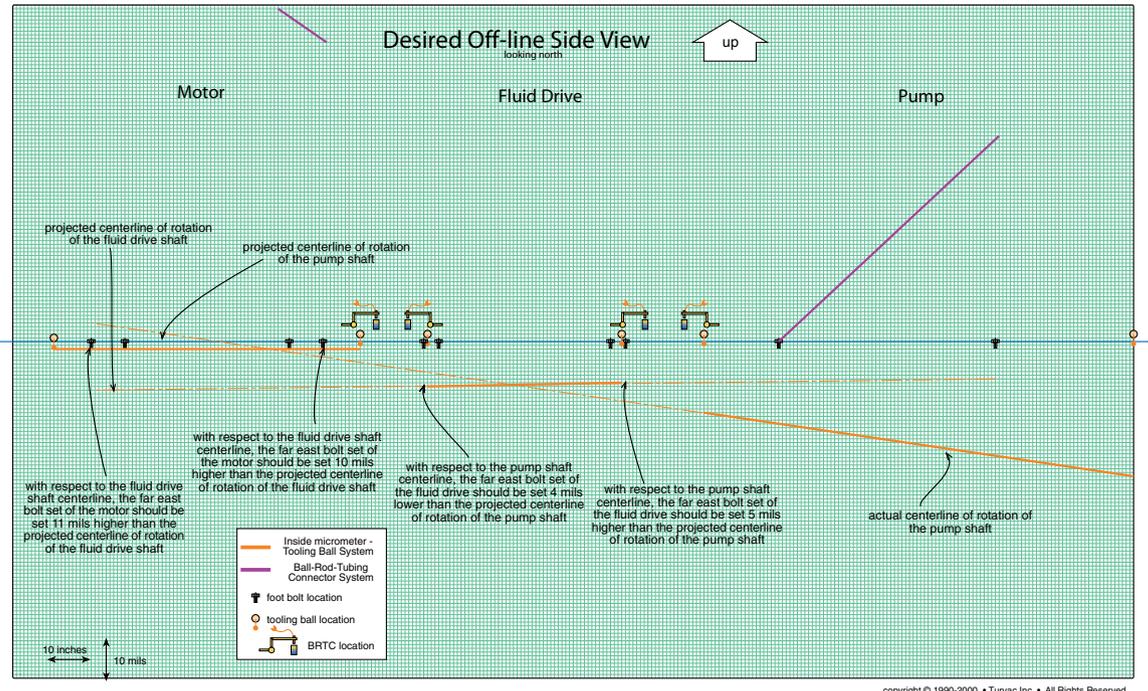


Figure 13 - Desired off-line Side View results from IMTB and BRTC measurements.

The fluid drive (hydraulic coupling) moved 22.5 mils to the west at the motor (west) end and 8 mils to the east at the pump (east) end.

Therefore, at the centerline of its rotation there was a 30.5 mil increase in the length of the fluid drive case. The pump moved 51.4 mils to the west at the fluid drive (west) end

and a whopping 87.7 mils to the east at the outboard (east) end.

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there was a 139.1 mil increase in the length of the pump case (that's almost 3/16"). As you can see, the amount of movement in the axial direction was far greater than the vertical rise

and lateral translation on every machine in the drive train.

Here is another interesting observation that

we made from looking at the IMTB data. Three of the four tooling balls at each pyramid arrangement were fastened to the floor and/or the baseplate, the 'target' tooling ball was fastened just below the centerline of rotation at each end of a machine.

Figure 12 on page 32 shows the tooling ball locations for the fluid drive and the change in distance between the baseplate & floor tooling balls from off-line to running conditions (e.g. any of the F-J, J-K, M-N and N-O). For example, the J-K distance when off-line averaged 49.6540" and 49.6694" when running. That's a change of 15.4 mils. Apparently the baseplate also thermally expands or at least changes its shape. As a reminder, extreme care was taken to insure that the Essinger Bar system inside micrometer was frequently checked in the calibration bar to insure the highest accuracy of measurement. In the absolute worst case, the overall accuracy of the measurements were maybe +/- 5 mils, but not three times that

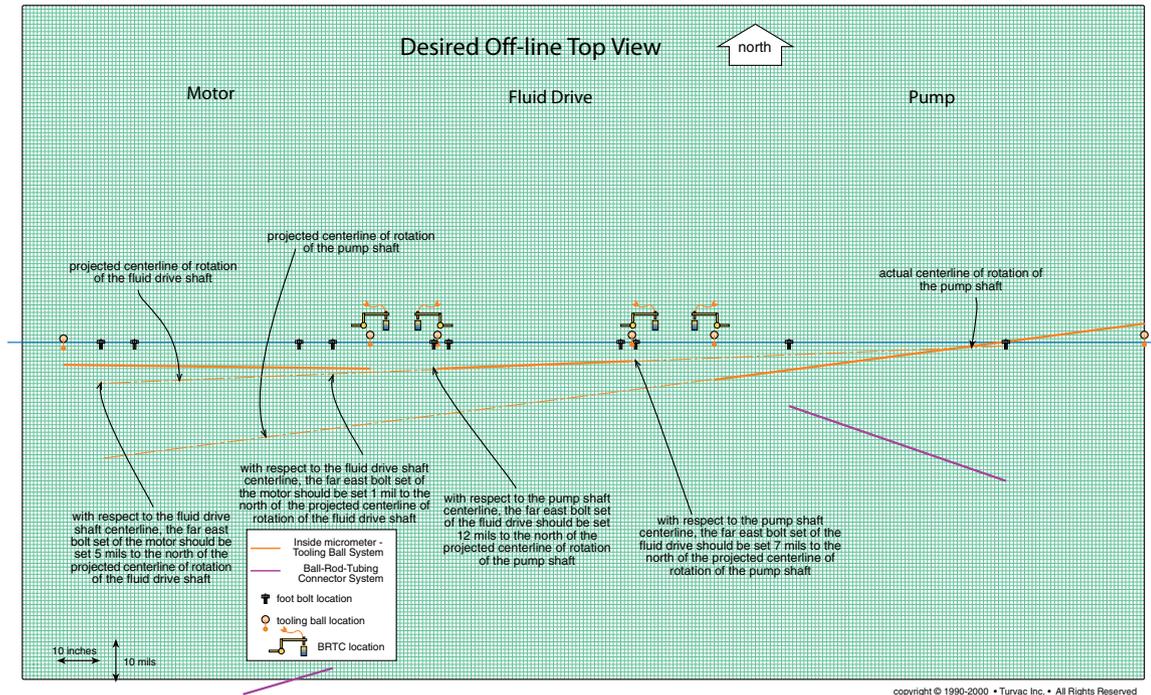


Figure 14 - Desired off-line Top View results from IMTB and BRTC measurements.

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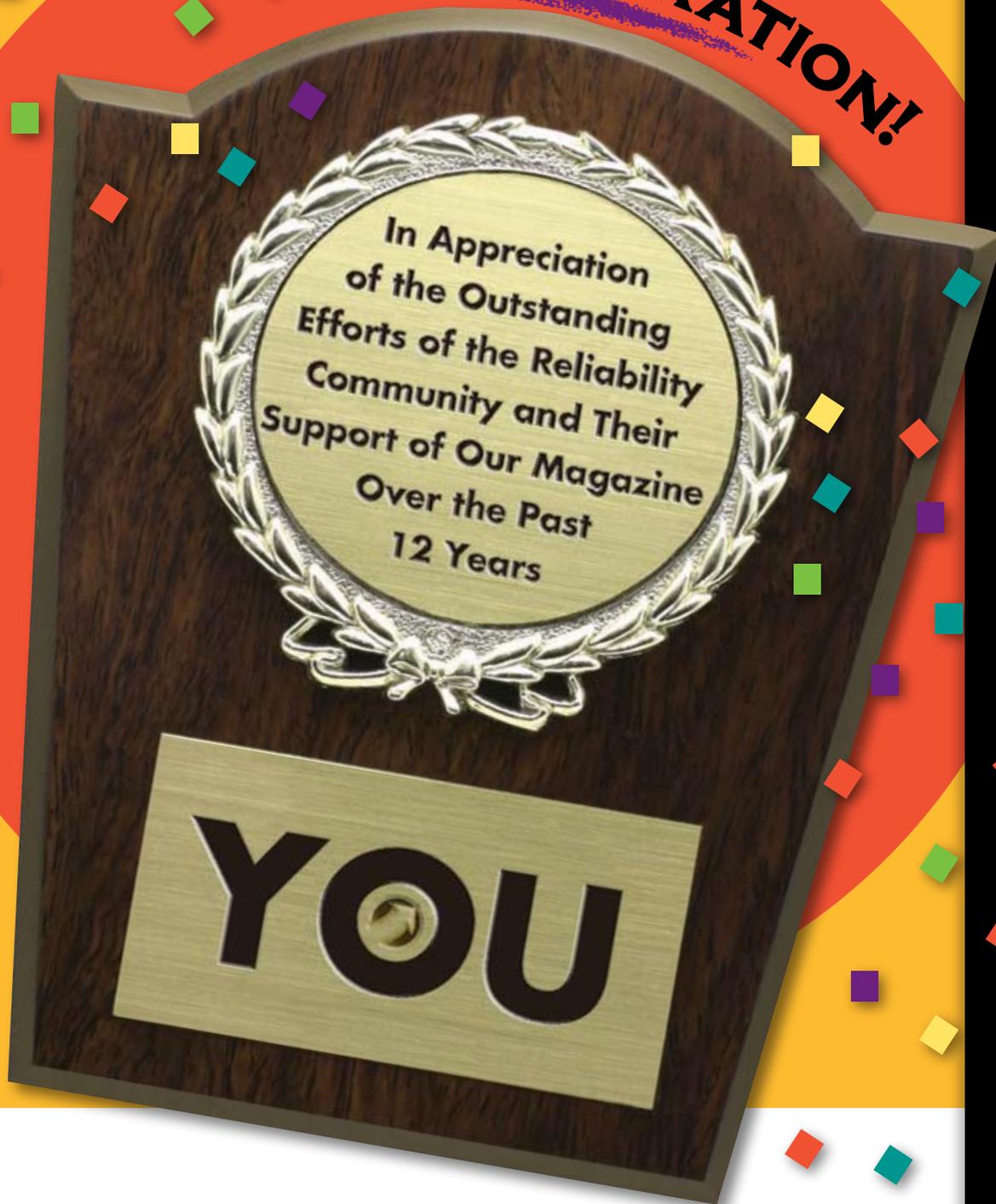
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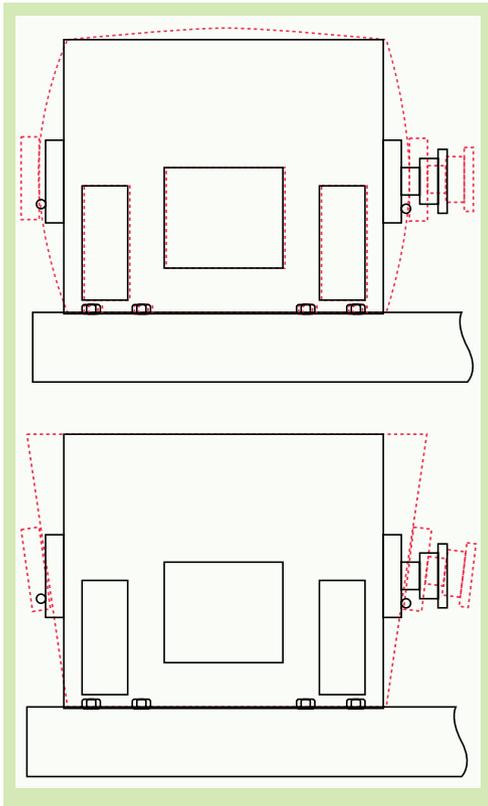


Figure 15 - Possible motor casing distortion.

amount. It makes you begin to wonder what exactly a “fixed” reference point really is.

Figure 11 shows the data summary of the BRTC system. Figures 13 and 14 show the desired off-line Side and Top View shaft positions of the motor, fluid drive, and pump. The orange lines represent the desired shaft positions of these three machines based on the data collected from the IMTB system. The purple lines represent the desired shaft positions of the motor and pump using the fluid drive shaft as a reference based on the data collected from the BRTC systems. As you can see there is quite a variation between what was observed by the IMTB system and the BRTC system. It is not known why there was such a radical difference between the IMTB results and the BRTC results. It is unlikely that the data was taken incorrectly and we were very careful to insure the most stable installation and repeatability of these systems. The most plausible explanation might be due to distortion at the anchoring points of the machine cases as illustrated in Figure 15. Does the movement of each machine case

toward each other during operation have an effect on the measurements?

Did the bars holding the BRTC system in place change their position or shape during operation? The data may not agree with the IMTB results, but are the BRTC systems showing us something we just don’t understand yet? We don’t have any answers right now, but it’s quite intriguing, isn’t it?

John Piotrowski is president of Turvac Inc, which provides industrial training and field service in shaft alignment, vibration analysis, balancing and performance analysis. John is the author of The Shaft Alignment Handbook and Basic Shaft Alignment Workbook. He is feverishly working on an e-book entitled “Turvac Filed Service Files”. This article is one of many case studies that will be included in the e-book. John is happily married with three children and six grandchildren. He enjoys, fishing, backpacking, white water rafting and makes a mean salsa. He can be reached at 513-923-2771 or contactus@turvac.com

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What's Your Point?

Getting Sharp Leads to More Consistent Readings

by Jim Hall

For years I have been using airborne ultrasound for bearing analysis, steam trap troubleshooting, leak detection, electrical inspection of switchgear, etc. But airborne ultrasound kits have two sensors. One sensor is typically used for leak detection, and is sometimes referred to as the scanning module. The other sensor, called the contact probe or structure-borne sensor, is typically used for bearing analysis, steam trap troubleshooting or for any inspections that require internal diagnostics such as valve inspections.



Figure 1 - Testing a valve with "sharp" point contact probe (SDT 170).

The structure-borne sensor employs the use of a rod, waveguide or magnetic base (above 20 kHz). At the end of this rod (toward the sensor) is a stretched copper diaphragm that makes contact with the thread set of the waveguide. When the rod is touching a bearing, for instance, the sound is transmitted to the receiver. The receiver then translates the signal to an audible sound that can be heard through a head set or speaker as a low-frequency.

Airborne ultrasound is sound above the human hearing range. Airborne ultrasound is also very directional, the sound wave is typically 1/8" to 5/8" of an inch long. When scanning for leaks you may be able to hear a leak 50 feet away and as you get closer the leak gets louder in the headphones. With the contact probe, you may be listening to a valve that is closed because you think it may be leaking past its seat when closed. In situations like this, or when listening to a bearing, you want the contact probe to hear subtle changes while you are listening to it.

However, if the structure-borne sensor you are using starts to walk along the surface, you will get a lot of noise that hampers you from hearing those subtle changes. A bearing that has a high level of vibration may cause the contact probe to walk, or move, on the surface. Here are

a few things you can do to prevent this.

- Adhere a small diameter washer to the bearing surface. The washer will give the contact probe a place to rest and prevent it from moving, or 'walking', along the surface.
- Use a pointed contact probe rod or waveguide. The sharp point will grab the surface and reduce the walking.
- Utilize a magnetic sensor. Many of the manufactures have them as an accessory.

It is always helpful for ultrasound technicians to practice the technique of using a contact probe or structure-borne sensor. You can create a standard with any easily accessed motor in the shop. For instance, if you have a grinding wheel motor in the shop, mark a spot on the motor for the technicians to come back to for consistency. Make sure they are aware of the proper angle at which they need to hold the sensor or instrument for this practice. Establish a baseline for each side of the grinder. Ask each technician to find that baseline number by applying only enough pressure to the instrument or sensor to match the baseline numbers.

This technique has been very helpful for me in training



Figure 2 - Notice the sharp point? Not much chance of this point walking due to vibration.



Figure 3 - From Top to Bottom: Three contact points from three different manufacturers.

individuals on how much pressure to use and how much is too much pressure. You will find that practicing the contact application will allow for more consistent readings from those in the field taking the readings.

It is a very good (and recommended) practice to use magnetic sensors whenever they are applicable. Although there are a few exceptions, you should be able to use the magnetic base on the vast majority of bearing housings. The reason the magnetic base is so good is that it provides a level of consistency for the reading that simply cannot be achieved by manually applying the contact probe.

One manufacturer just recently went to a sharp point on their contact probe. Another has been using the sharp point for several years. If you do not already have a sharp point, you might think about sharpening one of yours to a point and then purchasing another waveguide or tip. Having used a dull ended point for years to inspect bearings, I would continually slip from the base of the Zerk fitting when trying to read a bearing. Once I moved to a sharp point, I did not have the slipping problem any longer and I noticed a substantial decrease in readings over a period of time.



Figure 4 - Use a motor with similar bearings and wheels to practice setting a baseline.



Figure 5 - Using the SDT 170 on a bearing trainer.

In one particular 90 day period, I noticed that my readings were changing 4, 5 or even 6 decibels from one reading to the next. After switching to the sharper point, the readings dropped to a 1 to 2 decibel difference.

When training others to use a contact probe, I often tell them to apply just enough pressure to pierce the skin of an apple. It works for some people, but a lot of people have difficulty.

When trending or taking readings on bearings, gearboxes, valves, etc, it is a good practice to do one of the following: mark with indelible ink/paint, adhere a washer to the surface, use the base of the Zerk fitting or use a magnetic base. If you do use the magnetic base, be sure to caution others taking the readings that when you start a trend using a magnetic base, you stay with the magnetic base. Consistency is imperative.

For Accuracy and Repeatability...

For accuracy and repeatability, make sure your instrument's contact probe is repeatable among the same model. For instance, if your contact probe is not calibrated to a known "good" by the factory, you should always use the same instrument whenever taking readings. Consistency, consistency, consistency...

There are only a couple of instruments in the marketplace

that have repeatability. Check your instrument. A good place to test your instrument would be the grinding wheel baseline I mentioned earlier. Test all of your contact probes of the same models against one another and record the differences.

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 ultrasound training for several Fortune 500 Companies. 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). Jim is also president of All Leak Detection, LLC an underground leak detection company. Jim can be reached at 770-517-8747 or at jim.hall@ultra-soundtech.com

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Phase Analysis, Part 2

More Ammo to Combat Downtime

By Jason Tranter

Welcome to part two of this phase analysis article. If you missed part one, or if you do not fully understand phase readings or phase measurements, you may like to go back to the previous edition of the Uptime magazine (or read it on-line at www.ilearninteractive.com/phase). After reading part one of the article, I hope you will agree that phase readings are not difficult to collect or understand - in fact, if you have a two channel data collector, they are downright easy to collect.

In this article we will discuss how phase readings can be utilized to help you to diagnose a wide range of faults conditions. While spectra and time waveforms can provide an indication of a fault condition, quite often phase readings can help you confirm the exact nature of the condition by helping you to distinguish different conditions that have similar vibration patterns.

Quick Overview

By collecting phase readings at different points on the machine we can determine if it is correctly balanced; if the shafts or pulleys are correctly aligned; if the bearings are cocked on the shaft; if there is runout or eccentricity; if a shaft is bent; if a foot is cracked or loose; and more. We can also use phase readings to provide an indication of a resonance condition.

The correction of these problems will greatly improve the reliability of the machine; extending its life, and in some cases, producing products of higher quality. Missing the diagnosis will ultimately reduce profitability. And misdiagnosing the condition will waste time, labor, parts, and increased downtime.

Relative Phase Readings

We utilize relative phase readings to diagnose fault conditions. We do not care what the actual reading is on top of the motor; we are only interested in how it compares to the reading on the side of the motor and the reading at the other end of the motor. If they are in-phase, that tells us something. If there is a 90° difference (approximately), then that tells us something. And if the difference between the readings is something else altogether, for example 132°, then that also provides useful information.

We can do this by taking phase readings at each of the key locations on the machine relative to a reference (typically the tachometer), and comparing the readings between each of the points. Better yet, with a two-channel data collector we can perform relative

measurements between each of the points and simply record the difference. Depending upon what we suspect, we will compare the readings in the vertical, horizontal and/or axial direction.

You see, what we are actually analyzing is the dynamic motion of the machine. The forces due to mass unbalance cause the machine to move a certain way. A misaligned shaft causes a machine to move a different way. The same is true for a number of other conditions. So we use phase to detect the telltale movements. (It is also worth commenting that some faults do not generate characteristic forces. Thus, the phase readings do not provide a clear picture of the dynamic movement of the machine – however this, in and of itself, also provides a clue to the nature of the condition.)

Representing Phase

Rather than recording the phase readings numerically, we can record them visually. It can be difficult to look at a series of numbers and interpret the movement of the machine. However using graphical symbols makes this task easier.

We can do this by drawing a circle and a tail at the desired angle. It is then easy to quickly determine the angle with a quick glance, as shown in figure 1.

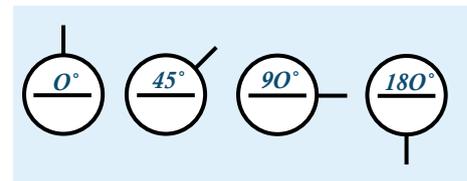


Figure 1 - Sample phase readings displayed graphically.

You don't even need to write down the phase angle - you can just draw the tails; either inside or outside the circle, as shown in Figure 2. You can easily see that these two readings are 180° out of phase. (Often the angle is written above the horizontal line and the amplitude is written below the line, or visa versa.)

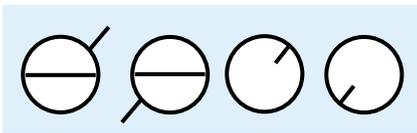


Figure 2 - Alternative methods to graphically display phase readings.

This data can be used in a number of ways, but one common method is called the bubble diagram (developed by Ralph T. Buscarello), as illustrated in Figure 3. You can take readings around the machine and enter them into the diagram, adding the tails according to the angle.

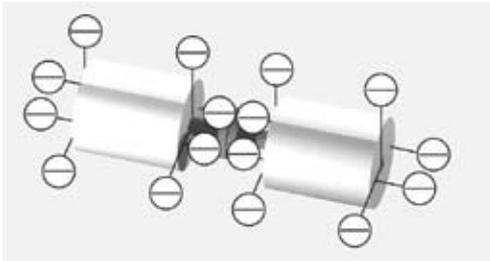


Figure 3 - Sample bubble diagram sheet.

Precautions When Utilizing Phase Data

You must be careful when comparing phase readings taken at opposite ends of a machine, or when comparing phase readings taken across a coupling. Phase readings are sensitive to direction. Therefore you have to add 180° to your readings if the accelerometer is turned 180° .

You must also be familiar with the phase convention used by your data collector. Figure 4 illustrates one such convention.

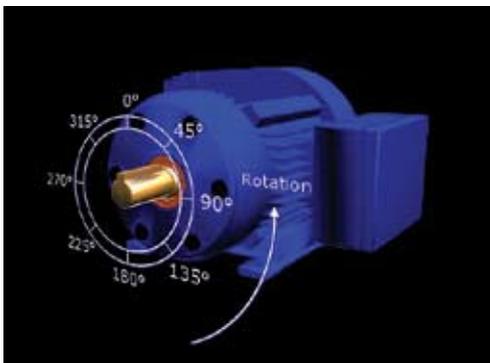


Figure 4 - One of the phase conventions used.

Also note that when we talk about the phase relationships between certain points of a machine, I may quote that the phase readings

should be in-phase, 90° or 180° out of phase. These are only approximate values. The actual readings may be up to 30° higher or lower and the rule still holds. For example, if the difference between two readings was between 150° and 210° , then you can consider the readings to be 180° out-of-phase.

Also, if the difference between two readings is approximately 270° , then that is equivalent to a 90° phase difference. Likewise the phase difference of -180° is equivalent to a 180° phase difference. It all depends upon the direction of rotation, the setup of the data collector, and the convention used by the data collector.

Diagnosing Fault Conditions with Phase

It is beyond the scope of this article to fully explain all of the amplitude and phase relationships that can be made in order to diagnose all of the fault conditions, or show the sample bubble diagrams – that's what training courses are for.

We will use a sample machine, shown in Figure 5, to look at how phase readings can help us to diagnose faults conditions.

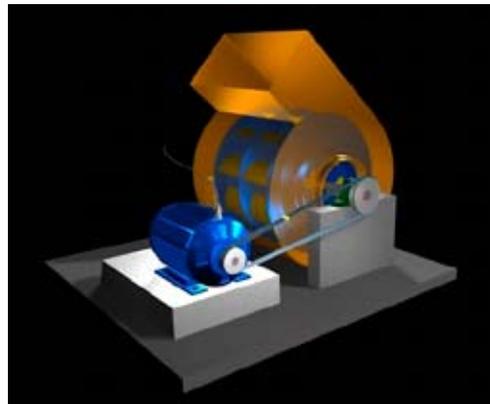


Figure 5 - The machine we will use to illustrate a number of the key phase relationships.

We can take a number of measurements in order to understand the motion of the machine. We can take readings vertically and horizontally at each end of the component. We can compare the amplitude and phase of vertical versus horizontal; we can compare the vertical readings at both ends of the component, and we can compare the horizontal readings at both ends of the component. For coupled machines, we can also take phase readings on either side of the coupling and compare the

readings.

Axial readings are also very important. Rather than a single reading, we can take readings on either side of the shaft; to compare the left side to the right side, and compare the top to the bottom reading. And again we can compare axial readings taken on either side of the coupling (for example on the motor and pump).

You might routinely collect a single axial vibration reading, but when you are collecting phase readings it is important to collect two axial readings, and in certain cases that we will discuss later, you may even collect four readings. Due to restricted access, safety issues, and machine construction, sometimes you may only be able to take axial measurements at one end of the machine.

Diagnosing Unbalance

Although considered by some to be the most common and simplest fault to diagnose, it is actually quite easy to confuse unbalance with other fault conditions. If you find a high 1X peak and assume it needs to be balanced, you may be quite wrong – and generate a lot of unnecessary work - and still not correct the fault.

We need to go back and study the motion of a rotor when it is not balanced correctly. If you understand the underlying motion you will be able to use phase data to prove that the rotor is in fact out of balance, and rule out other possibilities.

We will now quickly review the different forms of unbalance, and then look at how we can analyze the end-to-end phase readings and the vertical-to-horizontal phase readings (relative amplitude values are also very useful, but that is for another article).

Static Unbalance - The simplest type of imbalance is equivalent to a heavy spot at a single point in the rotor. This is called a static imbalance because it will show up even if the rotor is not turning - if placed in frictionless bearings the rotor will turn so the heavy spot is at the lowest position. We would expect that the motion at the two ends of the component would be in-phase (that is, the two vertical readings would be in phase, and the two horizontal readings would be in phase). Due to the circular motion, we would also expect

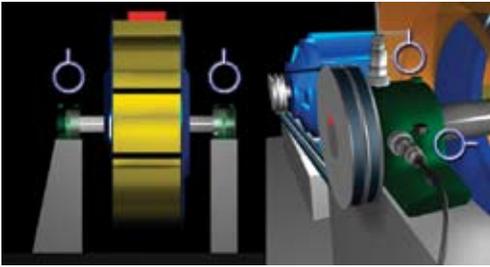


Figure 6 - Phase relationship when a fan is not balanced statically.

that the phase angle between the vertical and horizontal axis would be approximately 90°, as illustrated in Figure 6.

Couple Unbalance - A rotor with couple unbalance may be statically balanced (it may seem to be perfectly balanced if placed in frictionless bearings), but when rotated, it will produce centrifugal forces on the bearings, and they will be of opposite phase.

Therefore the phase angle between two vertical readings (taken from each end of the component) will be similar to the phase angle between the two horizontal readings; approximately 180°, as illustrated in Figure 7.

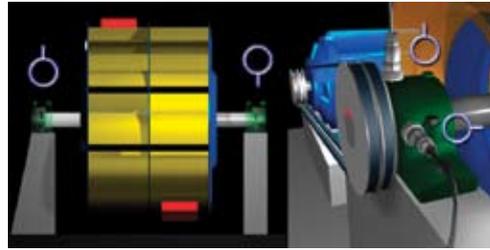


Figure 7 - Phase relationship for couple unbalance.

Dynamic Unbalance - In reality the amount of unbalance may not be evenly distributed along the rotor (unless it is a very narrow rotor or axial fan, in which case it will approximate static unbalance). We are likely to have a combination of static and couple unbalance, as illustrated in Figure 8. This combination is called dynamic unbalance.

Vertical Machines and Overhung Machines - Phase readings can also help us to diagnose unbalance in both vertical and overhung machines.

Vertical machines, such as vertical pumps, are usually cantilevered from their foundation, and they usually show maximum vibration levels (at the running speed) at the free end of

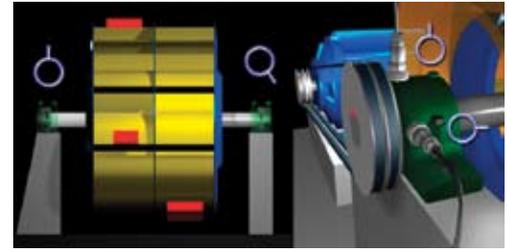


Figure 8 - Phase relationship for dynamic unbalance.

the motor regardless of which component is actually out of balance. Phase readings collected along the machine should be in-phase. Because of the circular motion that results from unbalance, the phase readings taken 90° around from the reference measurements should be 90° higher or lower; depending upon the direction of rotation.

The dynamics of an overhung machine are quite different; therefore our study of relative vibration levels and phase readings is quite different. Overhung pumps and fans are common in industry so you must examine the machine closely to ensure that you know whether a component is in fact overhung or supported on both sides by bearings.



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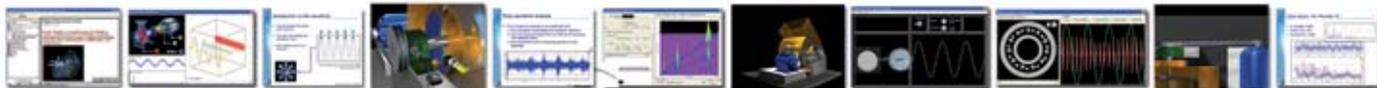
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The phase readings will be in-phase in the axial direction, as shown in Figure 9. Because of the bending motion there will be between 0° and 180° difference between the two horizontal readings and likewise between the vertical readings. The phase difference between the vertical readings will be similar to the phase difference between the two horizontal readings. And, because of the circular motion, there will be approximately 90° between the vertical and horizontal readings.

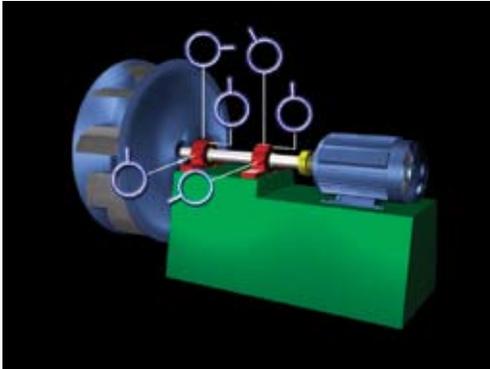


Figure 9 - Phase relationship for unbalance in an overhung machine.

Misalignment

Misalignment is very common. However, it can be difficult to detect misalignment with vibration spectra alone. Misalignment can be easily confused with other fault conditions, including imbalance and looseness. Phase analysis is a great aid.

When a machine is misaligned there are characteristic forces at play in proportion to the degree of offset and angle between the "rotational centerlines" of the shafts. These forces are very different to those observed when a machine is poorly balanced; therefore the phase relationships are quite different. If you

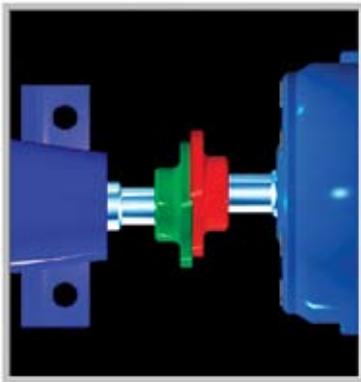


Figure 10 - Pure offset misalignment.

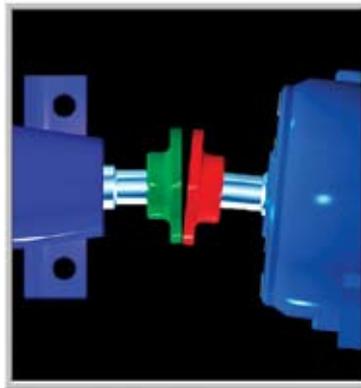


Figure 11- Pure angular misalignment.

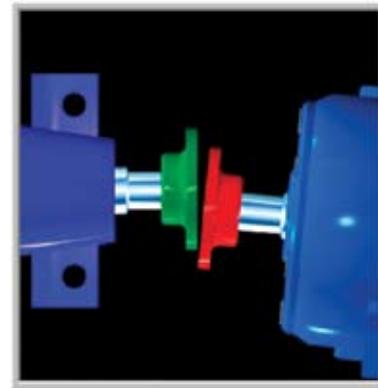


Figure 12 - Common misalignment.

suspect imbalance or misalignment, and you perform the tests described in the previous section and find that the rules are not met (for example, the phase angle between the vertical and horizontal axes is not between 110° and 70°), then there is a very good chance that the machine is misaligned.

1). The phase relationship between the vertical and horizontal readings taken at the ends of the machine will not follow the rules that we described with unbalance. Due to the motion created with angular and offset misalignment, and the effect that different coupling types will have on that motion, the phase angle between the ends of the machine will not be consistent in the vertical and horizontal directions.

2). If a machine is misaligned, we would not expect to see 90° difference between the vertical and horizontal readings taken at the same bearing. Instead they are likely to be closer to 0° or 180° .

When there is strong angular misalignment you would expect the phase readings to be 180° out-of-phase across the coupling.

When you compare the phase readings from each side of the shaft (e.g. on the left and right side of the shaft, taken on the face of the component), things can get a little interesting. If the readings across the cou-

pling (from one machine component to the other) should be out-of-phase, then you would expect a consistent phase relationship around the shaft – in order to maintain the cross-coupling relationship. However, because of the type of coupling, the design of the two machine components, and the actual bal-

ance of offset misalignment and angular misalignment, the phase readings may surprise you. On one component the readings may be in-phase, but on the other they may be out-of-phase.

Eccentricity

Eccentricity occurs when the center of rotation is offset from the geometric centerline of a sheave (pulley), gear, bearing, or rotor. The highest vibration will be in the axis of the

Shaft Alignment



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belt, so measurements should be taken in this direction, as shown in Figure 13. There will be a phase difference between the measurement taken in the axis of the belt and at right angles to that direction of 0° or 180°. Note that we are not taking phase measurements in the true vertical and horizontal directions. We are taking one measurement in line with the belts, and the other at right-angle to this direction.

Bent Shaft

A bent shaft predominantly causes high 1X

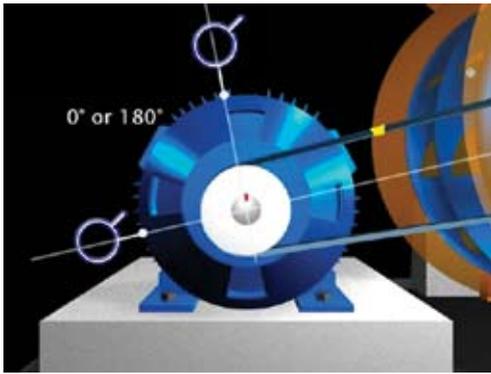


Figure 13: Phase relationships for an eccentric pulley.

axial vibration. The dominant vibration is normally at 1X if the bend is near the center of the shaft. However, you will see 2X vibration if the bend is closer to the coupling. Vertical and horizontal measurements will also often reveal peaks at 1X and 2X, however the key is the axial measurement. Phase is a good test used to diagnose a bent shaft. The phase at 1X measured in the axial directions at opposite ends of the component will be 180° out of phase.

It is also possible to take phase readings around the shaft – on both sides of the shaft,

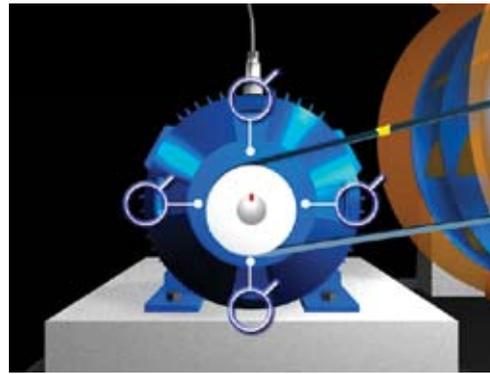


Figure 14 - Phase relationships for a bent shaft.

and above and below, as illustrated in Figure 14. We expect all of the readings to be in-phase.

Cocked Bearing

A cocked bearing, which is really a form of misalignment, will generate considerable axial vibration which can be confused with misalignment and other conditions.

There are actually two possible forms of cocked bearing. If the outer race of the bearing is cocked, the axial phase readings will indicate a 180° difference from one side of the shaft to the other. However, it all depends how it is cocked. The 180° difference may be seen from the left side to the right or it may be seen from the top to the bottom – but not both.

If the inner race is cocked on the shaft, then the bearing will appear to “wobble” as it rotates, generating a rotating 180° phase difference. There will be a 90° difference as you move from top to right to bottom, to left (or 12:00 to 3:00 to 6:00 to 9:00). The phase relationships are illustrated in Figure 15.

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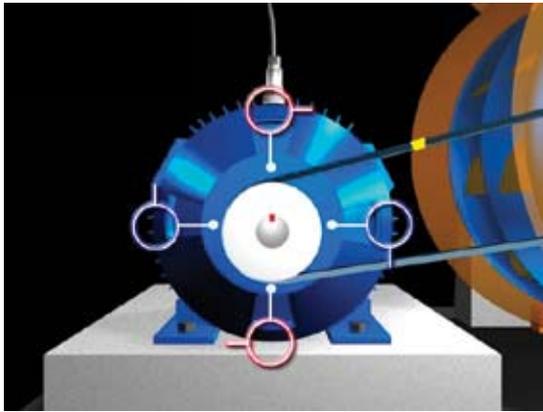


Figure 15 - Phase relationships for a cocked bearing.

Looseness

Phase analysis can also be used to help to identify looseness and foundation problems – but in a slightly different way.

First, because rotating looseness involves a 1X peak and harmonics, it can, in some cases, be confused with misalignment and even bent shaft and cocked bearing. However, the phase readings will not follow the rules we have discussed thus far, and will be random in nature (erratic). So this can help you distinguish between the two fault conditions.

In the case of structural looseness, where there is a problem with the foundations, phase can be used in two ways.

First, if the vibration levels are high enough, the machine may rock back and forth. Phase readings taken in the horizontal direction could be in phase, but unlike unbalance, there will not be a 90° phase difference between vertical and horizontal.

If there is a crack in the foundation or a loose hold-down bolt, you can monitor the phase while you move the accelerometer from point to point. When the accelerometer moves across the crack or loose boundary, the phase angle will change by approximately 180°.

Conclusion

I hope you now have a new or renewed interest in, and respect for, phase analysis. As we have seen, phase is a powerful tool that can help you positively diagnose a wide range of fault conditions. And, if you have a two channel data collector, phase readings are not difficult to collect. I encourage you to start using phase analysis today.

Jason Tranter is the founder of Mobius, the iLearn company, and the founder of The Mobius Institute. Jason is the author of iLearn-Vibration, iLearnAlignment, and the analysis tool, Interpreter. Jason began his career in vibration analysis in 1986 in Australia. After selling his business to DLI 1990, he spent six years working for the consulting and product development company near Seattle. Jason has written numerous articles, given papers, and delivered training courses in many countries around the world. Mobius, founded in 1999, has offices in Seattle, Knoxville and Melbourne (Australia), with training centers in over a dozen countries, and customers in over 80 countries.



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Fixturlaser XA

The video revolution has hit the machinery alignment industry. There are a lot of us that complain about how much time the kids spend playing video games. Well, now you can join in...on the job. And be productive, really productive. The Fixturlaser XA incorporates state of the art technology to increase the accuracy and speed of machinery alignment. John Walden, Director of Sales & Service (and part owner) of Vibralign, Inc, took the time to talk about some of the intricacies of what makes this instrument cutting edge. Considering his 25 years of experience in machinery vibration and alignment, the fact that he's really excited about the Fixturlaser XA says a lot. Here is what he has to say...



With the Fixturlaser XA, the graphic interface of Macromedia Flash walks the user step-by-step through the alignment process.

First, why don't you briefly explain why alignment is so important in the manufacturing and production industry?

Well documented since the 1950's in periodicals and professional publications, the root cause of the vast majority of machinery failures can be found in either misalignment or balance. Installing and maintaining machinery in proper rotational alignment directly extends Mean Time Between Failure. With the new generation of alignment tools, the process is easily understood at the mechanic level at price points that are no longer prohibitive, even to the smallest of manufacturers.

Fixturlaser XA is billed as the alignment system of the future. What are a few of the system's characteristics that make it so advanced?

The Fixturlaser XA laser alignment system takes great advantage of new technologies throughout its design. Several are readily apparent to the user – computer technology enabling movie-like machinery graphics which represent the exact alignment condition with true live mimic; Bluetooth II wireless, the next generation; line lasers that are

bright, easy to see and don't require manipulation to the target; relatively huge detector surfaces (30mm) to easily accommodate even the grossest misalignment over a long span; and a full VGA Touchscreen chemically hardened to strength surpassing tempered glass. Not as visible, but just as important is the utilization of CCD technology, a break-through in laser alignment systems with a common component part; Microsoft's Embedded Windows CE and Macromedia Flash technology to bring it all together in a package that can be updated and upgraded easily, protecting the user's investment.

I understand that the XA stands for Express Alignment. Explain why the system is so quick to setup and use.

It starts with the design of the box. All components are in logical positions, some pre-assembled so the user gets out of the box quickly and straight onto the machine to measure within minutes of arriving at the job. With the sensors mounted, the user need not struggle with lining up laser dots to targets.

But express alignment has other important considerations. First,

after mounting, the correct and accurate machine position is measured through automatically leading the user through the process. Customers are telling us they have alignment data within 5 minutes of setup every time. The new Express measurement method allows the instrument intelligence to prevent common mistakes from being made. Express Alignment is also about getting the job done right the first time, by ensuring the accuracy and letting the user know when he is finished. The XA intelligence ensures that so the user can also get off the machine quickly and back into the box.

The system seems very graphically oriented almost like a video game. Why don't you explain the rationale behind the user interface?

MMI has been a huge undertaking in the operations side of manufacturing over the last 15 years. All control rooms look like video arcades today, utilizing detailed graphics, color, etc. The Fixturlaser XA is an evolution of that technology into the maintenance arena. It takes great advantage of the visual sense, making it easier to understand for both the novice and the professional.

The Express Mode seems like a very interesting feature. Tell us how that feature works.

The Express Measurement mode is based on the logical progression of input and automatic measurement. First, the system utilizes simple features like a fingerprint to remind the user what the next step should be. Second, using the high resolution graphics, the system shows the user what input is required. And, third, a combination of new micro-electronic position technology and built-in intelligence assist the user in how to rotate the shafts to a correct position to obtain data it can calculate accurately to 1 ten-thousandths of an inch. When the XA senses everything is right, it obtains the measurement and moves forward in the program.

For readers not familiar with Fixturlaser, give us some details on the company itself.

Fixturlaser AB is a 22 year-old company manufacturing in Molndal, Sweden, on the outskirts of Gothenburg. Utilizing partnerships and internal capabilities for manufacturing and assembly, Fixturlaser is able to focus on the engineering side bringing real innovation to the laser alignment business. In the last 10 years that has been seen with low cost entry level, easy to use systems, break-through OL2R (an off-line to running measurement system to obtain alignment offsets using shaft alignment tools), the first with touch-screens, and now, built-in intelligence with new technologies.

We understand there is no software with the system. How can that be?

No software may be a little misleading, but it is true. The XA system saves jpeg graphic files in a Windows Explorer type file system. This gives the user full control of file names using a QWERTY keyboard pop-up, and saves all the measured and control data in a common file format. The XA also saves an alpha-numeric ASCII file. The beauty of this is the files can be used in any manner the user desires. If a report is required, simply copy and paste into any word processor. Or, append the file to a CMMS or vibra-

tion analysis software package. Or use the ASCII file to import to any database program. The simplicity is that it all transfers using a standard USB cable or USB memory stick available at every computer store in the world. Nothing proprietary!

What is the expected cost of ownership of the XA System?

Traditionally the Fixturlaser alignment systems maintain a very low cost of ownership. While it is difficult to fix a cost into the future of a new product, the XA system has some capabilities built-in that are unique. The XA has a built-in Ethernet port which will allow the repair team to access any machine remotely across the internet and troubleshoot program and component function. Component selection has been carefully engineered in the Swedish tradition to assure long, reliable life.

Give us a success story or two from the use of Fixturlaser XA.

I think the most proper measurement of success has to come from the experience of users. Recently, a mid-west manufacturing firm told us they got an XA system onto a compressor with a six foot jack-shaft and had measurement data in 5 minutes – a task that normally took them 2-1/2 hours in the past with another instrument. The alignment was complete in less than 30 minutes. A waste water treatment contractor in the north-west told us they were able to get alignments accomplished on 18 motor-pump sets in one 8-hour day. Now, that's EXPRESS.

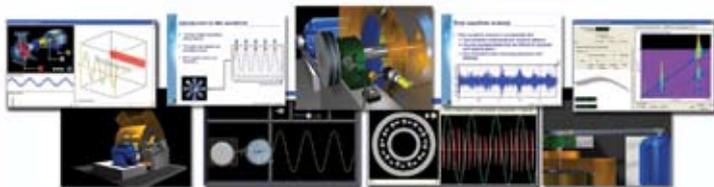
How can interested people get more information about Fixturlaser XA?

The first step should be to visit the web site – www.vibralign.com. You will be able to get a good feel for the XA System which will soon include an interactive demonstration. You can also find a copy of the brochures and spec sheets. Of course, we would always ask someone to call us at 800-379-2250. We will happily have a sales person come to their site for a demo at any time.



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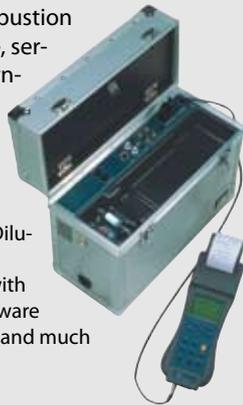
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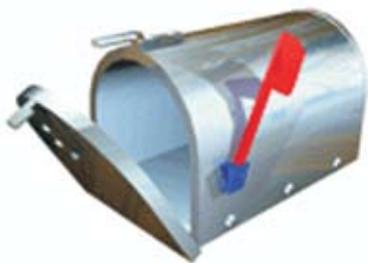
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In the February issue, on page 24 in the article entitled "Keeping up Resistance" we made a mistake in adding the parenthetical phrase "negative" after "red test leads". Widely accepted industrial standards dictate that red test leads are, indeed, positive. Our apologies for the confusion.

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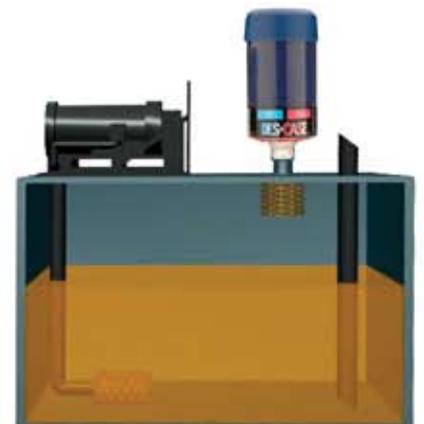
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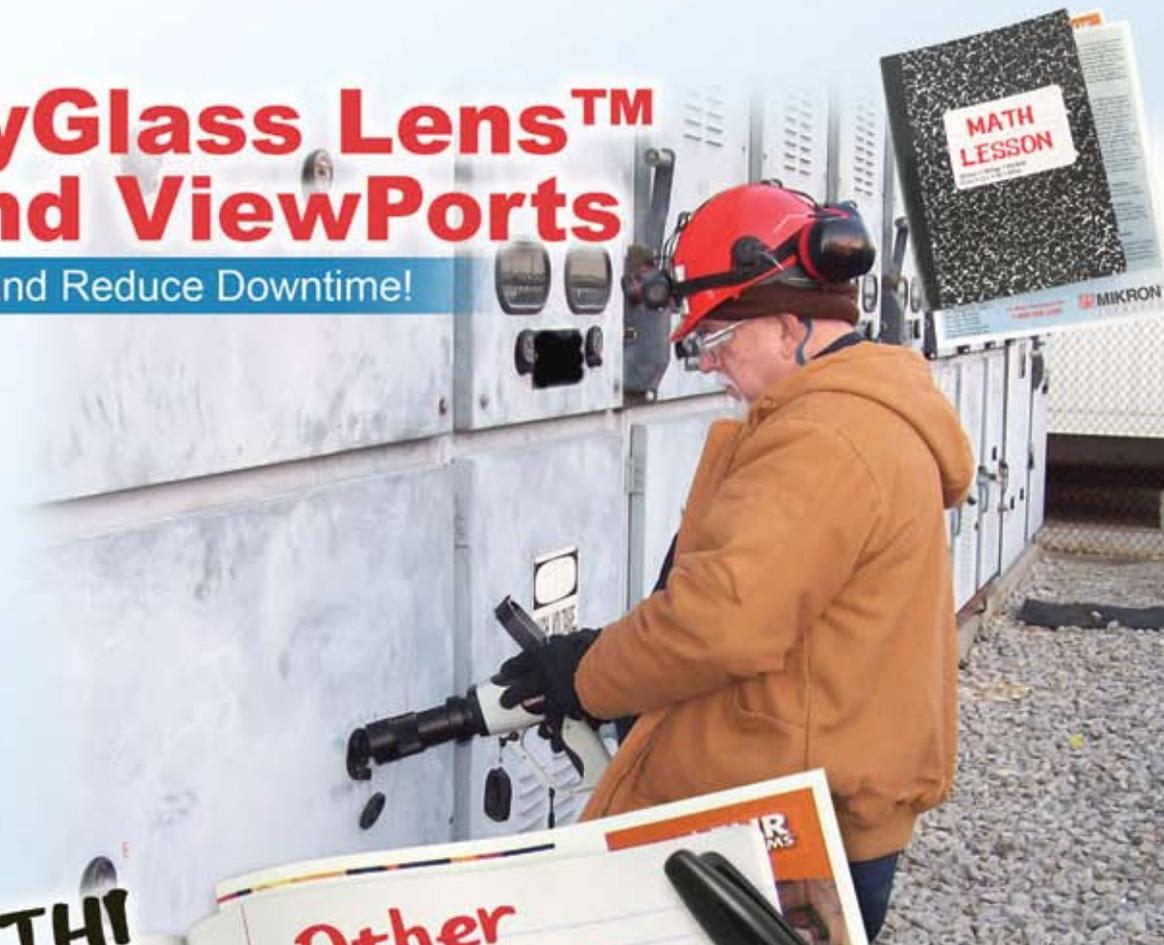
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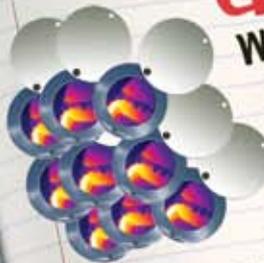


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