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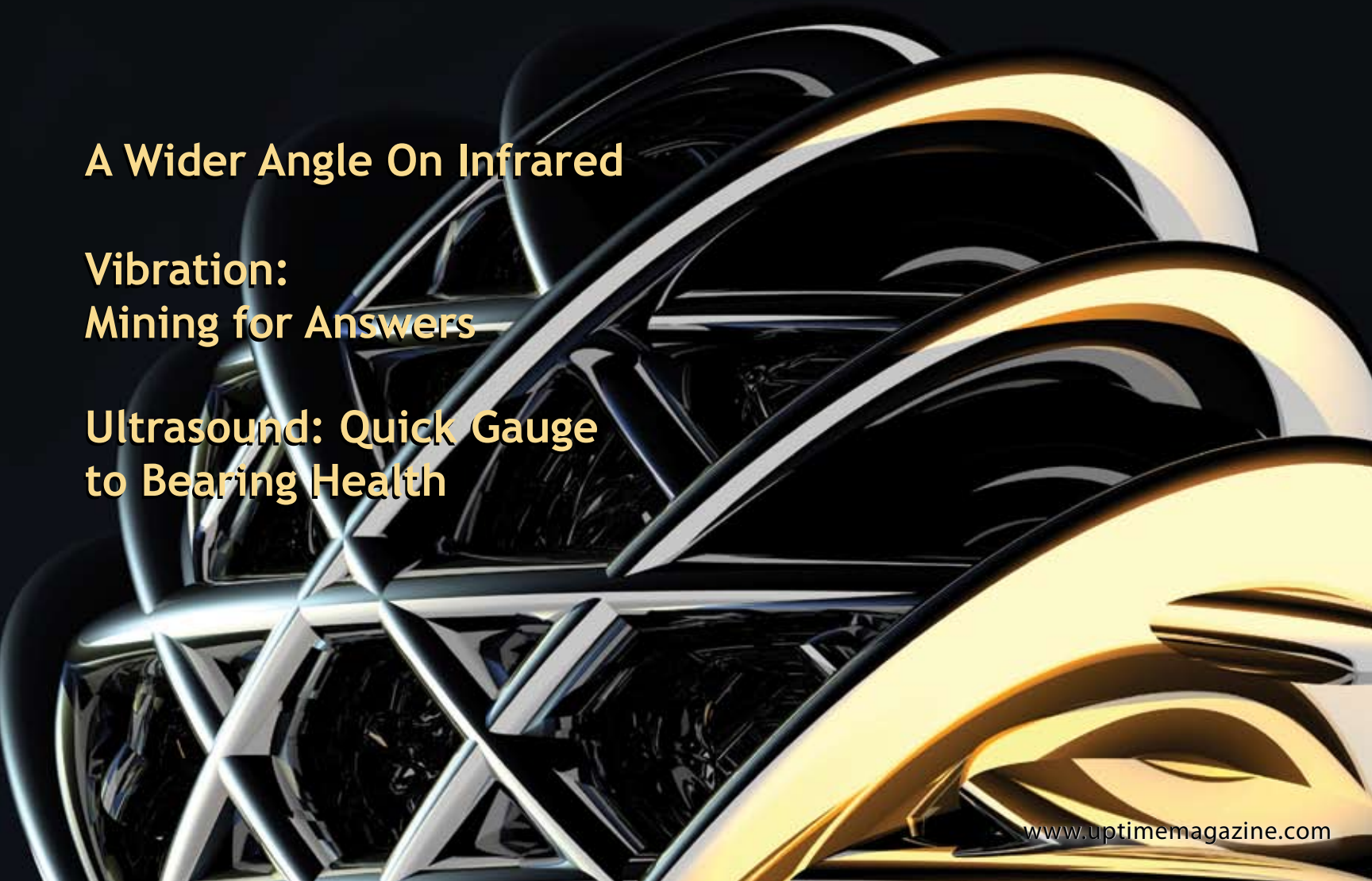
the magazine for PdM & CBM professionals

sept 2006

Looking Forward
The Future of PdM



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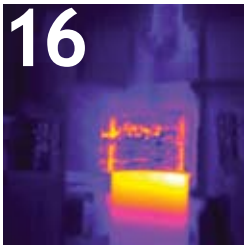

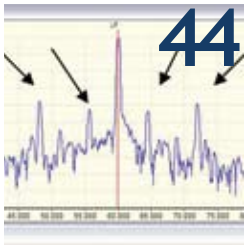

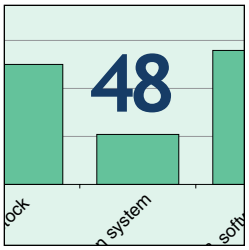

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What's Next?

Welcome to the September issue.

All I can say is Wow!

The quality of the entries for Uptime's 1st Annual PdM Program of the Year awards was...well...out of this world. All of the programs that were entered are doing some outstanding work in PdM and CBM. Our intent is for the awards to serve as a way to recognize the hard work that so many people put into maintenance and reliability. Everyone who took the time to enter their program has helped to elevate the industry. We appreciate it.

A special congratulations to all of the winners! These programs are truly the crème de la crème of the maintenance and reliability world. Please look on page 24 to see all of the winning programs.

We hope that you will enter your program in next year's awards. Your program could be a future winner.

As you'll read in this month's feature article, PdM has made impressive strides since its inception roughly 50 years ago. Who knows what the next 50 years will bring? There are many fascinating and exciting breakthroughs happening in the industry today; so future advances to be made in predictive technologies are not only thrilling to think about, they are closer than you think.

This month marks Uptime's 1st birthday. Our first issue was unveiled at the PdM-2005 conference last September. Time sure flies when you're having fun. I would love to hear some of your thoughts - good or bad - about how we are doing. We want Uptime to work for you.

I would be remiss if I didn't mention a blunder in the August issue. The author of the vibration story, Soul Mates, is Andy Calcagno, who works at the GM Spring Hill Manufacturing plant. We misspelled Andy's name. I hate it when that happens. My sincere apologies, Andy. Keep up the good work and thanks again for the article.

Thank you for reading. If you have any questions, comments or ideas that would make Uptime more useful for you, please let us know.

All the best,

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The Future of Predictive Maintenance

by Elsa K Anzalone &
Jack R Nicholas, Jr.

We are on the verge of another paradigm shift in the way organizations handle Predictive Maintenance (PdM) programs. This one follows two previous major changes in PdM programs: the first, when equipment went from heavy cart-transportable packages for data collection and some analysis (1980's) to microprocessor-based hand held packages; and the second, when field-portable laptop computers and desktop personal computers with robust software programs and substantial memory capacity came into use (1990's). Together they transformed collection, storage and analysis of data and, as a result, fundamentally changed predictive maintenance (PdM).

The original "PdM Farm System" at plants, where seasoned technicians mentored trainees learning to do vibration and other related condition testing, is falling by the wayside. In some plants, these groups have been disbanded altogether. Often expertise is shared among plants or outsourced, and is no longer resident in house. In other places, fewer but higher skilled and formally trained PdM specialists are beginning to apply multiple technologies for condition monitoring predictive analysis. They are becoming "knowledge workers," a phrase coined and defined by Dr. Peter F. Drucker, PhD, in his 1959 book entitled Landmarks of Tomorrow.

What are the options for providing the same, or even higher quality, information to plant personnel who have come to depend on this information to maximize production? How can we overcome the "time-space" continuum and be in two, three or four places at once? The answers to those questions lie, as they so often do, in rapidly developing new technology.

"Traditional" PdM Programs

Predictive maintenance and condition monitoring have been around for about 50 years, but already we can distinguish "traditional, old time" predictive maintenance programs from more modern ones. For most of that 50 years routine data collection was performed using "portable" equipment. In the earliest days of almost all technologies, such as vibration analysis and infra red thermography, "portable" meant that a team would lug or cart various components of a monitoring suite weighing 30 to 50 pounds each into areas of the plant where monitoring was required. This was cumbersome and time consuming even before data collection could be performed. The advent of microprocessors in the 1980's, reduced these data collection tools to "handhelds." Data could be collected and analyzed, at least to some degree, at the machine.

In the 1990's, the introduction of electronically cooled sensors allowed infrared thermographers to retire their liquid Nitrogen cooled equipment. This development, combined with ever increasingly capable integrated circuits and digital technology, enabled PdM practitioners to create much more vivid, intuitively interpreted images that even a novice could understand.

The introduction of personal computers in the late 1980's and battery powered lap top computers with sufficient memory in the early 1990's further enhanced the PdM technicians' ability to perform (with the help of increasingly sophisticated software) detailed analysis in the field. Even more recently, developments in wireless communication capabilities have made reporting from the field, either by humans or machines, even easier.

Today, for most technologies, such as those used in motor testing, ultrasonic analysis and on-site particle counting in lubricants and hydraulic fluids, the use of a monitoring electronics package combined with a laptop computer or a microprocessor constitutes "state of the art." The suites are packaged in briefcase, backpack or shoulder bag carriers and are capable of field operation on battery power for four to eight hours at a time. More sophisticated software may be resident in a desktop computer for use by the PdM analyst to perform more detailed analysis, report findings or in more advanced organizations initiate work requests based on the findings.

The most critical equipment, such as a turbine generator in a utility plant, will have an installed monitoring system which senses multiple condition indicators including vibration, clearances, temperatures and many other parameters. These installed systems are generally hard wired and networked to provide analysis and alarm data to operators for their decision making. The cost of such systems can easily exceed US$100,000. The return on investment, however, considering the values of the assets being monitored, is invariably worth while. Part of the continuing return is the savings in labor costs that would otherwise be required to manually collect enough data on high value assets to make useful decisions.

One can see that there has been a shift in allocation of time. Lighter suites of battery powered equipment can be positioned as fast as a person can get to the site. Data can be taken at the machine for on-site analysis. Also today, wireless communications networks can transmit (e.g., from Personal Data Assistants - PDA's) urgent reports or work requests right from the site of the degrading machine, a further savings in time.

So, the traditional PdM program has evolved into what we can call a "modern" approach based on commercially available combinations of sensors, microprocessors, computers and software, and permanently hardwired, installed monitoring systems.

The PdM practitioner has evolved into a "knowledge worker." Such workers don't come cheap, nor are they easy to retain. Training costs can average US$6,000 per worker per year, if a regimen of constant improvement in skills is pursued. Aside from training, a worker at an in-house program can cost US$80,000 to $90,000 per year, including all overhead costs. Capital investment in the upper end technologies (vibration, infrared thermography, motor testing) can cost US$50,000 each and require update and support costs of ~15% of the capital investment cost annually. Some very useful technologies such as ultrasonic analysis and portable lubricant particle count equipment have lower capital investment costs, but nearly equal annual costs for personnel and training.

Those who enter the field of predictive maintenance and condition monitoring are among the best and brightest in any organization. Their retention is generally a high priority, but it is not unusual for them to be able to move on to supervisory or even management positions. Thus, they can leave behind the hot, sweaty conditions that are the lot of PdM practitioners today. In addition, they can leave behind some of the more frustrating aspects of their field such as having their analysis results and reports ignored, and being looked at as the constant bearer of bad news concerning machines that need repair and production runs that have to be interrupted.

Some companies, aware of the costs of PdM programs, but unwilling to do without them, are starting to outsource their PdM. Thus, even at US$75-$150, when less than a full time PdM specialist is required, outsourcing becomes attractive. On-call, multiple technology equipped specialists are becoming available nationwide (even on holidays, and weekends when most emergencies seem to occur) from companies such as Allied Reliability, a new company operating in this field for about eight years.

Those who enter the field of predictive maintenance and condition monitoring are among the best and brightest in any organization.

The Next PdM Programs

What we have just described sounds thoroughly modern, and it is. But it's changing - and rapidly. The change is going to be as much of a paradigm shift as the ones from heavy suites of equipment to handhelds and from individual analysis to computer supported (and automated) analysis and reporting.

In an editorial in Sound and Vibration Magazine, Nelson Baxter made the following points concerning the future of Predictive Maintenance and Condition Monitoring:

- There will be fewer people collecting data and performing analysis, due to global competition, skyrocketing health care costs, deregulation and other factors.
- Where it is possible, data will be brought to the analyst, not the other way around.
- Data from similar machines will be archived and used to simplify problem identification across a fleet of like machines wherever possible.
- The combination of wireless networks and the Internet will enable the easy movement of data from the plant to the analyst.
- Large manufacturing organizations will have hybrid programs where more critical equipment is monitored daily or more frequently and less critical equipment less often.[1]

In addition to these predictions, which focused mainly on the application of sound and vibration monitoring, the following are actually happening or beginning to happen in the field of predictive condition monitoring (PCM):

- New and different sensors are being developed that will have application in the PCM market, even though at the present time these sensors are not targeted specifically for that market.
- Mobile platforms, manufacturing plants, commercial buildings, utility plants and their associated distribution networks, as well as infrastructure for many other applications, will be monitored in ways that are significantly different and more extensive than is done today.
- The monitoring systems will be cheaper, faster, more capable and easier to use, redeploy and configure than the systems in use today.
- While the labor intensity required for monitoring machines in a facility or platform will decrease because of increased productivity of PCM systems and support tools, the number of applications requiring monitoring will increase for a wide variety of (mostly economic) reasons.
- While the number of individuals engaged in PCM per site or fleet of vehicles will decrease, the number of PCM-skilled "knowledge workers" will increase as the value of PCM becomes known by managers, intent on competing effectively in the global marketplace.

What is occurring in the market place is that a number of technologies that can affect PdM are converging at the same time and at a single apex point. The convergence of these technologies is already creating a tremendous impact on how we manage and interact with our assets, products and physical environments. For example, even our understanding of the Internet is changing. The United Nations recently issued a paper on what it called "The Internet of Things". This is a marketing term that came out of MIT, where futurists see that the Internet will no longer consist of basically a web for publishing and transmitting information. It will be an Internet composed of machines, places, objects and things. A vending machine, a refrigerator, a "smart pump" and other machines will all be connected to the Internet. These connected machines will interact with each other and humans to deliver new services and create new service markets. Another marketing term that is being associated with this is called "M2M" or Machine-to-Machine and Machine-to-Man communications. At present, the Internet is the only standards-based communication medium uniquely capable of handling all these data, and doing it in a way that makes it cost effective for everyone to use. A wireless "Internet of Things" seems destined to converge with better industrial asset management practices now and into the future.

Analysis Methods and Support Tools of the Future

New ways of analyzing for predictive and condition monitoring of machines are also coming into use. We are moving away from human intuition and knowledge acquired on-the-job or in formal training courses or texts, and towards a merger of human and computer based intelligence. Many times in the past, vendors of PCM hardware have touted new software that "fully integrates" multiple technologies into a single software "package." What these really turned out to be were single software platforms with multiple modules that dealt with storage, recall and analysis for data from various technologies. However, in many cases, the data and analysis results were still contained in relatively isolated "silos." There was little, if any, integration of results from different technologies using any significant amount of correlative or correlation analysis.[3]

Fore example, a system called the Integrated Condition Assessment System (ICAS) is now in use in over 110 U.S. Navy ships and many commercial applications. With its graphic user interface programmable logic "rules" for alerting to degraded machinery, the system can arguably be considered representative of the current state of the art in diagnostic and prognostic analysis of major operating systems in mobile platforms, utilities and manufacturing plants. ICAS is now being supported by General Electric Corporation, which purchased all intellectual property rights to the software recently. Along with its acquisition of IDAX, Inc. (ICAS software producer), General Electric also acquired parts of Bentley Nevada, an internationally recognized manufacturer of installed and portable condition monitoring hardware, and condition monitoring software, most notably its System 1® package. A recent merger of the teams responsible for ICAS and System 1® under a single manager could lead to the creation of the next generation of predictive, condition monitoring software containing the best features of both systems, along with other capabilities such as those described below.

The company that first originated ICAS under U.S. Navy contracts, Dundics Enterprises (now called the DEI Group), recently teamed with an overseas-based organization to develop and apply, on a trial basis, an even more sophisticated analysis approach in one of the most difficult of applications - electric motors and drive trains.[4]

The Motor Condition Monitor (MCM) sensor system, described by its manufacturer as a "detective multimeter," is the result of collaboration by two companies, Artesis, Inc., and Inter Electric Electronic, both located in Turkey. The small MCM package, which can be held easily in the palm of one hand, is permanently installed in the front door panel of a motor control center. Its sensors (SOCs) are attached to power circuits inside the panel. The MCM applies model-based plant condition monitoring and early warning predictive algorithms originally developed for the aerospace industry in the USA under U.S. National Aeronautics and Space Administration sponsorship. The device uses only the three phase currents, voltages and line sig-

nals (wave forms) that are fed to the motor as inputs for analysis. Outputs are transmitted by a separate wireless transmitter to a network linked to an analysis computer containing the analysis software.[5]

The key analysis engine is a Bayesian Belief Network (BBN) for electric motor and driven load components using information from the MCM. The logic of the BBN was derived from MCM parameters (8 electrical and 12 mechanical), all the result of interpreting current and voltage values and waveforms. These are organized into spreadsheets of failure modes and related electrical and mechanical indicators. The MCM parameters are measured and made available to the BBN. The network then calculates the probability of a Failure Mode being TRUE or FALSE. Many BBN software products can only calculate in the one direction. The BBN based Machinery Diagnostic Reasoning Engine that DEI jointly developed with another partner, Quantum Leap Innovations, can calculate in either direction; fore-calculate or back-calculate. This predictive machinery solution supports:

The system provides estimation of current health and forecasts failure probability.

- Condition monitoring and continuous anomaly detection of dominant equipment dynamic failure modes;
- Estimation of current equipment health as related to residual useful life and forecasts the time of failure probability
- Recommendations for planning and scheduling options based on projected demand utilization and resource availability

The software component is populated with specific knowledge of the applicable plant equipment operation and symptom recognition developed by DEI Group engineering staff. When applied, for example, to a set of cooling tower fans driven through gearboxes, the system will recognize equipment anomalies that arise from: fan degradation, electric line problems, motor degradation, excessive bearing and gear box wear, imbalance of rotational equipment and misalignment between coupled equipment.

The system will alert personnel using visual or e-mail notifications. The system provides estimation of current equipment health and forecasts failure probability. Thus, the ultimate promise of "predictive" maintenance may be fulfilled by this development, which is the result of an international cooperative effort.

Equipment health, as related to residual use-

ful life, is represented as a calculation of the cumulative damage, or aging, that the equipment has accumulated since new, or since the last overhaul. The proposed predictive machinery management systems will use the results of the anomaly detection function and the probabilistic risk engine to estimate an instantaneous value for overall equipment health by combining the condition of all of the equipment's failure modes into a single representation of health.

Given the current health of the equipment, and the projected utilization of the equipment as defined by duty cycles (loads during time periods), the system estimates the future behavior of the equipment relative to degradation leading to functional or structural failure. Failure here is defined as the point of degradation where the equipment no longer supports the system requirements. The information is displayed as probability of equipment failure relative to a time scale.

The combination of the diagnostic and prognostic capabilities of the predictive machinery management systems is a powerful platform for linking equipment problems to the specific root cause. It provides risk-based advanced maintenance recommendations relative to the resolution of the recognized anomaly. The pre-engineered diagnostic and prognostic algorithms will store computed information in the embedded data historian. This allows using the built-in functions for constructing the user interface and displaying the condition and future risk of the pre-engineered machinery failure modes.

Integration with the installed Computerized Maintenance Management System allows automated initiation of advance logistic planning and scheduling to support plant operational requirements. The Maintenance Decision Support component assesses the following:

- Projected risk of equipment failure,
- Availability of required material and personnel resources,
- Planned operational requirements, and planned outage schedules in order to recommend requisite maintenance or operational activities associated with managing the predicted equipment risk. It's also capable of assessing the impact of maintenance deferral or changes in operational duty cycle demands

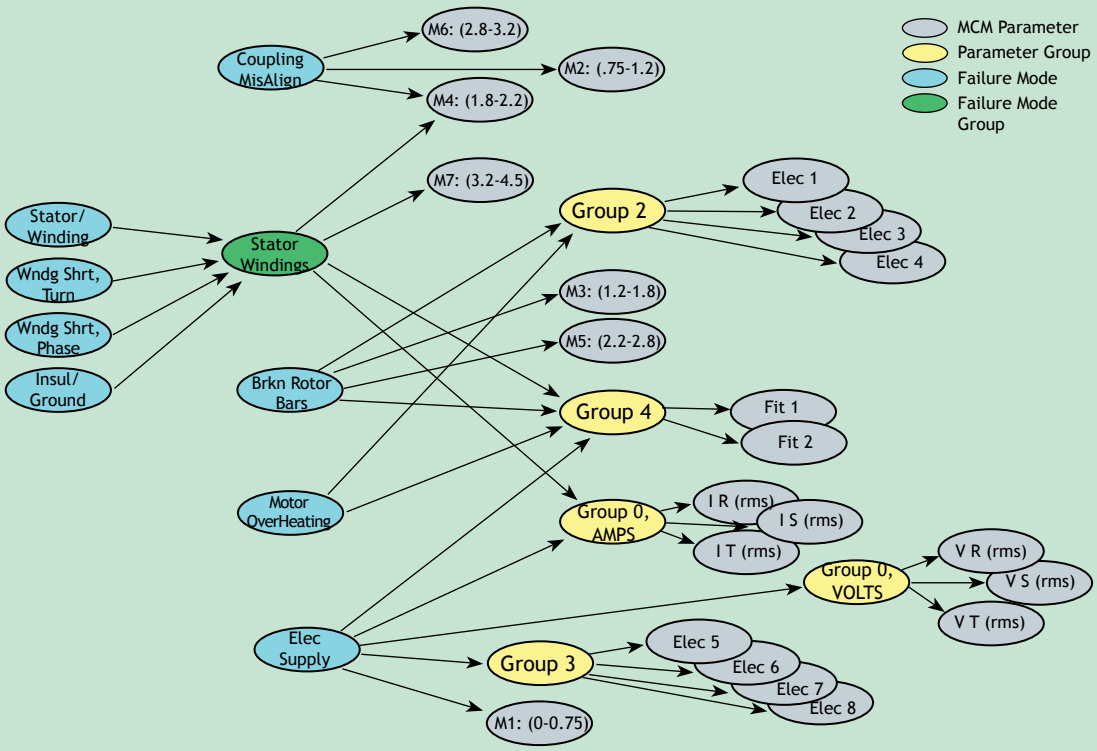

Figure 1 - Simplified BBN for Motor Faults - The nodes have states and conditional probability tables. For this BBN, a failure mode will have two states, TRUE or FALSE.

A simplified Bayesian Belief Network is illustrated in diagram in Figure 1.

The summary of all the analysis is a complete table of decisions and probabilities, based

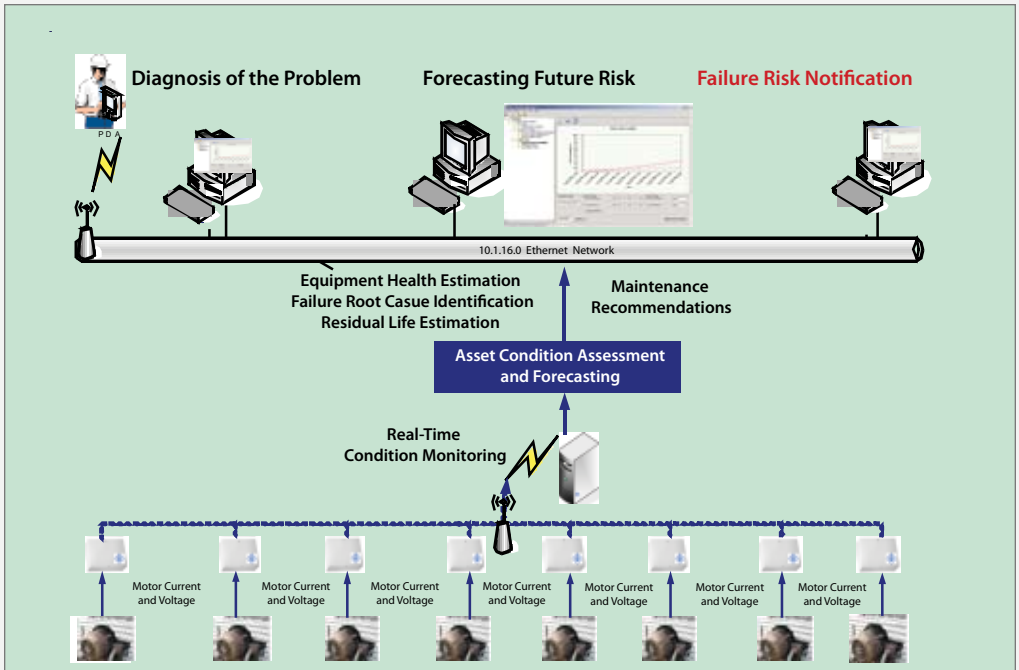

Figure 2 - Monitoring Concept for an 8 Fan Motors in a Cooling Tower

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...reports provided include diagnosis of the problem and a forecast of failure... the decision maker can make a more informed determination...

on machine history of failure modes and tied to current data on condition, which yields a "most likely" root cause of degradation, as illustrated. The entire concept for this very advanced PdM program is illustrated for a set of eight (8) cooling tower fans in Figure 2.

Note that the first leg of the data collection communications path in Figure 2 is the power supply cable between the motors from a water cooling tower to the weatherproof motor control center. The wireless link is between the MCMs or detective multimeters receiving the current, voltage and wave form data from the power cable sensors and the real-time condition monitoring analysis computer located in a building several hundred feet away. The MCM data are directed by wireless gateway to the wire- or fiber-based Ethernet network linked to computers containing the Bayesian Belief Network software and other communications links to decision makers in-house, at home or in other locations. The reports provided include diagnosis of the problem and a forecast of failure risk. With these reports, the decision maker can make a more informed determination considering importance of the production run in progress as well as the consequences of interrupting it to make a repair.

This system is already in use at the Koch Primary Energy site monitoring motor-driven ID fans and motor-driven feed pumps. Koch, historically one of the most progressive companies in application of cutting edge predictive, condition monitoring technologies and analysis methods, intends to apply this analysis method to its generators using the output from sensors on the output cables to monitor partial discharge (PD) data, a key indicator of generator insulation and internal component deterioration. Currntly, PD monitoring is done every six months using a portable monitoring system designed and sold by Koch's wholly owned subsidiary company, Iris Power Engineering of Ontario, Canada.

A Different Approach to the Future

Another method of Predictive Condition Monitoring is to provide a group of experts in various industries and machinery types. These experts are available to provide high-end analysis when a wireless networked sensor indicates the onset of conditions that may lead to failure. The key to this approach is the use of high speed Internet connection between the machine being monitored and the central analysis site.

Azima Inc, makes industry standard sensor devices wireless by connection to on-site interface and communications packages. These sensors are connected to wireless or wired hubs, which are then connected to a backbone communications link (which may be wired, fiber or a combination thereof, and contains the site server, any wired hub connected sensor data or video data). This network, in turn, connects via the Internet to the analysis computers and monitors. These may be anywhere, including at the site for local analysis and/or consultation, at home for observation by key plant employees, at the desk of a machinery vendor's expert analyst thousands of miles away, or at an Azima office where experts may also be located, servicing multiple clients. The data is available through any standard web browser, and access to the portal is controlled by the customer.

The concept of a typical Azima installation is illustrated in the Figure 3.

Driving Force for the Future of Predictive Maintenance

The principle driving force in the future for predictive maintenance is economics. Stand-alone, in-house programs will benefit because the capital investment requirements will be lower than today. At a nuclear powered generating plant the cost for a wired or fiber optic connected sensor may be $2-3,000. The price in other commercial installations can be US$1,000 or more. A simple wireless sensor package installation for a single parameter can be one-third that price.

In addition, the cost of labor to perform a potentially much greater data collection effort is reduced to a fraction of what it is today. The labor cost, shifted to the analysis function, whether in-house or outsourced, will enhance productivity of the overall program.

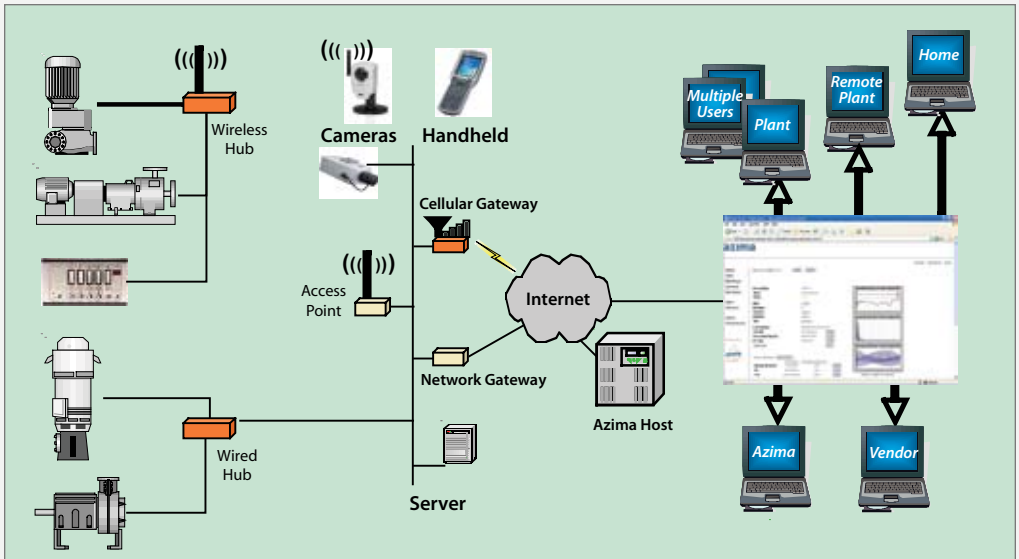


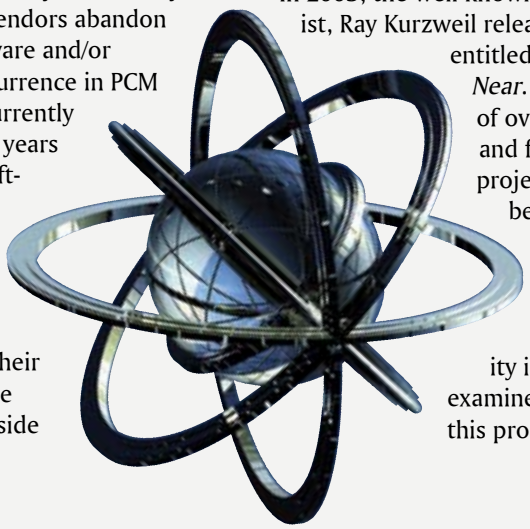
Figure 3 - AZIMA Concept for Monitoring a Variety of Components in a Plant

Another economic element is the willingness of companies to "partner" with organizations that install, maintain the sensor networks and provide complete or partial analysis services and support for a monthly fee. Thus, the client's capital investment requirement is greatly reduced or eliminated. This allows the decision concerning deployment of a wireless system to rest more on the requirement for Predictive Condition Monitoring to increase equipment reliability, throughput and productivity and less on the need to process a capital investment request, which in many companies can take years.

At the Covanta Energy Haverhill 48 Megawatt Resource Recovery Station waste-to-energy plant north of Boston, Massachusetts, Azima installed wirless sensing equipment on a critical-to-operation overhead crane and six key, hard to reach fans. Savings to the utility are delivered through better, more up-to-date knowledge of critical component condition, which has resulted in better planning for outages, and far less unplanned downtime and emergency repair costs. This places the control of when to conduct an outage for repairs into the hands of the staff and removes it from the whims of random failures of the production or service machinery.

For organizations involved in or affected by international trade, the major economic incentive to adopt PCM systems of the future will be their improved ability to compete and indeed survive in the global market.

From a more practical standpoint any organization applying PCM, whether in-house or outsourced, will be forced to consider use of systems like the ones described in this paper. This is because they may be the only alternative available as vendors abandon support for legacy hardware and/or software, a common occurrence in PCM product lifecycles that currently run only up to about ten years in length. In terms of software, the PCM vendors themselves are often forced to do this because the computer hardware and operating system vendors change their product lines at about the same frequency. The upside to this is that product user productivity is almost always improved by these changes.



Keeping Human Hands on the Machinery

While all these prognostications concerning the future of predictive maintenance appear to remove humans from the machines, one must be realistic and appreciate that final decisions concerning whether to shut them down for repairs and final post-maintenance decisions on returning them to production cannot, and should not, be made without "hands-on," up close encounters by human beings. The hardware they may use may be only some "old fashioned" hand held diagnostic tools, but they will also be bringing their most important tool, the software of their own experience and intelligence, which will always remain an integral part of the diagnostic and prognostic process.

Conclusions

Predictive Condition Monitoring systems of the future will be more sophisticated than those used today, and will involve more types of sensors to detect more indicators of machine and system degradation. At the same time they will be cheaper, easier to install and use, and networked internally and/or linked via the Internet with analysis engines that may be located thousands of miles away.

The link between human involvement and involvement by microprocessor and/or computer based analysis engines that make the promise of predictive maintenance really come true.

In 2003, the well known inventor and futurist, Ray Kurzweil released his latest book entitled *The Singularity is Near*. This is the latest of over three decades and five books full of projections on the union between the life and health of humans and the machines they have created. In The Singularity is Near, Kurzweil examines the next step in this process of unification, which he contends is inexorable. That step is the union between the human and machine in which the knowledge and skills embedded in our human brains will be combined with the vastly greater capacity, speed and knowledge-sharing ability of our own creations.

The singularity is indeed near as it applies to the future of predictive maintenance.

Acknowledgement

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2. Warner, Alex, President of Pedigree Technologies, Fargo, ND from an unpublished paper on products and services of his company prepared in support of this presentation
3. A description of correlation analysis, along with five other of the most common analysis techniques used in PCM is found in the text Predictive Maintenance Management , 1st Edition, September 2005 by J. R. Nicholas & R. K. Young ISBN 0-97199801-3-6
4. Most of the data on ICAS and MCM was provided by Morton Dundics, President of the DEI Group. Mr. Dundics was the originator of the ICAS concept. Marton can be contacted via the company web site www.dei-group.com
5. Artesis is a privately held company headquartered near Istanbul, Turkey. For more details on the company and the array of products it has patented and sells world-wide, visit the website a www.artesis.com

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A Wider Perspective

Seeing Inside Electrical Cabinets Now Easy & Inexpensive

by Jon Chynoweth

Let's make a deal. Do you think the cause of your next production stoppage is behind door No. 1, door No. 2, or door No. 3? If you're a plant manager concerned about the condition of electrical hardware, that can be a frustrating question. With today's higher equipment utilization rates and the "run to failure" philosophy at many plants, an aggressive preventive maintenance program for electrical panels is clearly needed. One graphic example of how frequent infrared inspections can save significant expense occurred recently at a gas enrichment plant in the western U.S. Using a new lens and port technology that facilitates closed-door infrared inspections, the plant's maintenance team discovered overheated, failing connection leads to two 4,500-hp, methane compressor motors which were critical to the 24/7 operation.

A similar electrical connection problem at the plant previously had caused an unscheduled outage that resulted in $1 million in lost production. The timely finding enabled plant managers to correct the problems on a controlled basis, avoiding costly unscheduled downtime and damaged equipment.

Two Inspection Options

The standard methods and options for performing a safe infrared scan have not been appealing. Removing or opening electrical panels always poses a risk when high energy is involved. Human error, equipment failure and other factors can transform stable conditions in the cabinet into a dangerous environment for the inspector and anyone nearby. Preferably, an arc flash assessment per NFPA 70E will be done first to determine safe boundaries. Certainly the correct level of personal protective equipment should be worn. Regrettably, the heavy protective suits, gloves, hoods and face shields that are sometimes required make this an arduous task in a hot environment, and sometimes discourage frequent inspections.

Closed-door inspection is safer and, if high-quality readings can be obtained, a better use of manpower, allowing the thermographer to work without the help of an electrician. Until recently, this has required installation of costly and fragile IR-transparent windows (or sight glasses) which allow a small portion of a cabinet interior to be viewed through a camera. Metal mesh ports are also available.

Fig 1 - Condition monitoring of high-voltage electrical connections, looking through a 0.5" viewport with SpyGlass™ equipped IR camera.

From a thermographer's standpoint, IR windows and metal mesh screens may add an unpredictable amount of IR attenuation or transmission loss, if improperly applied. The resulting temperature measurements may not be considered entirely accurate.

IR Window Design Considerations

IR-transparent windows used in sight glasses for electrical cabinets are made of various crystalline materials that allow light, in the wavelength of 0.13 to 10 microns, to pass through. Some cameras sense in this range. However, the range sensed by uncooled microbolometer cameras is 8-14 microns. If the sight glass only transmits up to 10.0 microns then the camera is not "seeing" 71.5% of the energy from the target. This reduction of signal/energy on the detector results in lower image quality and severely compromises temperature values based on camera algorithms established for energy from 8-14 microns. IR-transparent windows can be costly. Since some designs scratch and shatter easily if pressure is applied, they are easily vandalized and a camera can't be pressed against them.

Because only a limited area of the cabinet interior can be viewed through a sight glass, even with a wide angle lens, it may take

four or more sight glasses (at a cost of about $200-300 each) to scan the interior of a typical panel. Sight glasses also require a relatively large hole in the cabinet door which can be a safety hazard if the window breaks.

UL Approved Device For Closed-Door Inspections

Another alternative has recently been developed for closed-door inspections that requires no IR-transparent window or metal mesh. It allows a thermographer to scan a panel 60" x 45" from just 12" inches away, looking through a tiny 0.5" opening in the door (Fig 1). This system combines a viewport requiring no IR-transparent material with a mating fisheye lens, known as a SpyGlass™.

The combination of window-free port and fisheye lens makes company-wide standardization feasible and affordable, because the under $50 cost of the ports comes down as quantity goes up. Industry leaders such as GE, Exxon Mobil, Boeing, Dupont and Cargill already have thousands of these ports installed. The patented viewports have received UL approval, leading to a high level of confidence by early adopters.

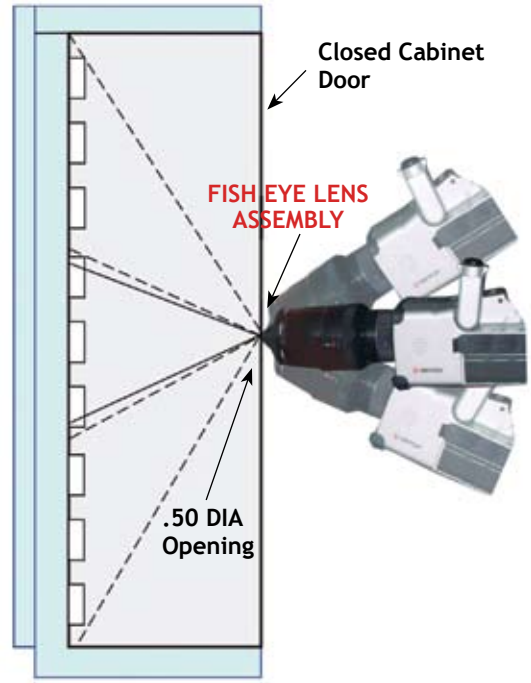

Fig 2 - Field of view with SpyGlass lens

The fisheye/viewport system enables closed-door thermal inspections of connected electrical switch gear, while maintaining the original safety rating of the cabinet. This applies to cabinets energized with 480 to 13,200 volts, as well as motor junction boxes with 4160 volts.

No IR Attenuation or Obstruction

The fisheye lens and viewport provide the clearest possible view and most accurate temperature measurement of electrical switch gear under load because the tiny port opening requires no IR-transparent window or metal mesh.

The viewport uses only a 0.5" aperture that is covered by a sealed, screw-on cap to maintain the integrity and safety rating of the cabinet when not in use. To prevent unauthorized access to the cabinet, a locking device for the viewport cap is available as well. Allowing an unobstructed view of a cabinet's entire interior, the viewport is unaf-

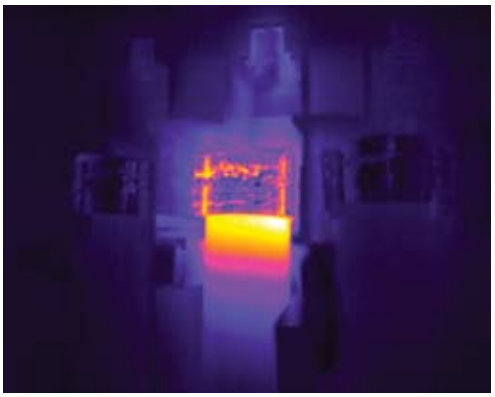

Fig 3 - A hot fuse clip, photographed with SpyGlass-equipped IR camera.

fected by moisture, dirt, UV and corrosive environments that can degrade IR windows or penetrate metal mesh covers. It also never needs cleaning or replacement.

The viewport is designed to mate with the cone-shaped tip of the lens barrel. The plastic-tipped barrel protects the lens elements from contact with the port or cabinet, and provides a layer of insulation to eliminate "path to ground" hazards. By contrast, a camera lens with a metal rim in contact with an IR window can damage the window easily, and a metal mesh screen used in place of a window creates a path-to-ground risk through the camera and operator.

In addition to the lens' wide field of view, its tip works with the viewport like a ball-and-socket joint, allowing the camera to be rocked at different angles to look up, down and to the sides, as well as straight ahead (Fig 2).

The viewport is UL approved and meets NEMA Type 1, 2, 3, 3R, 4, 5, 12, 12K and 13 specifications.

A Broad Field of View

The fisheye lens, with its wide field of view (53° horizontal by 40° vertical, or 66° diagonal), allows easy scanning of the interior of the electrical cabinet through the viewport, while providing a temperature measurement accuracy of ±3°C. Focusing as close as 3" and providing great depth of field, the fisheye lens reduces the need to re-focus for different electrical cabinet depths. It's worth noting that it could easily take up to four IR sight glasses to cover this same area for inspection with a typical wide angle lens.

20-Minute Installation

The viewport can be installed by one person in 20 minutes or less. The electrical equipment should be de-energized before installation. To install, simply open or remove the cabinet door, use a Greenlee punch to create the aperture, drill the screw mounting holes, affix the viewport and reinstall the door.

Versatile Applications

The viewport can be installed on any application where an expansive and unobstructed view behind a panel or door is desired, including mechanical rooms. Motor control centers, transformer terminal boxes, air circuit breakers, motor lead boxes and a wide range of mechanical equipment can also be outfitted with viewports. Three styles of viewport are available: with a screw-on cap, with a locking cap, and with an IR window and locking cap.

Jon Chynoweth has been involved in the development and marketing of thermal imaging cameras and related software for 20 years. He has been instrumental in developing smaller, higher-resolution thermal cameras, as well as technology advances for safer inspections of high-voltage electrical panels, remote substation monitoring for utilities, and critical vessel monitoring in the petrochemical industry. Starting out in sales of thermal cameras, he ultimately began developing imaging software needed for process control and utility applications, leading to a stint at Raytheon as manager of sales and marketing for uncooled cameras in North America. He later formed his own business – ultimately acquired by Mikron Infrared – to develop thermal cameras and software. Certified as an ASNT Level I thermographer, he is currently Vice President of Mikron's Thermal Imaging Division. You can contact Jon at 906-487-6060 or jon@mikroninfrared.com

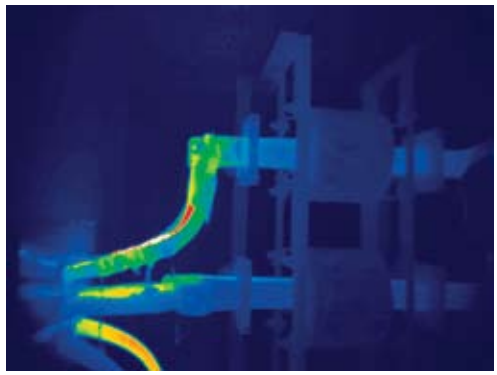

Fig 4 - Typical image of an electric motor lead taken with SpyGlass lens and IR camera.

Simple Steps

Tips To Improve Lubricant & Machinery Performance

by John Shephard & John Sutherland

Selecting the proper lubricants and maintaining their health is critical to sustaining an efficient operation, extending equipment life and enhancing equipment reliability. Furthermore, well-designed lubricants storage and handling practices enable significant savings in maintenance-related expenditures.

Select The Right Lubricants

First and foremost, work with your lubricants supplier to ensure that your lubricants meet the OEM's (Original Equipment Manufacturer) specifications for each piece of equipment, in terms of viscosity, oxidation stability and additive package. This is essential to ensure that your equipment gets not only the lubricants best suited to its needs, that enable it to run at optimal performance for extended service periods, but also those products that help uphold its warranty.

Keep Lubricants Cool, Clean and Dry

Secondly, keep your lubricants cool, clean and dry. Good housekeeping practices are as important in your facility as they are inside your home. Keep your facility spotless - a clean and dry storage area with a steady, moderate temperature will help maximize lubricant shelf life (see Fig 1). A dirty, moist environment with fluctuating temperatures will greatly reduce shelf life, since extreme hot or cold temperatures can cause chemical degradation, moisture contamination and performance losses.

If oil is handled incorrectly, it may become contaminated with dirt, water and other fluids, reducing the service life of equipment and potentially causing lower performance, catastrophic failures and exorbitant maintenance expenses. More than 50 percent of component failures directly result from fluid contamination, so it is important to have a cost-effective technique to remove contaminants. Today's equipment is built to exceedingly close tolerances so it takes a miniscule amount of dust to bring a massive diesel engine to a halt.

Filtration with a high quality filter can assist to reduce contamination and achieve compliance with ISO Cleanliness codes. Consequently, when the oil contains fewer contaminants, the oxidation rate is reduced, the oil has better hydrolytic stability and exhibits better water separability properties. All this helps reduce wear, decrease unscheduled downtime and extend equipment life.

Implement Proper Storage Techniques

Keep lubricants inside, protected from the weather. If this is not possible due to environmental, financial or space constraints, at least shelter them from rain and snow. Moisture and humidity must be avoided, since petroleum-based lubricants are hygroscopic, and water is the enemy of lubricants and all metal parts. Oil levels in reservoirs and storage containers rise and fall, much like human lungs when breathing. When exposed to humid air, lubricants naturally absorb airborne moisture, which immediately begins to degrade the additive package and accelerates oxidation of the lubricant's base stock. Desiccant breathers offer an effective solution to this issue, by removing both moisture and dirt from the air that the machine or storage container breathes.

Correct storage techniques for oil include using closed, sealed airtight containers that protect against water and particulate contamination. If you are using metal drums, it is best to have a drum cover, since even a sealed drum can accumulate water on top, which can enter the drum upon temperature changes. If covers are not available, tip the drum so the water will move away from the bungs. Bungs must be kept tight at all times and drum covers should be used whenever drums are stored in the upright position. Ideally, lubricants should be stored on their side with the bungs in a horizontal (three and nine o'clock) position below the lubricant level. This will reduce the

Fig 1 - Clean and Dry Indoor Storage Area
photo courtesy of Tote-A-Lube

ingestion of moisture and also the chance of the seals drying out.

Many companies have switched to polyethylene container systems (Fig 1). These systems are lightweight, reduce the risk of rust and allow the user to view the level of lubricant in the storage containers.

A guaranteed method to shorten equipment life is to fill it with the wrong lubricant. Careful labeling of lubricants storage containers and dispensing equipment can help avoid cross-contamination and confusion. Ideally, containers should be labeled with purchase, delivery and opening dates, product name, viscosity, inventory code, product application and color code (see Fig 2). Use clearly legible labels that can stand the test of time and also withstand exposure to the elements in cases of outdoor storage.

Use Correct Dispensing Procedures

It is equally vital to extend the labeling procedure to all dispensing equipment such as pails, hoses, reels, hand pumps and transfer carts, since dispensing oil through equipment that was previously used with a different lubricant mixes the two fluids and may damage lubricant properties and effectiveness. If dispensing equipment must be used with a variety of lubricants, utilize a comprehensive cleaning or flushing procedure to minimize the risk of cross-contamination. Always ensure that the dispensing container is clean and contaminant-free. Never use fuel cans, open tins or bottles since these will introduce contaminants.

Fig 2 - Airtight and Clearly Labeled Containers
photo courtesy of *i*Can products

Implement a Predictive Maintenance Program and Practice Oil Analysis

No predictive maintenance program is complete without oil analysis, the regular monitoring of the condition of in-service oils. This powerful diagnostic tool identifies problems before they become costly failures – failures resulting in unscheduled downtime and lost production. It also helps optimize equipment life and oil replacement intervals, thus assisting to improve your bottom line.

Regular sample analysis assures you that your lubricants are protecting your engines and other valuable investments. By tracking oil performance, you can identify lubricant-related needs as well as a variety of predictive maintenance requirements.

Many lubricants manufacturers can help you implement an effective oil analysis program that is designed to deliver the best possible information about the performance of lubricants, using tools such as an on-site database that provides immediate access to important oil analysis information and allows users to tailor reports and translate results into maintenance programs.

Train Maintenance Personnel

However, the best maintenance practices are inadequate to deliver results without educating and training maintenance personnel on a wide variety of lubricants concerns. It's important to empower maintenance staff with the best tools, techniques and knowledge to run a cutting-edge program that ultimately helps ensure equipment and system reliability. For large groups with a limited amount of time, the best type of training is the classroom lecture method, which can be provided at the suppliers' factory, or at the customers' facility. This is by far the most efficient way to impart a lot of knowledge to many people in a short amount of time.

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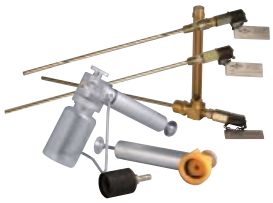

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In summary, operations can achieve increased efficiency and large savings through implementing effective lubricants management and predictive maintenance programs. In today's highly competitive global economy, these programs are essential for enduring success.

John J. Sutherland is the National Accounts Manager for Off Highway for Chevron and Texaco Lubricants for North America, John has 23 years experience with the company. He earned a BS in Civil Engineering from Kansas State University.

John Shepard is the NAL Commercial On-Highway Marketing Specialist for Chevron and has worked for Chevron for 5 years. His primary responsibilities are the management of the Chevron and Texaco brands and products in the On-Highway Commercial Sector. He has an MBA from the University of Dallas.

Fig 3 - High-quality storage containers and filtration devices will increase lubricant life and performance.

top left photo courtesy of Des-Case, bottom two courtesy of Tote-A-Lube

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I look forward to meeting you in Daytona Beach.

Best regards,
Terrence O'Hanlon, CMRP
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workshops

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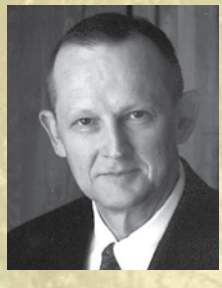

by Ron Moore, Author, *Making Common Sense Common Practice*

Results-oriented companies have discovered the proven impact of manufacturing reliability – maximized uptime, minimized unplanned downtime, improved process control, enhanced quality, minimized maintenance costs, and improved supply-chain performance. Attend this workshop, and you can too.

You'll learn how to apply the Reliability Process - design, buy, store, install, operate, and maintain for reliability. You'll review your plant's performance in light of best practices and benchmarks. And you'll leave with the ability to develop a strategic reliability improvement plan for your plant.

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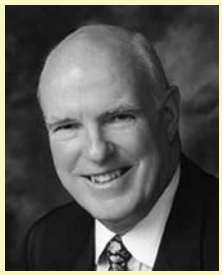
Workshop #2 (ws2) - Physical Asset Optimization and Management



by John Mitchell, Author, *Physical Asset Management*

Physical Asset Optimization is a "better way" of managing corporate equipment assets. It blends the best processes, practice and technology to assure highest effectiveness in your specific business, operating, organizational and material conditions. The purpose of Physical Asset Management is to ensure that the means of production/operation are available to meet mission, availability, yield, schedule, quality, and cost commitments at optimum effectiveness and return.

This definitive workshop provides a practical overview for executives, managers, and team members charged with gaining maximum productivity and effectiveness from systems and equipment in response to stated mission/business/operating imperatives.

Workshop #3 (ws3) - Reliability-Centered Maintenance (RCM) Methodologies, Metrics, Readiness Factors and Relationships to Other Elements of Asset Management

This workshop is designed to educate maintenance and reliability professionals to take a new look at RCM principles, various approaches available in the marketplace and potential benefits. This workshop describes pitfalls to avoid in order to improve chances for a successful outcome. For the first time, readiness factors to consider before entering into an RCM project are described and discussed.

Jack has developed for presentation in this workshop a logical description, partially based on actual applications, of how RCM fits with other major maintenance and reliability initiatives such as Total Productive Maintenance (TPM), 6 Sigma and Procedure Based Maintenance (PBM). In addition he will present for the first time a Preventive Maintenance Optimization logic, developed in 2005, that provides a screening tool for assessing current tasks, task periodicity and assignment criteria prior to preparation of procedures for their execution.

by Jack Nicholas, Jr., PE, CMRP

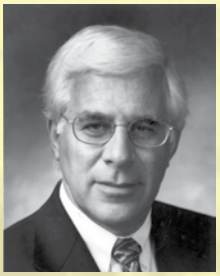
Workshop #4 (ws4) - Developing a Work Management Process

by Terry Wireman, Author, *Benchmarking Best Practices for Maintenance Management*

In plants and facilities today, over 50% of all equipment failures are related to the failure of preventive maintenance, whether it is poor inspection practices, neglect of basic lubrication or fastening practices. This workshop is focused on how to develop a preventive maintenance program that will support a "Best Practice" maintenance and reliability organization. Attendees will leave with a "blueprint" showing how to develop the proper preventive maintenance program for their plant or facility.

Workshop #5 (ws5) - Improving Maintenance & Reliability Through Cultural Change

This unique and innovative workshop explains how to improve your maintenance and reliability performance at the plant level by changing the organizations culture. It is specifically intended for managers in manufacturing, power and process industries. This workshop demystifies the concept of organizational culture and links it with the eight elements of change: leadership, work process, structure, group learning, technology, communication, inter-relationships, and rewards. If you want to break the cycle of failed improvement programs and instead use cultural change to help make significant and lasting improvements in plant performance, this workshop will show you how.



by Steve Thomas, Author, Culture Change for Maintenance & Reliability Professionals

Workshop #6 (ws6) - The Maintenance Planning & Scheduling Game

The Planning & Scheduling Game will demonstrate the importance of good Maintenance Planning & Scheduling practices and illustrate the impact of communications and teamwork on costs and reliability. This half day workshop will also exhibit how good Planning & Scheduling processes support production goals and schedules. It will also identify opportunities to fine tune your Planning & Scheduling implementation through the game play experience

by Steve Nelson, RMG

overview

December 6th & 7th include real world reliability case studies by Alcoa, Kennecott, Seminole Electric, Johns Manville, Praxair, Invista, Southern Company, Timken, Eastman Chemical, American Airlines, BP, Suncor, Nova Chemical, Saint-Gobain, GE, Coors, US Air Force, Chevron and more.

Join others from your industry for dedicated discussion about maintenance and reliability issues for Power Generation, Petrochemical, Life Sciences, Food Processing, Water/Waste Water and more.

You will also have an opportunity to participate in an intensive 4-day Reliability Excellence Experience conducted by Life Cycle Engineering to provide a more structured learning experience that will deliver a clear Roadmap to Reliability for your company.

You actually get two events for the price of one as CMMS-2006 – The Computerized Maintenance Management Summit is collocated with IMC-2006 offering you twice the learning opportunity.

Think you have NFPA 70E mastered at your plant? You might change your mind after you sit in on our NFPA 70E Mock Trial by Uptime Contributor, Greg Stockton.

You can meet over 70 of the best maintenance and reliability solution providers at the IMC-2006 and CMMS-2006 Expo including the popular SDT Ultrasound Learning Lab, the MasteringMaintenance.com Learning Lab and the ALL TEST Pro Motor Testing Learning Lab.

location

IMC-2006 is being held at:

Hilton Daytona Beach
Ocean Walk Village
100 North Atlantic Avenue
Daytona Beach, Florida 32118

Toll Free: 1-866-536-8477
Tel: +1-386-254-8200

Ask for IMC-2006 Special Rate: $115/night (*until Nov 1st*)

The Hilton Daytona Beach Ocean Walk Village is located directly on the beach. It's connected to Ocean Walk Shops and Movies and across the street from the Daytona Lagoon Family Fun Entertainment Complex, where you'll find a water park, go carts, laser tag, rock climbing, mini golf and more. Hilton Daytona Beach Ocean Walk Village is only minutes from Daytona International Airport, Daytona International Speedway and Daytona USA with many area attractions including beach activities right at your doorstep. Orlando International Airport, Orlando area attractions, St. Augustine and Kennedy Space Center are only 60 minutes away.

Hotel guest rooms feature oceanfront views on most rooms, voice mail, data port, high-speed internet access, coffeemaker, iron and board, hair dryer, in room movies, room service and Sony PlayStation. This Hilton hotel features restaurant, lounge, sports bar, pool and complete fitness center.

program

Tuesday, December 5, 2006

8:00am - 4:00pm	Pre-Conference Workshops (Lunch Included)				
Reliability Leadership for Manufacturing Excellence by Ron Moore, P.E. MBA	Physical Asset Optimization and Management by John Mitchell	Reliability-Centered Maintenance (RCM) Methodologies, Metrics, Readiness Factors and Relationships to Other Elements of Asset Management by Jack R. Nicholas, Jr., P.E., CMRP	Developing a Work Management Process by Terry Wireman, CPMM	Improving Maintenance & Reliability Through Cultural Change by Steve Thomas	Maintenance Planning and Scheduling Game by Steve Nelson
8:00am - 4:00pm	4-day Reliability Excellence Experience				
4:00pm – 6:30pm	Certifications: CMRP Exam				
4:00pm – 6:30pm	Welcome Reception Expo Hall				

Wednesday, December 6, 2006

8:00am - 8:15am	Opening Ceremony From Maintenance to Reliability to Asset Management by Terrence O'Hanlon, CMRP				
8:15am - 9:00am	Keynote - Reliability Excellence: The Impact of Reliability on Business Presented by Paul Campbell, Retired Regional President, Alcoa Primary Metals				
9:00am – 10:00am	Refreshment break in Expo Hall				
10:00am-10:45am	Learning Zone Sessions				
Bridging the Gap Between Reliability and Six Sigma by Lynn Nelson, CMRP, Certified Six-Sigma Black Belt, Kennecott	What is Predictive Maintenance and what it has done for Seminole Electric by Brian Thorp, Seminole Electric	Change Management for Maintenance and Reliability Professionals by Steve Thomas Author	Increasing CMMS/ EAM Productivity – Are you really getting what you paid for? by Terry Wireman, Author	Putting the total jigsaw puzzle together: PAS 55 standard for the integrated, optimized management of assets by John Woodhouse, Director, Institute of Asset Management	
10:45am -11:30am	Learning Zone Sessions				
Creating Sustainable Change: How Johns Manville leveraged Lean Six Sigma to achieve asset reliability by Craig D. Seibold CMRP, P.E., Master Black Belt Johns Manville	Strategies for Determining Monitoring Intervals by Gene Bradbury, Praxair	Managing Change by Ron Moore, Author	Moving beyond CMMS by Kahn Ellis, Vesta Partners	Rapid Transformation of Reliability Systems by Paul Zmick, Invista	
11:30am	Question and Answer Session Audience discussion with previous 2 presenters - moderated by session chairperson				
11:45am – 1:00pm	Lunch in Expo Hall				
1:00pm- 1:45pm	Learning Zone Sessions				
Plant Reliability Optimization by George Lum, Southern Company Services	Best Practices Lubrication for Maintenance Managers by Ray Thibault	Planning and Scheduling Made Simple - 2006 Survey Results by Ricky Smith and Jerry Wilson, Eastman Chemical	Overlooked Ingredient for CMMS by Jennifer Ohl, MBA Midwest Software Specialists	Introduction to Value Driven Maintenance by Remco Jonker	
1:45pm - 2:30pm	Learning Zone Sessions				
Reliability Issues in a Safety Sensitive Environment by Bill Brinkley, American Airlines	Wind Generator Condition Monitoring Case Study by Nigel Leigh, Commtest	How Effective is your Planning & Scheduling? by Jerry Wilson, Eastman Chemical	Data Cleansing by Jim Calvert, I.M.A. Ltd	Industry Specific Software used locally in conjunction with Global Enterprise Accounting System by Phil Bradbury	
2:30pm...	Question and Answer Session Audience discussion with previous 2 presenter - moderated by session chairperson				
2:30pm – 3:30pm	Refreshment break in Expo Hall				
3:30pm – 4:30pm	Maintenance & Reliability Challenges Moderated by Jack Nicholas, Bob Baldwin, and Terrence O'Hanlon				

please call 1-888-575-1245 with any questions

Wednesday, December 6, 2006 - cont'd

Join us for the Daytona Speedway Night of food fun and prizes!

6:00pm – Last Bus Departs For Daytona Speedway
6:30pm - Daytona Speedway Party
8:00pm - 9:30pm - Buses Depart for Hotel

Thursday, December 7, 2006

8:15am - 9:00am	Keynote Leadership - What is it? By Ron Moore, Author, Making Common Sense Common Practice			
9:00am – 10:00am	Refreshment break in Expo Hall			
10:00am - 10:45am	Learning Zone Sessions			
Defining, Justifying and Staffing the Maintenance and Reliability Planner Position in a Multi-Plant Organization by Jim H. Davis, PCA and Jeff Long, Mgr, Manufacturing Support and Industrial Risk, Saint-Gobain, Glass Container	Front-line RCA - Information and Insight from the People "Closest to the Work" by Mark Galley, ThinkReliability and Hank Ward, Coors	Monte Carlo Simulation Process in Maintenance & Reliability by Alberto Landeaux	Unlocking The Secrets of CMMS Data by Joel Levitt, Author	Getting Maintenance into the Boardroom by Scott Weiland, Oracle
10:45am -11:30am	Learning Zone Sessions			
Roles and responsibilities required to achieve a world class maintenance program. Dave Schultz Ash Grove Cement	Root Cause Analysis and Reliability Centered Maintenance - Complementary Tools that can be used together to improve reliability by Mark Galley and Doug Plucknette	Elements of a Successfully Applied PdM Program at the Timken Steel Mill by Mark J. Roether, Timken	How to Avoid Excess Inventory (And why it started with your new equipment spares) by Ron Schroeder	The use of 'Real Options' project financial analysis to promote a capital project with low likelihood of approval based on NPV, IRR and other financial metrics by Mike Johnson
11:30am	Question and Answer Session Audience discussion with previous 2 presenters - moderated by session chairperson			
11:45am - 1:00pm	Lunch in Expo Hall (Expo closes at 1:00pm)			
1:00pm - 1:45pm	Learning Zone Sessions			
Applying GE Leadership Tools: CAP, Workout™ and Six Sigma Methodologies to Reliability Initiatives by Michael G. Turek, GE Energy	NFPA 70E Mock Trial by Greg Stockton and cast	From Good to Great by David Crockett, CenTec	Asset Performance Management by Dr Peter Martin Invensys	Simple Steps to Developing and Managing Best Practices for Maintenance and Reliability by Ramesh Gulati and Ricky Smith
1:45pm - 2:30pm	Learning Zone Sessions			
Reliability the Chevron Way by John Malone, Chevron	Using the RPM method to manage maintenance. By Fred J. Weber, P.E., Author, *Wrench Time*	Maintenance Workforce Study Results by Howard Penrose, PhD	Implementing successful CMMS doesn't have to be difficult - A novel approach for small to mid-sized companies by David Griffiths	Multiple Assets - Multiple Sites by Dave Abecunas and Dave Juntti, Cleveland Cliffs
2:30pm...	Question and Answer Session Audience discussion with previous 2 presenter - moderated by session chairperson			
2:30pm – 2:45pm	Refreshment Break			
2:45pm – 3:30pm	Closing Statements, Action Statements and Alienware Laptop Giveaway			
5:30pm - ?	Beach Party - Daytona Beach Hilton			

Friday, December 8, 2006

8:00am - 4:00pm	Post-Conference Workshops (Lunch Included)				
Reliability Tools - What Tool? When? by Ron Moore. P.E. MBA	Scorecard Applications and Use by John Mitchell	Reliability Managers Workshop by Mick Drew	Planning and Scheduling Maintenance by Joel Levitt	Developing Key Performance Indicators by Terry Wireman, CPMM	Value Driven Maintenance Simulation
8:00am - 4:00pm	4-day Reliability Excellence Experience				

daytona usa

Daytona International Speedway Private Party at Daytona USA
Wednesday December 6, 2006

Reliabilityweb.com is pleased to invite all IMC-2006/CMMS-2006 attendees and registered spouses to join us for a night of exciting fun, food, drinks and prizes at one of NASCAR's most famous landmarks. Bus transportation is provided from the Daytona Hilton and back.

DAYTONA USA is a 60,000-square-foot interactive motorsports attraction that is the world-class showplace to soak in the history of America's fastest sport! From the heart-pounding thunder of bumper-to-bumper competition on the historic high banks of Daytona International Speedway, to the high octane thrills and spills of high-tech motion simulators - catch all the energy and non-stop excitement of DAYTONA USA, The Ultimate Motorsports Attraction.

We have the entire facility including NASCAR 3D: The IMAX Experience on a four story high screen, Speed Channel's "You Call The Race", EA Sports' "NASCAR Thunder" and the Ford 16-Second Pit Stop Challenge.

Make sure that you don't miss out on all of the ride along excitement on the various simulators allowing fans to see what it's really like behind the wheel! Take a fantasy ride in Toyota Tundra's Thunder Road. This two-seat full motion simulator allows riders to experience the thrill of racing in a Toyota Tundra and includes a 360-degree flip! Daytona Dream Laps is an iWERKS motion simulator ride based on NASCAR's premier race, the Daytona 500. The ride seats 32 guests for a full-range motion experience of NASCAR NEXTEL Cup Series racing at Daytona International Speedway. Or try your hand at Acceleration Alley where guests are put in the driver's seat . Buckle up and accelerate to over 200 mph in 80-percent scale NASCAR simulators that combine motion, video projection and sound for the ultimate head-to-head racing experience.

We will serve food and offer drinks and prizes so do not miss this premiere event!

staying connected

In addition to connecting with new and old friends at IMC-2006, Reliabilityweb.com and other exhibitors will also be sponsoring a fully functional Internet Café with high speed Internet access to keep you in touch with your email and online travel reservations.

workshops

You can wrap up your conference learning experience with your choice of 6 different Post-Conference workshops such as:

Workshop #7 (ws7) - Reliability Tools

by
Ron Moore,
Author
- What Tools When?

Ron will provide an overview of the more popular improvement tools and strategies - Lean Manufacturing, Kaizen, Total Productive Maintenance, Six Sigma, Reliability Centered Maintenance, Predictive Maintenance, Supply Chain Management, Root Cause Analysis, and included in the appendices material on Planning and Scheduling, Quick Changeover, Performance Measurement, and Managing Shutdowns/Turnarounds, outlining each process from a practical perspective, and offering suggestions for how to select the appropriate tool. He will also cover organizational issues related to leadership, managing change, and shifting the culture of the organization to foster future improvement. His insights are based on working with hundreds of manufacturing plants helping them to achieve manufacturing excellence.

Selecting the right tools will assure optimal production capability at a minimum, yet sustainable cost. Costs are avoided by selecting the right tools that help to eliminate the "defects" which cause the costs being incurred in the first place.

Workshop #8 (ws8) - Scorecard Application and Use

Scorecards can be used as a management system (not only a measurement system) that enables organizations to clarify their vision and strategy and translate them into action. Scorecards may provide feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results. When fully deployed, maintenance and reliability scorecards transform strategic planning from an academic exercise into the nerve center of an asset management system. You will be shown how to use Maintenance and Reliability Scorecards.

by
John Mitchell,
Author - *Physical Assest Management Handbook*

Workshop #9 (ws9) - Reliability Managers Workshop

This Workshop is designed to provide you with a better understanding of Reliability. It is a practical course addressing the integration of a range of reliability initiatives into an asset management strategy. Covers Reliability Centered Maintenance (RCM), Life Cycle Costing, Root Cause Analysis, Data Analysis and Plant Availability Simulation.

by Mick Drew,
Australian Reliability Expert

Workshop #10 (ws10) - Planning and Scheduling Maintenance

by Joel Levitt
Author -
Managing Factory Maintenance

Well-planned, properly scheduled, and effectively communicated jobs accomplish more work, more efficiently, and at a lower cost. This work will disturb operations less frequently, and be accomplished with higher quality, greater job satisfaction, and higher organizational morale than jobs performed without proper preparation. This Maintenance Planning and Scheduling workshop focuses on and deals specifically with the preparatory tasks that lead to effective utilization and application of maintenance resources. It is a vital training document for planners, an educational document for those to whom planners are responsible, and a valuable guide for those who interface with the planning and scheduling function and are dependent upon the many contributions of planning and scheduling operational excellence.

Workshop #11 (ws11) - Developing Key Performance Indicators

by Terry Wireman,
Author, *Developing Key Performance Indicators*

Since the maintenance department and staff have a significant impact on the condition and, ultimately, on the capacity of costly manufacturing machinery and other capitalized assets, there is a clear need to develop a maintenance business and then a proper measurement system for that business. In this workshop, the attendees will discuss how to develop the maintenance business function, how to measure each of the maintenance functions, how to classify the maintenance KPIs into Functional and Tactical Indicators Efficiency and Effectiveness Indicators. Financial Indicators, and Corporate Level Indicators, formulas for each of the Indicators. It will also introduce a series of measurement reports that can be produced by virtually every commercially available CMMS/ EAM System.

In addition, a model will be discussed that shows how Enterprise Level indicators can be monitored and using a linked indicator system, can pin point actual performance problems at a plant and department level.

Workshop #12 (ws12) - Value Driven Maintenance

by Remco Jonker,
Co-Author - *Value Driven Maintenance*

The book *Value Driven Maintenance, New Faith in Maintenance* clearly describes how to reveal the value potential within your maintenance process, how to define a maintenance strategy that truly aligns with your business goals and how to get Maintenance on the boardroom agenda. But sometimes reading a good book is not enough. You have to experience the power of the concept by applying it, learning by doing. Especially for this purpose, Mainnovation has developed an innovative maintenance business game, the VDM Business Simulation. The Business Simulation takes place in a competitive environment: several teams are faced with true life maintenance problem situations, conflicting demands that needs decisions with limited information. The effects of their decisions are measured against the 10 VDM KPI's and the team's maintenance performance is benchmarked every playing round. The team that creates the most economic value wins the game. As the eagerness to beat the other teams grows, the participants will be teased to find the real trade-offs in maintenance. After each playing round, the facilitators bring in a limited amount of VDM 'theory', explaining how decisions relate to value, under which conditions known maintenance best practices really create value, etc.

by Marc Haarman,
Co-Author - *Value Driven Maintenance*

what's included

Your Two Day IMC-2006 Conference and Expo Pass Includes:

- ~ Two Days of Learning Zone Sessions
- ~ Two Day Expo Hall Pass
- ~ Keynote Sessions
- ~ Expo Refreshments & Snacks
- ~ Daily Breakfasts
- ~ Daily Lunches
- ~ IMC-2006 Welcome Reception
- ~ IMC-2006 Daytona Speedway Hospitality Night
- ~ IMC-2006 Beach Party
- ~ IMC-2006 Proceedings CD ROM
- ~ Bonus CD ROMs
- ~ CMMS-2006 Pass
- ~ CMMS-2006 CD ROM
- ~ Conference Program Guide
- ~ Access to the Internet Café
- ~ Entry in Alienware Laptop Giveaway
- ~ Maintenance Conference Tote Bag

Optional Pre- and Post-Conference Workshop Registration Includes:

- ~ Meeting Materials (as provided) for the workshop(s) you attend
- ~ Refreshment Breaks
- ~ Complimentary Lunch

Expo Only Registration Includes:

- ~ One Day Expo Hall Pass
- ~ Conference Program Guide

Bonus Value when you register for IMC-2006:

Once registered you will be invited to network with workshop leaders, presenters and 4000+ maintenance and reliability professionals from around the world on the MaintenanceForums.com online community for pre-conference and post-conference connections.

the reliability excellence experience

What is the value of implementing Reliability Excellence in your organization?

Participate in the 4-day Reliability Excellence Experience - Develop a Business Case For Reliability for your organization.

IMC-2006 in conjunction with Life Cycle Engineering is offering an exclusive 4 day learning experience that allows you to participate in IMC keynotes, networking session, the Daytona USA Speedway Track night and attend the IMC-2006/CMMS-2006 Expo while attending an intensive dedicated 4 day Reliability Excellence learning session.

As a participant in the "Powered by Reliability Excellence" work stream of the International Maintenance Conference you will receive instruction and tools to build the business case for Midwest Manufacturing, a fictitious company, based on data provided during the conference. Then, using these same methods, you will be asked to develop the business case for your organization. Through the use of the Excellence Model, basic mathematics, and benchmark data, this workshop will help you:

- ~ Define the Excellence Model for implementing Reliability Excellence in your organization
- ~ Understand the impact of direct labor utilization on maintenance costs
- ~ Understand the value of leaning out the PM Program
- ~ Understand how to apply benchmark data to improve reliability
- ~ Understand how to determine the number of Planners, Engineers, and PdM Technicians needed to support the proactive workflow model
- ~ Understand the value of optimizing maintenance spares to reduce the total cost of maintenance
- ~ Understand the linkage between Reliability Excellence and initiatives like Lean, Six Sigma, and TPM

Space is limited to 40 so sign up early to reserve your seat!

for more info or to register visit us online - www.maintenanceconference.com

imc-2006 & cmms-2006 expo

No other maintenance and reliability focused event brings more products, services, software and training providers than the International Maintenance Conference and Expo. No other event does as much to help you make sense of the numerous purchasing options. The IMC-2006 together with the CMMS-2006 Expo is the place to find solutions as you make, develop and build your own best practices. Please find a quality solution provider by using the alphabetical list below.

Expo Hours

Tuesday	**Dec 5th**	**4:00 pm – 6:30 pm**
Wednesday	**Dec 6th**	**10:00 am – 3:30 pm**
Thursday	**Dec 7th**	**10:00 am – 1:00 pm**

exhibitor list

20/20 Foresight
Allied Reliability
All-Test Pro
Areva
Assetpoint
Atlas
Baker
BE & K
Chevron
CMMS Data Group
Commtest
Coastal Training
CTC
CWorks
Dexsil
DLI
DMSI
Electrophysics
Flir
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GKMCO
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SPC
SPM Instruments
SpectraQuest
STI
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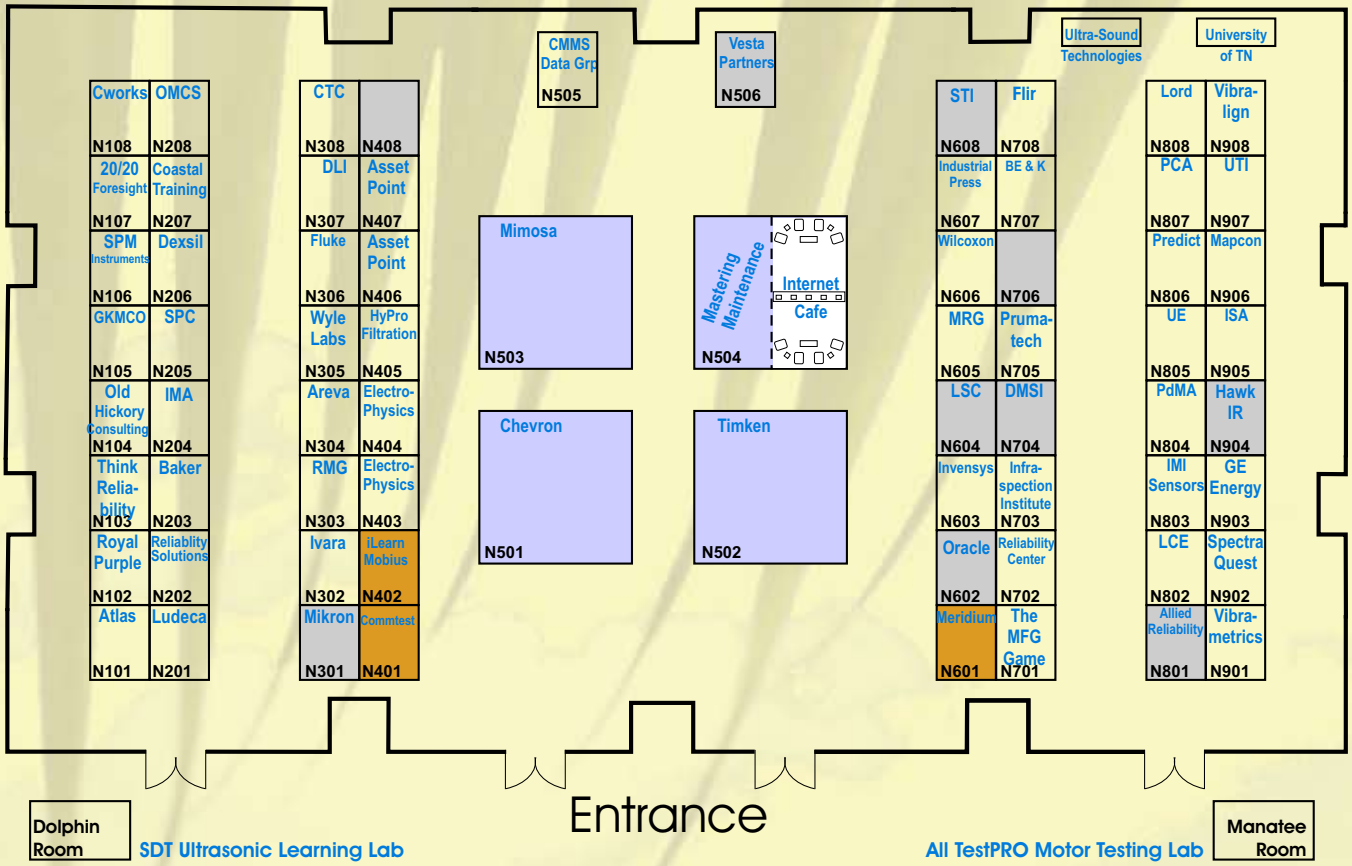
IMC2006 Mastering The Maintenance Process

Expo Hall Floor Plan

CMMS-2006 Mastering Computerized Maintenance Management

North Tower - 2nd Floor
Coquina Ballroom



Drawing current as of August 30, 2006

giveaways

Win an Alienware Laptop Computer!

Each fully paid attendee can be entered into a drawing for a free Alienware laptop computer, one of the most reliable computer systems available. The drawing for this and other great prizes will be held on Thursday afternoon during the closing ceremony.

for more info or to register visit us online - www.maintenanceconference.com

IMC 2006 Manufacturing and Process Reliability & CMMS-2006 Mastering Computerized Maintenance Management

21st International Maintenance Conference

December 5th-8th, 2006 Daytona Beach, Florida USA

The name and details provided below will be printed on your registration badge. Please provide the exact details that you would like to have used on your badge during the conference.

IMC-2006 & CMMS-2006 Registration Form - Please Print Clearly

Name:	Title:
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International Visitors! Get a $100 discount if registered before Nov 1st. E-mail info@reliabilityweb.com for more info.

IMC-2006 Conference Pass - includes CMMS-2006 Pass

Two day Conference pass includes the IMC-2006 Proceedings on CD-ROM, admission to the IMC-2006 expo and the following meals during the two days of conference Learning Zone Sessions: the IMC-2006 welcome cocktail reception (Tues evening), breakfast, lunch, snack/refreshment breaks (Wed & Thurs) and Daytona USA Speedway (Wed evening). Three or four day conference pass will also include breakfast, lunch and snack/refreshment breaks on the day of your chosen workshop. The conference fees do not include hotel room or travel expenses. The host hotel has a discounted room rate available to all IMC-2006 attendees, be sure to request the IMC-2006 special group rate when making your hotel reservations.

		After Nov 1	Before Nov 1
☐	**IMC-2006 Two Day Conference Pass** - Dec. 6 & 7, 2006 - Learning Zone Sessions and Expo Only	**$899**	**$699**
☐	**IMC-2006 Three Day Conference Pass** (circle workshop code below) includes the above & choice of one pre-conference **or** one post-conference workshop	**$1099**	**$899**
☐	IMC-2006 Full Four Day Conference Pass (circle workshop codes below) includes the above & choice of one pre-conference **and** one post-conference workshop	**$1299**	**$1099**
	WS1 WS2 WS3 WS4 WS5 WS6 WS7 WS8 WS9 WS10 WS11 WS12 **See inside pages for workshop descriptions**		
☐	**4-Day Reliability Excellence (Rx) Experience**	**$1299**	**$1099**
☐	**Group Discount** - Check here if you are part of a group of five or more. Buy 5 passes at one time and get the 6th of equal or lesser value for FREE!		
☐	**IMC-2006 Full Spouse Pass** Includes all conference meals, receptions, and social events as well as access to Spouse Networking room	**$129**	**$99**
Full Name to print on spouse pass:			

Fax registration form to 1-309-423-7234 or mail registration form to: Reliabilityweb.com c/o IMC-2006 PO Box 07070 Ft. Myers FL 33919

Call 1-888-575-1245 / 1-305-735-3746 [Int'l callers] or register online at www.maintenanceconference.com

IMC-2006 & CMMS-2006 Billing Information

VISA MASTERCARD AMEX DISCOVER	Billing Address:
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Credit Card #:	State:
Expiration Date: CW2:	PO #:

Please provide the exact address as printed on your credit card statements. Credit cards may be declined with wrong address.
CW2 code: 3-digits found on back of card after credit card number. Amex is 4-digits on the front of the card.

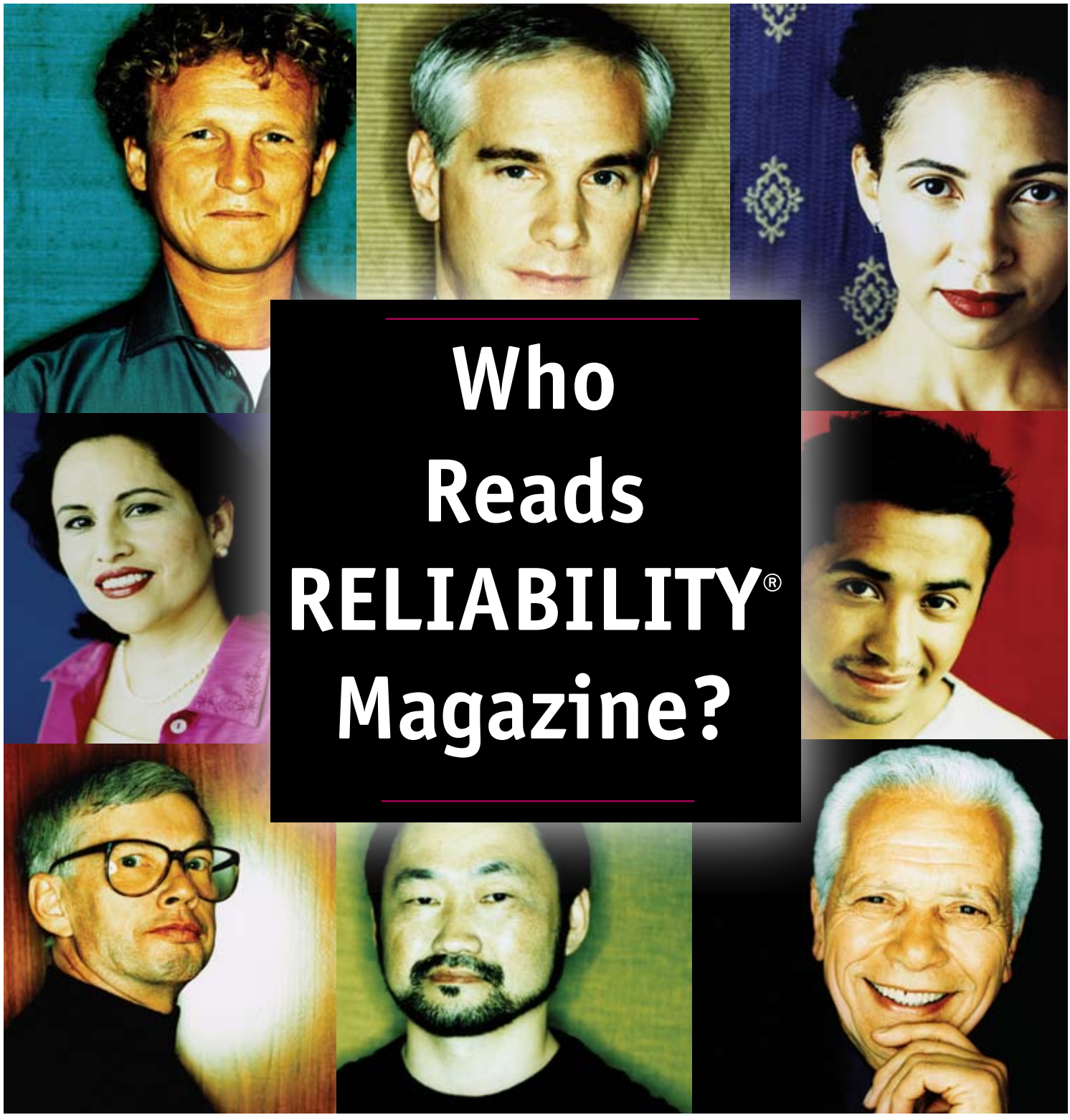
Payment Instructions: If paying by check or purchase order please print a copy of your unpaid invoice and include it with your check or fax it with your wire transfer advice. Send Checks to: Reliabilityweb.com c/o IMC-2006 PO Box 07070 Fort Myers FL 33919 USA. e-mail: customerservice@reliabilityweb.com or fax 309-423-7234 for bank wire fees and instructions.

Refund Information: Cancellation/Substitutions: In the event that the IMC-2006 attendee notifies Reliabilityweb.com Inc. of the attendees intent to cancel by November 1, 2006, a full refund of monies received, minus a $150 administrative fee, will be made. No refunds will be made for cancellations accepted after November 1, 2006. All cancellation requests must be made in writing. You can substitute a person from the same company by request.

Receipts/Invoices: Receipts & invoices will be delivered to an e-mail address provided on your registration form.

Hotel Reservations: Hilton Daytona Beach, Toll Free 1-866-536-8477 or 1-386-254-8200. IMC-2006 rate: $115/ night company by request before Nov 1st..

please call 1-888-575-1245 with any questions



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RELIABILITY®
THE MAGAZINE FOR IMPROVED PLANT PRODUCTIVITY

The Energy Efficiency Myth

When Motor Retrofits Go Wrong

by Howard W. Penrose, PhD, CMRP

The application of a machine designated 'Energy Efficient' (EE) or 'Premium Efficient' (PE) does not automatically infer guaranteed savings or payback. In many cases, it does not make economical sense to make a recommendation to replace a standard efficient, or U-Frame, electric motor with a newer EE or PE motor, for energy reasons. It is important to ensure that a retrofit or repair versus replace decision makes sense such that if the decision is made for energy reasons, it will meet expectations in both *perceived* energy savings and reliability. In other cases, it may make sense to replace an older motor with an EE or PE motor strictly for reliability reasons. In any case, it is very important to state the actual reason for the replacement of the original motor.

The Situation

The UAW/WFG Joint Task Team on Construction and Maintenance (JTT) is a joint United Auto Workers and General Motors team working within the Worldwide Facilities Group tasked with developing and implementing construction and maintenance best practices for all General Motors facilities. The scope of responsibility includes all equipment and structures right up to the production equipment. A few of the series of best practices include: Motor-System Maintenance and Management; Energy Efficiency; Equipment Commissioning; and, Condition Assessment. These best practices are implemented and the facilities graded on a red, yellow and green chart with savings (and other benefits) documented over time.

Following the change from U-Frame to T-Frame motors in 1968, most automotive manufacturers insisted that the electric motor industry design and maintain a series of U-Frame automotive duty electric motors. These motors referenced the 1968 version of the National Electrical Manufacturers Association standard MG 1-1968, including efficiency levels. These standards, including the General Motors Specification No. 7EH, identified these ratings that changed, for T-Frame machines, with the Energy Policy Act of 1992. In 2000, GM issued a new electric motor specification entitled: "Electrical Equipment Specification No. 7E-TA: High-Efficiency Industrial AC Electric Motors Totally-Enclosed Types 'T-Frame' Dimensions," which was updated in 2003. The purpose of this standard was to identify the replacement of integral motors to 500 horsepower with energy efficient IEEE-841 standard electric motors. It was expected that this specification would supersede the original 7EH standard. Following an evaluation using MotorMaster Plus, the use of IEEE-841 motors was adopted as a best practice.

In 2003, all of the General Motors Assembly Division plants' Quality Network Planned Maintenance PdM groups were assigned ALL-TEST Pro, LLC, Electrical Motor Diagnostics (EMD) equipment. The purpose has been to implement the next level in condition based assessment capabilities based upon experience at pilot plants throughout GM. Following several years of successful application, UAW/WFG best practices called for the requirement of each facility to use EMD on critical electric motors, where appropriate. Additionally, a series of best practices for commissioning spare and new equipment was established for all critical equipment and machines over specific sizes.

In June of 2006, one of the GM Assembly plants retrofitted a 200 horsepower, Delco, U-Frame electric motor in a critical paint fan application with a new premium efficient, 200 horsepower electric motor. The plant contacted the UAW/WFG JTT with several concerns, including: the motor drew much higher current than the original motor; the motor tripped off-line during operation, causing an interruption in the manufacturing process; and, the manager determined that there would be a moratorium on future EE and PE motor purchases as it appeared that it was unreliable. It was reported that the motor was an IEEE-841 PE motor.

The Site Visit

During the site visit, it was determined that an Electrical Signature Analysis (ESA) evaluation would be performed on the electric motor and compared to another electric motor in order to determine the actual savings versus the original calculated savings. Upon viewing the nameplate, it was immediately apparent that the electric motor was a U-Frame automotive duty electric motor with a nameplate efficiency of 94.5%, which is 1 point higher than the older 7EH standard, but falls below the 95% efficiency of the post 1992 MG-1 energy efficiency rating and well below the later premium efficiency rating of 96.2%. As both the newer and older MG-1 standards do not define premium efficiency for U-Frame motors, the manufacturer was able to call the motor premium efficient per their own internal standard.

Based on ESA data entered into the US Department of Energy's MotorMaster Plus (MM+) comparing this fan application with an original motor next to it, the original motor was determined to be 88.7% loaded and 92.9% efficient while the new motor was 93% loaded and 94.5% efficient. Using the cost of electricity and hours of operation, MM+ compared the average rewind cost to the full installation cost of the new machine, and determined the new machine cost an additional $1,495 per year to operate. However, using MM+, when the team was able to equalize loading to 88.7% and compare the motors, which resulted in an annual savings of $854 (4.1 year payback), well under the $5,000 predicted by the vendor.

MM+calculated that the U-Frame to IEEE-841 Premium Efficient T-Frame, with retrofit base and other required changes, would have had an equivalent cost as the new U-Frame motor that was purchased. Comparing the real data collected on the existing Delco U-Frame motor to the nameplate efficiency of a correct PE IEEE-841 T-Frame would have had a simple payback of 1.97 years, an annual energy savings of $1,761 per year, an After Tax ROI of 78.3% and an After Tax Benefit to Cost Ratio of 2.88 (see Figure 1).

Based on the data, using the IEEE-841 PE motors in any future replacements would clearly result in greater savings.

The Actual Motor Opportunities

However, all was not lost. The actual opportunities associated with the changing of the original 35 year-old electric motor related more to reliability and less to the expected energy opportunity. According to the motor vendor's records, there have been 21 failures of these fans over the past five years. This represents 40% of the motors in the application and the results show an average life of less than 11 years. Reliable motors, applied correctly, should be expected to see an average life of 15 to 20 years, or more.

The real risk of failure in these fan motors is the impact on the paint department. The loss of a machine during operation can result in reduced throughput, defective product and a reduction in on-time delivery. Any failure has a serious impact. This should place the energy opportunities at a relatively low priority and the reliability of the fan motors at the highest priority.

The new IEEE-841 motors are designed to assure the reliability needed in this application, which results in a higher initial cost. However, the materials used and the stringent testing required by the motor manufacturers reduces the likelihood of failure for at least the warranty period, which tends to be five or more years.

In this particular application, the ESA testing used to obtain electrical consumption and power quality measurements also provided information on the condition of the electrical and mechanical system associated with the electric motor. Several key items were observed in the application of these machines, new and old, that identified additional opportunities for improved reliability. Belt alignment and tensioning was an area identified for improvement, as well as bearing greasing. While these machines appeared to be operating quite well, it was determined that the proper alignment and tensioning tools were absent. At the time of the writing of this article, Optibelt, a belt alignment and tensioning instrument manufacturer, is working with the UAW/WFG JTT to come up with cutting edge best practices related to reduced belt wear and reduced belt maintenance.

Electrical Signature Analysis

One of the benefits of using the ESA device in collecting the data for MM+ was the ability to detect other electrical and mechanical

Life Cycle Analysis Results

Loan Amount ($)	3,250	After tax terurn on investment (%)	78.3
Capital recovery factor	1.00	Benefit-to-cost ratio (before tax)	4.03
Annual loan payment ($)	3,250	Benefit-to-cost ratio (after tax)	2.88
After tax net present value ($)	6,107	Levelized cost of conserved energy (mills/kWh)	17.0

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Year	Project Revenues (NominalS)	Loan Payment +Op Costs (NominalS)	Depreciation (NominalS)	After Tax Benefits (YBS)	After Tax Benefits (NominalS)	Cumulative After Tax Benefits (YBS)	Conserved Energy Cost (Nominal)
2006	1747	3250	650	-1887	-1887	-1887	87
2007	1834	0	650	1420	1203	-684	0
2008	1926	0	650	1479	1062	379	0
2009	2022	0	650	1542	938	1317	0
2010	2123	0	650	1608	829	2146	0
2011	2230	0	0	1449	633	2780	0
2012	2341	0	0	1522	564	3343	0
2013	2458	0	0	1598	502	3845	0
2014	2581	0	0	1678	446	4291	0
2015	2710	0	0	1761	397	4688	0
2016	2845	0	0	1850	353	5042	0
2017	2988	0	0	1942	314	5356	0
2018	3137	0	0	2039	280	5636	0
2019	3294	0	0	2141	249	5885	0
2020	3459	0	0	2248	222	6107	0

Figure 1 - Screenshot of Life Cycle Analysis from MotorMaster Plus

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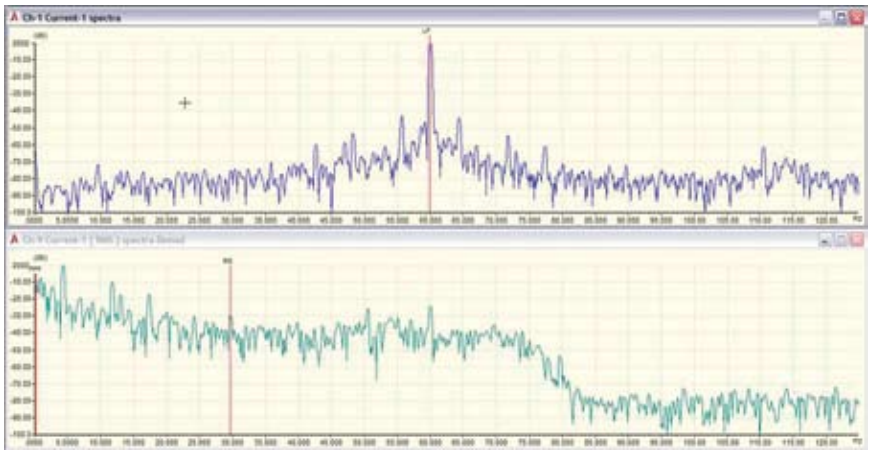


Figure 2- Electrical Signature Analysis of the old U-Frame Motor

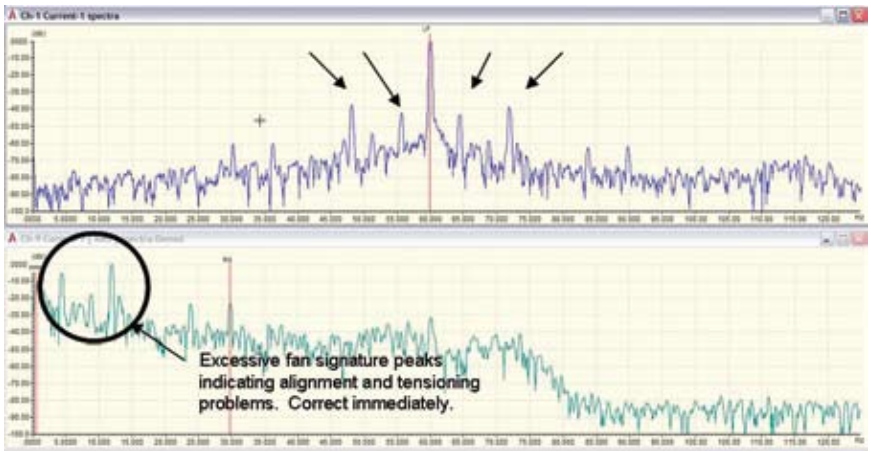


Figure 3- Electrical Signature Analysis of the new U-Frame Motor

defects in the equipment. The current data for the new motor showed excessive fan and belt signature peaks indicating alignment and tensioning problems which required immediate correction (Figure 3). The Delco motor peaks were slightly lower, indicating a similar problem, but not as extreme (Figure 2).

Conclusion

The retrofit from a failed Delco motor to the new U-Frame Automotive Duty motor did not have the energy impact that was expected by the motor vendor or the assembly plant. The actual motor that should have been installed, and properly commissioned, was an IEEE-841 PE motor which, when coupled with the best practices that have already been developed by the UAW/WFG JTT team, would have been far easier with less risk of error and have a greater combined energy and reliability impact.

The electric motor that was purchased will actually improve reliability in the application as the older motors have an apparently low resistance to failure. However, the expected high energy savings payback will not arise per the actual data collected and calculated through MM+. The on site visit provided the UAW/WFG JTT with additional information that supports proper maintenance and installation requirements for new and existing machines. It also supported the needs within GM for the maintenance best practices being developed jointly by the UAW and GM management team.

Dr. Penrose is the President of SUCCESS by DESIGN Reliability Services and the Executive Director of the Institute of Electrical Motor Diagnostics. He is a US DOE Certified MotorMaster Professional and serves clients, such as the UAW/WFG as an award-winning subject matter expert. Dr. Penrose can be contacted by e-mail at howard@motordoc.net

Hearing or Listening?

Results of Training Survey Show Big Difference

by John Piotrowski

Every successful business is based on the following premise: Listen to your customers and give them what they want. A company that listens to their own voices and ignores the concerns of their customers is doomed to failure in short order. However, I believe that there is another premise that truly successful businesses also heed: Listen to your employees. It is entirely possible that a company could intently listen to their customers, yet ignore their employees. They will be in business for a while, but they too are doomed to failure. Maybe not immediately, but eventually.

Why do I bring this up? Because I do not believe that many companies are listening to you or your coworkers. Some of you might not agree, but I suspect many of you do.

I have been conducting industrial training courses for seventeen years with customers all over the world. Our most popular course is the Basic / Level 1 shaft alignment training course where we have trained over 3500 people. In 1989 when I first started offering this course, I composed a questionnaire that I handed out at the end of the seminar. I asked the attendees not to put their name on the questionnaire (for their own protection) and asked them to honestly answer the questions. I really wanted to find out how I was doing and what the attendees wanted or needed to help them with their jobs. After collecting the questionnaires and compiling the information on each batch, I sent the results to the people who attended that course.

I did this for about six years, analyzed the results, and began to see a pattern emerge. For the next several years, I only sporadically passed out the questionnaire and observed that the same patterns appeared. Then, for a long while I didn't pass out the questionnaires at all, until recently, when I was asked by a customer to pass out the questionnaire to their employees who had just completed the Basic shaft alignment training course. The results were still the same. To date, the information below represents the cumulative results from 1070 people who answered the survey, The simple questionnaire we used is shown in Fig 1.

Fig 1 - Basic Shaft Alignment Training Questionnaire

Two days of training was...
___ too long
___ too short
___ right amount of time

The information presented was...
___ too hard
___ difficult, but with practice I could learn it
___ too easy

I will be able to apply that I've learned
___ definitely
___ doubtful

Align Tools needed...
___ shim stock
___ laser alignment system
___ Align & Balance demonstrator
___ dial indicators
___ computer software program to do graphing/modeling
___ books & training material
___ something to automatically correct soft foot
___ alignment graph paper
___ jackscrews
___ alignment brackets kit
___ other tools needed (list) _____

Shaft alignment is something that...
___ I could do with enough time
___ a contractor should do
___ need help doing

I think I should repeat the basic course.
___ yes
___ no

I would like to go to the intermediate or advanced shaft alignment course.
___ yes
___ no

There are other people in this company that need this course.
___ yes
___ no

Overall rating of the course.
___ excellent ___ fair
___ good ___ poor

I think I need additional training in...
___ motors
___ pumps
___ gears
___ more shaft alignment
___ couplings
___ vibration analysis
___ compressors
___ fans
___ antifriction bearings
___ cooling towers
___ other _____

The Results

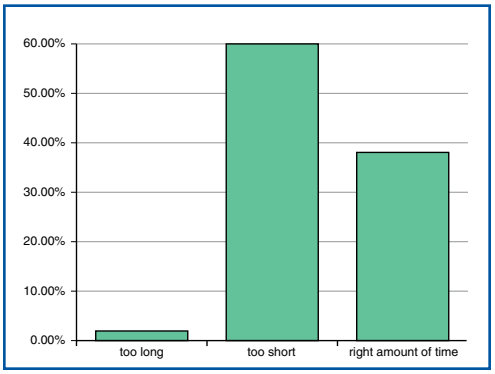


Fig 2 - Two days of training was...

Here are the results of the survey with some of my thoughts about each question.

One of the biggest challenges I, and I believe other instructors and training organizations have is ... How much time do we need to get the information across to the attendees versus how much time management will allow their personnel for the training? Here is a typical phone call I get:

Ring, ring (pick up the phone)

Me: Hello, how can I help you?

Customer: Uh, hello. Do you offer any training course in machinery alignment?

Me: Yes, we do. There are three courses we now offer. A two day Basic course, a three day Intermediate course, and a four day Advanced course.

Customer: *(2-5 second pause.)* Um, Two days? How could it possibly take two days to teach shaft alignment?

Me: Well, that may seem like a long time when you first think about it, but the number one complaint from former students is that the course is too short.

Customer: I see. Would it be possible to condense the course to four hours?

Me: Uh, not really. We could cover some broad topics in that time but I don't think the people who attend will get a good feel for all that is involved in the process of installing and properly aligning your machinery.

Customer: Well, we just purchased a new alignment measurement system and the sales guy told us that we didn't need a lot of training to use it. We have some very talented people in our maintenance department.

Me: I'm sure your employees are very talented, sir. There are a lot of very talented people in every company I've worked with. However, there are many things involved in the process of installing and aligning machinery other than just taking alignment measurements and moving machinery around.

Customer: Like what?

Me: Well, there's the issue of mounting your equipment on good baseplates and foundations. Then, there are concerns about the quality of your machinery and equipment being damaged because of poor alignment. Then there are the problems with excessive

runout, soft foot, piping strain, and ... well...I could go on about this for some time.

Customer: *(2-5 second pause.)*
Hmmm. I never heard of some of the things you just mentioned. The alignment tool sales guy never said anything about that. He did casually suggest that we do some training with him on what buttons need to be pushed on their alignment computer but he said it shouldn't take more than one or two hours to go over that. Could you send me a list of the things you will cover in the course and I'll get back with you.

Me: I'd be delighted.

End of conversation, and, frequently, the end of any further correspondence.

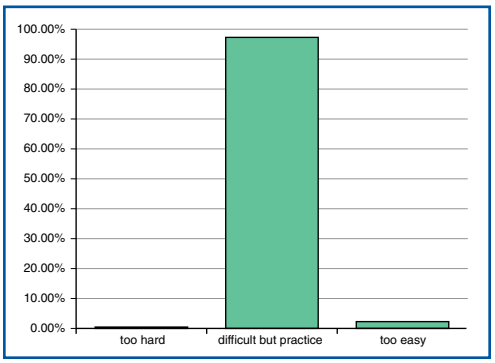


Fig 3 - The information presented was...

Well, it seems like the material isn't rocket science, but responses show (Fig 3) attendees would like to have some time to digest and practice what they were taught. One of the problems that I see is that a company sends their employees to a training course, but then do not allow them to reinforce what they learned immediately after the course has been completed. Practice makes perfect. It makes sense to give trainees time to practice techniques learned in the course so the processes get imbedded in their work practices.

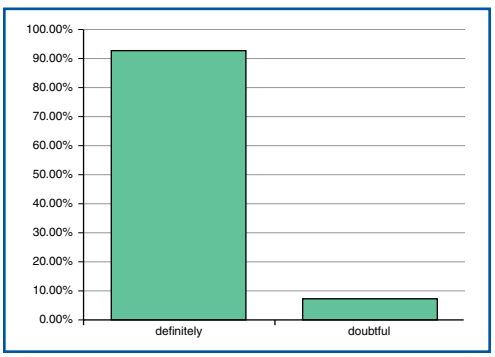


Fig 4 - I will be able to apply what I've learned.

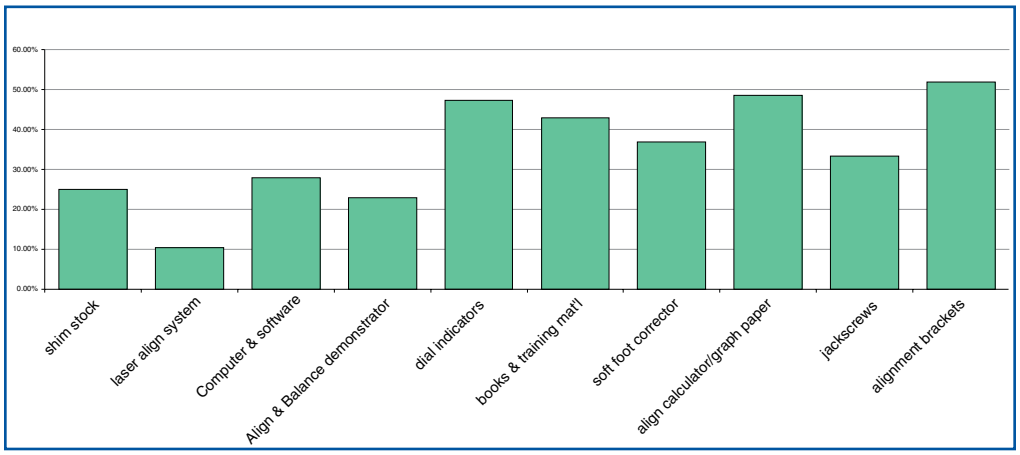


Fig 5- Align Tools needed...

In Fig 4, we can see that of the 1070 people who filled out the questionnaire, a small percentage responded that they did not think they would be able to apply what they learned.

I still remember the first time I read this response. It happened on one of the first training courses I did. One of the attendees came up to me after filling out the questionnaire and took me to the side. He said he wanted to explain why he answered this question that way and that he did not want me to take it the wrong way. He told me that the information in the course was great, but because his manager did not attend the course to hear and understand what he just learned, he did not believe that he would be ALLOWED to apply the techniques he was just taught. He went on to say that, since none of the staff had used these practices during his 20-year tenure at the plant, he thought it was highly unlikely that anyone would listen to him.

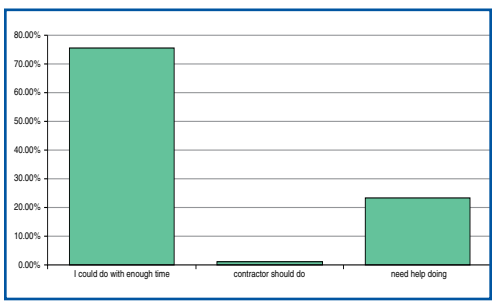


Fig 6 - Shaft alignment is something that...

Now, I don't want to offend anyone here. Just look at the graph in Fig 5. What do the people say they need? Is the maintenance staff being equipped to be completely successful?

In Fig 6, we see that 75% of the people believe that they can do shaft alignment if they are given enough time to do it. Let me repeat ... if they are given ENOUGH TIME to do it. Yep, that's another major complaint I hear from the people who go to these classes. They tell me that they are not given enough time to do the job correctly.

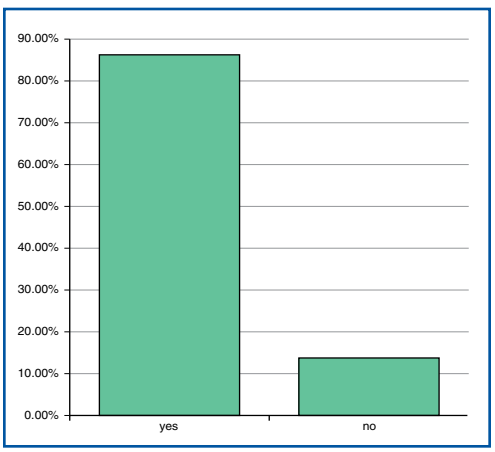


Fig 7 - I would like to go to the intermediate or advanced shaft alignment course.

Almost 70% of the people who take the class understand the information the first time through. And the results in Fig 7 speak volumes. They realize how much is involved and the overwhelming majority want to learn more so they can improve their performance. I'm no psychologist, but I do know that when

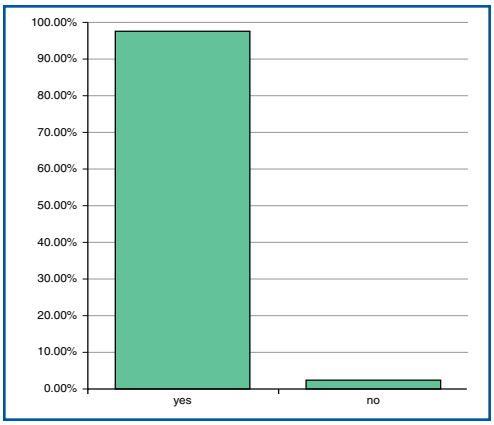


Fig 8 - There are other people in this company that need this course.

people actually want to learn, they absorb a lot more information. I also believe they will do a much better job with the information learned.

Again, the results in Fig 8 speak for themselves. Reflecting back on this, I think I should have asked who the "other people" should be. Their coworkers? Their maintenance managers or supervisors? The engineers in their company? The vibration technicians? The pipe fitters? The production manager? Possibly all of the above?

What should we learn from the results of this survey? I can't speak for everyone else, but I didn't learn about all of this in grade school or high school. Most of what I know about industrial rotating machinery I did not learn in college as a student learning mechanical engineering. If this isn't taught by industry itself, where will your employees learn it? I learned most of what I know in the "school of hard knocks", through my colleagues, professional organizations, the maintenance craft people I worked with, and having the courage to experiment knowing that I might fail. And at times, fail I did. But not always.

I have not gone back to every person who filled out the questionnaire and asked them if their companies have given them the tools that they need, additional time to perform the tasks necessary to do alignment correctly, and given them the opportunity to align machinery more often that twice a year. However, I have had the chance to talk with many of them. Their responses have been disappointing at best. They still don't have the tools they asked for, rather they were forced to accept the same tools they always had or were given an alignment system not of their choosing. One person explained that his company had six laser alignment systems and no shim stock. Does that make any sense?

At the end of a famous comedian's monologue, he finishes with the statement... "This is just my opinion, I might be wrong." The above information, however, is not my opinion. It is the opinion of 1000+ people. I don't think that many of them are wrong. What do you think? More importantly, what are we going to do about it?

Suggestions

- Treat your employees as if they were your most valuable customer.
- On an annual basis, ask all the employees the following things:

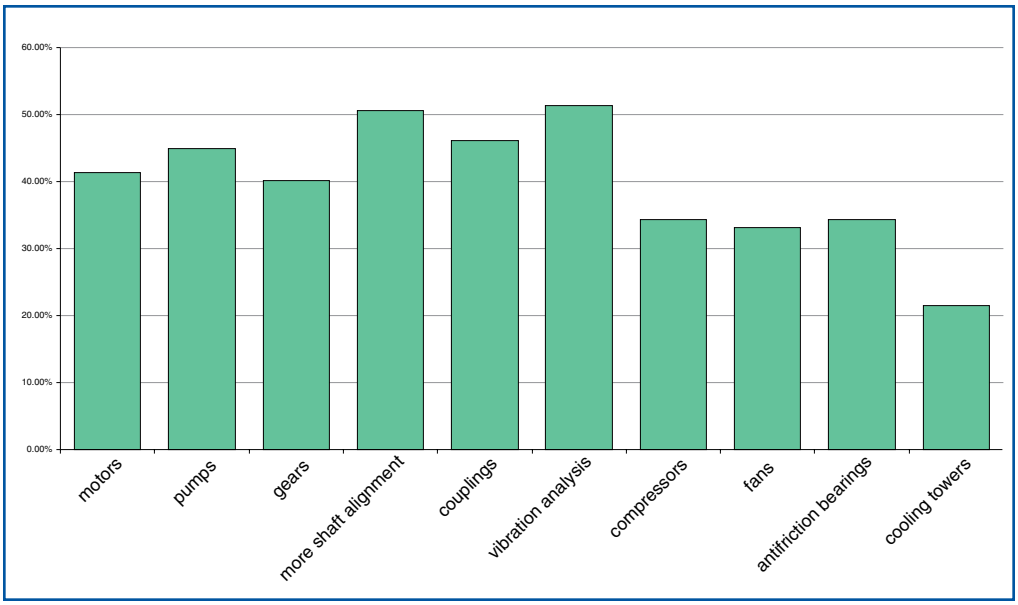


Fig 10 - I think I need additional training in...

1. What training do you need?
2. What tools will help you with your job?
3. Are we giving you enough time to do your job correctly?
4. If you are not excited to come here and work, why not?

If you are a manager, answer the above questions first by yourself. Then pass out a form to every one in your organization. Ask them not to put their name on the form and to be honest. Give them two days to think about it and ask them to turn it back in to you. I would recommend that you get prepared for some hard to swallow results. Then, have the courage to act.

John Piotrowski is president of Turvac, Inc which provides industry with industrial training in shaft alignment, vibration analysis, balancing and performance analysis. He conducts field service in machinery realignment, off-line to running machinery movement surveys, balancing, and performance monitoring. John is the author of The Shaft Alignment Handbook (© Marcel Dekker, 1986) and Basic Shaft Alignment Workbook. John is feverishly working on an e-book tentatively entitled the "Turvac Field Service Files", which will assist people in applying the principles and methods covered in the Shaft Alignment Handbook. John is happily married with three children and six grandchildren. He enjoys fishing, backpacking, white water rafting and makes a mean salsa. John can be contacted at 513-932-2771 or at contactus@turvac.com

When Time Is of the Essence

Using the Comparative Method to Determine Baseline Bearing Condition

by Jim Hall

Knowing when to remove and replace a bearing due to wear can be quite difficult, and over the years, has left countless technicians scratching their heads. The ramifications are large if the decision is not correct. Replacing a bearing that, once retrieved from the machine, shows no wear is not good. Loss of production, wasted maintenance man hours and loss of credibility are all part of the price paid for being wrong. However, it is even worse to delay changing a damaged bearing. A catastrophic failure can lead to major downtime, large production losses and sinking profits.

Ultrasound is a tool that can provide much needed help in the decision to change or not to change a bearing. And some technicians have been using it as a method for determining bearing failures for well over 30 years.

There are three methods of monitoring a bearing for failure when using an airborne ultrasound instrument: Comparative Method, Historical Method and Waveform Analysis.

Comparative Method - The comparative method requires testing two or more similar bearings for the purpose of comparing the differences using the same frequency and sensitivity.

Historical Method - The historical method first requires you to have used the comparative method to establish a baseline and then, over a period of time, determine failure by the degree of degradation.

Waveform Analysis - Waveform analysis can be used no matter whose airborne ultrasound instrument you are using. A waveform analysis of the bearing can be seen by utilizing the converted high frequency to low frequency sound from the headphone jack of most instruments to determine bearing condition.

But, not all technicians have the luxury of time to perform the historical method or waveform analysis. Most technicians are not vibration techs, nor qualified to operate a vibration instrument, nor read spectrum analysis, FFT's, or perform waveform analysis. Without using one of the before mentioned technologies, you cannot simply say a bearing is bad using an ultrasound receiver without first acquiring a history or baseline. If a history is not available, you can locate similar bearings and perform the "comparative" method.

The ultrasonic frequency most widely used for bearing diagnostics depends greatly upon the manufacturer of the equipment you are using (i.e. 30 kHz, 40 ± 5 kHz, 38.4 ± 2 kHz). If your instrument has frequency tuning, or the ability to change frequency settings, check with the manufacturer of your instrument or refer to your instruction manual as to what frequency to use for bearings.

If your instrument does not have frequency tuning, then select the applicable mechanical setting and simply touch each bearing, noting the difference. The bearing reading with the least decibels is the bearing to use as the "baseline" for the other bearings.

Some will credit a study by NASA, published in a NASA Tech Brief (newsletter) prior to 1990, with establishing ultrasound as a tool for determining bearing failure. In the brief, bearings studied were at frequencies of 24 through 50 kHz. The study found that incipient bearing failure occurred during changes in amplitude before other means such as vibration or heat changes. An impact produced as a ball passes over a fault or pit in the bearing race may produce a sound heard. An increase in amplitude or a qualitative change can then be heard and/or recorded.
Note: The NASA study did not mention any particular instrument or manufacturer.

When using the comparative or historical method a standard must be set to determine if the bearing is entering a failure. Most manufacturers believe that a change in amplitude of 12-50 times over the baseline reading is considered in the failure mode -with a 12 db difference meaning 'incipient bearing failure'. Yet, not all manufacturers use the same numbers to determine failure. For instance, one may say that a reading of 10 db's over the baseline is "lubrication" or incipient

Figure 1 - Bearing #1
Using the 'Mechanical' setting on the instrument, the reading is 47 decibels (5 decibels over baseline established on bearing #3).

Figure 2 - Bearing #2
The reading is 74 decibels (32 decibels higher than the Baseline Bearing).

Figure 3 - Bearing #3 - Baseline
This bearing had the least amount of decibels with a reading 42 decibels.

Bearing Trainer provided by V-Tek Associates.

bearing failure and that you should lubricate the bearing, retake the reading and watch the bearing for changes or degradation over time. However, all agree that at a reading of 50 db's over the baseline, a catastrophic failure is impending. With that type of reading, you should remove the bearing as soon as possible.

Do not compare decibels of one instrument to another instrument. Some manufacturers' instruments will not generate the same reading, even when using instruments of the same model. Using the same instrument make, model and serial number for your bearing program is suggested. You should also compare all instruments of the same make and model for bearing repeatability.

There is no mistaking that airborne ultrasound is an early warning system for bearings, because it can detect subtle changes in the ultrasonic range before other technologies such as heat or vibration can detect faults.

Digital Unit

The digital unit shown in Figures 1-3 has a predetermined frequency selected. The user must first select a mode of operation such as 'mechanical' (35-45 kHz). Then by simply touching the bearing surface a decibel reading can be displayed. The bearing displaying the least amount of decibels is the Baseline Bearing. In the examples shown in Figures 1-3 we tested three bearings. The third bearing tested had the lowest decibel reading, so it became the baseline at 42 decibels.

Analog Meter

When using the analog model shown in Figures 4-6, you must first select 30 kHz as the frequency (frequency tuner on bottom of instrument), 'linear' mode and lower the sensitivity (black potentiometer knob) till the analog meter reads '20'. The analog meter reads in increments of 20 (20, 40, 60, 80, 100), and each increment of 20 on the scale represents a 3 decibel difference (20-40 = 3 db's, 20-60 = 6 db's, 20-80 = 9 db's and 20-100 = 12 or more db's).

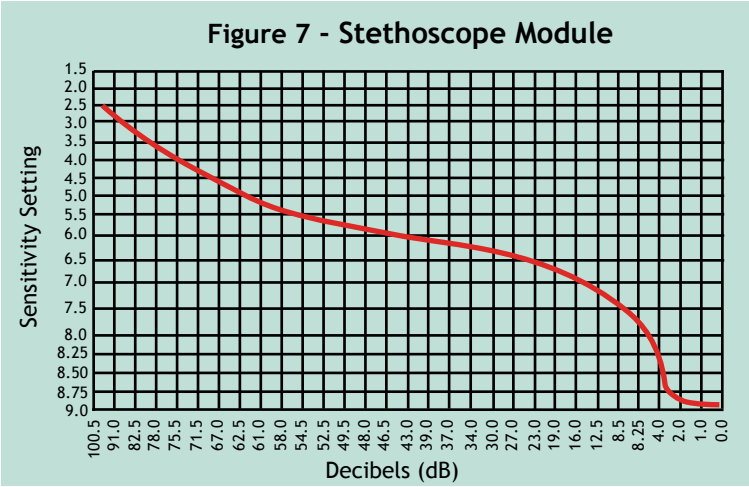
When testing Bearing #3 (Figure 4) the sensitivity was lowered to 6.05 (number in the window of the sensitivity knob and outer set of numbers of knob) until a meter reading of '20'. The sensitivity setting was not changed when testing Bearing #2 (Figure 5), and the scale read '100' - meaning that this bearing is 12 or more decibels higher than No. #3 the baseline bearing. When testing Bearing #1 (Figure 6), again using the same sensitivity, the reading on the scale was '60' - meaning that Bearing #1 is 6 decibels difference than the baseline bearing.

This same analog unit offers an attenuation transfer curve (Figure 7) for the contact probe to determine decibel range. Using the same frequency of 30 kHz and 'linear' mode, lower the Sensitivity setting until the meter reads '50' on the scale. Repeat this for each bearing to determine the decibel range, noting the 'sensitivity' reading (window of knob), and then cross reference the sensitivity reading to a decibel along the curve. Keep

Figure 4 - Bearing #3
Using 6.05 'Sensitivity' and a meter reading of 20, Bearing #3 is used as the Baseline to compare the other two bearings #1 and #2.

Figure 5 - Bearing #2
Using 6.05 'Sensitivity' Bearing #2 is 12 or more db's higher than Bearing #3 which is the bearing used as the Baseline with a meter reading of 20.

Figure 6 - Bearing #1
Using 6.05 'Sensitivity' Bearing #1 is 6 db's higher than Bearing #3 which is the bearing used as the Baseline with a meter reading of '20'.



in mind that the chart is 'serial numbered' to your specific instrument and cannot be used with any other instrument of the same model.

Note: When using an attenuation transfer curve, remember that the curve is serial numbered to your instrument only and cannot be used with any other instrument of the same model.

Using the attenuation transfer curve, Bearing #3 had a sensitivity of 6.3 and 30 decibels, Bearing #2 had a sensitivity of 5.5 and 54.5 decibels, and Bearing #1 had a sensitivity of 6.0 and 43 decibels.

So, the next time you are in a hurry and time will not permit either the use of waveform analysis and or the preparation of a historical trend, use the comparative method to quickly determine the difference between similar bearings.

The comparative method can be used for virtually any other airborne ultrasound application. For example, you can compare flow within several pipes or manifolds, you can compare similar gearboxes on an assembly line, or you can compare air leaks to determine if one leak is greater than another of the same pressure.

It may be worthwhile to reevaluate your ultrasound program to see if you are using your instrument for all the applications in which it can be used. If you have instruments from more than one manufacturer, and are not sure of the various tasks for which they can be used , seek additional training to ensure you're maximizing the benefits and capabilities of your equipment.

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 the new UPTIME Magazine. Jim has provided airborne ultrasound training for several Fortune 500 Companies in electrical generation, pulp & paper, petro-chemical and transportation (marine, automotive, aerospace). A 17-year civil service veteran, Jim served as an aerospace engineering technician for Naval Aviation Engineering Service Unit (NAESU) and with the Naval Aviation Depot Jacksonville Florida (NADEP).

Gold In Them Thar Hills

A Case Study from South America

By Bill Kilbey

Pump problems are common, and troubleshooting them often involves more than just simple spectrum analysis. In this case history, time waveform analysis, phase analysis, pump system knowledge, bearing loading and motor construction knowledge were all necessary to diagnose and fix the problem. Vertical pumps have a unique set of problems. Most of the time analysis is performed with vibration readings taken on the motor because the pump is usually inaccessible.

Fig 1 - Five Vertical Pumps at Large South American Gold Mine

The pumps analyzed here were installed in order to raise production of gold at a large gold mine in South America. The mine is situated at an altitude of 15,000 feet! Five pumps were installed and commissioned. The pumps are known as "barren solution pumps", as the gold, silver and other elements have been removed from the solution. The solution is then circulated through a leach pad of crushed rock to become "pregnant" with elements. The mechanics and operators noted "high vibration" but an investigation was not initiated until a motor failed. A consultant was called in and the diagnosis of "resonance at running speed" was the outcome of his testing. No actions were taken to correct this condition. Within three months, two more motors had failed, so another consultant was summoned. He also diagnosed resonance, and recommended a design modification to the pump head.

A set of vibration data was taken for reference before modifications. The data in Fig 2 shows all motor points on #8 pump. The highest levels are at 1X turning speed, in line with the discharge head, which was also the case on #10 pump. It is interesting to note that the highest vibration levels are at the bottom of the motor. This is abnormal, and phase analysis was necessary to understand the deflection shape of the pump. The highest reading is at the MIH position on #10 pump, shown in Fig 3. Note the very high 1X turning speed peak at over 3 in/sec pk. Fig 4 shows the measurement locations and amplitudes on #10 pump.

A negative averaging bump test was performed in order to better understand the natural frequencies. The results are shown in Fig 5. Negative averaging is a two step process. First the machine data is recorded along with the impact excitation. In this case the excitation was provided via a rubber mallet (it was actually a modal hammer, but only used as a tool to excite the resonance). The second step involves recording the vibration without the impact excitation. The "valley" to the right of the cursor marker at 3510 CPM is where the running speed vibration was subtracted.

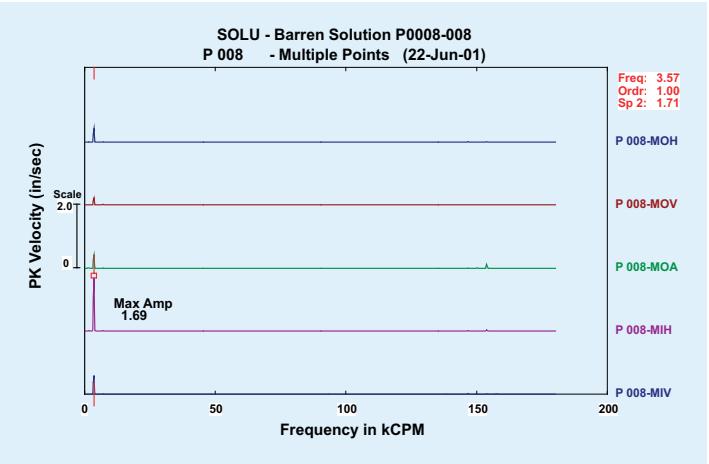


Fig 2 - Vibration Data, Pump #8.

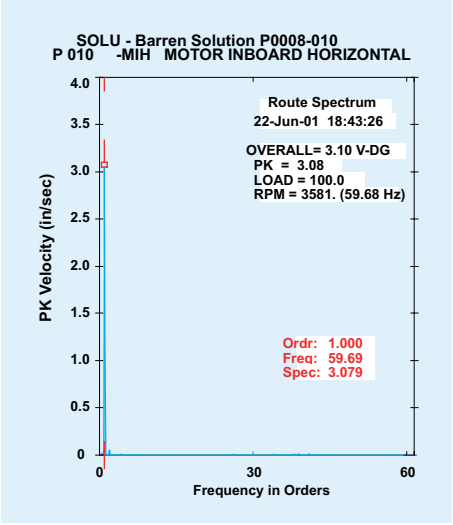


Fig 3 - Pump #10 Motor Inboard Horizontal Position.

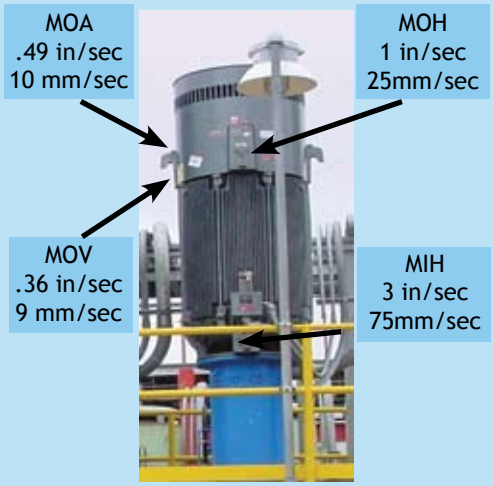


Fig 4 - #10 pump measurement locations and amplitudes

The first narrow peak at approximately 480 CPM is the first mode (cantilevered beam). This mode can be excited by flow turbulence or rubs and impacts. In this case, this mode was of no concern. The 2nd mode is shown as the group of peaks from 2400 CPM to 4400 CPM. The broad group of peaks suggests this mode is heavily damped.

Phase readings were also taken from the pump and motor with a two-channel data collector, and they supported the idea that a resonance problem may exist. With the top of the motor and pump moving 180° out-of-phase with the point at the bottom of motor, the classical "S" shape 2nd mode may be visualized. A full operating deflection shape analysis test was not performed.

An attempt was made to field balance the motor on the top balance ring. The amplitude and phase vectors did not respond to large trial weights. The coupling was checked for correct installation and the machine was checked for misalignment and bent shaft. All were determined to be satisfactory by the pump manufacturer's representative. The base was evaluated for flexing or motion, but these results were also considered normal.

I arrived at the same time as a representative of the pump manufacturer. He planned to implement design changes that were intended to stiffen the pump head. Fig 6 shows the pump after these changes were made.

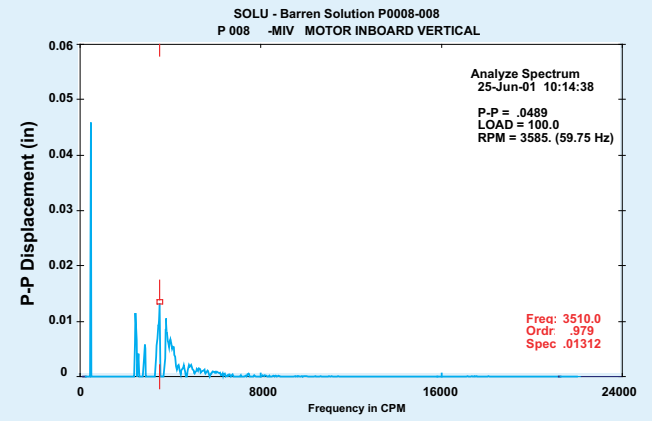


Fig 5 - Bump Test, 1st and 2nd Mode

Vibration data was taken before and after modifications were made to #8 pump. Although there was more than a 25% reduction in amplitude, the levels were still unacceptable for long term, reliable operation. The bottom line is the stiffeners were not very effective.

The forcing functions and the failure modes

Fig 6 - Stiffeners added to #8 Pump.

needed to be evaluated to solve the problem. The #10 pump motor had a failure during the testing process. The data shown in Fig 7 is a spectrum with 1X turning speed and harmonics. This may be associated with internal looseness or impacting.

The time waveform in Fig 8 is very asymmetrical (+5.5 G-s to -1.92 G-s) and truncated. This clearly shows impacting and rubbing. Note the two large impacts in each revolution of the shaft. They are very repetitive. This motor failed shortly after these readings were taken and was removed to a facility for inspection and repair.

Another look at the spectral data in acceleration from the #10 pump (Fig 9) motor shows a large synchronous peak in the area of rotor bar pass frequency (RBPF). The sidebands are spaced at 1X turning speed. This is a common indicator of dynamic eccentricity. The rotor may be out of round, or the bearing may be loose enough to allow the rotor to travel in an eccentric path.

An orbit test was also performed. The orbit (derived from filtered acceleration data) revealed the motion of the bearing.

The top bearing carrier assembly for the motor is shown in Fig 10. From the motor name plate we could see that the top bearings were 7226 BCB angular contact bearings. The seal area was severely galled from the bearing carrier assembly rubbing. This is normally a .010"-.015" clearance area, so the rotor was moving more than design tolerances.

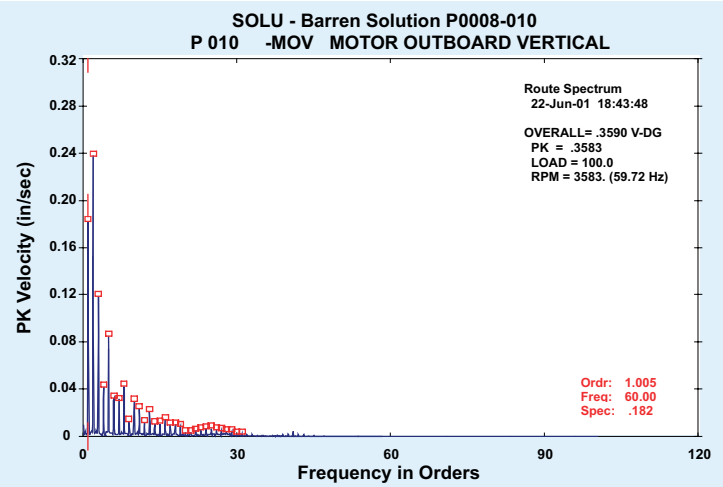


Fig 7 - Spectrum #10 Pump

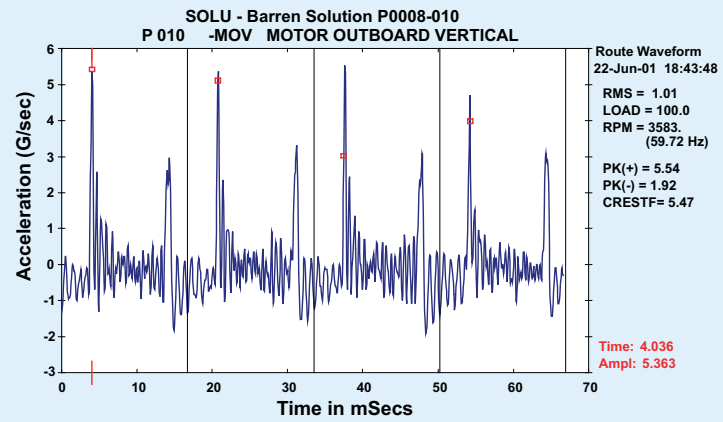


Fig 8 - Waveform #10 Pump

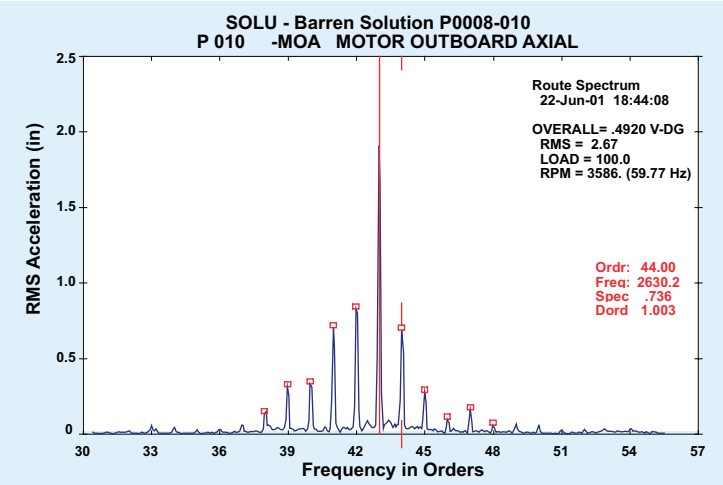


Fig 9 - Spectrum w/ Sidebands, #10 Pump

We suspected that the top bearings were not loaded sufficiently. An angular contact bearing must have sufficient axial load so the bearing does not allow excessive radial motion. We consulted the SKF Engineering Handbook Catalogue for minimum axial load requirements, and made some rough estimates of static loads from the weight of the rotor and pump assembly. The static load was not enough to load the bearing. The pump develops head (pressure) and provides loading

Fig 10 - Top Bearing Carrier Assembly.

to the bearing when in operation.

Fig 11 (next page) shows a typical pump curve. Pumps can produce output at points along their curve for a given impeller diameter, speed and horsepower. There is a point of operation known as the "Best Efficiency Point" (BEP), which is where the pump is designed to minimize flow disturbances and most efficiently impart velocity to the fluid. This velocity is converted to head (pressure) in the piping. Operation at points far away from BEP may introduce noise, cavitation, unbalanced dynamic pressures and vibration.

A gauge was then installed in the discharge pipe to measure flow/pressure. We determined the pump was operating to the far right side of the pump curve in a high flow, low head condition referred to as "run out". In this condition the pump was not developing the head which would have loaded the top angular contact bearings sufficiently. The bearings were then able to move in the radial direction, and the rotor was moving in a gyroscope path at the top. The rotor would then impact and rub, exciting the 2nd mode shape.

To prove that too much flow was causing the excessive motion and vibration, the discharge valves were temporarily throttled 30%. The resulting vibration decreased from 1.8 in/sec to .3 in/sec. The pump was operating closer to BEP with less flow and more pressure. The additional head pressure was loading the pump impellers in the axial direction, which loaded the angular contact bearings, reducing radial clearance. The running speed also increased by 17 RPM. So, by throttling the discharge valve, the pump had lower flow in GPM, which put less load on the motor, making it run faster.

The root cause was found to be in the system piping. The pump was designed for approximately four miles of piping, but because the mine was relatively new, all the piping was not yet installed.

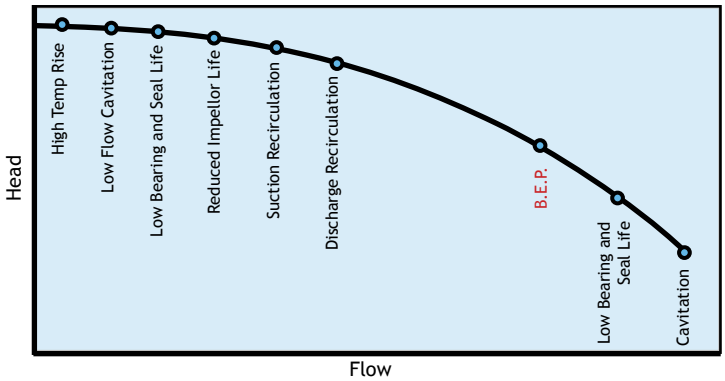
The fix was to remove a stage from the multi stage pump, and install a restrictor plate in the discharge piping to decrease flow and increase the head. The angular contact bearing configuration was changed from tandem (same direction) to face-to-face so the bearings would load each other, therefore assuring proper axial loading.

The pumps were then evaluated again and the results are shown in Fig 12 and Fig 13. The vibration at 1X turning speed decreased from 3 in/sec to .25 in/sec. Success!

This case history shows the importance of pump system knowledge and how it relates to vibration. Careful study of all spectral data, waveform and phase were important, as was knowledge of bearing installation and operation. All performance data (flow, pressure) and pump curves may be needed.

Bill Kilbey is the Director for Worldwide Training at Mobius Institute, the "iLearn" company. Bill delivers courses in the United States, and manages Mobius training partners around the world. He was most recently the Manager of Worldwide Training for Emerson Process

Fig 11 - Operating Away From the Best Efficiency Point (BEP) of a Centrifugal Pump



Management, CSI. Bill was responsible for the development and delivery of all CSI Training activities and personnel since 1997. He received his initial vibration and reliability training while serving as a sound and vibration analyst in the submarine force for the United States Navy. He went on to become a machinery reliability consultant with a large rotating machinery repair organization. Bill has a wealth of troubleshooting experience in many industries including petro-chemical, pharmaceutical, wood/paper products, mining, automotive, food processing and general manufacturing. He has 10 years experience in teaching a variety of reliability related courses including balancing, alignment, basic and advanced vibration analysis, CBM software, Root Cause Failure Analysis and management focused courses. Bill can be contacted at 865-675-1328 or bill.kilbey@mobiusinstitute.com

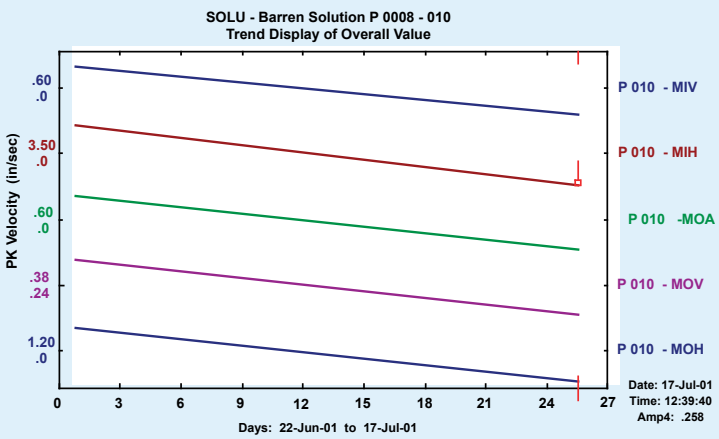


Fig 12 - Display of Overall Vibration Values

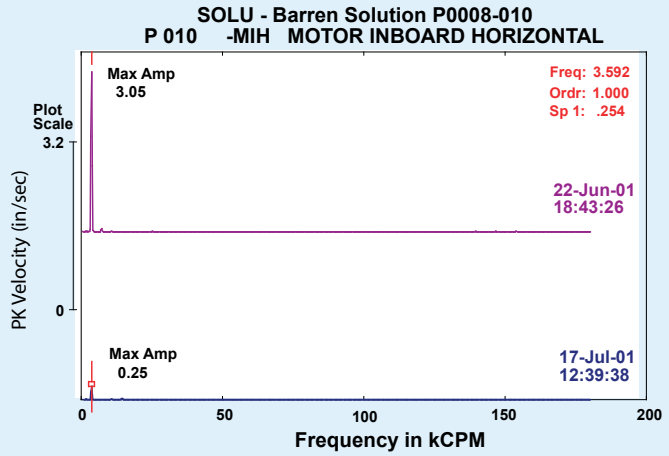
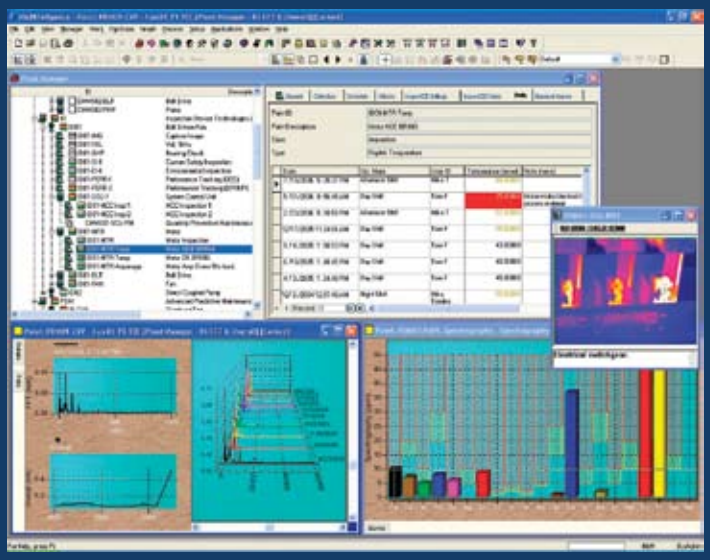


Fig 13 - Before and After Vibration Levels

Looking for a comprehensive, versatile and easy to use product that will help you reduce breakdowns & repairs, increase equipment reliability & maintainablility...

MAINTelligence

There is a good chance this product could make your life easier by creating a highly organized framework and schedule for basic equipment inspections, condition based maintenance, and both maintenance and asset management. We tracked down (and we do mean tracked, because he was on vacation at the time) Steve Reilly, vice president of Design Maintenance Systems, Inc., to discuss a pretty unique piece of software called MAINTelligence. Steve is a well-known innovator in the reliability and condition monitoring industry who has designed and developed systems for vibration analysis, lube oil analysis, maintenance management systems and operations inspection.



Can you give us a brief overview of the MAINTelligence program?

MAINTelligence is one system that handles maintenance management, work orders, predictive maintenance, data collection and analysis, and asset basic care. The benefit is that it provides users with automatic integration of what normally constitutes three separate software systems (EAM/CMMS, PdM, and TPM/inspection systems). To the best of my knowledge, it is the only system that brings all three together.

MAINTelligence is used in hundreds of sites worldwide, ranging from single ships to some of the world's largest industrial operations. It is used to manage Asset Basic Care programs (operator-based reliability initiatives), predictive maintenance programs and as a CMMS system.

There are several modules available within MAINTelligence. Could you explain each one briefly?

The modules integrated within MAINTelligence are in four major areas: Asset Basic Care (inspections, operator-based reliability and lubrication management), Integrated Predictive Maintenance (modules for vibration data collection and analysis, lubrication analysis, thermography, ultrasonics and process data), Diagnostics (rule-based diagnostic system for automatic data analysis) and Asset Management (task scheduling, work order management, parts management, purchasing)

In the last five years, the asset basic care module has generated the most interest because it seems to generate the greatest reliability gains in the shortest time. This module directly interfaces with Windows Mobile™ handheld devices (MAINTelligence InspectCE) for operator inspection and lubrication management.

Our latest innovation adds further integration to the asset basic care and predictive maintenance areas, an interface from our MAINTelligence InspectCE handheld to a digital output accelerometer. This allows operators to collect time waveform and spectral vibration data while conducting their inspections.

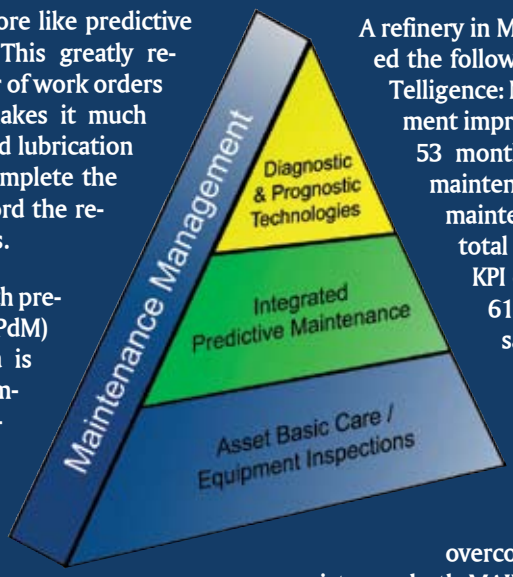
What sets MAINTelligence apart from other Asset Management software/CMMS's?

A typical CMMS is not so much a maintenance tool as a work order accounting system. Data is recorded in the CMMS for cost management, not to monitor or improve the reliability of the assets.

In designing MAINTelligence, my primary objective was to create a framework that incorporated the CMMS aspects, (collecting costs and allocating resources). However, our customers made it apparent that there was demand for more focus on the management of predictive and inspection based maintenance data, along with standard corrective and preventive maintenance work orders. Thus, MAINTelligence differs in that it provides both CMMS and integrated asset reliability functions.

Many times the data in a CMMS can be collected but not acted upon. How does MAINTelligence overcome this problem?

MAINTelligence information is considerably more active and relevant to condition of the asset than the information found in most CMMS databases. Inspection and lubrication work, which often comprise a high percentage of the total number of work orders in a CMMS, are handled more like predictive maintenance rounds. This greatly reduces the total number of work orders in the system, and makes it much easier for operators and lubrication technicians to both complete the actual task and to record the results of the inspections.



One major problem with predictive maintenance (PdM) programs is that data is collected, but recommendations for proactive maintenance never get turned into actual work orders. By integrating both asset basic care and predictive maintenance findings directly into the maintenance task schedule, work from PdM procedures is automatically generated, just like time or meter-based PM tasks. This allows maintenance planners to handle all tasks the same way, no matter what their origin. The significance of this is that maintenance schedules can automatically change based on the inspected or measured condition of the asset. And it doesn't have to just be MAINTelligence as the CMMS – we have interfaces to many other ERP and EAM systems that allow us to trigger work orders automatically.

What types of industries are currently using MAINTelligence?

Our largest number of customers is in the pulp, paper and wood products sector, but we have a significant number of customers in utilities, mining, petrochemicals, discrete manufacturing, transportation and the military.

What kind of impact can MAINTelligence have on overall plant and machinery reliability? What kind of cost savings can a company expect from using MAINTelligence?

First of all, its important to understand that technology is only an enabler—technological solutions like MAINTelligence will not have any effect if the management and organizational cultural do not support a reliability initiative. Also, cost savings vary from operation to operation (your mileage may vary!) A couple of examples show the reliability improvements and cost savings that can be expected.

A refinery in Memphis, TN, has reported the following results using MAINTelligence: MTBF for rotating equipment improved from 42 months to 53 months, reduced unplanned maintenance from 80% total maintenance expense to 15% total maintenance expense, KPI on pumps has improved 61% and a documented savings of $1 million dollars in maintenance cost/year.

At a pulp and paper mill in Louisiana in early 2004, after overcoming some initial resistance, both MAINTelligence-based asset basic care and a predictive maintenance program were implemented. Mechanics' inspections generate approximately 300 corrective work orders per year that have improved the overall stability of the manufacturing process. By June 2005, the integrated reliability program was credited with a 20% ($30 per ton) reduction in maintenance costs. This happened at time when paper mills had been shutting down due to high operating costs and oversupply. Plant personnel achieved the cost reductions by embracing the integrated reliability concept and the culture of self-discipline that it implied.

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

Our customers range from some of the world's largest operations, such as the POSCO steel mills in Korea, to some relatively small operations like Aquarium of the Pacific in Long Beach, CA.

Although we spend a lot of our time dealing with very large corporate installations, I often think the small operations actually get more "bang for the buck" from MAINTelligence. For a smaller operation, a single investment in MAINTelligence can be turned to many different uses – it can be used as a CMMS, a vibration analysis system, a lubrication analysis tool, an asset inspection system, an electric motor tracking system, and many other applications. Large operations tend to use MAINTelligence as a point-specific application – they acquire it to implement a specific program.

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

Canfor Corporation implemented an Asset Basic Care program utilizing a shared server over a wide-area network accessed by three of their large pulp and paper mills. All three facilities access the same database, use the same procedures, inspections, identifications, task management and reports. The shared database allows each facility to share machine histories, trends, machine failure characteristics other reliability information.

Lafarge utilizes DMSI Asset Basic Care (inspection technology) at the Harleyville location for inspection routes that include safety/housekeeping checks, motor inspections, and equipment specific checks such as pumps, compressors, etc. They have reported many examples of money saving inspection catches including pump bearing failures, fan motor bearing failures, fan drive belt failures, feed bucket elevator vibration, gearbox oil leaks, and more.

How can people interested in MAINTelligence get more information?

Visit DMSI's website, www.desmaint.com to download product literature and/or schedule a live product overview by a DMSI support person via the web. Alternatively, call DMSI at 604.984.3674 or email info@desmaint.com.

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Bijur Delimon International, a leader in automated lubrication systems, has launched a new web site-- www.luberevolution.com-- dedicated to the needs of the packaging, bottling and process industries. The site gives engineers an interactive tool to explore a variety of standard and innovative lubrication solutions. Enter the type of lubricator (pneumatic, electric, manual, single-point), lubrication metering device (series progressive block or injector) and the number of points they need to lubricate and the tool generates a system ideally suited to these requirements.

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VibrAlign Inc. introduces the new Fixturlaser XA, a breakthrough in laser shaft alignment designed to allow users to perform alignments more quickly.

The Fixturlaser XA is the result of an effort to completely reinvent laser shaft alignment . The system incorporates many technologies new to laser shaft alignment, along with completely redesigned software. The result is a laser shaft alignment system that is more user friendly than any previous offering. With the XA, users will be able to perform alignments significantly faster. In fact, "XA" stands for "Express Alignment".

The touch-screen graphical user interface, first pioneered in laser alignment systems by Fixturlaser, now incorporates Flash® animated, 3-dimensional graphics. The screen graphics keep the user in touch with exactly where they are in the process, and prompts them through the correct steps to quickly complete an "express alignment".

Other new technologies incorporated in the new Fixturlaser XA include: rectangular 30-mm detectors to eliminate preliminary rough alignment, a line laser to improved target acquisition and range and CCD technology for better laser reception.

The system has laser transmitter-detectors pre-mounted to save set-up time. Optional wireless transmitters eliminate of wires connecting the transmitter-detectors to the computer display unit. The system is PC compatible and comes with network, RS-485 and USB ports allowing options for data download and upload.

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The Vibration division of PCB Piezotronics (PCB®) has announced new Model 3711, a high sensitivity, MEMS DC (steady state) response accelerometer designed expressly for automotive and off-highway testing.

The sensor's footprint is 0.85 in. (21.6 mm) x 0.85 in. (21.6 mm) x 0.45 in. (11.4 mm) in a welded titanium case design, with a choice of either hermetic connector or integral cable version. The accelerometer is well-suited for any vibration sensing application requiring DC acceleration, high resolution, and high sensitivity, yet able to survive high g events.

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Responding to market demand, AEMC's new OX 7104-CK Oscilloscope is the first 12-bit four-isolated-channel 600V Cat III on the market with up to eight traces on the screen. This all-in-one portable and rugged hand-held instrument features five complementary tools: an Oscilloscope, FFT Analyzer, TRMS Multimeter, Harmonic Analyzer and a Recorder. It has both reporting and recording capabilities. Its four-channel high-speed digital recorder function has sample rates as fast as 800µs. The automatic measurements window displays up to 18 parameters of a signal, including AC and DC voltage measurements, current measurements, resistance measurements and temperature measurements.

Lisa M. Ramuta **AEMC® Instruments**
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New Radial Poly-Round® bearings from EDT Corp directly interchange with industry-standard unmounted ball bearings. They are designed for locations where traditional radial bearings fail due to problems associated with rolling element operations (in places that are wet, dirty, hot or cold, etc). They offer superior life in harsh environments because they operate completely without grease. These new EDT Poly-Round® bearings are made of self-lubricating stainless steel and high performance polymers, and require no oil or grease. They can provide many times the life of conventional rolling element bearings in applications where lubrication would normally fail.

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The Flowserve Logix 3200IQ high-performance digital positioner offers quick setup and calibration of either diaphragm- or piston-operated valves without the need for additional handheld devices, software or configuration/calibration tools. The 3200IQ can provide wide-ranging data to a facility's control system (DCS or PLC) or to its maintenance database software. It is used in industries employing control valves, such as oil and gas production and refining, chemical processing, and pulp and paper production.

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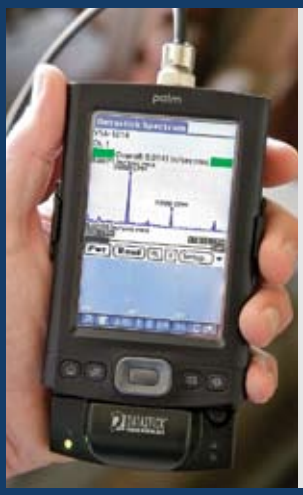

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DATASTICK® SYSTEMS

Pinpoint Laser Systems®, Inc., is introducing a new right angle beam bender called the 90-Line. The 90-Line takes the reference laser beam from the Microgage 2000 and turns it precisely 90 degrees. The 90-Line can be used to square machinery and equipment, set and adjust parallel tracks and rails, align web rollers, idlers, and reels, check gantry travel and position, monitor and adjust machine tools, and assist in geometric alignment.

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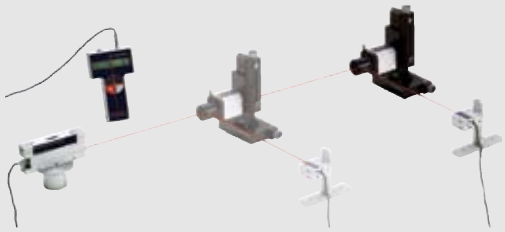
Pinpoint
800-757-5383
www.pinlaser.com



The Vibration Division of PCB Piezotronics, Inc., (PCB®) has expanded its line of Health & Usage Monitoring Systems (HUMS) products, to include new ICP®, charge output and high temperature sensors. HUMS products are designed for in-flight monitoring and predictive maintenance of critical flight systems on helicopters and some fixed wing aircraft. The HUMS sensors feature a robust design, are available in either ICP® or charge output designs, with top or side exit electrical connectors, and in a variety of hermetically sealed physical configurations. High temperature versions are also available.

Vibration Div, PCB Piezotronics, Inc.
888-684-0013 (in U.S. & Canada)
vibration@pcb.com **www.pcb.com**

American Sensor Technologies introduces the new AST47SM Series Pressure Sensors designed to perform in the rugged environments of the steel and aluminum industry. The AST47SM sensors are a direct plug-in for steel mill applications including rolling mills, pumps and coolant systems. Featuring a one-piece sensing element, the AST47SM Series of Pressure Sensors have no silicone oil, welds or O-rings, eliminating the chance of contamination from outside media. A stainless steel housing welded to the sensing element and cable connection withstands system wash downs. Units are rated for over 100 million pressure cycles and have 100Vm of EMI/RFI to protect against electrical noise.

American Sensor Technologies
Karmit Siddhu
kssidhu@astsensors.com
www.astsensors.com

Engineers at Bijur Delimon Intl have substantially redesigned the company's FL Series of positive displacement lubrication injectors to achieve 400,000 lubrication cycles without leaking or failing. This is about two to four times longer than comparable units currently in use in the packaging industry. The new FL Series injectors rely on the most advanced system to date for delivering a precise dis- charge of grease or oil and are adjustable, so that customers can avoid costly waste and spill- ing. The improved, rugged injectors are manufactured of stainless steel or carbon steel with zinc surface protection and standard double Viton® seals.

Jim Carse or Scott Batchelor
919-465-4448 **www.bijurdelimon.com**

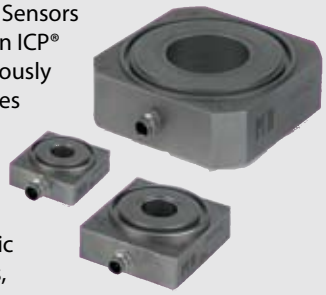
Technekon introduces the only pen-size data collector with FFT capabilities. This is the smallest FFT analyzer in the world, and is capable of waveform and spectra col- lection for predictive maintenance. Perform machinery diagnostics on-site, collect on- and off-route data anytime. USB port connection allows you to store data on PC, analyze machine condition, plan maintenance. Very easy to use for a beginner.

Andy Tutrin **Technekon**
+ 33 (0)6 24 26 70 35
andy.tutrin@technekon.com **www.technecon.com**

Thermo Electron Corporation, a world leader in electrochemistry technology, has introduced the Orion 5-Star pH meter, the newest addition to Orion Star™ Series, a line of meters, electrodes, accesso- ries and solutions for electrochemistry measurement. The portable Orion 5-Star meter is capable of measuring pH, mV, salinity, TDS, ORP, dissolved oxygen and con- ductivity, and can be purchased by itself or in a convenient package including all electrodes, buffers and a field case.

Laura Brockway
(978)-232-6057
laura.brockway@thermo.com
www.thermo.com

Series 260A Triaxial Piezoelectric Force Sensors from PCB® Piezotronics, Inc., available in ICP® and charge output versions, simultaneously measure dynamic and quasi-static forces in three orthogonal directions (X, Y, and Z-axes). The sensors are used to study large, off-highway vehicle chassis dynamics at interfaces be- tween shock absorbers, struts, hydraulic actuators or other chassis components, such as those typically found on dump trucks, payloaders, backhoes, and bulldozers.



Force/Torque Division
PCB Piezotronics, Inc.
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force@pcb.com **www.pcb.com**

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