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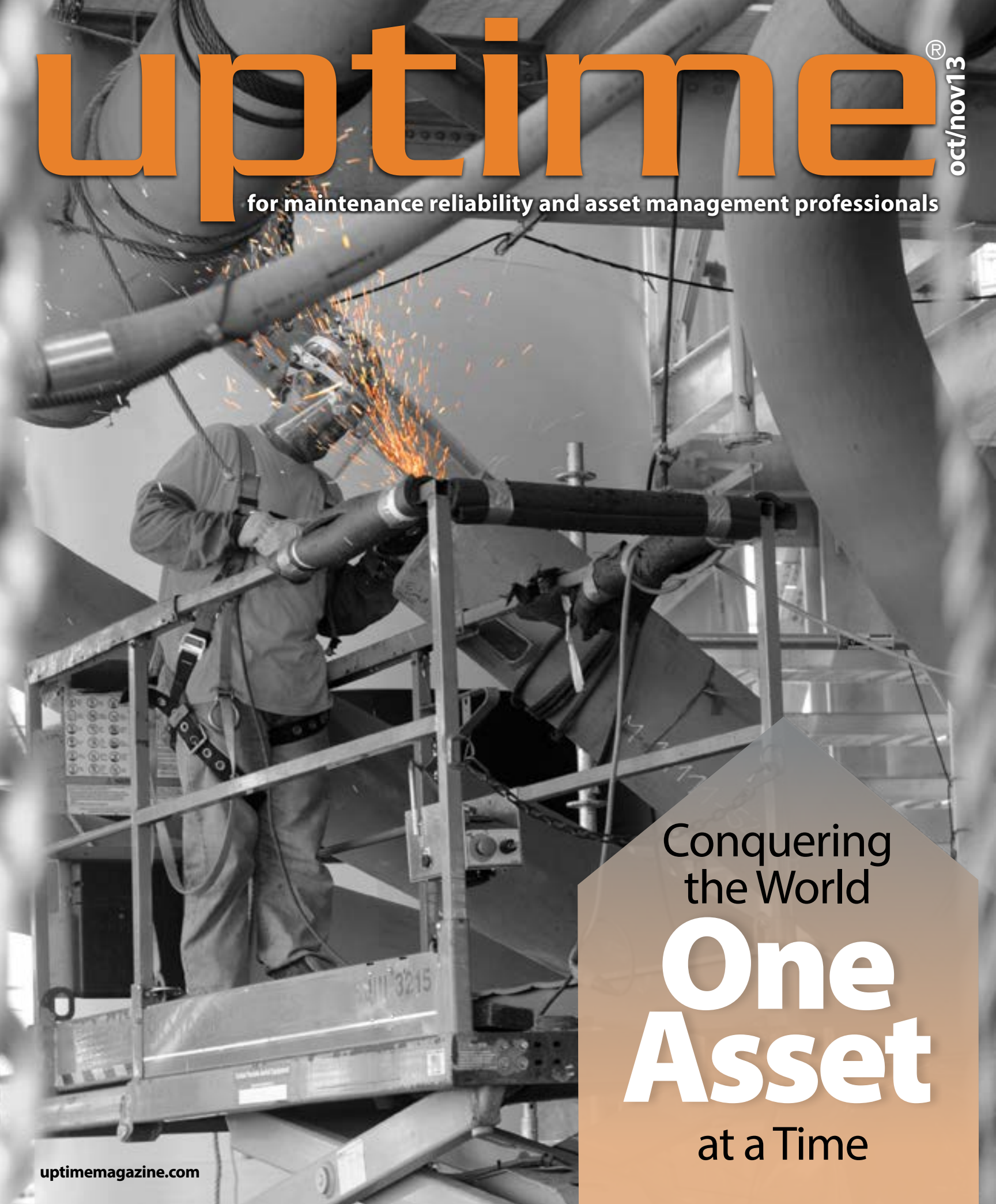
for maintenance reliability and asset management professionals



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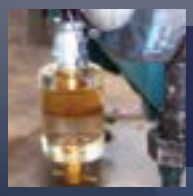

Standard Oil Sight Glass with drain port

3-D Bullseye Oil Sight Glass on oil reservoir

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COURSE	WHO SHOULD ATTEND	YOU WILL LEARN HOW TO	DATES & LOCATION	DAYS/CEUs	COST
Lean Maintenance (DELIVERED BY JOEL LEVITT)	All levels of maintenance personnel, including Supervisors, Planners, Managers, Engineers and Maintenance Workers	Effectively eliminate waste in maintenance operations and projects, and use tools and processes to create a Lean organization.	Mar 11-13, 2014 (CHS) Aug 5-7, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Materials Management	Materials Managers, Storeroom Managers, Planner/Schedulers, Maintenance Managers and Operations Managers	Apply sound storeroom operations principles. Manage inventory to optimize investment. Understand the role of purchasing. Implement effective work control processes.	Oct 22-24, 2013 (CHS) Apr 8-10, 2014 (CHS) Sep 30-Oct 2, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Maintenance Planning and Materials Management	People working in all areas of cross-functional support in a plant	Develop Maintenance Planning and Scheduling and MRO Management objectives and targets to achieve reliability goals.	Oct 8-10, 2013 (CL) Apr 29-May 1, 2014 (CL)	3 consecutive days 2.1 CEUs	$1,495
Maintenance Planning and Scheduling	Planner/Schedulers, Maintenance Supervisors, Maintenance Managers, Operations Coordinators, Storeroom Managers and Purchasing Managers	Apply preventive and predictive maintenance practices. Calculate work measurement. Schedule and coordinate work. Handle common maintenance problems, delays and inefficiencies.	Nov 4-8, 2013 (CHS) Feb 10-14, 2014 (CHS) Visit website for more dates	5 consecutive days 3.2 CEUs	$2,495
Operator Care (DELIVERED BY JOEL LEVITT)	Production Supervisors, Operations Managers and Personnel, Maintenance Supervisors and Personnel, Team Leaders, Lean Implementers	Improve production performance and asset reliability with an Operator Care program. Make data-driven decisions to create effective Operator Care tasks and achieve operational stability.	Feb 25-27, 2014 (CHS) Apr 8-10, 2014 (CL) Sept 9-11, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Planning for Shutdowns, Turnarounds and Outages (DELIVERED BY JOEL LEVITT)	Members of the shutdown or outage teams, planners, plant engineers, maintenance engineers	Save time and money on your next shutdown by learning how to effectively plan for and manage such large projects. Learn processes and strategies for optimal resource allocation.	Oct 1-3, 2013 (CHS) May 20-22, 2014 (CHS) Oct 21-23, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Predictive Maintenance Technologies (DELIVERED BY KEITH MOBLEY)	Plant engineers and managers, Maintenance, Industrial and Manufacturing Engineers, Maintenance Supervisors and Managers	Collect and analyze data to assess the actual operating condition. Use vibration monitoring, thermography and tribology to optimize plant operations.	Oct 8-10, 2013 (CHS) Apr 22-24, 2014 (CHS) Sep 9-11, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Problem Solving	Front-line Supervision, Quality Personnel, Team and Business Unit Leaders, Area Managers, Support Staff, Process Operators	Select and apply effective problem-solving methodologies and resolve problems that limit performance using five data analysis tools.	Mar 11-13, 2014 (CHS) Aug 19-21, 2014 (CHS)	3 consecutive days 2.1 CEUs	$1,495
Prosci® Change Management Programs	Executives and Senior Leaders; Managers and Supervisors; Project Teams; HR and Training Groups; Employees	Build internal competency in change management. Deploy change management throughout your organization. Become licensed to use Prosci's change management tools.	Contact us to schedule a private onsite class.	Sponsor: ½-day Coaching: 1-day Orientation: 1-day Certification: 3-day	Contact us for pricing
Reliability and Operations Excellence (DELIVERED BY RON MOORE)	Operations Directors, Site Managers, Change Managers, Operations and Maintenance Managers, First Line Supervisors, Reliability Leaders	Apply operations excellence and reliability principles. Learn to deliver competitive advantage through asset productivity, defect elimination and workforce engagement.	Contact us to schedule a private onsite course.	2 consecutive days 1.4 CEUs	Contact us for pricing
Reliability Engineering Excellence	Reliability Engineers, Maintenance Managers, Reliability Technicians, Plant Managers and Reliability Personnel	Learn how to build and sustain a Reliability Engineering program, investigate reliability tools and problem-solving methods and ways to optimize your reliability program.	Oct 29-31, 2013 (CL) Mar 11-13, 2014 (CL) Visit website for more dates	3 consecutive days 2.1 CEUs	$1,495
Reliability Excellence for Managers	General Managers, Plant Managers, Design Managers, Operations Managers and Maintenance Managers	Build a business case for Reliability Excellence, learn how leadership and culture impact a change initiative and build a plan to strengthen and stabilize the change for reliability.	SESSION 1 DATES: Oct 8-10, 2013 (CHS) Mar 25-27, 2014 (CHS) Jun 10-12, 2014 (CHS) Visit website for more dates	12 days total (4, 3-day sessions) 8.4 CEUs	$5,995
Reliability Excellence Fundamentals	Personnel involved in applying or are impacted by Reliability Excellence, and people who influence business process improvement.	Experience the fundamental concepts of Reliability Excellence in order to drive performance improvement efforts within your organization.	Feb 25-27, 2014 (CL)	3 consecutive days 2.1 CEUs	$1,495
Risk-Based Asset Management	Project Engineers, Reliability Engineers, Maintenance Managers, Operations Managers, and Engineering Technicians.	Learn to create a strategy for implementing a successful asset management program. Discover how to reduce risk and achieve the greatest asset utilization at the lowest total cost of ownership.	Nov 5-7, 2013 (CL) Apr 29-May 1, 2014 (HOU)	3 consecutive days 2.1 CEUs	$1,495
Root Cause Analysis	Anyone responsible for problem solving and process improvement	Establish a culture of continuous improvement and create a proactive environment. Manage and be able to effectively use eight RCA tools to eliminate latent roots and stop recurring failures.	Oct 22-24, 2013 (CHS) Apr 29-May 1, 2014 (CHS) Oct 7-9, 2014 (HOU)	3 consecutive days 2.1 CEUs	$1,495

***LOCATION CODES:** (CHS) = Charleston, SC | (CL) = Clemson University | (HOU) = Houston, TX | (UA) = University of Alabama

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Culture Eats Strategy for Lunch

Regardless of how good your reliability strategy is, it is your organizational culture that will determine its performance. Culture is built from within and it is "cultivated" by leaders who aim to engage employees in delivering the performance of the organization.

World-class organizations recognize that success is achieved through leadership; however they also realize that success is delivered through engagement and empowerment of everyone in the workforce. Leadership does not come from one person, it comes from everyone. This is especially true for reliability.

Management authority is derived through job description and title. Leadership authority is derived through integrity and example. When integrity is lacking, so is reliability. (Watch for my feature on integrity in the next issue of Uptime Magazine).

A very special team has been extremely busy working on the new Uptime Elements Certified Reliability Leader™ (CRL) program, with plans to offer the first certification exam at IMC-2013, the 28th International Maintenance Conference, being held December 9-13, 2013, in Bonita Springs, Florida.

The goal of the CRL designation is to make you and your team into the best reliability leaders you can be.

Just as Mendeleev created the periodic table to show all the fundamental elements, Uptime Elements express a unified theory to explain the fundamental elements of reliability and how they relate.

Individual Uptime Elements can be extremely complex and difficult for non-specialists to understand. Yet, Uptime Elements allow everyone to gain an understanding of reliability at the appropriate level in which they work. How can people contribute to an effort they do not understand?

Growing up in America in the 1960s, the prize in some breakfast cereal boxes was a decoder ring that allowed my friends and I to write coded messages that only another friend with a decoder ring could understand.

Uptime Elements is that decoder ring.

It is also important to understand that reliability is a journey and a journey requires a map. Uptime Elements are also useful as a map for the journey.

As you will discover at the ISO55000 Asset Management Forum at IMC-2013 in December, an asset is something that has potential or actual value to an organization. Asset management is a coordinated set of activities to realize that value. Reliability enables asset management by assuring the capacity and function of the assets where value is demanded.

What if you had a way to engage and empower every stakeholder in your organization as a reliability leader? It is possible with the CRL program.

Uptime Elements represent a reliability leadership system that is applied to engage and empower people at all levels of your organization. The combined visual and textual aspects of the system make it easy to understand and apply. It is designed to embed reliability as deeply into the organizational culture just as safety is.

Please contact us to find out more about the CRL exam and the Uptime Elements Certified Reliability Leader Body of Knowledge (BoK) and Community of Practice (CoP). Even if you cannot join us at IMC-2013, you can participate in the learning and certification programs.

Before I see many of you at IMC-2013 in Bonita Springs, Florida, I will travel to Salvador, Brazil; London, UK (twice); Abu Dhabi, Saudi Arabia; Uruguay and Indianapolis, Indiana. I am looking forward to creating an army of reliability leaders everywhere I go.

I hope to meet you and learn about your reliability journey at one of the points on my journey.

One thing is for sure – reliability is a journey and the destination is always just over the horizon.

Warmest regards,

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RELIABILITY®

IN THE NEWS

RCM Subject Matter Expert Tim Allen leading a short course at the Reliability Leadership Institute in Fort Myers, Florida, during CBM-2013.

CBM-2013

Reliabilityweb.com hosted CBM-2013 together with Lubrication World at the Reliability Leadership Institute in Fort Myers, Florida from July 23-26, 2013. Topics included balancing PM and PdM, Direction Condition Monitoring with RCM, Uptime Elements Reliability Leadership and the Big 5 Condition Monitoring technologies of Vibration Analysis, Infrared Thermal Imaging, Motor Testing, Oil Analysis and Ultrasound. CBM-2014 is now known as ACM-2014 (Asset Condition Management) and will be held July 28-31, 2014 at the Hyatt Regency Coconut Point Resort in Bonita Springs, Florida. **maintenanceconference.com**

Asset Management Certification

Uptime Publisher Terrence O'Hanlon earned the first US IAM Asset Management Certificate from the Institute of Asset Management (UK). The IAM Asset Management Certificate is aimed at achieving formal recognition of knowledge and experience of physical asset management. The IAM Certificate consists of five Modules, the content of all of which must be covered for the full qualification:

1. **Introduction to asset management**
2. **Asset-related risk**
3. **The asset management lifecycle**
4. **Asset information**
5. **Financial and business impact**

The content of the IAM Certificate is directly linked to the IAM Competences Framework and is also mapped to the specifications of PAS55:2008, the emerging specifications of ISO55000.

I N M E M O R Y

Ralph T. Buscarello

On September 5, 2013, an icon in the vibration world passed away. With over 50 years of experience in practical vibration-related machinery improvement, Ralph T. Buscarello shared his knowledge around the world and was instrumental in getting vibration analysis where it is today. Mr. Buscarello founded Update International, Inc. in 1966 and was principally responsible for Update's reputation as the world leader in vibration-based machinery maintenance training. Uptime Magazine and Reliabilityweb.com has had the pleasure of working with Mr. Buscarello over the years and will greatly miss this industry expert.

SALVO Project

Aging infrastructure and reinvestment are subjects of pressing concern both in the UK and around the world. Over £200 billion is estimated as needed in the UK, and $1 trillion in the USA. During the last three years, a consortium of major organizations has collaborated in addressing their headaches of aging infrastructure, capital constraints, uncertain data and risks while facing growing performance demands.

This SALVO Project (Strategic Assets: Lifecycle Value Optimization - www.SALVOproject.org) has yielded some valuable new insights and demonstrated practical ways to justify and prioritize asset renewals and/or life extension options. The consortium has developed processes and tools that enable more effective targeting of resources and better harnessing of technical/engineering knowledge within business finance and risk decision-making.

Release of program results and process guidance will be held October 3, 2013 in London, England. Reliabilityweb.com's Terrence O'Hanlon will be attending this critical event.

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Results Oriented Reliability and Maintenance Management *For Operations and Maintenance Management*	Oct. 22			
Reliability & Maintenance Management *Processes & Precision Skill Sets*	Nov. 4-8			
Planning and Scheduling of Maintenance	Dec. 3-4 ◄ ***NEW DATE JUST ADDED!***			

IDCON's Best Practice Seminar Schedule for 2014

Reliability & Maintenance Management *Processes & Precision Skill Sets*	Jan. 13-17	March 17-21	May 5-9	Oct. 6-10
Planning and Scheduling of Maintenance *and Reliability Base Spare Parts & Materials Management*	Feb. 17-19	May 12-14	Aug. 25-27	Nov. 17-19
Preventive Maintenance/Essential Care & Condition Monitoring	Feb. 20-21	May 15-16	Aug. 28-29	Nov. 20-21
Root Cause Problem Elimination Training™	April 28-May 1	June 23-27	Sept. 15-19	Nov. 3-7

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Conquering the World One

Tedd Weitzman

Southern Company is a large power utility focused on generating and selling electricity in the southeastern United States. In 2012, Southern Company provided over 40,000 megawatts of power generation to 4.4 million customers and had operational revenue of $16.54 billion.

Asset at a Time

Copyright of Mississippi Power Company

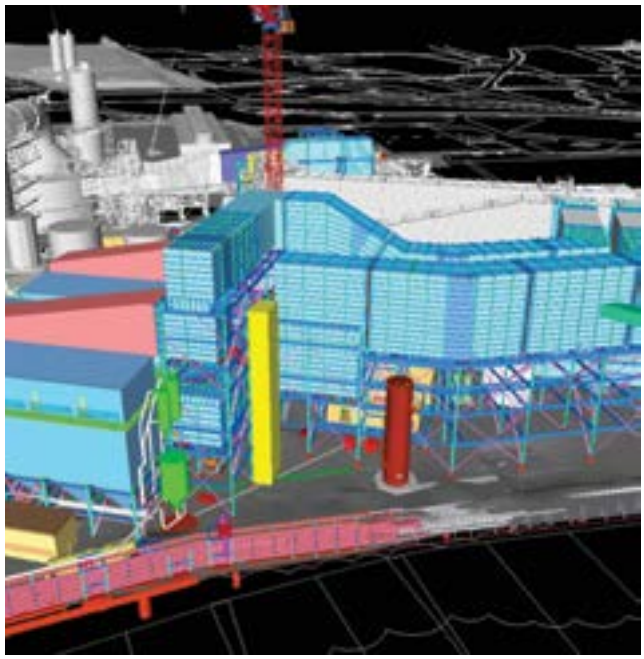
With asset holdings of approximately $45 billion, Southern Company, one of the South's best-kept secrets and a stock broker favorite, ranks 84th internationally in infrastructure assets on the Bentley *Infrastructure 500*. The utility ranks just slightly ahead of New York City.

The company is known for big bets and it is tackling two of the industry's biggest – nuclear power and clean coal. As the world watches, Southern Company is among the first in the U.S. to build new nuclear units in more than 30 years—Vogtle Units 3 and 4 near Waynesboro, Georgia. The reactors represent a capital investment of more than $14 billion dollars.

At the same time, Southern Company is building another world stage project in Kemper County, Mississippi—an integrated gasification combined cycle unit using Transport Integrated Gasification™ (TRIG) tech-

nology power. The units at the Kemper County energy facility are scheduled for commission in 2014 and are sponsored by Southern Company, KBR, and the U.S. Department of Energy (DOE).

While investing in these megaprojects, Southern Company spent $8.3 billion deploying environmental projects throughout 2012, mostly at existing coal-fired facilities. The company plans to invest at least another $3.6 billion through 2015 on further environmental projects, including baghouses, precipitator upgrades, active carbon injections, sulfuric acid mist clouds, and other technologies that reduce mercury emissions and flue gas particulate so common at coal plants.



Future investments for environmental projects - Baghouses

Southern Company is an engine with many parts and acts as an umbrella for its operating companies—Alabama Power, Georgia Power, Gulf Power, Mississippi Power, Southern Nuclear and Southern Power—which run and maintain the facilities. Southern Company also boasts an operations engineering and construction services group (E&CS) that acts as an engineer, procure, and construct (EPC) contractor for capital expenditure (CAPEX) projects. E&CS is an extension of the facilities and executes annual budgeted operational expenditures (OPEX) projects, referred to internally as retrofit projects. By maintaining and supporting E&CS, Southern Company is uniquely positioned in the U.S. power industry to deploy a comprehensive asset lifecycle information management (ALIM) program, including engineering information management (EIM) and seamless handover of asset documents and data to facilities for operations and maintenance – a goal much easier to state than to execute.

ALIM and EIM are complicated subsets of an already complicated subject, asset management. ISO55000 is a new international standard for asset management. The challenges and best practices of collecting and maintaining engineering information, and saving time and money through a project execution process are well known in the industry.

Project execution processes live or die by asset data and document management strategies. Without these, data and document handover to a facility is nearly impossible. The goal is to provide a peek under the EPC hood, giving system owners and operators a language and set of concepts to better engage engineering and construction partners about asset information management. The responsibility is shared – a seamless handover rests not only on the EPC, but also the owner. Without a clear understanding of how data is managed throughout the project execution process, how can an owner expect a clean handover of asset information? Owners often know what they want regarding data and documents as a project winds down, but often do not have requirements explicitly defined in contracts. They often lack the understanding needed to tackle the challenges associated with generating and maintaining the data and documents.

Many of the ALIM issues encountered during project execution are the same asset data maintenance issues facilities encounter during operations. Keeping data complete and up-to-date is hard, and here distinctions must be drawn; data is not information, information is not knowledge. Information is derived from data and when this information is valuable, it can be considered knowledge. Information, generally speaking, is processed data put into context.

SOUTHERN COMPANY IS UNIQUELY POSITIONED TO DEPLOY A COMPREHENSIVE ASSET LIFECYCLE INFORMATION MANAGEMENT (ALIM) PROGRAM AND SEAMLESS HANDOVER OF ASSET DOCUMENTS AND DATA TO FACILITIES FOR OPERATIONS AND MAINTENANCE

Even a small system generates a tremendous amount of asset data. One pivotal and seemingly easy bit of data to collect about an asset is drawing references. It is seemingly easy because the statement, "provide document references for assets on this project," is easy to say and the final requirement easy to visualize. There are many assumptions made in this statement:

- Documents and document data are managed.
- Asset data is managed.
- Asset relationships to documents are managed.
- A format for both documents and assets is agreed upon (a document reference to an unrecognized asset tag is useless, as is an asset tag reference to an unrecognized tag).

Further assumptions can be added to the list. The execution of any list item is far from trivial, but the return on investment (ROI) for maintaining the alignment of document to asset data is tremendous. Southern Company justified purchasing an ALIM program based on the expected ROI estimated by associating quality records and documents to functional asset locations and tags. This very conservative ROI is calculated at $4 million per 200 Southern Company employees engaged with assets and documents. For the life of the facility, this equates to hundreds of millions of dollars saved by reducing the amount of time spent searching for asset-related documents. Another big assumption is embedded in this last statement: the asset-to-document relationships are maintained throughout the facilities and asset lifecycles.

Southern Company has a robust process for managing documents of record, including a program to keep drawing content up-to-date with current field conditions. Drawing approval and distribution is strictly controlled.

Unfortunately, purely managing documents of record did not include maintaining asset references to the drawings. The company formally rec-

ognized the benefit of creating and maintaining these references in 2006 and developed a program to fill the information gap that provided the ability to search against functional tag locations. Success for this kind of functionality is dependent on the relationship of three things: technology, people and process.

Though in practice these three constituents must work in tandem, the processes in the development phase are the key to success. Technology must support processes documented in clear procedures and standards that are executable by actual people.

MANY OF THE COMPREHENSIVE ASSET LIFECYCLE INFORMATION MANAGEMENT ISSUES ENCOUNTERED DURING PROJECT EXECUTION ARE THE SAME ASSET DATA MAINTENANCE ISSUES FACILITIES ENCOUNTER DURING OPERATIONS

In early 2007, Southern Company started developing an ALIM system: Bentley Systems Incorporated's eB Data Quality Manager. By the end of 2007, it was clear that the system was not executing tasks as desired. Southern Company's first major success in the deployment of the ALIM system was recognizing that this failure was not attributable to the deployed technology. The failure was in the processes, procedures and standards, creating a culture that rendered the company's ALIM goals difficult to execute. For example, asset tags were not managed to standard because the standard did not reflect best practice. Also, procedures did not require asset data reviews in the iterative design process. In other words, data quality was not an integral part of the design process.

Southern Company recognized that design data must be reviewed with the same rigor as documents. This requirement is often viewed as a burden by design teams culturally oriented to producing drawings. In order to solve this problem, the company had to develop a data-centric culture that technology could support. In 2007, eB Data Quality Manager as a technology was shelved to address outstanding process and people issues.

Construction of the Southern Company

Copyright of Mississippi Power Company

A two-year period, referred to internally as the "circle of strife," ensued. The moniker accurately represents the challenges—a wholesale change of culture. In that two-year period, the seed for a data-centric environment was planted and nurtured. By 2009, enough progress was made to pull the technology back off the shelf. Several business unit subject matter experts (SMEs) were involved with the project since 2006. The team coordinated with IT and the software vendor on the initial configuration of the eB Data Quality Manager and participated in the many circle of strife meetings that hammered out the procedures and standards to support the new data-centric environment. The electrical design SME was asked to lead the technology development component in 2009.

An estimated 50 percent of the employee's time was required over a two-year period to lead the configuration and final deployment. At the end of that period, the SME would walk away from a fully functional and deployed system and go back to electrical design duties 100 percent. If Southern Company's first major success was recognizing that the early failure in deployment was not seated in the technology, its second major success was recognizing, partly through the SME's encouragement, that deploying this technology was neither a part-time job nor a project with an end. The initiative required full-time resources to support both the technology and the processes it enabled. Fortunately, the ROI justified the dedication of full-time, permanent resources to the effort.

Nearly five years after the initial project initiation, eB Data Quality Manager went into production in April 2011. eB Data Quality Manager went online specifically to support the 21st century clean coal Kemper County energy facility.

The facility will produce less nitrous oxide, sulfur dioxide and mercury emissions than traditional pulverized coal plants. Additionally, the facility plans to capture at least 65 percent of the carbon produced. The captured carbon will be used in enhanced oil recovery and is expected to yield an additional two million barrels of domestically sourced oil every year. As of July 2013, over 300,000 asset records are managed in eB Data Quality Manger for the plant. It is important to note that this count includes over 30,000 documents that are considered assets. Assets also include more than 100,000 functional locations, approximately 40,000 process lines and segments, and more than 100,000 physical assets extracted from the model, mostly individual pipe spool pieces. The data set available for the facility through the project execution phase is deriving more than $4 million ROI related to startup and commissioning activities alone when compared to costs on previous projects. The ROI may seem small. However, when compared against the budget specifically for startup and commissioning processes, which includes very little physical asset cost, the savings are significant, realized through processes incorporating the availability of quality data and automations that data enables.

Since fall of 2012, asset information for environmental projects at six existing facilities is managed in the system, bringing total asset counts to more than 700,000. Two more facilities are anticipated to go online by year end 2013. An estimated 15 facilities will be live by the end of 2014. The end goal is to have the entire coal and gas fleet modeled in the system and all the data available to the facilities. The system provides transparency of the asset's engineering information, including drawing references, through all phases of an asset's lifecycle.

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An important aspect of the ALIM system is the ability to manage asset location changes, keeping information intact as it relates to current conditions, but also reflecting planned changes for publication when executed or as built. If an organization does not have a process in place to manage as-built drawings, managing as-built data poses an almost insurmountable problem. In other words, managing data is a more difficult task than managing documents, so learn how to manage and maintain documents first. Many of the principles of managing quality documents are applicable to managing data, including review and approval processes.

Another key component to managing data is ensuring it is represented accurately across multiple systems. Realizing the concept of "one source of truth" as it relates to asset information is not possible. One example is the need for operations and maintenance personnel to maintain and access information through a computerized maintenance management system (CMMS). This system reflects much of the engineering information created upstream in design tools. But the CMMS is not a place to manage engineering data or to make design changes. Devising ways to keep the design engineering information synchronized with the CMMS is a non-negotiable requirement. Develop processes to ensure consistency. Anyone attempting this task will run into immediate, high-level issues keeping the data aligned. The first challenge is ensuring tagging in both systems is aligned. The tagging that follows an asset through design execution is rarely the tagging used in the CMMS. CMMS

tagging is typically more intricate and complex, relating directly to facilities accounting or account classification. Overcoming just this one tagging discrepancy can pose an almost insurmountable problem to the information flow from system to system. Even at Southern Company, manual processes are required to bridge the gap. What seemed at one time a gorge the size of the Grand Canyon is now a river with a boat to ferry data to operations or a bridge is in place.

ANOTHER KEY COMPONENT TO MANAGING DATA IS ENSURING IT IS REPRESENTED ACCURATELY ACROSS MULTIPLE SYSTEMS

Attention to detail is important. At first glance it seems like a mirror image, but upon closer examination, there are subtle but distinct differences between the CAPEX and OPEX support structures. It happens to any facility in operation and often earlier during design execution. No matter how many conditions are accounted for, actual construction of the design leads to inevitable discrepancy. In many instances, designers and engineers do not select specific equipment to reside at a location. They only define the criteria. The equipment operation at the facility meets real-world conditions. That is where discrepancy between design information and a CMMS creeps in over time. Processes must take into account as many variables as possible to mitigate system data misalignment.

For better or worse, the technology available at our fingertips has produced an expectation to produce the right information at any given moment instantaneously. For the most part, the technology is capable of executing this expectation. The greater effort is ensuring processes are in place that the technology can actually support. Southern Company is still on its journey, discovering variables that affect ALIM processes in making asset information available. Some variables are easier to accommodate than others, but none can be dismissed. A phased and linear approach was adopted with both short- and long-term goals, including quantifiable ROI. The approach is flexible, frequent changes to process and standards are anticipated, and dedicated resources are recognized as a key to success. Southern Company has proven that committing resources to an ALIM strategy produces quantifiable results and that the ends do justify the means.

DEVISING WAYS TO KEEP THE DESIGN ENGINEERING INFORMATION SYNCHRONIZED WITH THE CMMS IS A NON-NEGOTIABLE REQUIREMENT

Tedd Weitzman has worked for Southern Company's Engineering and Construction Services for 12 years. He has focused on project execution processes, configuration management and automations to ensure efficient availability of information for CAPEX projects and O&M. Since 2009, Tedd has spearheaded the configuration and implementation of Southern Company's Asset Management Database. This project won Bentley Software's 2011 and 2012 Be Inspired Awards for Innovation in Asset Lifecycle Information Management.

You Think a Computerized Maintenance Management System Is an Option?

Think Again...

If You Are Thinking Equipment Reliability

Gary Brown

SIX QUESTIONS TO CONSIDER BEFORE ANSWERING:

1. Is there a **Compliance Standard/Organization** for your industry?
2. Is **Enterprise Asset Management (EAM)** a factor in your success?
3. Are **Competitive Pressures** growing in your industry?
4. Is this pressure squeezing **Operating Budgets**?
5. Are you being challenged to find and retain competent **Skilled Personnel**?
6. Is protecting your investment in assets/personnel important to your **Continued Success**?

If you answered "Yes" to these questions, it is safe to assume that you are a business that expects to have a future. Your future, expressed in terms of today, is preparing for and performing in a competitive environment and is not just surviving, but thriving. To survive and thrive you need a computerized maintenance management system (CMMS).

A CMMS IS THE DATA BACKBONE FOR DOCUMENTING INDUSTRY COMPLIANCE AND RESPONDING TO AUDITS

In our global economy, standards and compliance have become a way of life for manufacturing organizations. Audits are commonplace today to ensure compliance and failing an audit is unacceptable and often has an immediate impact on current and future business.

The CMMS is the repository for data that documents the maintenance program, availability of maintenance spare parts and work order history. The history maintained in the CMMS also supports root cause analysis, resulting in improved engineering and manufacturing solutions. Bottom line, the CMMS is the cornerstone of supporting current operations, trending failures and providing knowledge for improvements that impact the bottom line.

THE CMMS DATA SUPPORTS THE METRICS NEEDED FOR IMPROVED OPERATIONS

The impact of the CMMS on the future of a business is brought to light when you consider that "maintenance management generally makes up 40 percent to 50 percent of operational budgets; the savings made possible from increased efficiency and reduction of waste is staggering."[1] This reality has been clearly demonstrated in assessments following implementation and use of a CMMS. It has been my experience that equipment reliability can increase from 35 percent to 50 percent; better workflow management leads to further savings of five percent to 15 percent of overall maintenance costs; cost savings from optimizing inventory and purchasing are as high as 20 percent of the total inventory cost; and a 20 percent gain in equipment uptime results in improved productivity and resource allocation.

A CMMS STRENGTHENS ASSET MANAGEMENT

The need to capture and maintain historical, accurate and meaningful information about assets leads companies to invest in the CMMS. This interactive information database is the continuous medium that is the

lifeblood of the maintenance function. In an era of increasing global competition, organizations today are in a constant state of change. Key trends driving this change include rapidly expanding technology, increased demand for individual and organizational competencies and capabilities, ever decreasing cycle time and changes in skilled personnel requirements. The CMMS is the vehicle for meeting these needs and allows for the planning, measuring, evaluating, operating and maintenance practices, and provides information on the condition of critical assets.

THE HISTORY MAINTAINED IN THE CMMS ALSO SUPPORTS ROOT CAUSE ANALYSIS, RESULTING IN IMPROVED ENGINEERING AND MANUFACTURING SOLUTIONS

A CMMS BUFFERS LABOR TRANSITIONS

The condition of assets isn't the only issue; there's the skilled personnel to maintain them. Consider the amount of information that can leave a company when a key maintenance employee leaves. Years of critical technical information can be lost the moment the employee walks out the door. And walking out the door will be happening with greater frequency in the coming years. The baby boom generation will retire in large numbers, ongoing in the 2000s and peaking in 2012 and they're not being replaced by sufficient numbers of highly skilled workers.

The U.S. Bureau of Labor Statistics estimates a shortfall of about 10 million workers within the next six years and the number of prime age workers—those between the ages of 25 and 54—will shrink dramatically.

As far back as 2004, a report from the Herman Group titled, "Top Ten Work Place/Workforce Forecast 2004," indicated that, "As the economy picks up, employers will face the most severe shortage of skilled labor in history." Underlying the looming workforce shortage is a demographic shift of historic proportions. Businesses needing skilled labor—positions traditionally held by tech-savvy workers—could be particularly hard hit unless they begin attracting older workers. A labor shortage could also throw a wrench into the workings of small manufacturers. "A talent shortage could not happen at a worse time," says Jerry Jasinowski, past president of the National Association of Manufacturers. "Unchecked, a shortfall could quickly hobble our manufacturing competitiveness once the global economy recovers in earnest."

In the larger scheme, a labor shortage could mean a brain drain for companies. Employers of every size in every industry who ignore the statistics and predictions could risk the future success of their businesses. In the 2012 forecast, the number one concern was: Recruiting will intensify among smaller employers. Employers attempting to recruit experienced people will find their challenges increasing. The number three concern was: More communities will wake up to the critical need for workforce development. More communities will become aware that they will simply not grow economically without having an available skilled workforce---with the skill sets their prospects seek.[2]

A CMMS doubles as both the best defense and offense by placing important historical and cultural knowledge in a safe, standard repository, while simultaneously making this information available to the incoming labor force.

THE CMMS PROJECTIONS DEFINE KEY SKILL NEEDS

The skills required by the workforce of the future are changing in virtually all occupations, but by and large, employees are not obtaining them sufficiently. Science, math and computer skills will be in the greatest demand, but far too small a percentage of today's students focus on those areas. Enrollment is down at many technical schools and vocational programs, a troubling development because they do a better job preparing young people for technical professions than four-year colleges.

Skill set requirements vary by occupation, of course, but in the future, almost all jobs will require some degree of technical expertise, even those not traditionally viewed as requiring higher-level knowledge. For example, topping the list of employers' key expectations for administrative staff is that they be skilled in new and emerging technologies, according to the International Association of Administrative Professionals (IAAP), based in Kansas City, Missouri. In addition, employers want proficiency in the Internet, intranets, e-mail, online services and a wide variety of PC software. Knowing what you need and how much of it better prepares employers for meeting the future training and technical demands of their business.

A CMMS PROVIDES THE COMPETITIVE ADVANTAGE FOR EAM

Every business is based on profit and profit comes from the very simple equation, W=PT, where W stands for wealth (profit), P for physical resources (traditionally land, labor, assets) and T for technology.[3] With resources as an available equivalent, the variable driving wealth and creating success is the application of technology-based knowledge. *Knowledge is the source of all sustainable competitive advantages.*

EVERY BUSINESS IS BASED ON PROFIT AND PROFIT COMES FROM THE VERY SIMPLE EQUATION, W=PT, WHERE W STANDS FOR WEALTH (PROFIT), P FOR PHYSICAL RESOURCES (TRADITIONALLY LAND, LABOR, ASSETS) AND T FOR TECHNOLOGY

According to figures supplied by James Appleberry, cited by José Joaquín Brunner, internationally recorded discipline-based knowledge took 1,750 years to double for the first time, counting from the start of the Christian era; it then doubled in volume every 150 years and then every 50. It now doubles every five years and it is projected that by 2020 knowledge will double every 73 days.[4] Utilization of existing technology and the acquisition of new enabling technology provide the competitive advantage for the future. Timing for capital investments, when to repair, when to replace and when to upgrade processes are all knowledge intensive actions that require an informational database that can support the decision-making process. The CMMS is the platform to maintain this database and provide key information in a timely manner.

THE CMMS MITIGATES GOVERNMENT REGULATORY AND COMPLIANCE ISSUES

Government regulatory compliance and exposure to health and safety liability are major factors in the business environment today. A CMMS can be used to schedule training, record training schedules, monitor attendance and provide audit trails supporting compliance training. In addition, safety requirements can be transmitted to employees with work orders verifying proper methods of work performance and documenting company practices that are to be followed. Reduction in work-related accidents and the liability exposure the company is subjected to can be greatly reduced by proper documentation and communication of safe work practices. Finally, summary reports and the supporting documentation can be produced to certify compliance with required standards that conversely reduce liability exposure and lost business opportunities due to non-compliance claims.

A CMMS –SOPHISTICATION OR SURVIVAL?

A computerized maintenance management system is not simply an "add-on" or a "nice addition" to your list of productivity enhancing tools; it is a necessity! Large or small, you need what the CMMS has to offer. Your competition is using it and if you lose the knowledge-based technology battle, you have lost your competitive advantage.

With a CMMS, you've enabled that winning advantage.

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OVERCOMING A TYPICAL TESTING DILEMMA

We WANT to Test, But We DON'T (really) Want to Find Anything...

George Frey

Being both Instrumentation & Electrical (I&E) planner and electrical testing supervisor can be an uncomfortable position. You want to do your job well and keep the plant running at tip-top shape, but if you find a motor or process problem, you know it will cost money to fix it. It can be the proverbial double-edged sword. For those of us in the electric motor testing business, this is an all too familiar situation. In other words, what are the repercussions of a test failure? How will failing a test affect the motor? Could it be out of commission? How much money is it going to cost to replace or repair? Is higher management going to go along with your findings and be open to doing the right thing?

Figure 1: 100MW generator in Boulder, CO

Figure 2: In-service pump motors in Boulder, CO

To understand these questions better, we must talk about the effects of a test failure. For example, what happens when a test works as it should – and *finds a problem*?

TYPICAL MOTOR TESTING SCENARIOS

An industrial facility awards its motor maintenance and repair contract to a local electric motor repair shop. This shop has the ability to repair and replace defective motors, has trained electricians and motor technicians, and has invested in predictive maintenance motor testing technology.

The shop is contracted to test the population of electric motors during a periodic outage. The motor shop goes about its business; however, the industrial facility has spent little time discussing the effect of finding bad motors. When (and if) the motor shop reports back finding several bad motors, it can create a tense and time-consuming series of complicated events. "We don't have a spare," "you are delaying our restart," "you touched it, you broke it," etc., etc.

If the plant staff has any misunderstanding of electrical testing processes, accusations of "destructive testing" may be thrown around.

The motor shop's stance is: You hired us to find bad motors, and now that we did, you are mad about it!

The best response would be: So now what do we do from here?

MANEUVERING THE MINE FIELD

If it is your job to ensure plant maintenance or motor quality, you know you need to test. So how can you traverse the many pitfalls? Sharing of information is paramount to the success of your testing or predictive maintenance program. Before any testing is done, make sure each individual involved is versed in **the goal of testing and understand the repercussions of that goal.** In a nutshell, the goal of the electrical testing is to identify "bad apples" and repair or remove them from the process – preventing or mitigating the effects of an in-service failure.

Appropriate Testing Levels

If called into a facility for your first baseline testing, give consideration to test voltages. Poorly maintained, aged, or contaminated motors may already be apparent simply by visual inspection. Therefore, lower, yet still searching test voltages may be appropriate. Instead of 2e+1kV, de-rating test voltage to 60 percent to 80 percent may be called for to determine fitness for more sensitive testing.

When doing baseline and maintenance testing, a general rule of thumb for each test is:

- **Kelvin Resistance: A resistive unbalance of one percent or less.**
- **Meg-Ohm: Greater than 100Meg-Ohms for medium voltage motors.**
- **Polarization Index: >1.5, stable readings and review trend history.**
- **Step Voltage: Low levels of leakage current, with linear plotted response.**
- **Surge: Stable response curves/traces without indications of breakdown.**

Food for Thought

1. Use best practice methods to develop cohesive processes for testing.
2. Look closely at the history of plant testing to develop the plan.
3. Have good spares in warehouse or immediately available if needed.
4. Partner with a motor shop or your own supply chain to house critical spares.

Figure 3: In-service pump motor detected 33 percent resistive unbalance

From a motor shop doing the testing to upper management that is signing off on the contract for testing, everyone needs to fully understand. Full disclosure and review of the testing history, including test reports (if available) of past problems, such as cables, gear box and bearing issues, or motor stalling/tripping problems, need to be discussed. If testing reports are unavailable or have not been kept, the best course of action is to obtain a baseline of motor testing. A battery of tests can be performed at appropriate levels that will provide valuable information on each without decreasing any remaining life in the motors. Once a baseline is established, further testing can be done to find potentially failing motors.

Another discussion prior to testing is to ensure that all testing standards have been reviewed and are fully understood. These IEEE standards include, but are not limited to, IEEE 43, IEEE 95, IEEE 112, IEEE 118, IEEE 522 and IEEE 1415. These testing standards, established by the Institute of Electrical and Electronics Engineers, give a good framework to testing and offer the basis for moving forward in an effective manner. Once there is a general understanding of the goals and processes, guidelines for testing can be developed for all parties involved.

BASELINE TESTING AND APPROPRIATE LEVELS OF TESTING VOLTAGE

Once all guidelines have been discussed and decided, baseline testing can commence. Testing theory usually dictates that testing be done in an increasingly rigorous manner. In this manner, the motor receives only the tests that it can withstand and doesn't get tested further upon a finding with a less rigorous test. Here's an analogy to better understand this concept:

IN A NUTSHELL, THE GOAL OF THE ELECTRICAL TESTING IS TO IDENTIFY "BAD APPLES" AND REPAIR OR REMOVE THEM FROM THE PROCESS – PREVENTING OR MITIGATING THE EFFECTS OF AN IN-SERVICE FAILURE

If you see a road sign saying the bridge is out, pull over and take a look. Don't just keep driving and go off into the creek!

Testing, with an eye towards gathering a baseline, should be performed in this order:

Kelvin Resistance: This measurement does not stress the motor or the windings, so it is unlikely that any type of failure would occur from performing it. The downside is that it is not an electrical insulation test.

Meg-Ohm: Even if a motor winding is severely contaminated, this test has an infinitesimally small risk of further weakening a motor's ability to run. It may be appropriate to start at a very low voltage, e.g., 250V DC, and look at results before rising to higher voltages used on medium/high voltage motors (>1000V DC Meg-Ohm test) Unacceptable results tell you everything you need to know. No need to continue to more sensitive tests.

Polarization Index (PI) (on larger motors): This has the same type of infinitesimally small risk as the Meg-Ohm test since it is typically performed at the very same test voltage. Unacceptable results tell you everything you need to know. No need to continue to more sensitive tests.

DC Step Voltage: This test can be performed in two ways: As a step-up to line voltage to see how the motor insulation reacts, guiding the decision to go to higher voltage, or as a proof test to determine the validity of the insulation. Some companies (properly) employ very rigorous proof tests during an outage and between intervals perform a less rigorous DC Step Voltage to a lower, prescribed level.

Surge: A step surge method can be employed to lessen the effect of finding a problem. Sometimes, information can be gleaned from simply running a surge test to line voltage. It can show instability of the waveform and emit partial discharge readings. These are often indications of weakness within the motor.

ANOTHER DISCUSSION PRIOR TO TESTING IS TO ENSURE THAT ALL TESTING STANDARDS HAVE BEEN REVIEWED AND ARE FULLY UNDERSTOOD

Motor testing is a process-driven necessity that keeps industrial facilities running smoothly and effectively. When testing results become a problem simply because there is a finding, there is a lack of communication and misunderstanding of the goal of testing. With every action, there is a clear reaction. If communication is strong and everyone is on the same page, avoiding potholes and doing the right thing is easier. Yes, finding bad motors can be very painful, however, not finding them and having them fail in operation is a lot more painful to the bottom line. Coming up with a clear and concise method is your best bet and will garner greater success. If everyone understands the reasons behind the set goals and what the true meaning behind testing really is, the finding of bad motors can be a blessing instead of a curse.

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Leadership for Reliability — Opx operational excellence

Part 2

The Lightning of Empowerment

Give Feedback Like a "Super Coach"

The Best Coaches Know How to Deliver Developmental Feedback. Here's What—and What Not—to Do.

IMC 2013 Keynoter

William C. Byham, Ph.D.

One of the best ways to view leadership is an ongoing conversation between leader and team members. Sometimes that conversation is about what's going right and, conversely, it also sometimes must be about what needs to improve.

To be a leader who is a "super coach"—one who knows how to get the best out of his or her team and drive them to peak performance—you need to be able to master both forms of the conversation. That means providing both positive and developmental feedback when needed.

In the Aug/Sept 2013 issue of Uptime (visit www.uptimemagazine.com), Part 1 of this series, I offered tips and pointers for providing positive feedback. In this article, I will address the flipside: how to deliver developmental feedback to those who need to improve their performance.

GIVING DEVELOPMENTAL FEEDBACK

Developmental feedback means letting people know when they could have done something more effectively, what they could have done instead and why the alternative would have been better. The goal when delivering developmental feedback is to either help the person or group see how to improve their performance so they can meet their job goals, or build on an already strong performance so they can perform even more effectively.

In part one, we suggested you follow the STAR approach when delivering positive feedback. STAR reminds you to describe:

- The **Situation/Task (ST)** the person or group faced, such as a problem, business opportunity, special challenge, or routine task.
- The person's or group's **Action (A)**, such as what they said or did, or failed to say or do, to handle the situation or task.
- The **Result (R),** that is, the consequences of what the person or group did.

When delivering effective developmental feedback, you should follow STAR and include:

- An ***alternative Action*** - what the person might have said or done instead.
- The expected ***enhanced Result*** - why the alternative action might have been more effective.

Using STAR/AR as your guide, you will want to make sure your comments are:

- **Specific**—When you specifically compare current performance to goals, people can see clearly what adjustments they need to make to ensure success in the future.
- **Timely**—You need to give feedback for improvement as soon as possible because:
  - When the details of performance are fresh, you'll be able to explain exactly what the person did that was less than effective.

- The person receiving the feedback probably will remember what he or she did and why these actions were less than effective.
- You'll help people make adjustments before they face similar situations.

- **Balanced**—It's important to balance developmental feedback with positive feedback to maintain a person's self-esteem and openness to feedback. Even when someone performed very poorly or made a major mistake, it's still necessary to balance feedback. In other words, find something the person did well and provide developmental feedback at the same time.
- **About the performance or behavior**—Keep the focus there and not on the person or the person's motives.

Here is an example:

Don't say: *"Jane, when you were teaching Mark to operate the system, you told him he just wasn't 'getting it.' He got angry and stopped asking questions. You need to go easier on him."* This feedback doesn't describe an ***alternative Action*** or the ***enhanced Result*** it would achieve.

Instead, say: *"Jane, when you were teaching Mark to operate the system* (**Situation/Task**), *you told him he just wasn't 'getting it'* (**Action**). *He got angry and stopped asking questions* (**Result**). *A better approach would have been to acknowledge that it's difficult to operate the system and that his questions are appropriate* (**Alternative action**). *That would have maintained his self-esteem and encouraged him to keep trying* (**enhanced Result**)."

COMMON COACHING PITFALLS

Here are some common coaching pitfalls associated with delivering developmental feedback:

Pitfall: Giving vague feedback or feedback you can't support with data or examples.

If all you can offer is generalities, not specifics:

- You will seem empty or insincere. Saying "good job" but not supporting it with details makes it seem as if you don't know what was done or why it was valuable.
- You increase the likelihood that people will become defensive.
- You can be seen as asking for too much, especially when you suggest improvements when the person or group is generally doing well.

Pitfall: Saying someone did something well when you don't believe it.

If you provide positive feedback that you don't believe:

- You'll seem insincere, or worse, dishonest.
- The person or group might think you're being manipulative.
- The person or group might wonder about your real motives for providing the feedback.
- Your credibility will suffer.

Pitfall: Guessing at motives.

If your feedback is based on assumptions or guesses, you:

- Can weaken your feedback and give people the impression you're making excuses for their behavior or performance.
- Will sound as if you don't believe what you're saying.
- Don't give enough specific information about what needs to be done differently.

Tips for Effective Developmental Coaching

- Pay attention to others' behavior and anticipate when they will need help.
- Set performance expectations that are clear, observable and measurable.
- When people come to you for advice, ask open-ended questions that encourage them to think through situations themselves.
- Provide positive or corrective feedback as quickly as possible.
- Think before you correct someone. Ask yourself, "Is it really important? Does it make any difference in terms of getting the job done?"
- On a daily basis, model the values and behaviors you are trying to teach.

***Pitfall: Using words like* always *and* never.**

If you use these words in your feedback:

- You'll sound like you're describing a long-standing performance trend.
- The person or group might get angry with you for not providing the feedback sooner.
- The person or group will think their general performance, not just performance in a particular situation, is unacceptable.
- People will become demoralized.

Pitfall: Waiting too long to give developmental feedback.

If you wait too long, the person or group might become:

- Embarrassed that other people saw there was a problem when they didn't.
- Angry because it's too late to do anything about it.
- Insulted that you even brought it up. After all, if it was so important, why didn't you say something when it happened?
- Resistant to this surprise feedback and not accept it.
- Frustrated because it will be difficult to remember and discuss the specific details of the situation.

Pitfall: Avoiding giving developmental feedback altogether.

If you don't balance developmental feedback with positive feedback, the person or group might:

- Resent it.
- Begin to doubt their abilities.
- Become frustrated and demoralized.
- Feel as if they can't do anything right.
- Be afraid of making more mistakes.

Pitfall: Giving only positive feedback.

If you don't balance positive feedback with developmental feedback, the person or group might:

- Miss opportunities to become even better.
- Think you're being dishonest.
- Become overconfident and, as a result, make mistakes.

BECOMING SUPER

Applying the STAR/AR approach can help you avoid these pitfalls. But mastery of coaching skills—knowing how and when to use them—requires one critical thing: practice. No leader becomes a super coach overnight and no leader improves his or her skills without practice.

If you want to be a super coach, the pointers provided can help put you on the right path. Apply them diligently and repeatedly, and you'll be well on your way to becoming the coach—and leader—you really want to be and your organization needs.

William Byham is co-founder, chairman and CEO of Development Dimensions International (DDI), a global human resources consulting firm specializing in hiring and leadership development. Bill has pioneered important human resource technologies that have had a significant impact on talent in global organizations. He is a speaker and the author of numerous articles and more than 20 books, including the bestseller, Zapp! The Lightning of Empowerment. www.ddiworld.com.

The Operational Excellence Difference

Kevin Duggan

By now, most companies have embarked on a journey of continuous improvement. Team members employ techniques, such as value stream mapping, kaizen events and action workout events, to target an area of the operation that needs improvement. Each day, this process continues: Find areas that need improvement, improve them and then embed the improvements into standard work.

The organization repeats this cycle over and over again to create a culture of continuous improvement. But even if we apply the best tools correctly, make an improvement and sustain it, then make another improvement and sustain it, the best we can achieve over time is a slow, steady climb up the staircase of continuous improvement.

However, we can break the myth that a continuous improvement journey should go on forever by instead believing that improving operations is about reaching a destination. Our destination should describe what we are really trying to do with all of our continuous improvement efforts. That is, we are trying to create an operation where *"each and every employee can see the flow of value to the customer and fix that flow before it breaks down."*[1] In other words, our destination is to create operational excellence.

CREATING SELF-HEALING FLOW

In operational excellence, we do not create flow to increase productivity or efficiency. Rather, we create flow so that everyone understands how their activities flow the necessary material or information through several processes to the customer, regardless of whether an employee works on the factory floor building products, in engineering designing products, in sales taking orders, or in any other area.

When we set our destination as operational excellence, all employees know:

- What they work on next.
- Where they get their work from.
- How long it will take them to do their work.
- Where they send it.
- When they send it.

Not only do the value streams flow at the rate of customer demand, they are made visual in such a way and to such a degree that every employee in the organization can physically see that flow. Each can see whether the flow is working normally or abnormally. Once everyone can see normal and abnormal flow, the next step is to create what's known as standard work for abnormal flow. This means that people working in the flow have a standard methodology for correcting things when they go wrong.

The end result is something called self-healing value streams, which means when flow breaks down somewhere in the operation, the employees working in the flow are able to fix it without a schedule, without a dispatch or expedite list, without a supervisor telling them and without management needed to deliver the product to the customer. When this happens, we have reached the destination of operational excellence.

OPEX DRIVES BUSINESS GROWTH

Operational excellence is not about eliminating waste, improving efficiency, or reducing cost, although it will have a significant, positive impact on them. What we are really after by achieving operational excellence is a positive impact on the business or, more specifically, sustained business growth.

How will achieving operational excellence in the operational side of the organization affect business growth? Consider this: If employees who build the product can also adjust and fix the flow before it breaks down, and do all this with little or no management, then what will managers be doing when they are not chasing parts, people and suppliers, managing resources, and so on? In a world of operational excellence, managers will be busy growing the business.

The concept is simple. We cannot grow the business unless we have time to grow the business. When we achieve operational excellence, we won't need management involvement in the day-to-day happenings of the operation. Instead, operations can become a strategic part of the business by spending its time on activities that generate top-line growth. It can have an impact on market share, break into new markets, adapt to changing markets, keep the business ahead of the competition and return sustained shareholder value.

THE BOTTOM LINE IS CONTINUOUS IMPROVEMENT IS NOT ABOUT ELIMINATING WASTE - IT'S ABOUT SETTING UP AN OPERATION THAT WILL ENABLE PERPETUAL BUSINESS GROWTH

The bottom line is continuous improvement is not about eliminating waste. It's about setting up an operation that will enable perpetual business growth.

OPERATIONAL EXCELLENCE IN ACTION AT PARKER HANNIFIN[1]

Parker Hannifin is a publicly traded corporation that employs 55,000 people across 390 sites around the world, 304 of which are manufacturing locations. Since 2001, Parker Hannifin has had a strong continuous improvement program in all its divisions. The focus has been on lean and value stream flow, with a heavy emphasis on using processes and guidelines to drive results.

While Parker Hannifin's companywide continuous improvement initiative has served it

well, one group – part of the Instrumentation Products Division - Europe (IPDE) – has taken this initiative to another level.

Like all businesses, Parker IPDE wanted growth. "We knew then that every improvement we made would be worthless unless it led to increased sales or business growth," said the innovation and technology manager for the division. "It's one thing to use continuous improvement tools to create an efficient factory, but it's quite another to have the new products that customers want when they want them." They soon discovered the linkage between improving operations and increasing sales through innovation.

While Parker's companywide continuous improvement program evolved to include flow and value streams, Parker IPDE did not stop with implementing flow; it knew that each operator had to know the status of flow or the state of delivery to the customer in a way that didn't involve the resource-consuming management meetings that were usually needed to get the product to the customer.

Given this requirement, Parker IPDE adopted visuals on the shop floor that let every employee know whether the flow was normal or abnormal and began teaching employees what to do in each case. After refining the process on the shop floor, the managers moved on to other areas of the operation where few companies today have ventured to implement flow, including warehousing operations, the office and the supply chain.

The result of Parker IPDE's transformation as an early adopter of the guidelines and principles of operational excellence has been profound.

- In five years of internal quarterly business reviews, the company has never talked about manufacturing or production issues. It always leads with quarterly growth and potential growth opportunities for the future.
- The factory used to be a problem for the sales manager, who lacked confidence in it when he was providing delivery dates to his customers. It isn't a problem anymore. Now, quick, consistent, on time deliverability is part of what enables Parker IPDE to charge a premium price. It also enables Parker IPDE's customers to place orders in a way that better suits the needs of their business because the factory is flexible enough to deliver what the customers want, when they want it and in the mix they want it.
- By implementing flow and being able to fix it before it breaks down, Parker IPDE essentially made the operational side of its business neutral; it was no longer in a position where it was slowing down or even had the potential to slow down the rest of the business.
- Because of the improvements made by pursuing operational excellence, Parker IPDE had the ability to hire five employees for the technology manager's area to help him develop a new line of manifolds with an eye toward their manufacturability. By integrating this skill set into the innovation process, Parker IPDE was able to drastically reduce the time it took to begin manufacturing new manifolds. Within one week of beginning production, on time delivery was already at 90 percent.

Looking forward to the future, Parker IPDE sees operational excellence as a driving force in its growth and a strategic weapon that gives it an advantage over the competition.

References:

1. Duggan, Kevin. Design for Operational Excellence: A Breakthrough Strategy for Business Growth. New York City: McGraw-Hill, 2011.

As the Founder of the Institute for Operational Excellence, Kevin Duggan has formally educated and assisted many major corporations worldwide over the past 12 years. Kevin is a renowned expert in applying advanced lean techniques to achieve Operational Excellence and the author of three books on the subject. www.instituteopex.org

Jobs

A Consequence of Being Competitive

Every morning in Africa a gazelle wakes up, knowing that it must run faster than the fastest lion, or be eaten. The same morning a lion wakes up, knowing it must run faster than the slowest gazelle, or starve to death. Whether you're a lion or gazelle, you must be prepared to run as fast as possible. - African Proverb

Ron Moore

The above proverb is something I frequently use to open presentations to manufacturers. When asked if the sentiment of the proverb is true, almost everyone will agree. Occasionally, there will be someone who suggests that it's not true – "If I'm a gazelle, I don't have to outrun the lion, only the slowest gazelle." My reply is always, "Yes, of course, but what will you do next week, when the lion is hungry again?" Longer term thinking is important.

Most people believe that Charles Darwin created the concept of "survival of the fittest." Actually, he did not. Herbert Spencer, a noted British polymath philosopher of Darwin's day, observed on reading Darwin's work, *On the Origin of Species*, that it was about the survival of the fittest, or more accurately, "survival of the fitting," the difference being that it's not the biggest, strongest species that survive, but rather those that adapt and "fit" into changes in their environment. Without this adaptability, they perish.

JOBS – A CONSEQUENCE OF BEING COMPETITIVE

With this in mind, let's return to the title of this article: "Jobs – A Consequence of Being Competitive." There is no doubt in my mind that this is the case and there's a very simple explanation for it.

Let's pretend you're going to buy something, anything really. You have certain requirements for this purchase. These requirements can include any number of parameters, depending on what you're buying, e.g., color, size, quality, endurance, reliability, convenience, and even brand (you may pay more for a particular logo because of status or perceived quality). Let's further pretend that you've narrowed it down to two or three vendors, but you're having difficulty deciding from which one to buy. As far as you can tell, all three vendors meet your requirements. From which one do you buy? The vast majority would reply, "The cheapest." During one workshop, a union president in the group said, "I wouldn't." I said, "You wouldn't what." He said, "Buy the cheapest." Surprised, I responded, "What would you do?" Proudly, he said, "I'd buy the one made in America!" I observed, "Well, your wife wouldn't." He admitted, "Yep, we've had that talk." Everyone had a good laugh.

MOST OF US WILL, IN FACT, BUY WHAT WE PERCEIVE TO BE THE CHEAPEST ITEM THAT MEETS OUR REQUIREMENTS

Most of us will, in fact, buy what we perceive to be the cheapest item that meets our requirements. Yes, we can be fooled from time to time, but this will change our perception of the cheapest, since it didn't meet our requirements. In any event, we tend to buy the cheapest item that meets our requirements. It's only natural to try to maximize the benefit we receive from the income we have.

What happens in the marketplace when we buy the cheapest goods that meet our requirements? What's the natural consequence of our behavior? It puts pressure on prices, downward pressure. Manufacturers know this, so they work really hard to put the cheapest one in front of us and still make a profit. So over time, our costs must come down as well. Granted, manufacturers will come up with new ideas and better products, and in the short term charge a little more for this new feature. Over time though, their competition will develop a comparable feature, renewing the pressure on price. Of course, price is also subject to supply and demand, and can vary greatly depending on any number of issues. Over the long term however, price, adjusted for inflation, generally trends downward for most goods. Oil and land are two notable exceptions, since the supply is relatively fixed and the demand is increasing with a growing population and economy.

Given this, in business we must constantly work to put the cheapest product (for a given set of requirements) in front of people *and still make a profit*. Discount marts recognized this phenomenon long ago and have been really good at capitalizing on it. Of course, this means that our costs must continuously trend downward. However, we have a dilemma here. In most

organizations, people, justifiably so, expect an annual increase in pay, particularly at the CEO level (a topic for another day) and routinely ask for more benefits, all of which induce additional costs. These are natural and proper tendencies. However, a critical question must be: How do we allow for that and still make a profit in a marketplace where there is continuing pressure on price and costs because most people buy the cheapest item that meets their requirements? The answer is fairly simple: Our productivity must improve, year after year, after year. For example, we must engage our workforce in improving reliability so we can be as productive with our people and equipment as possible.

JOBS ARE A CONSEQUENCE OF BEING COMPETITIVE

Unfortunately, this simple phenomenon is not well understood. ***Jobs are a consequence of being competitive*** in this Darwinian world of capitalism. We, myself included, buy the cheapest item that meets our requirements, but also lament that jobs are going overseas. We do this all the while expecting, or at least hoping for, increases in pay and benefits, at times without consideration as to the commensurate improvements in productivity that are needed to support the pay and benefits, *and still remain competitive*. If you aren't competitive, there are no jobs. Some U.S. auto manufacturers learned this the hard way. Expecting higher pay and benefits without commensurate increases in productivity will only diminish the potential for future jobs. Again, when we buy the cheapest, it puts pressure on prices, and therefore, on costs, wages and benefits. A proper and effective balance must be struck and productivity must improve, year on year. One question I always ask, particularly among unions, is: "If your work rules make you less competitive, whose jobs are you putting at risk?" Yours and everyone else's.

IN CONCLUSION

In closing, I want to affirm that there is no doubt in my mind that Americans can compete in this Darwinian world of capitalism. But they have to step up to the challenge and improve productivity. A high-level analysis indicates that even though the typical Chinese manufacturer has a 10:1 labor cost advantage, when you add in the various other supply chain costs and risks, Americans only need to be about 20 percent more productive. That is well within our grasp. But, the environment in which we compete must be inculcated in the view that productivity improvement is essential, year on year, for the simple reason that when we buy things, we buy the cheapest one that meets our requirements. Jobs are a consequence of being competitive.

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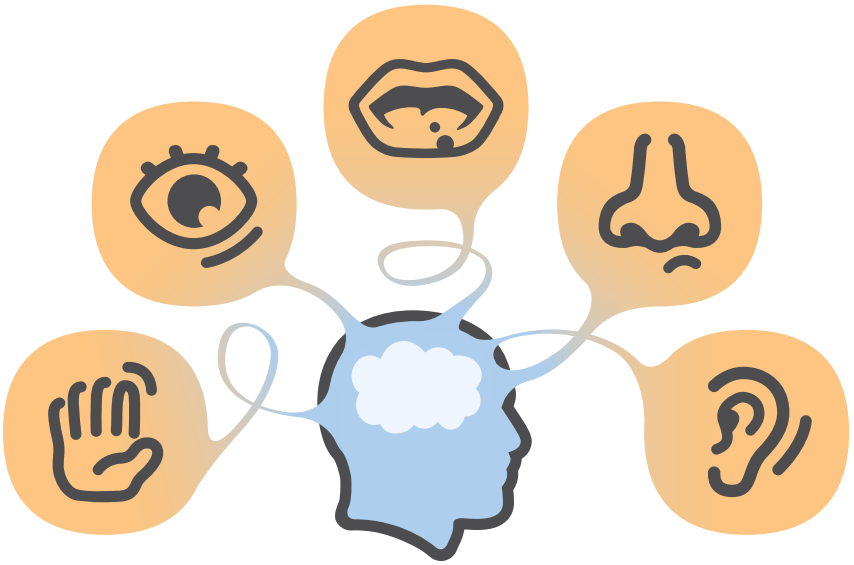

Moving Beyond Our Human Senses

Trent Phillips

Many different tools have been used over the years to detect changes in machinery condition. The human hands, eyes and ears have been the oldest tools used to detect conditional changes in machines. However, it is important to understand the value and limitations of our human senses.

Most machines give some indication that a potential component failure is about to occur that will lead to a functional failure. Our goal should be to identify, monitor and correct components that are failing before they create a functional failure that will prevent the machine from performing as intended. Condition monitoring (CM) is the primary tool used for this process. For example, a bearing defect is an example of a potential failure. The bearing would be monitored for degradation and replaced before it completely fails, preventing the machine from performing its intended function (functional failure).

It could be argued that God created the first condition monitoring instrument when he created man. Our main senses are touch, sound, sight, taste and smell. Additionally, humans have other senses that can detect balance, heat, pain, etc. All of these senses can provide very valuable data about the environment around us and the equipment we work with each day. Therefore, the human being is the first CM instrument to be used—versatile in application and proven to be a very beneficial tool.

Every employee is a condition monitoring tool that can provide tremendous value to your reliability efforts. Operators and maintenance employees should be trained and encouraged to use their natural senses to look for potential failures on the equipment placed in their care. CM analysts also should conduct visual inspections of the equipment they monitor during their routine data collection activities. A means to document these findings should be provided to each employee so corrective action can be taken in a timely manner. This can provide a very cost-effective method for identifying potential failures before they occur, thereby avoiding the costly consequences.

Some facilities do not use their employees' natural senses at all. Other facilities seem to rely too much on human senses as their primary or only means of condition monitoring. The human senses have very specific limitations in their use. We can only "see" certain wavelengths of light, "hear" a certain range of sound (frequencies), "smell" certain odors, "feel" certain sensations, etc. Each of these senses tends to deteriorate over time as we grow older. If we do not sense something, it does not mean that nothing is there or that something hasn't changed in condition. The human senses can be influenced by our surroundings, state of mind and time allowed to complete the inspection. Moreover, the perception of a condition can vary from individual to individual. Severity of the detected problem can be difficult to determine as well. Standards are difficult to incorporate due to inconsistencies between individuals. Reporting any problems found can be problematic as well. Therefore, it is essential to use these tools within their natural confines.

The P-F curve is a function for identifying when a potential failure starts, progresses to a point of detection (P) and finally reaches a point of functional failure (F). The earlier a problem is detected, the fewer the inspection intervals required and more time is available to take corrective action. The goal of a reliability effort should be to detect the failure as early as possible so corrective action can be planned, scheduled and executed before a functional failure occurs in the machine. This is where one of the main disadvantages of using the human senses as a condition monitoring tool is realized. Our human senses are only capable of detecting a problem (P) when it is rather close to the point of functional failure (F). This requires more frequent inspection intervals to detect the problem and provides less time to respond to a detected problem to prevent the unwanted consequences. A lot of failures are undetectable by the human senses. This results in defects that will unavoidably lead to functional failures if not detected by other means. Equipment downtime, reduced production capacity, safety issues, environmental concerns and additional costs are often experienced as a result of these failures from undetected defects.

Again, the goal should be to identify problems as close to their inception point as possible. Doing this requires detecting smaller conditional changes in the components of concern. This requires detection capabilities that go beyond what the human senses are able to sense. Technologies, such as vibration analysis, electrical testing, temperature and thermography, ultrasonic monitoring, lubrication analysis and other non-destructive testing (NDT) methodologies, have been developed and refined to provide the necessary detection sensitivity required to monitor the conditional changes of equipment.

This collection of technology, methods and procedures is known collectively as condition monitoring. CM itself is at the core of a reliability centered maintenance (RCM) approach. Most CM technologies are an extension of our human senses. However, if applied correctly, they allow us to detect point P (a deleterious change in condition) very close to the point of initial change. This is very important because it allows additional time to identify, mitigate and avoid the unwanted consequences.

On-condition maintenance activities (human senses or technology) should not be deployed in an arbitrary way. Careful consideration must be given to their limitations, selection, application, management, reporting, etc. If done correctly, the results can lead to better equipment reliability, improved quality, increased capacity, reduced costs, reduced risks and improved profits. Some companies decide not to employ the modern technologies described above and are subject to the negative financial risks that result. Other companies utilize these technologies in an ineffective way and do not realize the reliability gains and resulting positive financial results they seek. Some of the common mistakes made when implementing a CM program are:

- Improper technology selection;
- Improper technology application;
- Not applying the technology to the proper equipment;
- Having unrealistic expectations;
- Providing insufficient training to employees;
- Not utilizing available "technology experts" (vendors, consultants, etc.) to gain implementation and deployment support;
- Inadequate support from management;
- Not creating a sufficient level of awareness of the value these technologies can provide;
- Missing or inadequate standards (reporting, analysis, etc.);
- Not having a continual improvement plan;
- Improper monitoring frequency (based upon haphazard intervals or not on the P-F interval);
    - Not implementing the recommendations that result from the CM activity;
        - Not selecting the right individuals to utilize the CM technology;
            - Only applying CM efforts part time.

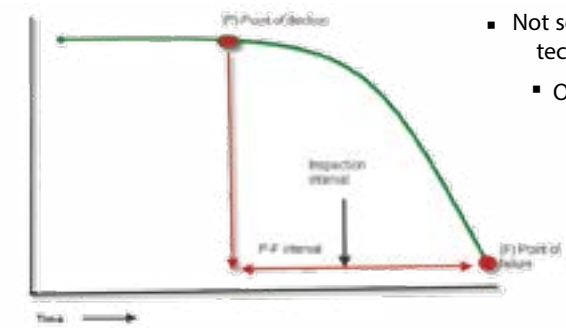

Figure 1: Monitoring interval

Figure courtesy of Ludeca, Inc.

THE P-F CURVE IS A FUNCTION FOR IDENTIFYING WHEN A POTENTIAL FAILURE STARTS, PROGRESSES TO A POINT OF DETECTION (P) AND FINALLY REACHES A POINT OF FUNCTIONAL FAILURE (F)

Each of these common mistakes have individual aspects that should be known and avoided for a successful condition monitoring program.

Most companies are constantly seeking increased capacity, lower product costs, less risk (financial, safety, environmental), improved profits, etc. These goals are not of much value unless they are achieved reliably and sustainably. In many companies, management does not view maintenance reliability efforts as value-added functions. Instead, maintenance reliability efforts are viewed as a cost! These efforts should be viewed as value-added investments that are critical to the success of the company. On-condition maintenance activities, such as visual inspections, vibration monitoring, ultrasonics, thermography, electrical testing, etc., can help achieve reliability and sustainability in these goals.

Unfortunately, statistics show that most condition monitoring and reliability efforts fail. The reasons for failure are many and a few are outlined in this article. The question within your organization should not be, "Do we apply or not apply condition monitoring?," but rather, "Are we applying the correct mixture (visual inspections and technology based)?" Other questions that should be asked are: Is proper support being provided to ensure success? Are these efforts being focused on the correct equipment? Are the results of our CM efforts being reported correctly? Are the recommendations of these activities being implemented before functional failures occur? and Are these activities being used to eliminate root causes of equipment failures? If the answer to these questions is "yes," you will find that your business goals become much more attainable and less costly.

Trent Phillips is the Condition Monitoring Manager of LUDECA Inc., a leading provider of shaft alignment, vibration analysis and balancing equipment. He has worked for many years creating and managing reliability programs and in the development of condition monitoring technologies. Trent has several certifications in condition monitoring technologies. www.ludeca.com


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A Guide for Using the Weibull Distribution in Failure Mode Analysis

Larry Tyson

This detailed guide provides the basic process for using the Weibull distribution in failure mode analysis (WFMA) on a turbofan jet engine.

The engine had numerous in-flight aborts (IFA), which is a direct safety-of-flight issue. This guide also demonstrates how to use Weibull in combining or merging different failure modes to form a new failure mode. The versatile distribution is very useful in root cause analysis (RCA), reliability-centered maintenance (RCM), reliability and availability (RAM), and other processes that lead to a solution for failure modes.

Users of this guide should have taken at least one class in Weibull analysis and several classes in theory and practical problem solving. Users also should be in the reliability field, have experience in using their Weibull software, and have good knowledge about their system(s) and components. It is also recommended that users review the Crow-AMSAA 101 and Weibull 101 basics by Paul Barringer at www.barringer1.com/pdf/Barringer-Kuwait-1.pdf.

PREPARATION

In preparing to use the Weibull distribution in failure mode analysis, first create four folders in the directory containing the failure and failure mode data. Name these four folders:

1. Lrr;
2. Wrr;
3. W3P;
4. Not a Weibull.

When you separate all failure modes (217 in my case) and start the WFMA process, each failure mode will be classified in one of the four above categories. Weibull distributions depend on data; that is the data selects the distribution. Up until Dr. Weibull's methodology was accepted, a distribution was selected, then data was found that matched the distribution. Today, the Weibull distribution is the leading method in the world for fitting and analyzing life data.[1]

The Weibull distribution is the choice for analysis of life-limited components' failure modes, such as turbofan jet engines' blade cracks, disk cracks and other life limits placed upon any component. In this guide, the x-axis is defined in engine flight hours (EFH). The x-axis is always engine flight hours; there are no changes or deviations in the x-axis definition. Each Weibull plot will have this notation on the x-axis: EFH (Hours).

It is very important to understand the data requirements for Weibull plots. To determine failure time precisely, there are three requirements:[1]

- A time origin must be unambiguously defined.
- A scale for measuring the passage of time must be agreed to.
- The meaning of failure must be entirely clear.

As stated in The New Weibull Handbook, "The age of each part is required, both failed and nonfailed. The units of age depend on the part usage and the failure mode." Keep in mind the, "both failed and nonfailed," age for the part because there will be examples of this using various parts/components of a turbofan jet engine. No matter the time base selected or failed or nonfailed, age is a requirement. This will be demonstrated on the next pages.

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The 14-Step Weibull Failure Mode Process

THE 14-STEP WEIBULL FAILURE MODE PROCESS

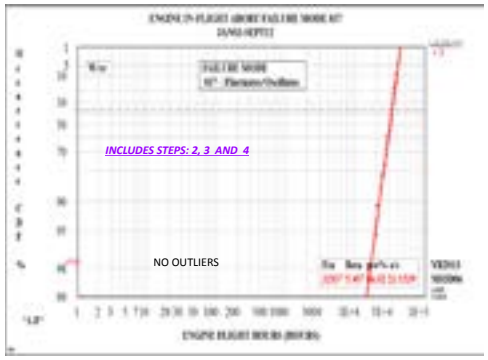
First, I will provide my 14-step process, then use an actual turbofan jet engine component to show the software input/output. However, some caution when using Weibull software. There is only one software that complies with International Electrotechnical Commission (IEC) Weibull analysis and that is SuperSMITH (SS), which complies with IEC-61649. SS software greatly reduces the maximum-likelihood estimation (MLE) of small data bias.

In beginning the 14-step process using data from past analysis in Weibull failure mode analysis, I use two failure modes, 037-Fluctuations/Oscillations and 398-Oil Consumption Excessive.

FAILURE MODE 037 EXCEL

MONTH	EFH	037 - Fluctuates/Oscillates
	-1	1539
Jun-12	19483	1
Sep-12	19883	1
Mar-12	22365	1
Jul-09	23501	1
Aug-08	26455	1
May-08	27669	1
Jul-06	27856	1
Jul-08	28802	1
Jul-08	28802	1
Jul-04	30450	1
Jul-03	31986	1
Jul-03	31986	1
Jan-04	32136	1
Feb-04	33164	1
May-05	34344	1
May-06	34882	1
May-06	34882	1
Apr-04	34920	1
Jan-03	37726	1
Jan-03	37726	1
Mar-04	40676	1

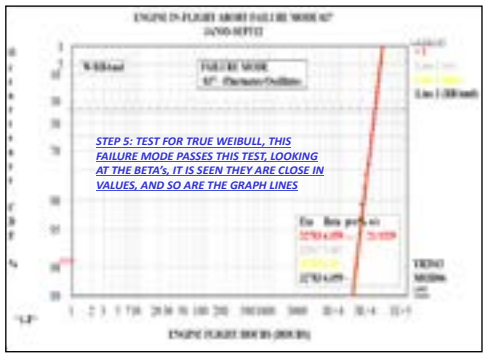
1 Organize each failure mode (FM) into Weibull input data format using Excel. Figure shows input for engine in-flight abort failure mode 037-Fluctuations/Oscillations.



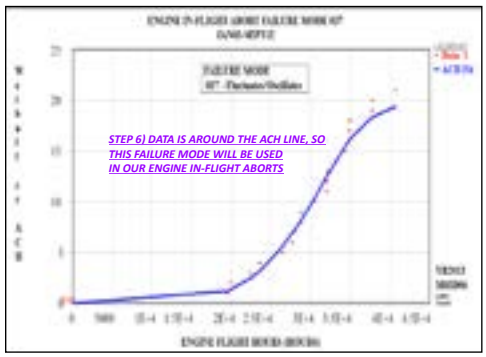
2 Input data into the Weibull software.

3 Perform outlier data test, remove any outlier data points. Figure shows no outliers.

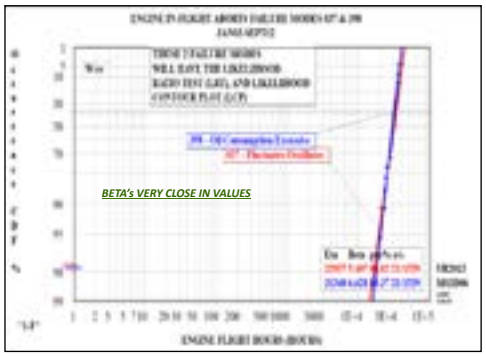
4 Perform distribution analysis for failure mode 037. This is a Wrr Weibull.



5 Check if the data is a true Weibull. Figure shows the Wrr, Wmle and W/RBAmd with lines associated with the distribution.



6 Use the Aggregate Cumulative Hazard (ACH), which is the best method for detecting batch problems. The New Weibull Handbook Appendix F describes this function and its optional use for the possibility of more than one failure mode. CAUTION: There are other methods for looking at the Weibull data plot. I use the ACH method, you may or may not elect to use ACH at this time. However, it is most imperative that a batch detection method be used after combining different failure modes data. The ACH plot for failure mode 037 is shown. Notice the data is close to the ACH line; we accepted this plot, so this failure mode will be used.

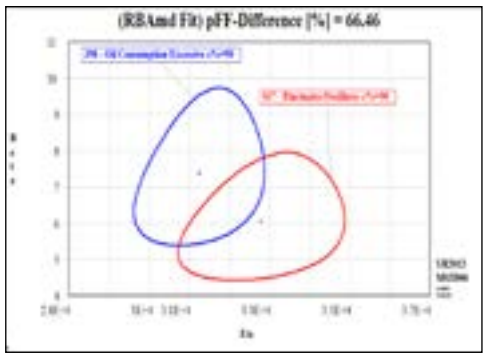


7 Select two failure modes from the same distribution family. Failure modes 037 and 398 will be chosen since both have been verified as true Weibull's and are now ready for additional analysis.

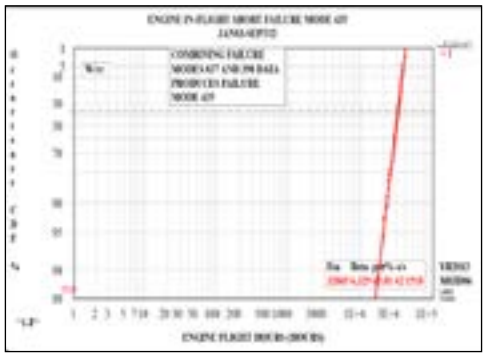
LIKELIHOOD RATIO TEST

- Weibull Ln Likelihood (LL) Comparison: Set Quantity = 2
- Difference = Small (Possible With Additional Data)
- 66.46 % pFF-Value Difference
- Set 1-2 Comparison
- With Modified Likelihood Ratio Test
- Additional Information:
- (69.3 % p-Value With Standard mle Test Bias)
- LL2 = -417.1219 For Set Quantity 2
- LL1 = -418.3028 For All Data In 1 Set
- LL2 - LL1 = 2.36184 / 2 << GOOD RATIO

8 Perform set compare on the selected Weibulls. Figure has the LRT.



9 Perform the likelihood contour plot (LCP). Above is the contour plot and we see a good intersection between the two failure modes. Based upon the LCP, the data from these two failure modes may be combined to form a new failure mode.



10 Merging the failure modes data produces failure mode 435, the Weibull is shown.

STEP (K) OUTLIER TEST

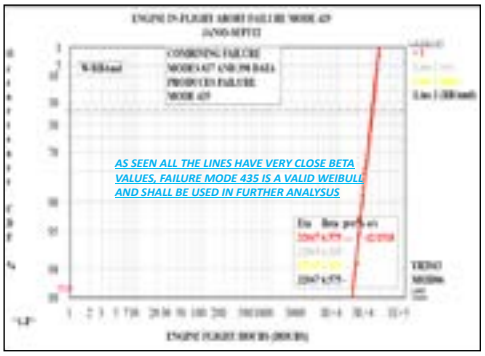
- Outlier Test At 90% P-Value
- Note: For All Occurrence Only
- Set 1: (Lower Point ***OK***) ... (Upper Point ***OK***)

11 Performing the outlier test. No outliers.

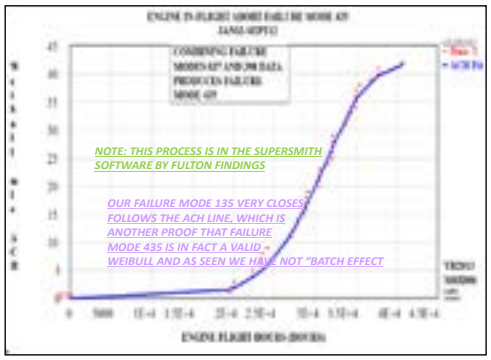
STEP L (DISTRIBUTION ANALYSIS)

- Life Data Distribution Analysis
- Note: Life Equations Only ... Select 'Method / Input' To Add Normal
- Comparison Method: Regression Fit Value [pve%]
- Set 1 - ' 1'
- W:Weibull [t0 = None ... 2 Parameter]
- W: Correlation(r)=.98944 r^2=.979 ccc^2=.9394 pve%=65.01 (OK)
- W: Characteristic Value (Eta)=32065 Weibull Slope (Beta)=6.329 Method=rr
- 3:Weibull [t0 = 5028.571 ... 3 Parameter] [Scale Not As Recorded]
- 3: Correlation(r)=.98944 r^2=.979 ccc^2=.9694 pve%=30.3 (OK)
- 3: Characteristic Value (Eta)=26986 Weibull Slope (Beta)=5.161 Method=rr/t0
- L:LogNormal [t0 = None ... 2 Parameter]
- L: Correlation(r)=.97622 r^2=.953 ccc^2=.9557 pve%=7.91 (pve%<10!)
- L: Log-Mean Antilog (MuAL)=29419 Std. Dev. Factor (SigF)=1.213 Method=rr
- Optimum = Weibull [t0 = None ... 2 Parameter]

12 Distribution analysis proves it is a Wrr Weibull.



13 Test for true Weibull: Figure shows the proof. The Beta values are very close and the various lines have very little deviation, therefore, this failure mode is a true Weibull.



14 Use the ACH function on failure mode 435: Above is the ACH plot and the data is very close to the ACH plotted line. Failure mode 435 is acceptable to use for additional failure mode analysis.

The absolute goal of the 14-step process is a reduction in many failure modes to those "few" that are major contributors to system failures. The 14-step process must be followed in the given order, otherwise you will incorrectly make errors in your system failures.

If you have less than 20 data points, the data values will be above and below the ACH line, but do not discount these due to the plot. Always use best engineering and logistical practices. Out of 217 possible failure modes, the 14-step process reduced these to only five, with one major and one minor failure mode.

Are these steps the only way to perform Weibull failure mode analysis? Absolutely not! But they are definitely worth considering.

References:

1. Abernethy, Dr. Robert B. *The New Weibull Handbook*. Houston: Gulf Publishing Company, 2008.

Technical Adviser: Dr. Robert B. Abernethy. Technical Assistance: James W Fulton, Fulton Findings and Paul Barringer, Barringer Associates.

Part 1 and 2 of the article titled, "Improving the Reliability of a Turbofan Jet Engine" by Larry Tyson can be found in the June/July11 and Oct/Nov12 issues of Uptime Magazine.

Larry Tyson, retired, has spent 24 years in the U.S. Naval Service. Currently working for government service, his tasks include: support equipment specialist, involved in LIFE-CYCLE-COST (LCC), and reliability and maintainability (R&M) for avionics, support equipment, airframes, hydraulics, and power plants, both propeller and jets. Larry is involved in the TURBOFAN Community with a concentration on R&M analysis, RCM, and RCA.

Leadership for Reliability — Cbl competency based learning

Where Do Reliability Engineers Come From?

Dr. Klaus M Blache

Where do reliability engineers come from? To address this, we need to start with a few definitions, then reliability engineering can be best explained by listing some examples of what reliability engineering can do towards improving your operations.

Although I will use the term "reliability engineer," I am referring to both reliability and maintainability engineering. In practice, it's often the same person, so my examples and discussion will be regarding both practices.

Reliability is: "The likelihood that process/product/people will carry out their stated function for the specified time interval when operated according to the designed conditions."

Reliability is usually expressed as a percent probability. I believe it is important to include "people reliability" in the definition. Also, "process" refers to the entire system, including machinery, equipment, operations and engineering processes. Reliability is usually expressed as mean time between failure (MTBF).

Maintainability is: "The ease and speed of maintenance to get the system back to its original operating condition."

Maintainability should be designed in to reduce service and repair time. It is usually expressed in hours as mean time to repair (MTTR). The outcome of good reliability and maintainability is "availability."

Availability is: "Being ready for use as intended."

Availability is typically measured as a percent of time that machinery/equipment works when needed. This can be an actual value or a calculated probability.

$$\text{Availability} = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

These are the basic definitions of reliability, maintainability and availability. But, what does a reliability engineer do? This professional's primary role is to evaluate and manage system (process, product and people) reliability risks. For many, this is mostly a focus on physical assets (building, machinery and equipment). For others, it's about the product.

A good reliability engineer understands total productive maintenance (TPM), can use analysis tools (e.g., Weibull, root cause analysis, fault tree and reliability modeling), and has a knowledge of the production system and product. It's not surprising that reliability engineers are in high demand. There are many individuals with the title "reliability engineer," but are only performing a fraction of the full skill set. Most discussions regarding the role of reliability engineer fall into three categories.

Design in and continuous improvement to:

1. Reduce risks and losses;
2. Manage assets based on lifecycle (total cost);
3. Partner with operations, engineering and maintenance to enable practicable problem solving.

Pay close attention to item number three because my studies with over 300 facilities worldwide have shown that by getting workforce buy-in for a change, you are seven times more likely to be successful.

Typical examples of what a reliability engineer can do include:

- Develop a reliability and maintainability (R&M) plan with measurable goals.
- Data analysis, trending and other data mining to find solutions to chronic problems.
- Manage asset risk as related to health, safety and environment (HES), production, quality, regulatory compliance and cost.
- Be an integral part of the design, installation and buy off of assets - for new assets and major changes to assets. This is important because over 90 percent of the lifecycle cost is decided early in a project.
- Work with the ergonomics or industrial engineer to improve maintainability using human factors.
- Take a systems-thinking approach (machinery, equipment, controls, processes, utilities, safety, environmental, people and more) to ensure reliability.
- Monitor production and maintenance losses to improve throughput and reduce cost (reduce MTTR, increase MTBF and improve availability).
- Conduct a failure mode and effects analysis (FMEA).
- Establish test procedures and perform reliability testing.
- Perform maintainability prediction calculation and demonstration.

- Develop and implement R&M specifications for purchasing.
- Apply R&M concepts to meet R&M design requirements.
- Perform reliability modeling to make tradeoff decisions (what to implement).
- Help design a product for easy maintenance (easy disassembly, standardized parts, mistake proofing, etc).
- Evaluate field data for R&M improvement.
- Specify maintainability targets for assets, products, or their components.
- Provide a R&M checklist for buying off on asset purchases.
- Use R&M analysis tools to identify low reliability and high level of maintenance components/tasks to enable redesign of selecting other approaches.
- Uses historical maintenance data, production data, safety data and other sources to deliver a comprehensive strategy for improvements.
- Protects people from unexpected outcomes.
- Guides implementation of reliability-centered maintenance (RCM) strategies.
- Reviews maintenance requirements from the machine supplier.
- Performs analysis for make-buy, repair–replace and redesign.
- Analyzes preliminary engineering design concepts of naval vessel, aircraft and ground vehicles for operational R&M. Recommends needed testing/validation.
- Understands the workings of the software reliability of programs and control systems.
- Considers the impact of an aging workforce when doing analysis of maintainability.
- Evaluates a situation and knows whether or not to use maintenance predictive technologies, condition based monitoring, time based intervention, or run to failure.

This list can go on and on, but it also reveals both the strengths and weaknesses of the term reliability engineer. As a strength, it takes into consideration all of the aspects that influence asset, uptime and production readiness, as well as delivering products that are reliable and maintainable.

This requires many other parts of the organization (maintenance, operations, engineering, quality, HES, etc.) and leveraging data tools and techniques that are also used by those organizations. That a reliability engineer touches so many areas brings variation to our understanding of what an R&M engineer is and does.

Some factories are using technicians/skilled trades to perform specific R&M tasks, which is good for plant floor buy-in and brings good experience. However, it's important that the big picture of total factory and product R&M strategies be developed (reliability roadmap), communicated and implemented.

In my automotive management days, this was done by a manufacturing engineer, in which R&M was included in the job description (responsible for throughput, removing bottlenecks and increasing throughput). Because of the depth of knowledge and the experience needed, many companies advertise for a specific reliability engineer – electrical, mechanical, nuclear, medical, paper mill, coal, etc. Beyond the core R&M skills and knowledge (R&M concepts, tools and techniques), it requires practical experience and lots of it.

So back to the original question: "Where do reliability engineers come from?" An ideal reliability engineer needs to have:

1. A solid engineering background;
2. A good overall background in R&M;
3. Practical experience.

Typically, when you hire an engineer from a university, you only get one of the three needed ingredients. If you use a person with plant experience (but not an engineer), again, you typically only get one of the three needed ingredients. Some companies are training groups of engineers on R&M because the large number needed is not readily available (and they are already starting with two of the ingredients).

To address this, the College of Engineering at The University of Tennessee (UT) and its Reliability and Maintainability Center (RMC) offer programs for engineers and technicians/skilled trades to fill this gap. Since 1996, the RMC has existed to advance reliability and maintainability education and practices within the industrial and academic communities.

The UT-RMC model is focused on providing both knowledge and experience. The key is knowing both what to do and how (actually performing the skills or tasks).

"It's not what you know, but what you do with that knowledge that's important. It's the ability to analyze, problem solve, apply and implement that brings value to the R&M profession."

WHERE INDUSTRY AND ACADEMIA MEET FOR R&M

When deciding on a reliability engineering career or searching for one, know what you want to be able to do upon completion.

For example:

- If you are interested in management and it will advance your career area of interest, then follow a degree program path.
- If you are a highly technical person and will be making high risk decisions in R&M, then follow a degree program and specialize in the analytical tools of choice.
- If you are an engineer (not pursuing a graduate degree), technician, or skilled tradesperson needing R&M knowledge and wanting to get more training and be recognized, then take a professional development path. Get a certificate that has both a training and implementation component. Decide in advance if you are looking for a broad R&M background or want to learn in-depth in a specific area.

I have never seen the industry demand for R&M knowledge and engineers higher than it is now. Similarly, more students are becoming aware of the opportunities resulting from a RME education and experience. The spring 2013 maintainability course (required for a RME minor) had 112 students. Also, about 10 percent of the May 2013 College of Engineering graduates will have earned a RME minor with their bachelor of science in engineering degree.

This article goes into further discussion on the reliability and maintainability education, company training, professional development, internships and more at www.uptimemagazine.com.

Ask yourself...

What must you learn to perform your job better?

Do you want a university degree or certificate?

What new R&M knowledge and skills do you want to learn?

What do you want to be able to do with new knowledge and skills?

Know whether or not you are interested in college credit (degree program) or professional development (certificate). There are plenty of programs that sound like you may be eligible for more, but remember it's either a university degree or a certificate (regardless of the name of it). Both have their purpose and are valuable based on individual need.

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Benchmarking, Best Practices, Standardization...

Development or Envelopment?

Daniël A. Lachman and Roy O. F. Tjoen A Choy

This article provides insight into the reasons why concepts, like benchmarking standards, best practices and standardization, can be harmful to entities, such as businesses, industries, departments, etc. It introduces the notion of "context" and argues that concepts that have proven their merit shouldn't be blindly adopted and implemented in alien contexts. They should be validated first and be adjusted or modified based on the results.

Though this is common sense, "copy and paste" seems to be the norm, especially in financially woefully times, but this article provides some striking examples. The article uses the multi-level perspective to describe the struggle between "copiers" and "context-conscious" people, and gives examples about some who have provided solutions to mitigate the dominance of blindly following the herd to one's own detriment.

THE HOLY TOTEMS OF BUSINESS

Benchmarking. Best Practices. Standardization. These are some of the more common concepts in business that are regarded holy and untouchable, and which are taught in expensive training sessions and applied in top companies. Thus, you don't question them and you don't go against them.

However, in this controversial paper, we will make an attempt to demonstrate that the application of the same concepts, procedures, practices, etc., in different circumstances does not yield the advancement in business *by definition*. As a matter of fact, this article will go as far to say that this form of "copy and paste" can be even detrimental to business.

We are not against standardization, but we will discuss an important factor (some might even say *the* most important factor) to be considered when applying standardization. Nothing we bring forward in this article is extremely sophisticated, groundbreaking, or highly scientific. Rather, the main idea here is mainly built on common sense, but, unfortunately, reality shows us that this common sense is often something that is hardly present.

"COPY AND PASTE"

Concepts, such as benchmarking, best practices and standardization, are all around us. They are used to gain maximum performance, ease comparisons between different entities (e.g., countries, businesses, etc.) and create transparency in the sense that one can know what to expect in different parts of an entity. The latter is of particular importance for relatively large entities, like countries (e.g., standardization between regions and cities, respectively), multinationals (e.g., standardization between business units, locations, etc.) and industries (e.g., standardization between different companies within one industry). Standardization makes the different parts that constitute the entity to work in unison. They understand each other's language, are adjusted to each other and thus work seamlessly together. This minimizes risk for financial bleeding and poor environmental, health and safety performance.

WE WILL DISCUSS AN IMPORTANT FACTOR (SOME MIGHT EVEN SAY THE MOST IMPORTANT FACTOR) TO BE CONSIDERED WHEN APPLYING STANDARDIZATION

The application of benchmarking, best practices, standardization, etc., is not only experienced on different levels, but also in different aspects within levels. Examples of these are problem solving, engineering standards and solutions, productivity targets, cost performance/financial indicators, daily management practices, safety standards, etc.

WHAT IS GOOD FOR YOU, IS NOT GOOD FOR ME, *PER SÉ*

Of course, many will agree on the above-mentioned arguments for adoption and deployment of best practices, performance benchmarking and trickling down standardization in the entire organization. However, caution is required when doing so.

Consider a subsidiary of a multinational in a developing country that is obliged to keep its spare parts stock down to a best practice/benchmark figure established within that multinational. A situation could occur where there is insufficient spare parts during a sudden breakdown because the developing country has no local suppliers/manufacturers of some specific machinery/part and its remoteness makes it logistically difficult (and thus expensive and time-consuming) to deliver parts from abroad. The *context* in which the subsidiary operates (i.e., no local suppliers/manufacturers and the relative remoteness), makes it detrimental to keep low spare parts levels as is the norm in other contexts (e.g., developed countries with several suppliers/manufacturers nearby and good logistics).

Or take for example productivity figures of several parts (let's assume factories) of a multinational that are measured up against each other. If one factory has a much older infrastructure and machinery, then consequentially, it is logical to assume that its productivity figures (defined as amount of product produced per full time equivalent or FTE) *might* differ from its sister equivalent that has a newer and more sophisticated infrastructure and machinery; the older plant might require several machines with low capacity to produce a certain output, whereas the new plant uses only one machine to produce the same output and thus, requires less operational and maintenance personnel. Their *context* differs and taking into account this context when considering whether the application of a particular standard will be fruitful is nothing else than considering the reality against which you test those standards. If you know where you want to go, the only way to assess the amount of effort required to get there is *by knowing where you are now*.

STANDARDIZATION MAKES THE DIFFERENT PARTS THAT CONSTITUTE THE ENTITY TO WORK IN UNISON

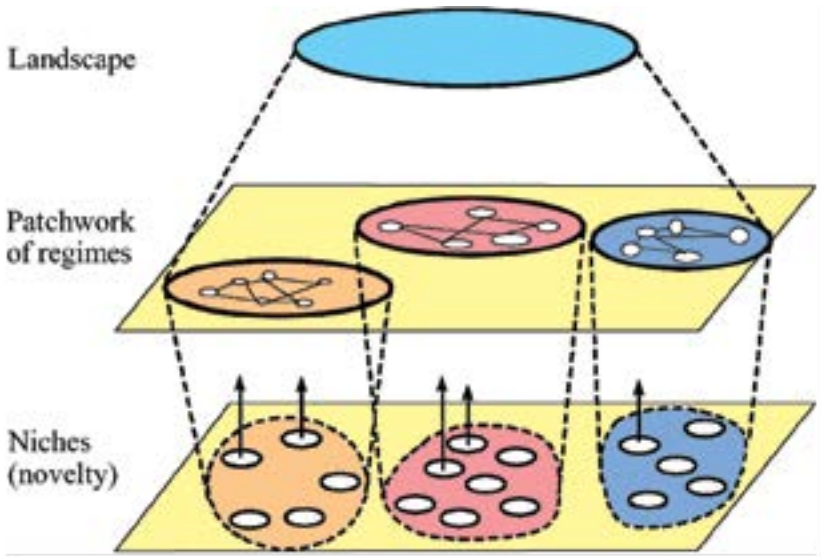

Figure 1: The multi-level perspective

And we just can't leave out Ron Moore's fantastic work.[1] There are some companies that mandate a particular tool must be used for a multitude of diverse problems. However, Ron Moore indicates that this isn't always the most productive problem-solving method since every tool has its benefits and disadvantages and is particularly suitable in specific circumstances.

DEVELOPMENT AND ENVELOPMENT, REGIMES AND NICHES

Concepts, such as benchmarking, standardization and best practices, should be used for the further development of an organization. In this context "development" means further advancement and sophistication, to grow out of the origins, maturing, improving skills and knowledge, etc. As a matter of fact, in Dutch "to develop" is translated as "ontwikkelen,"

which literally means "to unwrap." Glancing at the examples mentioned in the previous section, we would like to apply a term that was recently coined (http://uptime4.me/crscenter-pdf): "envelopment." It is the opposite of "development," and means "to wrap" (like you do with an envelope). When looking again at the earlier mentioned examples, *to incorporate an entity in a project that is alien to the entity's context*, this might sound like a scientific xenophobe, but, as stated before, this is all just common sense. What is good for you, is not good for me, per sé.

In an earlier Uptime article[2], we discussed the multi-level perspective (MLP). The MLP consists of three levels: landscape, regime and niche (see Figure 1). The landscape level is defined as an exogenous environment that influences both niches and regimes. Regimes are the rule set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures.[3] Niches are the locus where innovative activity takes place and where time-limited protection is offered against dominant selection rules.

ONE SHOULD NOT BE PROFICIENT IN THE USE OF A TOOL, BUT BE PROFICIENT IN KNOWING WHEN TO USE WHICH TOOL

What is currently experienced is *the adoption and implementation of benchmarking standards, best practices, standardization, etc. – regardless of context! – is the ruling mindset or regime, which implies that any thinking about the validity of these concepts in a different context belongs to the niche realm and is pushed aside by regimes.*

As mentioned before, this is no rocket science, but actual common sense. As a matter of fact, Paul Karl Feyerabend wrote in his masterpiece, *"Against Method,"*[4] that one should not be proficient in the use of a tool, but be proficient in knowing when to use which tool. Also, in IBM's famous "diversity management" experiment in the 1970s, the researchers noted that groups consisting of different members (race, as was the case of this research) would yield faster and better solutions compared to a homogenous group. It is nothing more than permitting stuff from outside the box to be compared with stuff inside with regard to their applicability in reality.

CONCLUSION:
ALL KNOWLEDGE IS CONTEXTUAL

As is currently happening with a lot of industries, companies have the tendency in financially crippling times to place an increased focus on financial parameters, which is reflected by placing people in top positions with a strong financial or business management background. These people usually have a bias towards looking at figures, which pushes the notion of context to the background. Standardization measures are put into place without much positive effect: the financial performance is not achieved, the company is not sustainable (financially) when looking at the middle- or long-term, and/or a lot of dismay, frustration, disbelief and distrust exist within the company.

Therefore, it is of the utmost importance that entities do not blindly copy success stories across the entire spectrum. Each and every tool, concept, methodology, theory, technology, etc., should be tested/validated first with the context in mind and needs to be adjusted where deemed necessary, or discarded when deemed unfit/unrealistic for that context. Science, after all, that is not grounded in reality is science fiction.

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RESONANCE

Machinery Rock & Roll

Ron Newman

Vibration monitoring and analysis are recognized as key components of a well-founded reliability centered maintenance (RCM) program. Machinery health and long-term reliability are interpolated from trends in vibration amplitude; however, often these levels increase to dangerously high values with little or no warning! Resonance is frequently identified as the root cause. Understanding the physics of natural frequency, and the tools and methods used to recognize and confirm a resonant condition are essential skills for the vibration analyst.

All structures exhibit natural frequencies similar to the ringing of a tuning fork. In a practical sense, machines and machine components can be viewed as a summation of tuning forks, or simple single degree of freedom, mass, spring, or damping systems. Viewing the dynamic behavior of just one of these mass, spring, damping units illustrates how the elements interact to determine natural frequency. Effectively, when subjected to force(s), each element – mass, stiffness and damping – is working to restore the natural "at rest" state and is more or less successful depending on frequency. Below the natural frequency, the resulting response (vibration) is largely controlled by mass, whereas above the natural frequency, the response is governed by the stiffness. Unfortunately, precisely at the natural frequency, the mass and stiffness effects are 180 degrees out of phase with each other, so in theory, the vibration would go to infinity were it not for damping. The basic relationship for the mass/spring/damping model is defined in the Figure 1 equation.

$$\omega_n = 2\pi f_n = \sqrt{\frac{k}{m}}$$

ω = angular frequency in radians/sec (radian is the angle subtended by an arc length equal to the radius)
π = Pi (~ 3.14)
f = frequency in cycles/sec (Hz)
k = stiffness
m = mass

Figure 1: Generally, natural frequency (ω_n) is the square root of stiffness (k) divided by mass (m)

It can be seen from Figure 2 that by increasing the number in the denominator (mass), the resulting natural frequency would be reduced.

$$\omega_n = 2\pi f_n = \sqrt{\frac{k}{m + m_1}}$$

Figure 2: Adding mass (m) lowers the natural frequency

Conversely, increasing the number in the numerator (stiffness), the natural frequency would increase, as shown in Figure 3.

$$\omega_n = 2\pi f_n = \sqrt{\frac{k + k_1}{m}}$$

Figure 3: Adding stiffness (k) raises the natural frequency

Damping serves to minimize or reduce the amplitude at the natural frequency and is often regarded as a measure of the frictional energy that is defined by the molecular characteristics of the structure. Again, in a practical sense, the tuning fork is a lightly damped structure versus, for example, a heavily damped tabletop. See Figure 4.

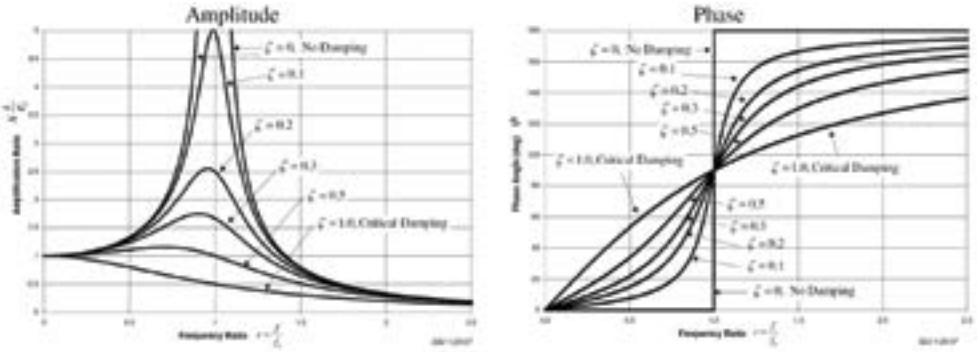

Figure 4: Relative response magnitude (left) and phase (right) with damping factors (ζ) of 0 (no damping) to 1.0 (critically damped)

A condition of resonance occurs when a machine's natural frequency coincides with a forcing frequency within the operation of the equipment. The forcing frequency results from the dynamic forces generated by the rotating elements and can be either discrete, i.e., 1x, 2x, 3x … n^{th}x due to unbalance, misalignment, looseness, blade or vane pass, etc., or broadband, i.e., widely distributed noise due to severe looseness, flow turbulence, cavitation, sliding/rubbing contact, frictional energy, etc.

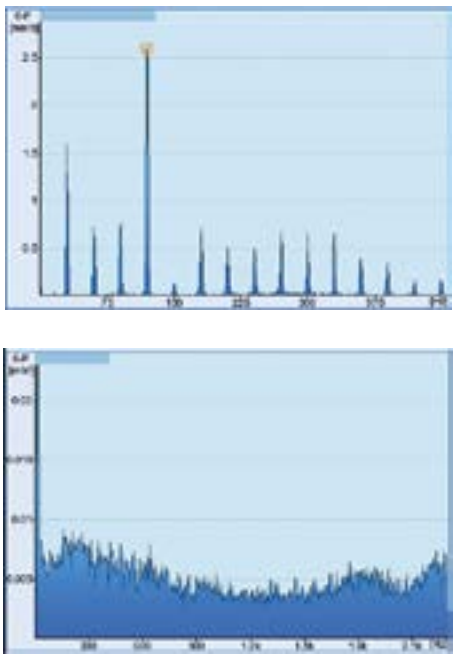

Figure 5: Forcing frequencies may be discrete (top) or broadband (bottom)

Unlike our single degree of freedom model, machines will have several degrees of freedom, each with their own dynamic characteristics, so it should not be too hard to imagine that one or more of these natural frequencies may be excited, resulting in a serious resonant condition.

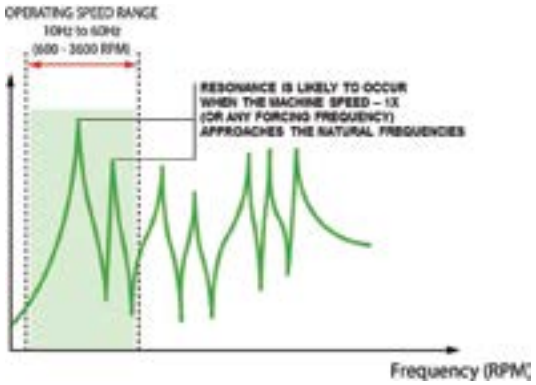

Figure 6: Resonance will occur when machine speed coincides with a natural frequency peak (green curve)

The problem is exacerbated by the modern VFD motor. Because it operates over a wide speed range, the likelihood that a natural frequency will be excited increases substantially. Vibration can increase by a factor of 10 to 30 at this critical speed. Left unresolved, component or complete catastrophic failure is inevitable.

Note: Large turbo-machinery will often reveal a rotor critical speed referring to the elastic deformation of the shaft at a natural frequency. General plant machinery, such as fans, pumps, blowers, rolls, etc., will exhibit a critical speed due to a structural resonance -- that is a resonance of the bearing pedestal, fan shroud, pump volute or piping, base, drive belts, or any of a number of structural support members.

A common method that is useful in identifying a possible resonant condition is comparing

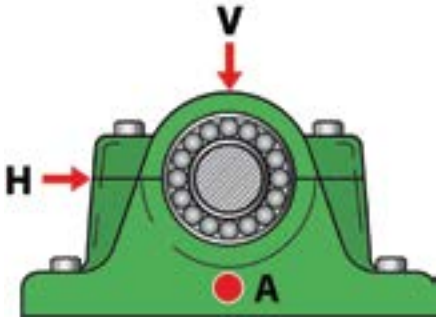

Figure 7: Suspect resonance when amplitude ratios reach ≥ 10:1

the vibration levels at a specific measurement point in each of the axis – horizontal, vertical, axial. When a large ratio (≥ 10:1) is found, for example between the horizontal and vertical, resonance should be suspected.

Dramatic changes in vibration amplitude arising from moderate speed variations, as well as broken welds or cracks, are sure signs of fatigue due to resonance. The vibration analyst has a number of diagnostic tools to confirm a resonant condition.

1. Bump test
2. Two-channel impact test
3. Run-up/coast-down measurement
4. Order tracking

BUMP TEST

The single channel bump test provides the user with information regarding the dominant natural frequency. It is simple to perform and requires no additional hardware beyond a data collector with sufficient functionality. NOTE: The amplitude of the peak is only relative to the impact, i.e., it is not a measure of the "gain" or "amplification" at the resonant frequency and no phase data is acquired.

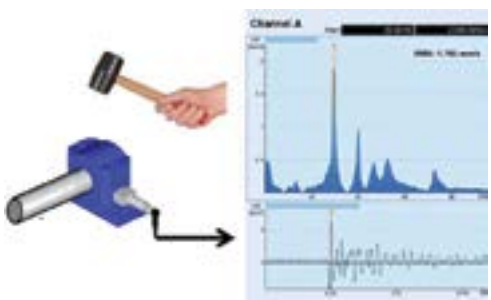

Figure 8: Bump test

TWO-CHANNEL IMPACT TEST

The two-channel impact test measures both the input to the structure (force) and the output response of the structure (acceleration). The ratio of output to input gives the frequency response function. Here, unlike with the single channel bump test, the user acquires phase data AND the amplification factor.

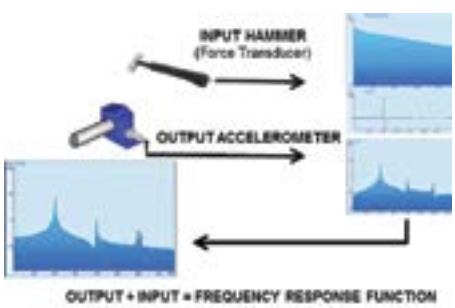

Figure 9: Two-channel impact test

RUN-UP/COAST DOWN MEASUREMENT

The run-up/coast down is another method used to highlight a resonant condition at a specific operating speed. The graph plots amplitude vs. frequency vs. RPM.

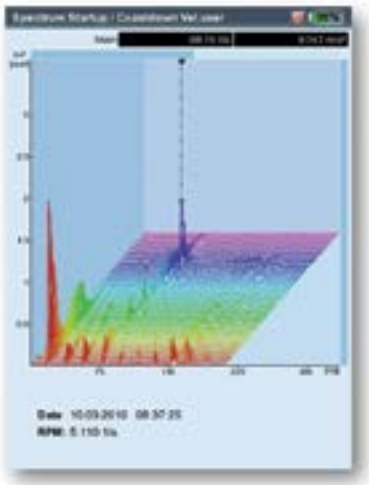

Figure 10: Run-up/coast down measurement

ORDER TRACKING

Order analysis plots amplitude and phase vs. RPM. The data can be represented as a BODE plot (top) or NYQUIST plot (bottom) with amplitude and phase plotted as vectors in polar coordinates.

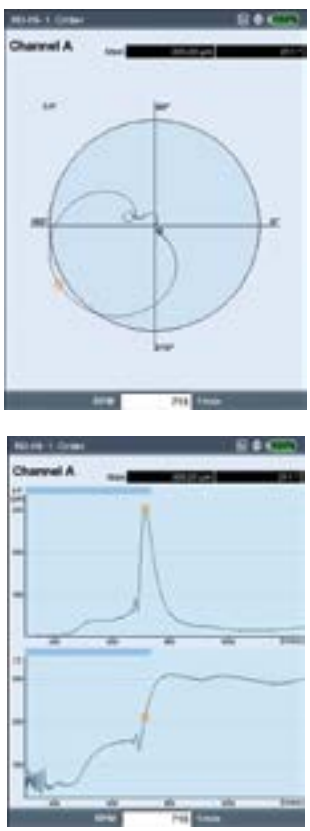

Figure 11: Order tracking

Resolving the problem may mean a simple modification or an expensive reengineering of the equipment. Initial, low-cost options include minimizing the forcing frequencies. As an example, often the primary forcing frequency is due to a multiple of running speeds (1x, 2x, etc.), but balancing the rotor to a better quality grade and/or employing a laser alignment will yield good results. It should be noted that field balancing and laser shaft alignment are also key components of a precision maintenance strategy. Another economical solution is to operate the machine at a different speed.

When structural modifications are required, additional measurement data is essential to ensure changes will be effective from both an engineering and cost point of view. Modal analysis and operating deflection shape (ODS) seem to be competing methodologies to the casual observer. In truth, modal analysis is principally useful to the design and development engineer needing to know the structural properties of the device. It characterizes the structure in terms of natural frequency, damping and shape independent of the excitation.

An operating deflection shape tells the user what is really happening in-situ. ODS is the weighted summation of the modal responses, the weighting depends on the excitation or forcing frequencies, i.e., it is a combination of the forcing functions and the structural modes.

Modal Analysis characterizes the parameters of these normal modes in terms of:

- natural frequency, damping, shape

Operating Deflection Shape is a weighted summation of modal responses:

- weighting depends on excitation force(s), i.e., the forcing frequencies

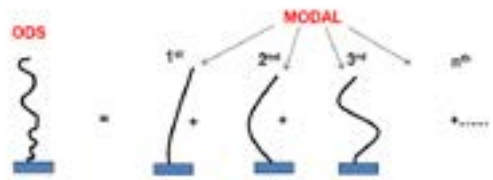

Figure 12: Operating deflection shape (left) is the weighted summation of the modal responses (right)

Commercially available software will aid the operator in the creation of a simple computer model of the structure's geometry, identifying the measurement points and collecting the data. The model is animated so the user can visually see where significant nodes lie, thus optimizing the modifications required. In the sense that these modifications are attempting to shift the natural frequency higher or lower, there are preferred methods to accomplish the task. ODS provides the user with information that will be valuable in identifying points on the structure, where, as an example, stiffening (raising the natural frequency) will be most effective. Other

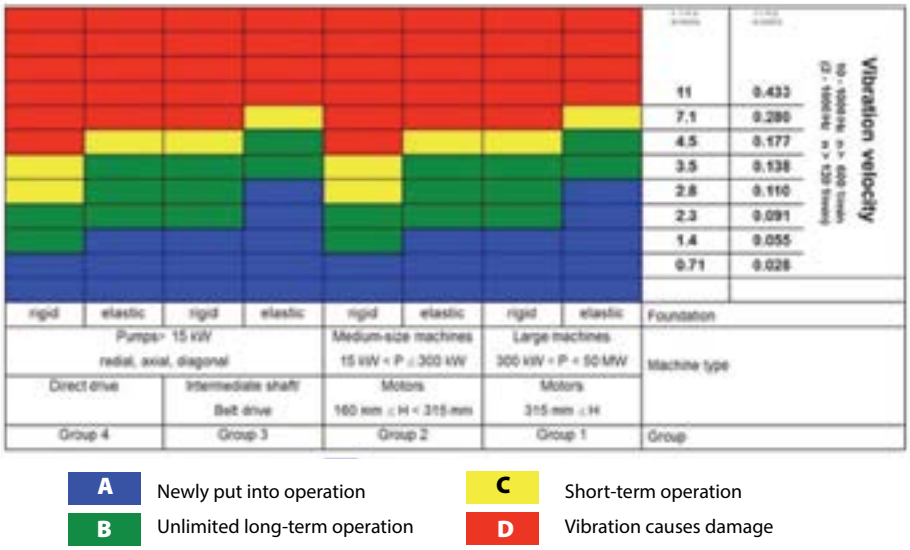

Figure 13: Vibration severity according to ISO10816-3

less commonly used options to resolve a resonance problem include additional damping and/or a dynamic absorber. Since damping is an integral property of the structure, unless the aim is basic noise reduction of a resonant panel, shroud, coupling guard, cowling, etc., damping is less practical for large machinery. Dynamic absorbers have been used successfully to minimize vibration on large vertical boiler feedwater pumps. The design is critical to their success.

In the end, the objective is to ensure a smoothly running plant. Understanding the issue of resonance is one more step along the way to a world-class maintenance organization.

COMMERCIALLY AVAILABLE SOFTWARE WILL AID THE OPERATOR IN THE CREATION OF A SIMPLE COMPUTER MODEL

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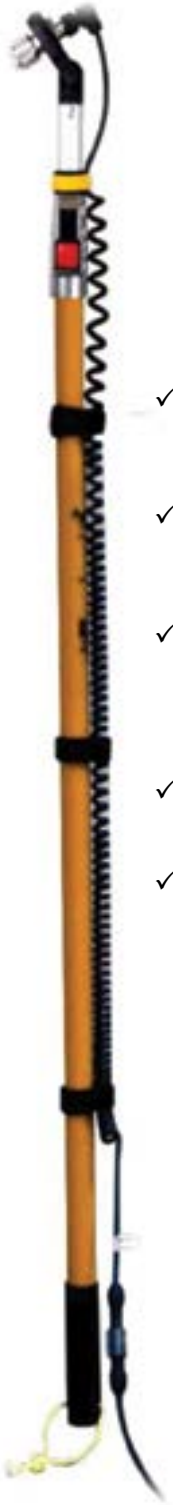

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SAVE YOUR PLANT

6 Challenges & Solutions

Joe Van Dyke

A condition-based maintenance (CBM) program is part of a comprehensive maintenance management program, which should consist of one or more non-intrusive testing technologies applied in a routine scheduled manner for critical assets in your plant.

These technologies include vibration testing and analysis, thermal imaging, lubrication sampling and analysis, reciprocating equipment testing, motor testing and ultrasonic testing, among others. Larger companies often employ in-house personnel and have their own equipment to perform these services without help from outside vendors. Conversely, midsize and smaller companies more often choose to purchase these services from qualified vendors outside the company due to the high costs associated with maintaining equipment and technology, training, and the limitations to staff and/or funding. But even large companies can benefit when outsourcing, depending on the limitations or gaps in their in-house capabilities to run an effective CBM program.

When evaluating your ability to sustain a CBM program, **knowing your challenges is essential.** Spending the time to be realistic about your limitations up front will allow you to choose the right mix of outsourcing and in-house CBM components.

Evaluate your organization by considering these six challenges:

1 Time constraints: Your awareness of how little time you and your staff have is probably crystal clear to you. Staffing cutbacks and personnel assignments have left most people with more to do with less help available. It is also a limitation in which you probably have little control.

2 Expertise: If your company is like most, you don't have enough access to staff with high levels of training, certifications and knowledge. This includes in-depth understanding of machinery design, operation, common failures and best maintenance practices. It also includes more specific and fundamental expertise, such as software system familiarity and data analysis skills. These analysis skills can include vibration test setup and analysis of variable speed equipment.

3 Machinery knowledge: Experienced maintenance staff should be familiar with machines and systems that they are responsible for maintaining. That's the assumption, but the fact is, this is not guaranteed and certainly is not the case for all your equipment. Furthermore, staff new to the plant or the industry may have little or no exposure to the types of equipment critical to the operation of your plant. This puts you at a distinct disadvantage when issues arise. Addressing gaps in machinery knowledge normally requires hiring consultants or looking outside your immediate organization for corporate personnel with the necessary experience.

4 CBM technology knowledge: Advanced test techniques that are within the capability of the tools you possess can offer important information in the hands of those trained to use it. These same tests can provide little or negative value if misunderstood or misapplied. High frequency envelope processing of vibration measurements is a good example of this. Given the right application, this technique can provide early warning signs of bearing wear and race cracks, but if the wrong filters are chosen or the wrong test location or sensor is used, the results will be incorrect or misleading. This could cause you to waste money and/or lose all credibility personally and with your program in general.

5 Continuity year over year/day after day: One of the most significant challenges facing maintenance managers is long-term consistency in approach and competency as it relates to the operation of technical inspection programs like vibration testing and other condition monitoring. If and when in-depth analytical and procedural understanding is assumed as a requirement for personnel heading up and running the program, risk of interruptions and cessation of the program is high. If one person retires, leaves, or gets hit by a real or proverbial bus, all of this critical knowledge instantly disappears. Turnover of personnel can be a distinct disadvantage when attempting to run a con-

dition monitoring program. When turnover occurs, part or the entire CBM program can get dated quickly, shelved and forgotten.

6 Money: A given. Who doesn't have this as a challenge?

Solutions for common challenges

Adequate awareness of these challenges, along with others, allows you to address them and provide improvements on your maintenance program's effectiveness. One very effective solution that addresses all of the above limitations and allows for overall program improvement is the concept of outsourcing your predictive maintenance (PdM) needs. The values that CBM service vendors are able to deliver to their customers are valid and undeniable.

1 Time constraints: By its very nature, outsourcing solves time constraint issues. Allowing a trusted and competent service provider to handle the most time-consuming part of PdM, such as the test setup, analysis and reporting, it frees up valuable time for maintenance departments. Outsourcing these tasks results in focused and consistent high-quality results conducted by someone with specialization and experience and relieves your organization of the time commitment.

2 Expertise: Selecting a provider comprised of teams of analysts with education, training, experience and exposure to your industry and equipment types will maximize your success in addressing both routine and specific machinery maintenance issues. Outsourcing can provide ready and routine access to a team with a broad base of talent. When this team includes analysts with expertise in your industry and especially experience with specific machinery that you maintain and in applications that are relevant to your process, it will be invaluable when problems occur. Selecting a provider with a good team means your program will have consistency year after year and not be susceptible to turnover, retirements and other causes of expertise loss.

3 Machinery knowledge: Closely related to expertise, relevant knowledge of machinery details, including operational principles, design flaws, historical uses in industry, common failure modes, common maintenance issues and applications, are invaluable when addressing maintenance issues and troubleshooting problems. Your existing staff, if they have been with your facility and equipment for an extended time, will probably have the necessary background and knowledge. However, if it's new equipment and/or the staff is on the learning curve, you would do well to link up with a team of maintenance professionals with broad exposure through years of experience in various industry verticals. Outsourcing portions of your CBM program can provide immediate access to these experts and guarantee a level of continuity and familiarity with your equipment that won't vary with staff reductions, retirements and transfers.

4 CBM technology knowledge: This is where outsourcing makes the most sense. The technical work of setting up test parameters, establishing baselines or thresholds and setting up diagnostic criteria and fault identification parameters can be tricky processes. This work, along with the analysis and interpretation of resultant measurements, requires years of specialized training and exposure to various testing constraints and scenarios. Contracting this out to specialists will ensure that you obtain the most accurate, efficient and effective CBM program results. Choosing a provider that controls the software and hardware development and deployment process provides an even greater advantage. This contractor will have guaranteed experts in the application of their technology and will be in the unique position to develop and configure the tools to best meet the needs of your CBM program.

Figure 1: Vibration Analyst using diagnostic software for CBM program

5 Continuity year over year/day after day: Institutionalizing CBM program components through outsourcing provides a means for establishing continuity. Your staff turnover is not going to easily affect the program either in its continuity or quality. The service provider will be tracking the machinery status, trending this information, and watching compliance with the program's testing and data acquisition requirements. Continuity of quality, performance and content is maximized when selecting and keeping with a single provider who can maintain a database of results and provide routine, business-level metrics, such as program compliance statistics, long-term risk assessment trend statistics, safety program compliance metrics, and other historical and strategic measures of asset management effectiveness.

6 Money: This limited resource is the whole point of having a CBM program. An effective CBM program is about cost avoidance. When properly applied, elements of a CBM program will provide benefit-to-cost ratios in the neighborhood of 20:1. This ratio will be higher in the beginning years of the program while critical maintenance issues are first identified and eliminated. The ratio will then most likely taper off to a repeatable and sustainable benefit level that is realized through reduction of downtime and unplanned repairs, elimination of unnecessary periodic maintenance, reduction of spare parts inventory, reduced overtime labor costs and avoided collateral damage from identifying issues early.

In summary, it has been established that identifying the challenges faced by your organization and working to fill these gaps by selecting an appropriate level of outsourced CBM services and expertise can result in a number of significant advantages that translate directly to the bottom line. This can increase your overall equipment reliability because it removes obstacles to performance. The right partner can offer effective services in testing, analysis and reporting, while also supplying added depth of knowledge, technical expertise, continuity of results and metrics, industry experience and advice that provides lasting advantages in maintenance strategy.

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21ST CENTURY OIL ANALYSIS

Fantastic Gains

Still More to Learn and Do

Jack Poley

A year ago, I wrote an article on the New Paradigms in Oil Analysis and Condition Monitoring (Uptime Feb/March12) **citing the huge gains in-service oil analysis (OA) has made in the last decade.**

These included:

- Online and inline sensors instantly creating a third tier of testing:
  - Tier 1 – Sensors (no longer does vibration have an online monopoly).
  - Tier 2 – Onsite laboratories and test instruments.
  - Tier 3 – The traditional commercial lab (the original format).
- Large particle inspections out of the reach of standard UV metals analysis.
- Automated intelligent agent data evaluation and comment generation.

Each of these developments has resulted in new, improved capabilities and insights into machine condition. It's exactly the kind of progress the maintenance community has implied it wanted. But although numbers of new capabilities have emerged, complexities also have been introduced and the considerations that need to be made can be perplexing, if not overwhelming.

EACH OF THESE DEVELOPMENTS HAS RESULTED IN NEW, IMPROVED CAPABILITIES AND INSIGHTS INTO MACHINE CONDITION

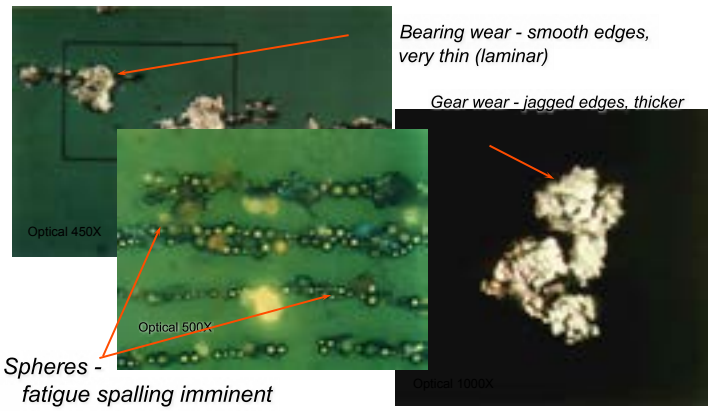
When I began my career in 1961, there were a handful of commercial labs performing OA throughout the country, but only one (luckily the one that employed me) had an ultraviolet (UV) spectrometer that could analyze for metallic elements in lubricants. This device, the direct-reading, semi-automated spectrometer, completely changed the rules for oil analysis because previously, labs were testing lubricants for contamination and suitability for continued use. Occasionally, additional information might be gleaned regarding engine maintenance needs, such as fuel leaks (fuel line or pump issues) or excessive soot (timing or restricted intake, maybe worn rings). And, yes, the testing in the 60s was restricted to diesel engines for the most part.

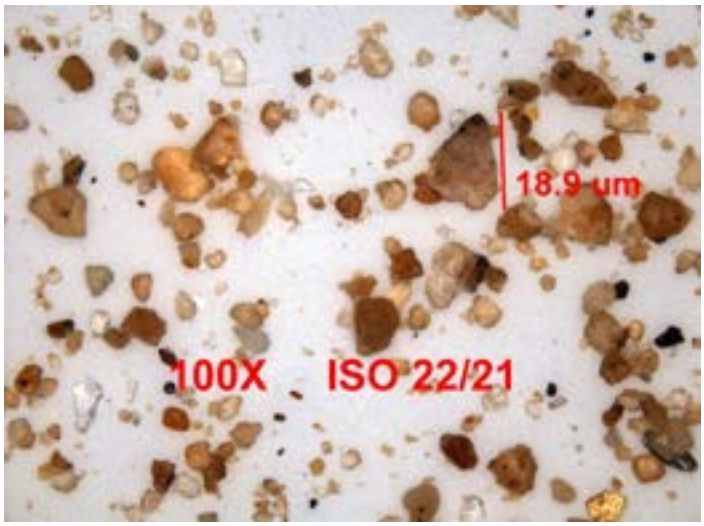
Wear metals measurement -- the Big 4 being iron (Fe), aluminum (Al), copper (Cu) and lead (Pb) -- changed the paradigm of OA from oil condition to machine condition monitoring. Lubricant integrity and cleanliness were still part of the analysis, certainly, but the focus was now firmly on the component and its health as a revenue generator.

Interestingly, the U.S. Navy also followed suit with this lone commercial lab with a UV spectrometer and applied the technique to single-engine jet fighter planes, with mixed, if not disappointing results. Failures continued to occur often without being identified in the metals wear patterns. What went wrong?

It was a number of years before the OA community learned that UV spectrometers, while sensitive and accurate for measuring metals in solution, or even at small particulate levels, were not able to detect, let alone measure, particles much above a few microns in diameter. This simply was a technological limitation. Luckily, diesel engines did very well when UV spectrometric testing was employed because a good portion of the wear mechanisms in diesels is sliding wear, which tends to produce very fine particle diameters.

Super-speed turbine shafts, such as those in Navy jets, however, were spewing out significant amounts of larger particles when developing wear trauma. These particles went undetected. This was just bad luck. When the Denver and Rio Grande Western Railroad began its testing of lubes for wear metals, its chemists (that's who one needed in those days) would ash the lube, then acidize the ash to render the metals in full solution, creating an easy sample for a UV spectrometer to analyze quite accurately. The semi-automated UV, while speedy, relied on an arc spark zapping (rotating disc electrode) of the sample to achieve ionization via brute force. Later, inductively couple plasma (ICP) began to compete with the arc spark instruments. Either approach, while adding





enormous convenience, throughput and repeatability in its own right, spawned a process that, to this day, is incomplete in the OA world. Wear particles are never naturally in a solution phase, though they can be very small approaching the properties of solution. When that occurs, the UV spectrometer can hold its own. Thus, the diesel engine and other reciprocating components, such as some compressors, played an unwitting role in the OA process, one that was not completely understood for a decade.

PRESENTLY

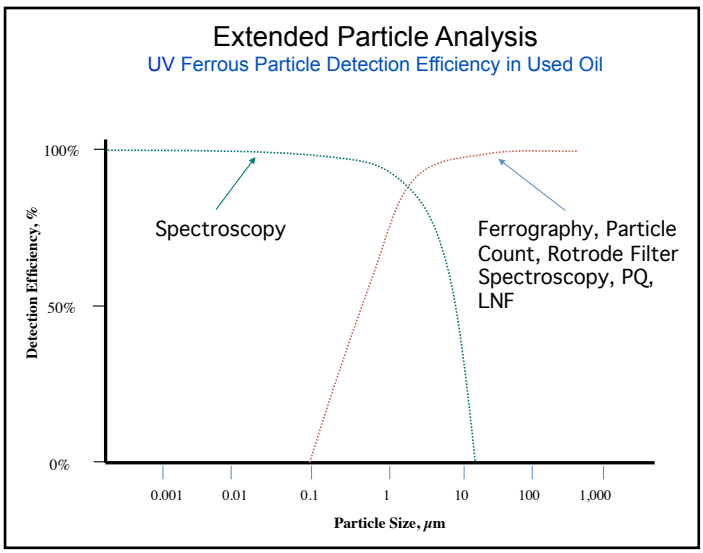
Diesel engines, to this day, benefit from UV spectrometric analysis, with the same trauma detection upon which the OA model was formed. Unfortunately, not everyone in OA, particularly on the user/customer side, is aware of this limitation. And it should be noted that the two most popular, and by far the majority of instrument types in use, can have varying sensitivity versus each other, element by element, due to technical differences in their respective analytical processes.

NOWADAYS, GEAR SETS, HYDRAULICS AND A GREAT VARIETY OF ROTARY MACHINERY HAVE THEIR LUBRICANTS TESTED FOR WEAR METALS VIA UV SPECTROMETERS - THIS IS A GOOD IDEA, BUT IT'S NOT ALWAYS ENOUGH

Nowadays, gear sets, hydraulics and a great variety of rotary machinery have their lubricants tested for wear metals via UV spectrometers. This is a good idea, but it's not always enough. There are times when this test needs supplemental support from other testing; enter large particle testing (LPT).

Here are some LPT approaches:

- Particles visible to the naked eye (~50µ upwards) – Filter element inspection.
- Particle counting without compositional (PC) data, typically from 4µ to 70µ in six bins, with some variation dependent on the instrument/method employed.



- Microscopic examination:
  - Optical
    - Filter patch (micropatch) or other substrate;
    - Ferrography (special grooved slide used).
  - Scanning Electron.
- Ferrous particles (all methods utilizing magnetometry):
  - Direct reading ferrography (DRF);
  - Particle quantifier (PQ);
  - Online sensors:
    - Particle detection from 40µ-1000µ:Fe; 135µ-1000µ, non-Fe;
    - Particle quantification (no sizing) over time: per hour, per minute, etc.
- LaserNet Fines: Combination analyzer for particle count, water and bin sizing, and morphology of particles >=20µ. Often considered as good as dedicated PC.

These are not all the possibilities for LPT. Nevertheless, if one is monitoring rotary equipment, a UV spectrometer is insufficient or, at best, risky to place one's singular faith in. How does one select which of these technologies to use?

The answer to this question can be surprisingly tricky and is dependent on:

- The component type being monitored.
- If applicable, filter type and micron rating.
- Where and how the sample is being taken.
- Other non-LPT tests being performed in addition to LPT.
- Whether it may be helpful to use more than one LPT.
- Customer's objectives and commitment.

Once one has addressed the need for LPT in the test suite based on the component types to be monitored, there are still important items to be considered.

This is a modest introduction into the complexities of choices one is faced with in the evolution of oil analysis. There are other interdependencies and knowledge gaps worth exploring in this sometimes arcane maintenance tool we call oil analysis.

Jack Poley is technical director of Kittiwake Americas and is managing general partner of Condition Monitoring International, LLC (CMI). Jack has a B.S., Chemistry and B.S., Management and has completed 50 years in Condition Monitoring and Oil Analysis. www.conditionmonitoringintl.com

Table 1: Component vs. LPT

Component Type	Plausible Approach	Comment	Sensor for LPT (Fe, primarily)
Diesel	PQ	May not often be of need	• UV spectrometer does well • Slow-Speed best candidate
Reciprocating Compressor	PQ	May not often be of need	• UV spectrometer does well • Optional
Gear set with rated filter	PC or LNF, option PQ	Particle count may not always apply - Pick only one from PC & LNF	Yes
Gear set with no filter	PC or LNF, option PQ	Large ferrous particles can be monitored	Yes
Hydraulic	PC or LNF, option PQ	Cleanliness is the most important aspect of monitoring hydraulics	Yes
Gas Turbine	PC or LNF, option PQ	May be component type with the highest ratio of large:small particles	Yes
Steam Turbine	PC or LNF	Keen interest in monitoring contamination, as well as wear	Yes
Wind Turbine, with Gear or Gear-Free	PC or LNF, option PQ	Some type of LPT essential, in addition to UV spectrometer	Yes

Table 2: Test Suite, Basic

Component Type	UV Spectrometer	Fuel Contamination	Soot	Oxidation	Nitration	Water	Water Karl Fischer	VIS	LPT
Diesel	Y	Y	Y	Y	Y	Y		100 C	Optional
Reciprocating Compressor Reciprocating Natural Gas Engine	Y		4-cycle NG	Y	Y	Y		100 C	Optional
Gear set with rated filter	Y			Y		Y		40 C	Y
Gear set with no filter	Y			Y		Y		40 C	Y
Hydraulic	Y			Y			Y	40 C	Y
Gas Turbine	Y			Y			Y	40 C	Y
Steam Turbine	Y			Y			Y	40 C	Y
Wind Turbine, with Gear or Gear-Free	Y			Y			Y	40 C	Y

Machinery Health Monitoring Depends on Accelerometers

PART 1 What's an Accelerometer?

Wayne Tustin

This is Part 1 of a five-part, lighthearted series entitled, Machinery Health Monitoring Depends on Accelerometers. Part 1 deals with the mechanical aspects of using accelerometers, while Part 2 covers the electronic aspects of dealing with those small signals. Part 3 discusses calibrating accelerometers to determine their sensitivity. In Parts 4 and 5, we attach accelerometers to various machines so they can report on machinery health.

INTRODUCTION

Some sensors respond to vibratory displacement or position, others respond to velocity. Here, we're talking about sensors that respond to vibratory acceleration, the second time derivative of displacement to changes in velocity -- accelerometers.

Whereas a microphone responds to changes in pressure, an accelerometer senses the motion of some structure to which we've attached it. Our accelerometer converts that motion into an electrical signal. We measure that signal to determine the acceleration of our structure. OK?

Particularly at higher frequencies (e.g., 1000 Hz), our displacements and our velocities are so small that measuring them is difficult. Yet accelerations and thus, accelerometer output signals, may be reasonably large and fairly easy to measure.

Over the past century, machinery speeds (and thus vibration frequencies) have risen tremendously. But while use of displacement and velocity sensor has declined, the use of accelerometers (also spurred by significant accelerometer improvements) has risen. Figure 1 shows one significant improvement: Accelerometers have become much smaller and lighter, much less affecting the vibration they are emplaced to measure Accelerometers are self-generating, others require a DC power supply, but with all, sensitivity is given in mV/g.

Figure 2 shows that they all resonate at some natural frequency (f_n) and they all over report vibrations around fn. Don't try to use them above $0.1f_n$ or $0.2f_n$.

Figure 1: Accelerometers have gotten smaller

Photo courtesy of Endevco, now Meggitt

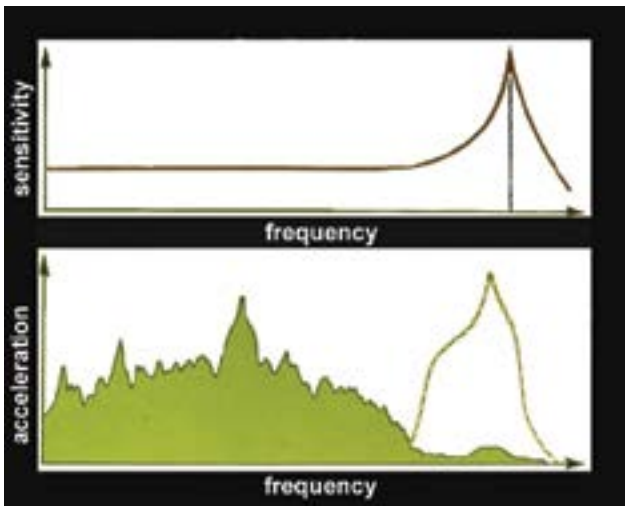


Figure 2: Effect of a too low accelerometer f_n

TRI-AXIAL ACCELEROMETERS

That's a misnomer. Accelerometers are single-axis devices. However, three accelerometers (mutually perpendicular directions) in one case are called tri-axial. Align it with your machine's fore-and-aft, vertical and left-right axes to measure fore-and-aft, vertical and left-right motions. From such an assembly, as seen in Figure 3, come three acceleration signals, often through a delicate multi-pin connector. Those three signals usually differ greatly.

Figure 3: Tri-axial accelerometer

Photo courtesy of Dytran

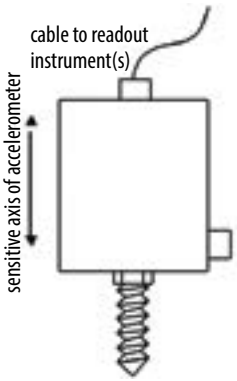


Figure 4: The handheld accelerometer

THE HANDHELD ACCELEROMETER

Occasionally, you will want to measure motion at a series of locations without attaching your accelerometer. Figure 4 suggests a handheld accelerometer, an ordinary accelerometer with an extra long, sharp pointed accelerometer stud.

CABLE DISCONNECTS

Figure 5 suggests connector complexity. Considerable skill is required to properly attach connectors. Your people probably have not had sufficient time to develop that skill. The data you gather is so valuable that you need the best possible cables. When you even suspect a cable is bad, destroy it!

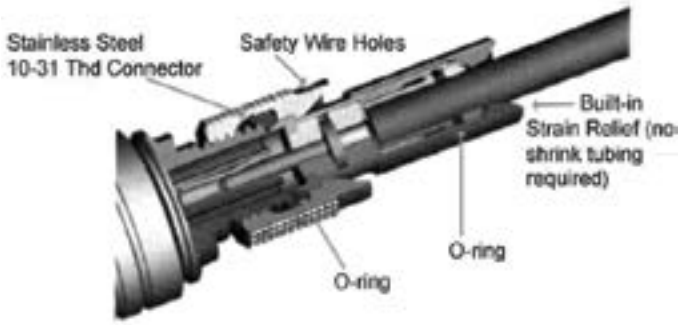


Figure 5: Cable disconnect Image courtesy of Kistler

ACCELEROMETER MECHANICAL ERRORS

Each millivolt of signal from our accelerometer should represent a specific magnitude of acceleration, at all frequencies. Thus, we certainly will calibrate our sensors (Part 3). However, all sensors do, unfortunately, respond to all inputs.

Table 1 shows factors that can upset the ideal 1:1 relationship. The left column factors are those that affect the sensor. Those in the right column affect signals on the cable.

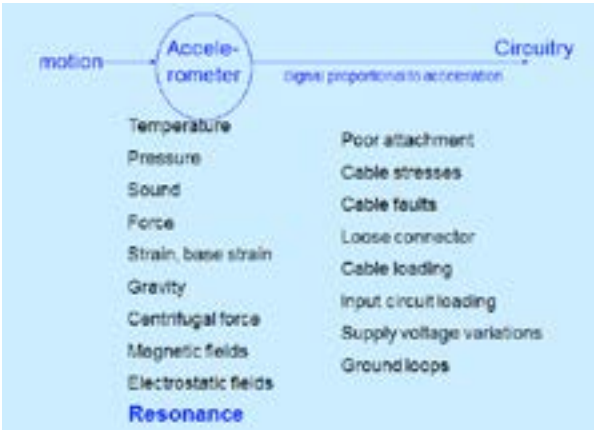


Table 1: Error-producing factors

Sometimes, mechanical errors can result from other factors, like dropping the accelerometer, see Figure 6. If that does occur, be sure to "red tag" that accelerometer. Don't use it until thoroughly recal-

Figure 6: Avoid dropping accelerometers

ibrated over its entire frequency range (to be discussed in Part 3). Single frequency checking is not sufficient.

Similarly, don't remove a cemented or epoxied accelerometer with a hammer. Soften the cement, then carefully twist it off. Use an appropriate solvent to soften any remaining cement and wipe off the remainder. Don't scrape the accelerometer base!!!

We want our accelerometer's contact with its mounting surface to be flat and smooth. But peaks (asperities) occur on accelerometers and on mounting surface contacts. We tighten the mounting screw, which flattens the asperities, leaving dips, cavities and air pockets. Oil in those pockets couples better, so before we screw on our accelerometer to attach it, we apply a bit of light oil.

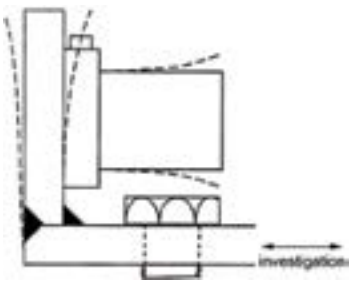


Figure 7: Avoid bracket resonance

AVOID ACCELEROMETER BRACKET RESONANCES

Suppose we want to measure vibration parallel to a surface. We need a bracket, something like Figure 7. Our bracket's first natural frequency f_n should be at least three times (five times or even 10 times is better) the highest forcing frequency f_f. One or two gussets will help stiffen the bracket.

MOUNTING DEVICES

Figure 8 shows various studs, attachment pads, etc., used for mounting accelerometers onto the machine you'll be monitoring. Two in the rear are electrically insulated (to prevent "ground loops" - see Part 2 of this series). Cement or epoxy B and B', as shown in Figure 8, onto structures you'll investigate, then screw your accelerometer into place. Stud mounting A and A' gives your accelerometer the stiffest and most intimate contact with the machine you're investigating. Accelerometer and flat mounting surface must be clean; a little oil fills microscopic voids and stiffens the connection.

Figure 8: Attachment devices

MOUNTING METHOD EFFECTS

Accelerometers can be stud-mounted to permanent magnets for attachment to steel machinery. This works, although not as well as stud mounting. Stud mounting gives the widest flat response range of frequencies and, thus, is safest to use.

TEMPERATURE CHANGES AFFECT SENSITIVITY

Sensor sensitivity, unfortunately, varies with temperature. How much? This requires specialized calibration (to be covered in Part 3).

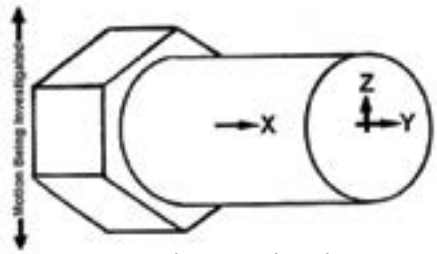


Figure 9: Accelerometer's lateral sensitivity

LATERAL OR "CROSS-AXIS" SENSITIVITY

Motion sensors are supposed to respond only to motion (x axis in Figure 9) perpendicular to their bases. Unfortunately, they respond a bit to y and z motions.

Remember that an accelerometer's sensitive axis is perpendicular to the base.

PROTECT ACCELEROMETERS

Particularly around paper and similar manufacturing where strong chemicals splash and spray, we need to keep our sensors dry. Hence, the "boot" in Figure 10.

Figure 10: Protective boot (Photo courtesy of Dytran)

In Part 1 of this series on accelerometers, our concern has been mostly on the mechanical aspects. Next, our emphasis will focus on the associated electronics.

*The material provided has been extracted from iBook 7, Acceleration & Force Sensing, from the series on Randon Vibraion & Shock Tesing.

Wayne Tustin has been involved with vibration and shock measurement and testing since about 1950, mainly as a teacher. He emphasizes the practical aspects of vibration and shock measurement and testing and he favors simple explanations. www.equipment-reliability.com

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Precision Lubrication

Requires Precision Documentation

IMC 2013 Conference Speaker

Jarrod Potteiger

Most maintenance professionals understand that lubrication preventive maintenance (PM) should be documented, but many fall short when it comes to writing effective lubrication procedures. The lubrication instructions in the average PM are often something like, "lubricate all lube points." How many lube points are there? Lubricate them with what? How much oil or grease should be used? Should the machine be running or not?

These are all questions that should be addressed by the PM procedure, along with instructions on how to perform the task(s). The more information omitted, the more likely it is that mistakes will be made, such as using the wrong lubricant, missing lube points, over/under lubrication, etc. Well documented lubrication PMs allow for precision and consistency in execution, which are key elements in a precision lubrication program.

The first step in creating an effective lubrication PM program is to assess the current program. If the current program is found to be inaccurate or lacking greatly in detail, the best path forward may be to start over. Begin with an accurate equipment list and then break the equipment down into a hierarchy that works with the type of equipment you have. You may want to assign PMs at the machine level, the component level, or the lube point level, depending on the complexity of the equipment. With the lube points identified, the next step is to identify the required lubrication tasks and determine the optimum frequency for each. Each type of lubrication task has required variables, such as lube type, amount, required operation state, etc. Create a simple spreadsheet or database to house this information for inclusion in the documented PM procedures. There is really no one size fits all solution for this item, but using a systematic approach will make this project surprisingly simple.

EQUIPMENT HIERARCHY

A well thought out equipment hierarchy is a crucial foundational element for the program design work. The hierarchy should have enough layers to accommodate the necessary data collection at the beginning and later to sort tasks in lube routes. In some cases, such as with mobile equipment, it is more practical to create PMs for an entire machine and assign tasks based on coinciding frequencies. With mobile equipment, it is common to assign multiple tasks to multiple lube points in a composite PM that combines all the tasks that should be executed at a particular time. For stationary equipment, it is usually more efficient to create PMs that assign a particular task to the component or lube point level. Later, these tasks can be sorted into convenient lube routes by application type, lubricant type, frequency, etc. Regardless of the level to which PMs are assigned, the individual tasks and their variables should be associated at the lube point level. A common hierarchy structure for lubrication program engineering would be: plant, unit or area, process, machine, component, then lube point. In many cases, the component will only have one lube point, but the structure should still be consistent.

TASK ASSIGNMENT AND TASK VARIABLES

With the detailed equipment list and hierarchy in hand, the lubrication tasks can be identified using a variety of sources, such as equipment maintenance manuals. For the most part, lube points of a particular type will generally have the same tasks. For example, a wet sump lube point, like a gearbox, will have a routine inspection and an oil drain and fill at a minimum, and possibly other tasks, such as oil sampling, off-line filtration and others. Once the tasks are assigned, the necessary data fields or variables for a particular lube point can be identified based on the type of component and the associated tasks. Remember, more information is better, so when creating data fields, try to consider any information that could be useful. In addition to the primary data, such as component type, make, model and size, include other information, such as operating temperature, vibration, contamination and other environmental factors that might lead to deviations from standard practices or task frequencies.

$$Gp\ (gm) = 0.005 \times D \times B$$
(note: D & B in mm)

$$Gp\ (oz) = 0.114 \times D \times B$$
(note: D & B in inches)

Gp = grease replenishment amount
D = bearing outside diameter
B = bearing width

Figure 1: Calculated values, such as grease volumes, should be determined using valid engineering methods. In addition to documenting the values, the methods also should be documented for future validation.

CALCULATIONS

Many data field values, such as lube specs and sump volumes, can be looked up in original equipment manufacturer (OEM) literature, but others must be calculated or determined using standard lubrication engineering techniques. Grease volume and application frequency are two such values that typically require some calculation or research to obtain the optimum value. If there is insufficient expertise on staff to determine these values, it is a good idea to bring in outside help, or at least consult with a subject matter expert. Methods for determining these values are available in lubrication engineering texts and bearing manufacturer manuals, but recently, some manufacturers, have created software applications that do much of the work for you. If one of these applications is to be used, it is still a good idea to become familiar with the underlying principles to help rationalize the computed values. Additionally, lubricant specifications are not always available, or they may lack sufficient detail. If an OEM manual just lists particular lubricants, then that product type should be converted to a generic specification so it can be cross-referenced to a product already in use.

A GOOD LUBRICATION PM SHOULD SERVE MORE THAN ONE PURPOSE

PUTTING IT ALL TOGETHER

A good lubrication PM should serve more than one purpose. It should serve as a training tool for new technicians or those unfamiliar with the job, and as a checklist and feedback tool for experienced technicians. To make this practical, two versions of each PM procedure should be created in both a long and an abridged format.

The full or long version procedure should follow a standard procedure template that includes task name and asset identification, purpose, scope, summary, detailed instructions and safety considerations. The task procedure instructions should contain sufficient detail to allow technicians to complete the task even if they are unfamiliar with the equipment. If the machine or component contains multiple lube points, an annotated picture or detailed rendering should be included to identify each lube point. Be sure to use consistent nomenclature when naming components or lube points. It is not uncommon for different individuals in a plant to refer to the same component by different names. Again, the pictures or drawings should avoid confusion.

The abridged version of the procedure is intended to serve as a checklist for an experienced technician. Step-by-step instructions on how to drain oil or apply grease are not necessary, but certain items should still be included. The most basic details, such as the lubricant type and the amount to be applied, should be on any lubrication PM. In addition to the basic information, checklist items also should be included, especially for inspection items. Even the most experienced mechanic can miss something from time to time if there is no prompt on the PM worksheet. The final item on the abridged procedure should be a section for feedback. A lack of a proper reporting mechanism may result in observed problems slipping through the cracks until it is too late to correct them.

When creating new procedures, it is a good practice to include technicians in the design process. Because of their familiarity with the equipment, their input will likely streamline the project, identifying problems before the new procedures are deployed.

EXECUTION

Once the new program is complete, everyone in the program should be trained on the proper execution of common tasks. This will help ensure that tasks are completed to the desired standard and performed in a consistent manner. With some tasks, such as taking an oil sample, consistency is almost as important as quality.

LONG-TERM BENEFITS

Properly documenting procedures for lubrication tasks not only increases the quality of the program today, it helps ensure success in the future. In the absence of good documentation, the program really resides in the minds of individuals who can retire, change jobs, or leave the plant at any time. If this happens, their experience, education and training will leave with them. With an aging workforce, this is an ever present risk, so protect your program and your hard work by documenting everything, including the decision-making processes. By documenting the methods used to make lubrication decisions, such as lube specs and grease volume, those who come behind you will be able to carry on the program and avoid starting over.

Jarrod Potteiger is Educational Services Manager, Des-Case Corporation. Jarrod has published a variety of technical articles, has trained thousands of maintenance and reliability professionals in public and onsite seminars and has presented workshops and papers at a variety of technical conferences. Jarrod holds a Bachelor of Science degree in chemical engineering. www.descase.com

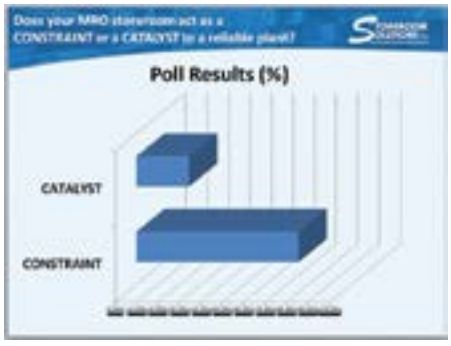
MRO Stores

A Constraint or a Catalyst?

IMC 2013 Conference Speakers

George Krauter and James Rogers

At the 2013 Reliability 2.0 Las Vegas (produced by Reliabilityweb.com and Uptime Magazine) **conference, attendees voted on whether their MRO stores operation is a constraint or a catalyst to a reliable plant. Voting was in real time using live text message polling technology and paper ballots at the trade show booth. During the course of the show, the majority – 76 percent – of voters said MRO is a constraint rather than a catalyst to a reliable plant; only 24 percent said MRO was a catalyst.**



In addition, although those that voted it a constraint, many responding really did not know how MRO affected reliability. They chose constraint because they knew MRO stores was not a catalyst. If there had been a category called "I don't know," many would have voted for that option. Whether an "I don't know" or "constraint" response, the fact is that only a quarter percent thought their MRO operation helped them. It is interesting to note that the words "constraint" and "catalyst" gave the respondents cause to consider what was meant regarding MRO; meaning it was provocative and revealed MRO is overlooked when considering a reliable plant strategy.

Any function within a plant that loses money or causes inefficiencies for other initiatives should be a target for change. What other plant discipline would be sustained when only a small percent of the people affected thought the function had merit. If a given lean initiative was considered to be ineffective by those involved, that program would be adjusted to perform to the benefit - the catalyst - for all concerned, or it would be eliminated.

Why does this condition continue to exist in the MRO area of operations? Major reasons are:

- Little recognition of the MRO effect on plant reliability and drain on profit.
- Erroneous assumption of no time/dollars to invest in change without building business case.
- Acceptance of status quo; "It is what it is; put up with it."
- Ability to circumvent MRO stores to obtain parts (i.e., buy around stores operations).
- Opportunity to establish sub-stocks for critical spares.
- Unsure of how to affect change; who will do it?
- Inertia; this is how we have always done it.
- Entrenched suppliers; we can always rely on ABC Supply.
- Low priority in cost recovery agendas.
- Lack of recognition regarding negative effects on reliability programs.
- Those assigned the management of MRO may not be those who rely on MRO performance.

So here is a situation where 76 percent show dissatisfaction or at least disinterest with MRO, yet there is little to no effort placed on improvement. This situation continues to exist while companies invest large sums in lean and reliability programs to achieve a reliable plant. The gaping hole in these programs stores operations unconnected with plant reliability strategy and execution – MTTR, MTBF, etc. is just not recognized. Of those sur-

ANY FUNCTION WITHIN A PLANT THAT LOSES MONEY OR CAUSES INEFFICIENCIES FOR OTHER INITIATIVES SHOULD BE A TARGET FOR CHANGE

veyed who expressed dissatisfaction, only two asked for follow-up information to improve. It seemed that most felt that an effort to change MRO was too complex and would involve too many people who have other (more important?) functions.

So what is the answer?

Companies that have attempted to solve the problem have done so by investing substantial sums of money into systems and capital to achieve a balance of cost reduction and reliable supply. The problem is measurement, sustainability and conformance. Company-operated stores remain at various levels of efficiency based on who is reporting. In addition, MRO stores are rarely connected to the needs of maintenance and its mission to deliver a reliable plant. In one real-life situation, an on-site provider had improved fill rates from 60 percent to 98 percent. However, the two percent represented 12 people who did not get parts (when needed), which were critical spares. These 12 people, albeit two percent, criticized the storeroom as inefficient and unreliable which, to them, it was. The problem here is an example of an unconnected storeroom. If the two percent had been routinely using MRO, there would be no problem. The fact that the missing parts caused downtime was the effect of stores operations unconnected with the critical needs of maintenance.

THE ANSWER TO ACHIEVING A RELIABLE MRO STOREROOM IS TO HAVE STORES CONNECTED TO THE NEEDS AND PROGRAMS OF MAINTENANCE AND PLANT RELIABILITY

The answer to achieving a reliable MRO storeroom is to have stores connected to the needs and programs of maintenance and plant reliability. In this situation, a connected store would have had the information necessary to ensure 100 percent availability of the critical spares.

What is a maintenance-connected MRO storeroom?

Here are the components:

- Proper investments in people, processes and technology:
  - The people are not only 'parts experts,' but understand the parts' applications to plant equipment.
  - The processes include tight integration with maintenance for faster and safer execution of maintenance work at a lower cost.
  - The technology includes interfacing with a company's EAM/CMMS to ensure an accurate minimum equipment list (MEL) and identification of critical equipment systems with fully populated bills of material (BOMs).
- Ability to affect maintenance improvement by helping to manage maintenance backlog and contributing to reducing mean time to repair (MTTR).
- Ability to affect reliability improvement by participating in failure analysis and contributing to improving mean time between failure (MTBF), for example failure mode effects analysis (FMEA), failure reporting, analysis and corrective action system (FRACAS), etc.
- Ability to affect reliable equipment performance by connecting expert supplier engineers with maintenance initiatives.

Maintenance contributes to the manufacturing mission by delivering a reliable plant. To be reliable, the plant must have reliable equipment which, in turn, must have a reliable MRO stores operation. To be reliable, stores must be connected to the manufacturing mission via maintenance reliability programs.

How to achieve a reliable MRO stores operation that is connected to maintenance while providing an optimum cost position? First, assign a "positive" project manager who will:

1. Obtain agreement from all disciplines that the investment in change has a positive ROI scenario; it is needed and critical to a reliable plant.
2. Define the goals of change and establish key performance indicators (KPIs) to sustain the goals.
3. Decide if the company has the knowledge and is willing to assign necessary personnel for success or investigate an on-site third-party MRO company provider with experience to provide connected reliability operations.
4. Recognize that a maintenance coordinator is critical to success and serves as the principal liaison between maintenance and stores operations. This person must be laser-focused on providing stores expertise to maintenance reliability improvement projects. If stores are to be operated in-house, the company must hire an experienced maintenance coordinator who can affect the change. If a an outside provider is selected, that provider must have a maintenance coordinator on staff to implement and sustain the effort. The maintenance coordinator contributes stores expertise to the areas of required maintenance.

In this example, the maintenance coordinator applies stores expertise to each phase of managing maintenance work, ultimately affecting MTTR.

1. Work Identification: Assist with MEL development, identification of critical equipment systems and development of respective BOMs.
2. Work Planning: Assist with providing planners visibility to available inventory to develop work plans and populate backlog.
3. Work Scheduling: Assist with expediting scheduled work by eliminating "waiting for material" work order status.
4. Work Execution: Assist with kitting and staging of material for planned maintenance events.
5. Work Reporting: Assist with providing material usage and cost at the plant, area, equipment and work order level.

RECOGNIZE THAT A MAINTENANCE COORDINATOR IS CRITICAL TO SUCCESS AND SERVES AS THE PRINCIPAL LIAISON BETWEEN MAINTENANCE AND STORES OPERATIONS

In conclusion, when 76% of respondents to the survey said that MRO was a constraint or did not even consider MRO as factor in reliability, there should be no question that there is a need to change the management operations of MRO stores in order to contribute to plant reliability. The exceptional value that can be released from MRO needs to be defined and recognized so that the 76% can be turned around.

Whether the change can be made by utilizing the talent and time of existing personnel and doing it in house or to hire a third party expert provider, this decision needs to be centered on the following: existing condition of stores, management's attitude regarding MRO, and the recognition that there is value in change that must be captured.

George Krauter currently serves as Vice President for Storeroom Solutions, Inc. Mr. Krauter is recognized as an authority on methods to achieve reliable, maintenance-connected MRO storerooms. He holds a B.A. and M.B.A.A. from Temple University and has conducted seminars internationally and at domestically.

James Rogers is Business Unit Director, Maintenance & Reliability Services, for Storeroom Solutions, Inc. He has dedicated his career to reliable plant performance, with experience ranging from "mega projects on a global scale" to owning and operating a plant services company. A trusted adviser in the field of maintenance improvement, he is heavily invested in manufacturing initiatives in his home state of South Carolina. www.storeroomsolutions.com

It's Time to Start Having the Right Conversations about ISO55000

Grahame Fogel

We sit as a community ever closer to approaching the final release of the ISO55000 suite of standards for the *management of physical assets.*

Any cursory review of the chat boards on the Internet concerning ISO55000 will tell you that the question on everyone's mind is how to reason the benefits case for implementing an asset management system to executive management.

There is a perception that simply having a list of benefits will be the persuasive conclusion that creates resolution to the issue of whether an organization should adopt the standard or not.

In the quicker, cheaper, faster world we live in, the challenge from management to show the benefits is a very real issue and one to take seriously. Changing a set of organizational perceptions into a go forward position for adopting ISO55000, or the principle of putting in place an asset management system, will have to be treated in a more mature and comprehensive manner for success to be achieved.

The purpose of this article is to frame the issue and present a structured framework around which discussion about the topic can take place.

RESPONDING TO THE INITIAL PERCEPTION ISSUE

As one raises the argument for implementing a strategic asset management system, the immediate response is going to be a challenge of showing the financial benefit.

Management is conditioned to respond with this challenge. In the myriad of issues that face executive teams on a regular basis, it is the first filter for any next step discussion or meaningful consideration. The reactionary position and immediate concern is wrapped around a mental model of potentially devoting significant resources into a new idea that has no tangible and credible business benefit. This mental model is represented in Figure 1. In this model, significant input energy is expended without a measurable tangible benefit. We refer to this as the vicious cycle of going nowhere, which needs to be addressed comprehensively in order to progress to a more structured and productive position.

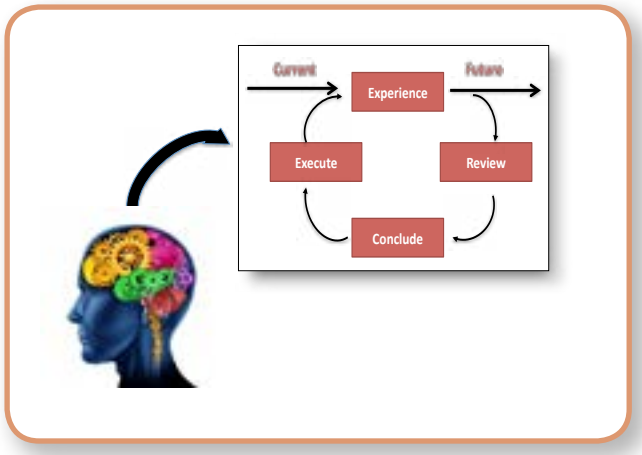


Figure 1: The vicious cycle of going nowhere

The great fear, for which there are many precedents, is that committing to an ISO55000 future will lead to a disruptive churn that will demand resources, absorb organizational energy and, ultimately, land up at a point not dissimilar to the point of departure, i.e., there is a perception *of investment with no value gain.*

To break through this organizational perception or mental model, one has to embark on a much more considered and strategic approach that will lead to a structured discussion and review. The goal is to create a new organizational perception that has a value enhancer paradigm represented in Figure 2.

CREATING ACCEPTANCE - Planning and Designing the Persuasive Argument

Minds are hard to change and scientific research tells us that the flexibility of thinking reduces with age. That means the older the person (read senior management), the more challenging it is to create a paradigm shift from an existing mental model. There has been significant research conducted into formulating a persuasive argument, and from this, we present a structured approach for preparing such an argument. The model consists of seven levels to be used as a template to become an effective persuader. Let's consider them.

REASON – Reason involves using logic, analogies and other rationale processes to persuade. Most management teams, especially engineers, consider themselves rational and wish for this to be the foundation for persuasion. Within the reason argument, one has to provide examples, show alignment to real business needs, and show with examples what has happened and how a management system could have prevented it. It is also useful to provide industry comparisons. Finally, one has to craft a value argument linked directly to the individual business.

We also have to recognize that even though individuals like to think they are rational, all of us live in a multidimensional mental world where we are all subjected to emotional and political aspects to our cognitive decision making. This means we have to broaden our approach – with the following considerations.

RESEARCH – Reason has a multiplier effect. Argument is much more persuasive when backed up with research. This means you need to be prepared to answer the "why" question with researched, organizational-related facts. Research needs to look at data and analyze it in a systematic manner (often statistical). Using data, one can analyze basic facts to understand trends, conditions and opportunities.

Bear in mind that the data synthesized into information has to be persuasive to warrant a change of mind. There is the cycle of transformation of data to information and then finally into action. Remember, you make your arguments as clearly and unambiguously as possible based on the facts. Arguments can be made more persuasive by adding a "because" statement to it. …. Because it will give us consistency of execution between operations and engineering leading to higher use of installed capacity, based on ….

RESONANCE – While reason and research appeal to our cognitive aspects of the mind, resonance applies to our emotions. Again, behavioral research shows if one can appeal to another's feelings and emotions to create an emotional resonance, one has the most powerful lever for changing minds and gaining support. Reason and research, though logical, may not be enough if your audience doesn't care about the issue.

The issue has to be communicated in a way that sounds or feels right, on an emotional level. This may follow reason and research, but occurs when a connection occurs at a subconscious level. We are also told that while reason and research are processed in the cortex within our brain, resonance occurs within the limbic system and, as such, has to be addressed differently.

REPRESENTATIONAL REDESCRIPTIONS – This is an elaborate way of saying you need to make your argument in a number of ways and through different media. Individuals have different learning preferences and methods of processing information. Some can quickly assimilate information from a chart or graph, others prefer to read a narrative, still others want to hear it personally and yet others require pictures or stories. So present the argument in different forms, all of which should explain and reinforce the same key concepts.

RESOURCES AND REWARDS – So far, the arguments lie in the domain of an individual who has an open mind. At this point, one has to revert to the specific, what's in it for the individual argument. *For example - better throughput, leading to improved profitability, leading to recognition, leading to improved status within the organization*.

The resource argument is also a key consideration, as it often represents a no-go restraint. In the cost constrained, resource limited situations that most organizations find themselves in, clear valuable initiatives often are not considered due to the limitation of resources. This needs to be considered and addressed in the argument for implementation. The point being there needs to be a clear indication of the resources required to create the solution and some consideration as to where the resources (money, skills, capacity, know how) may come from.

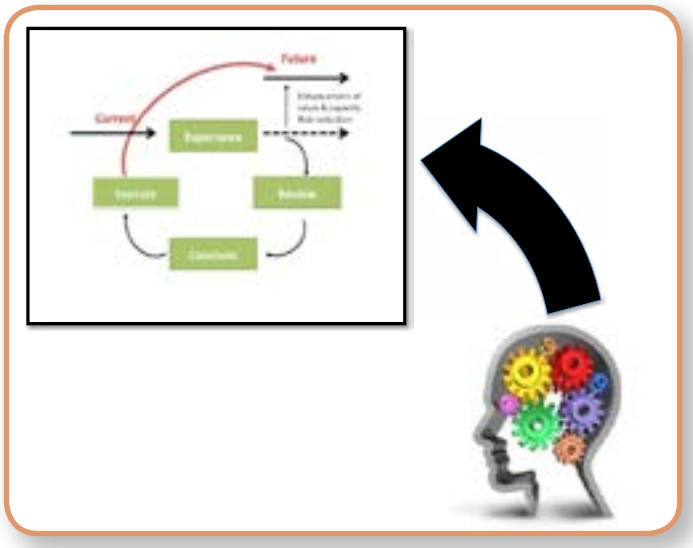


Figure 2: The value paradigm

REAL-WORLD EVENTS - ***The risk argument***. Sometimes, one has to change mindsets on a large scale through events. Recent asset-related events abound, such as the Deepwater Horizon oil spill disaster, the Toyota safety recall and the Fukushima nuclear disaster. It is easier to convince an audience to motivate for change when facing real, identified major risks even if the facts are lacking. One real-world event is more and more regulators looking at using ISO55000 as a framework for regulation and how that will affect your industry/organization. There is also the evidence-based conclusion that managing risk is well rewarded. This is summarized from the work of the Aberdeen Group shown in Figure 3 and Table 1.

There is also more and more discussion regarding insurance companies looking at the presence of an ISO55000 management system as a consideration for insurance.

Potentially, in the near future, this may be a license to operate issue within certain industries.

RESISTANCES - Expect teams and individuals to be more comfortable with the status quo. The strongest force that resists changing minds is the comfort with the as is. Compounded this is the fact that changing minds becomes more difficult with age. Therefore, it is important to show the arguments around not changing in the most **uncomfortable** light.

A useful perspective is to build a detailed, credible picture of the scenario of what happens if we don't put in an asset management system. This argument leads to the point that if the organization needs to get better, there has to be a structured process to get there and a management system in place to sustain the gains.

ESTABLISHING PURPOSE – Creating Organizational Intent

Once through the gaining acceptance phase, the next challenge, and the biggest challenge of all, is execution and implementation. Much as we reasoned the absorption of a strategic approach when presenting the argument for implementation to management, we recommend a strategic approach to creating organizational purpose around ISO55000. We make this argument based on four key reasons:

1. Creating an Empowering Governance Structure

So often, really good initiatives within an organization never overcome the first barrier that confronts execution. There is a thin dividing line between those initiatives that succeed and those that do not. To ensure an initiative has the maximum opportunity for success, one should establish a fully sponsored power coalition that acts as the steering committee for the initiative. This steering committee acts as an advisory committee made up of high-level stakeholders and experts who provide guidance on key issues. The more sponsored and powerful the organizational governance structure, the greater the chance the execution phases will have of overcoming the inevitable obstacles regarding implementation. A powerful coalition of support will clearly indicate the organizational importance of intent.

This steering committee should have executive representation, as well as representation from production and other areas of the organization. It should have a charter for success and

meet regularly to review the steps along the way. Barriers need to be identified early in the journey and the governance structure needs to play an active role in removing or lowering the magnitude of the performance barriers.

2. Establishing Clear Purpose

The purpose of this article is to provide a framework around which meaningful conversations can take place within organizations regarding the relevance of implementing the ISO55000 standard. At its core, ISO55000 will provide an accountable and manageable system that drives value from the ownership of an asset. This purpose needs to be clearly analyzed, reviewed and articulated in an organization's own frame of reference and defined in such a way that organizational purpose resonates in clear articulation of intent.

Having this clearly articulated purpose crisply defined provides the basis from which many organizational conversations can start and a point of meaningful reference along the journey.

Organizational purpose can be captured in vision and mission statements, but these are often cladding that gets lost in noise. The real point is for the implementers to make purpose reside in all considerations by whatever means possible.

3. Aggregating the Improvement Initiatives

In most asset-intensive organizations, there are a number of competing improvement initiatives driven from different centers and different angles into the organization. Examples include Six Sigma, defect elimination, focused improvement, practical problem solving, etc.

While individually, there is a good chance that they may be yielding benefits, there is a greater chance of a multiplier effect and organizational sustainability of results if they are strategically encapsulated within a management system.

Therefore, we argue that there is a strong case for aggregating the improvement initiatives together to create asset productivity within the strategic context of the organization. This implies the convergence of both production and engineering goals, encapsulated within a management system.

4. Embedding the Key Concepts

There are a number of key concepts to embed into the management system and culture to manage progress, including:

- Establishing a ***line of sight*** between overall organizational objectives, how the asset is being operated and maintained, and everything in between.
- Implementing a management system that involves establishing a number of accountable processes. The key for these to create value is the concept of ***in place, in use***. In other words, not just a paper exercise.

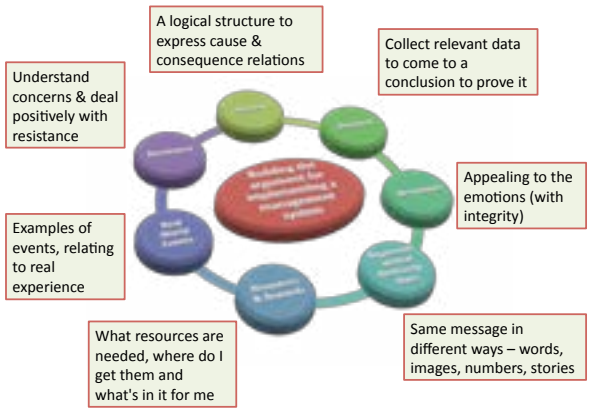


Figure 3: Designing the persuasive argument

Definition of Maturity Class	Mean class Performance
Best in Class: Top 20% of aggregate performance scorers	• 94% accuracy of cash flow forecasts • 17% improvement of effectiveness in risk detection & assessment year over year • 3% of revenue loss over past 12 months
Industry Average : Middle 50% of aggregate performance scorers	• 83% accuracy of cash flow forecasts • 10% improvement in effectiveness of risk detection and assessments year over year. • 12% of revenue in financial loss over past 12 months
Laggard: Bottom 30% of aggregate performance scorers.	• 77% accuracy of cash flow forecasts • 10% improvement in effectiveness of risk detection and assessment year over year. • 18% of revenue in financial loss over past 12 months.

Table 1: Breaking Free from the Viscous Cycle Paradigm

- Basing decisions and operational practices around the concept of driving value contribution through the ***total life cost of ownership*** of the asset.

IN CONCLUSION

At the end of the day, one will inevitably have to list the tangible benefits from implementing ISO55000. There are seven that are formally listed and six more that I added. For reference, they are:

1. **Improved Financial Performance** – Improved services, outputs, return on investment and reduced costs without sacrificing short- or long-term performance. This can lead to the preservation of asset value.
2. **Managed Risk** - Reduced financial losses, improved safety, and minimized environmental and social impact, all resulting in reduced liabilities, such as insurance premiums, fines and penalties.
3. **Improved Services and Outputs** - Consistently matching the needs and expectations of the customer and achieving required service levels.
4. **Corporate/Social Responsibility** - Improved ability to demonstrate socially responsible and ethical business practices within the organization's community.
5. **Demonstrated Compliance** - Transparent conformity with requirements and adherence to asset management standards, policies and processes can be achieved.
6. **Enhanced Reputation** - Through improved customer satisfaction, stakeholder awareness and confidence improves.
7. **Improved Organizational Sustainability** - Appropriate handling of short- and long-term effects, expenditures and performance can improve sustainability of operations and the organization.

To which I add the following:

8. **Improved Knowledge Management** plus improved decision-making creates a learning organization.
9. **Greater Overall Accountability** leads to more assured governance.
10. **Allocation of Responsibilities** occurs at the right level through the organization.
11. **Ability to Elevate Asset Management** as a key strategic enabler to the executive level.
12. **Ability to Create a Cross-Functional Rhythm** of operation that transcends traditional organizational boundaries.
13. **Ability to Move Improvement Initiatives** from the temporary, metastable state to the more permanent, sustainable and accountable state.

Grahame Fogel is an Asset Management Consultant with experience covering 25 years around the world. Grahame has been associated with many of the recognized benchmark programs, such as US Steel, Pfeizer Pharmaceuticals, PJB Power, Boeing and others. He has a depth of experience in the power, pharmaceutical, mining and chemical process industries. More recently, he has been on the forefront of implementing PAS 55.