UPTIME MAGAZINE

uptime®

feb/mar 18

for reliability leaders and asset managers

FEBRUARY/MARCH 2018

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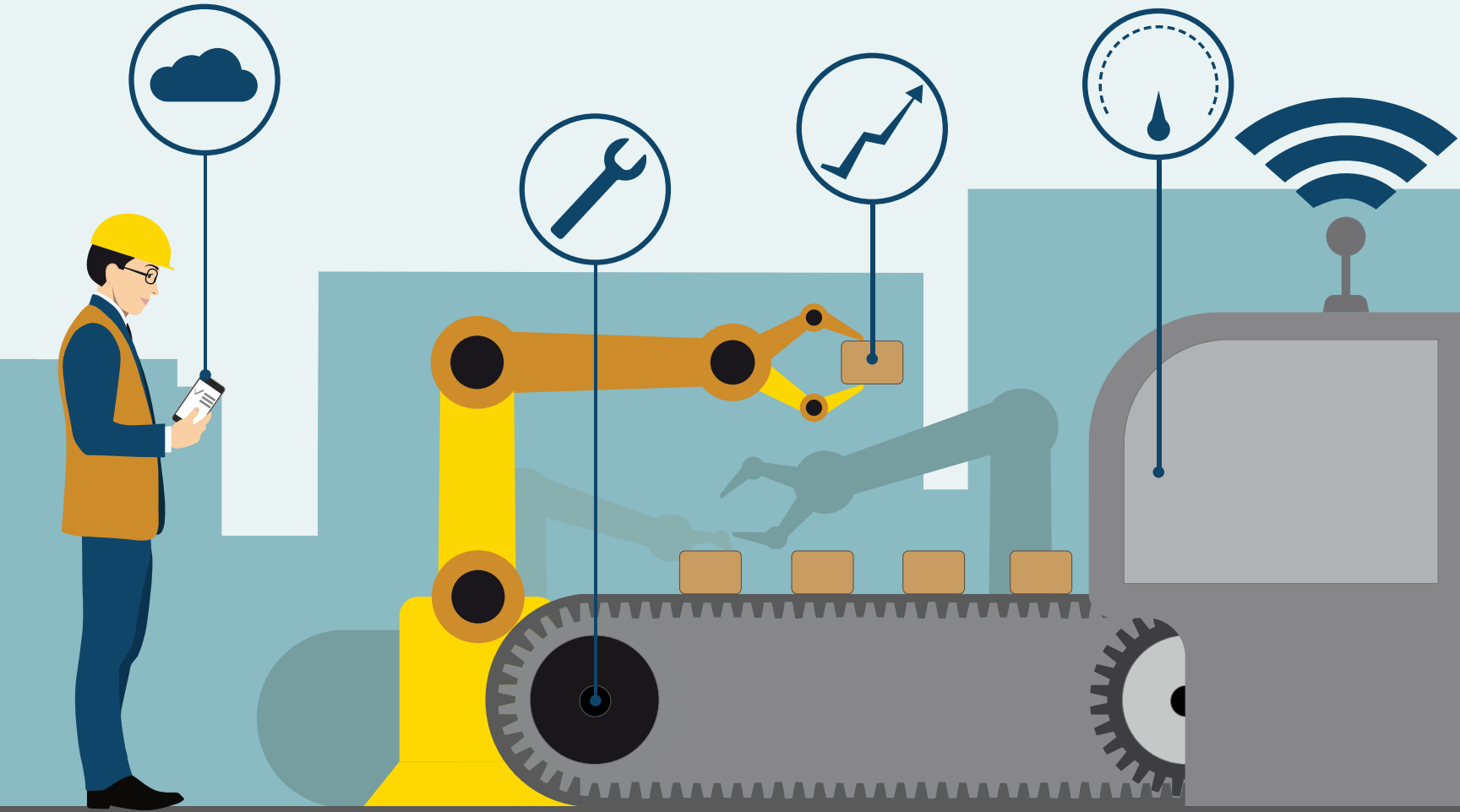

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COURSE	WHO SHOULD ATTEND	YOU WILL LEARN HOW TO	DATES & LOCATION	DAYS/CEUs	COST
Maintenance Management Skills	Maintenance Managers and Supervisors, as well as Supervisors from Operations, Warehouse or Housekeeping areas	Lead a world-class maintenance department using planning and scheduling best practices to drive work execution, improve productivity, motivate staff, increase output and reduce waste.	Apr 17-19, 2018 (OSU) Sept 25-27, 2018 (KU) Dec 4-6, 2018 (CHS)	3 consecutive days 2.1 CEUs	$1,895
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.	Apr 2-6, 2018 (CHS) May 7-10, 2018 (KU) July 23-26, 2018 (CHS) Sept 24-27, 2018 (CU) Nov 5-8, 2018 (OSU)	4 consecutive days 2.8 CEUs	$2,495
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.	Feb 13-15, 2018 (CHS) Oct 23-25, 2018 (CHS)	3 consecutive days 2.1 CEUs	$1,895
Planning for Shutdowns, Turnarounds and Outages	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.	Aug 7-9, 2018 (CHS)	3 consecutive days 2.1 CEUs	$1,895
Predictive Maintenance Strategy	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.	Apr 3-5, 2018 (CHS) May 15-17, 2018 (OSU) July 31-Aug 2, 2018 (CU) Nov 6-8, 2018 (KU)	3 consecutive days 2.1 CEUs	$1,895
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 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.	Feb 27-Mar 1, 2018 (KU) April 24-26, 2018 (CU) Jun 19-21, 2018 (CHS) Oct 23-25, 2018 (OSU)	3 consecutive days 2.1 CEUs	$1,895
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. CMRP exam following Session Four.	SESSION 1 DATES: Mar 20-22, 2018 (CHS) Aug 28-30, 2018 (CHS)	12 days total (4, 3-day sessions) 8.4 CEUs	$7,495
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.	Feb 6-8, 2018 (OSU) Mar 27-29, 2018 (CU) June 12-14, 2018 (KU) Oct 2-4, 2018 (CHS)	3 consecutive days 2.1 CEUs	$1,895
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.	Mar 20-22, 2018 (OSU) June 12-14, 2018 (CU) Aug 21-23, 2018 (KU)• Oct 30-Nov 1, 2018 (CHS)	3 consecutive days 2.1 CEUs	$1,895

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***LOCATION CODES:** (CHS) = Charleston, SC | (CU) = Clemson University in Greenville, SC | (KU) = The University of Kansas | (OSU) = The Ohio State University | (PR) = Puerto Rico

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Can you find the hidden Uptime logo on the cover? uptime magazine

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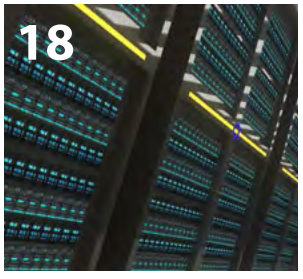

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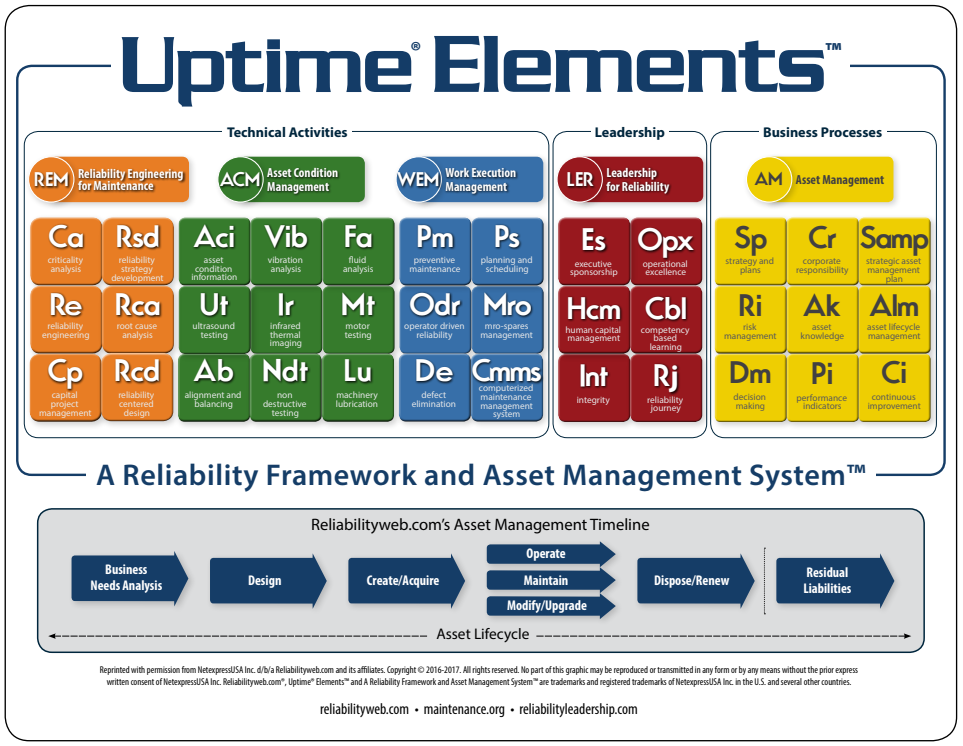

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WHO ARE WE ASKING YOU TO BE?

Reliability for Everyone with No One Left Behind!

Since the creation of Reliabilityweb.com as one of the first reliability-focused web communities in 1999, we have asked you to learn, share, grow, adapt and collaborate with us as we work to advance reliability and asset management.

Out of that collaboration, we have honored our relationships by creating a voice for reliability leadership that is being spoken by tens of thousands of reliability leaders and asset managers around the world, thereby making people safer and more successful.

Our well-being depends on your well-being. Our future depends upon your future. Our view is that innovation has always been an investment in human capital – the capabilities and competencies we create together.

The result has been nothing short of transformational. Of course, we know that many of you simply "observe" the work we do and choose not to interact with it. If that describes you, please know that we simply keep an open door and outstanding invitation available when the time, place and initiative exists. Others try to explain our work in comparative terms. If they tell you that what we do "is like something else," they miss the opportunity that the new context for reliability offers.

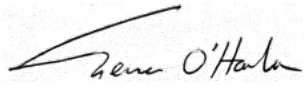
We also know that there are many who have been changed as a result of our work. They understand what we are asking them to become: smart, safe, effective reliability leaders. People who take a stand for reliability. People who stick their neck out and work at risk to advance reliability in spite of the resistance and ignorance. People who stand inside their declaration with integrity and use that as a possibility to generate reliability. People who empower a context of *Reliability for Everyone with No One Left Behind*!

These individuals range from a kindergarten teacher who became a maintenance manager, a maintenance planner who drove the asset management policy throughout an entire enterprise, an 86-year-old RCM pioneer who learns something new every day, to an asset manager in the world's largest infrastructure agency who created a future that was definitely not going to happen anyway!

We are asking you to join them in a way of working that is better and more satisfying for you, your family, your enterprise and your community.

There is something good going on, so we ask you to join us on our journey to advance reliability and asset management.

Warm regards,



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LER

RELIABILITY

IN THE NEWS

IMC2017

The 32nd International Maintenance Conference

Reliabilityweb.com® held a successful IMC-2017, the 32nd International Maintenance Conference, with over 1,100 reliability leaders and asset managers from over 41 countries participating.

Reliability Leadership Institute Community of Practice Member Meeting

CRL Workshops

Dubai - November 21-22

Santiago, Chile - November 28-29

Bonita Springs, Florida
December 12-15

2017

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Uptime magazine congratulates the following outstanding programs for their commitment to and execution of high quality Predictive Maintenance and Condition Monitoring Programs.

Uptime® Awards

2018 Uptime Awards Submissions! Visit: uptimeawards.com

Uptime® Awards

Best Overall Reliability Program

JACOBS A&T, TIDEWATER OPERATIONS GROUP, HAMPTON, VA

Jacobs is one of the world's largest and most diverse providers of technical, professional, and construction services. At Jacobs, our focus on building long-term client relationships has helped us become one of the largest and most diverse companies in our industry. Today, our more than 70,000 employees around the world provide a broad range of technical services to our industrial, commercial and government clients in multiple industries.

JACOBS TIDEWATER OPERATIONS GROUP / NASA CBM PROGRAM HIGHLIGHTS:

Our efforts have significantly enhanced system reliability for NASA's Langley Research Center (LaRC) to the point where we have not experienced a single unplanned asset failure on CBM-monitored assets since 2015! At the same time, we have significantly reduced overall maintenance costs, improved maintenance documentation (drawings, PM plans, and O&M manuals), and increased efficiency and productivity without jeopardizing safety – all of which are directly aligned with our company and our partner's (NASA) vision, mission and goals/AIM.

To date, the continued maturation of the Jacobs program, founded in the shared principles of the Uptime® Elements™ – A Reliability Framework and Asset Management System™, is the basis for our Jacobs Tidewater Operations Group program and are exemplified in the following accomplishments:

1. A sustained focus on proactive maintenance as demonstrated by 99.78% safety critical PM completion and 99% non-safety critical PM completion FY17 cumulative ratio percentages;
2. Continued implementation of CBM, including primary support for OSI/PI/Meridium data analysis software application and usage;
3. Tailored RCM procedures provide the right level of analysis based on system complexity and impact of failures;
4. Maintenance and reliability team supports multiple visits to LaRC by outside industry organizations (NRO, NAVFAC, USCG, Boeing, Lockheed, etc.) for them to observe Jacobs' world-class overall asset management in practice and common sharing of best practices;
5. Completed PM optimizations resulting in an overall 30% reduction in PM requirements or over ~12K hours;
6. Our PT&I/CBM predictive efforts from early 2014 to present date have resulted in over $3.5M in cost avoidance, in addition to reduced costs overall, allowing our customer to allocate maintenance funds to critical ROI projects;
7. FMEAs conducted on equipment types with high failure rates has directly led to **ZERO** unplanned failures for those assets in our CBM program;
8. Partnership with the NASA Geospatial Information System Team to locate assets, of which, data has successfully been utilized to optimize PM routes for domestic water values and increase productivity on all dispatched activities;
9. Conducted multiple maintenance and best practices training classes and have 34 CMRPs and four CMRTs on our staff, including all of our core site leadership team (General Manager and Executive Directors). Jacobs has recently become a contributing member of the Reliability Leadership Institute, and we are looking forward to furthering both our contributions and our education through the Certified Reliability Leader (CRL) certifications.

Uptime® Awards

Best Reliability Engineering for Maintenance Program

BRISTOL-MYERS SQUIBB

Bristol-Myers Squibb (BMS) is a global biopharmaceutical company whose mission is to discover, develop and deliver innovative medicines that help patients prevail over serious diseases.

The function of the reliability engineering program is to help deliver the company's mission by ensuring its assets, systems and infrastructure run as designed and achieving the highest possible uptime without compromising safety or quality to our patients.

The reliability engineering program at BMS focuses on a system lifecycle approach to equipment from design, build, acceptance, use and disposal. Strategies for this approach are continually aligned to the business mission. Real-time key performance indicators (KPIs) to a strong failure reporting analysis and corrective action system (FRACAS) help monitor the effectiveness of the program while also striving for continuous improvement.

Reliability-centered maintenance (RCM) approaches are also employed - a main component being criticality ranking of equipment, which aids in the level of RCM assessment given to a piece of equipment. The RCM for high critical equipment may include: work order history analysis, FMEA, BOM, maintenance strategy optimization and lifecycle costing. Condition monitoring strategies are also determined using the level of criticality. The criticality ranking is configured in the enterprise asset management system and allows for priority of work scheduling, as well as aiding in focus of failure analytics and reporting.

Without question, this program is most effective due to the leadership and culture developed at BMS and at all levels in the organization. Cross-functional teams from engineering, operations, quality, management, maintenance, metrology and supply chain all take part in reliability forums and training on the Certified Reliability Leadership program using the Uptime® Elements™ framework.

Uptime® Awards

Best Work Execution Management Program

SKOOKUM CONTRACT SERVICES

SKOOKUM CREATES JOBS FOR PEOPLE WITH DISABILITIES

Since 1988, we have helped people with all types of disabilities join the workforce by providing critical logistics and facilities management services to business and government.

RESPONSIBLE SOCIAL ENTREPRENEURS

Over 1,200 Skookum employees provide a wide range of services to a growing number of customers. Today, Skookum's wings cover 10 different states plus Washington D.C., in every geographical region of the United States. Our home office is located in Bremerton, WA.

Skookum has a reputation of excellence, open communications, transparent operations and an outstanding workforce!

Our focus is twofold, with a culture of customer support: "we meet our mission when our clients meet theirs," and our mission of "creating opportunities for people with disabilities."

Skookum utilizes IBM / Maximo and the EX Max Mobile products to put the best possible tools in the hand of our workforce. The ability to leverage technology and process improvement more than demonstrates our ability to help our clients meet their mission, while allowing our employees the ability to be as productive as possible. In essence, Maximo provides assistive technology that helps our employees succeed in their jobs.

Being recognized for our efforts with the 2017 ***Best Work Execution Management Program*** Uptime Award is greatly appreciated and demonstrates our quality in support of our client, in this case the United States Army at Fort Lee, VA. At Fort Lee, we have developed the technology that is the springboard for our team leveraging this experience for other locations across Skookum. Currently, we have over 300 users on multiple Maximo installations nationwide.

Aptime® Awards

Best Leadership for Reliability Program

MERCEDES-BENZ U.S. INTERNATIONAL, INC.

Mercedes-Benz U.S. International, Inc. (MBUSI), founded in 1993, is a five million square foot plant in Vance, Alabama, that is capable of producing 300,000 units annually, including the GLS, GLE, GLE Coupe, and the C-Class. The maintenance department at MBUSI has managed to change its culture through evolution, not revolution. After benchmarking maintenance practices at plants across many industries, including automotive plants in the U.S. and Germany, pharmaceutical, aerospace, chemical processing, oil refineries, steel mills, even a brewery and a theme park, we realized it's not "what you do" but "how you do it" that's important.

First, we trained the organization in reliability best practices and simultaneously began clearly communicating our goal to become more proactive instead of reactive. The team developed a program based on best practices, including criticality analysis for the purpose of optimizing preventive maintenance tasks, organized breakdown response, data-driven problem-solving, work planning and execution, predictive maintenance tools, storeroom stocking levels, technical obsolescence, plant-wide training, and an improved partnership between maintenance and operations. We dedicated cross-functional resources from all levels of the organization to spend eight hours per day designing sustainable solutions that fit the DNA of MBUSI.

We created a program management office to manage the interdependencies and implement and sustain the new solutions according to a plan. Not only have we successfully implemented reliability best practices and changed our culture from reactive to proactive, but we've also seen that, when given the opportunity to improve their organization, people will step up and develop into leaders at all levels of the organization.

Uptime® Awards

Best Asset Management Program

SOUTHERN GARDENS CITRUS PROCESSING

Southern Gardens Citrus (SGC) Processing is a worldwide supplier of 100 percent pure, Florida, not-from-concentrate orange juice to private label industry and major brands. Our mission statement is, "Continuously improve and become the low-cost supplier of high-quality citrus products to our customers, while maximizing returns to our shareholders."

In 1995, a maintenance excellence effort was established to improve the maintenance program. Part of this initiative was to advance project and asset management. We established an asset list where we catalog assets and estimate the assets' useful remaining life. As items begin to reach the end of their useful life, they are reviewed by management and put on the 5-year capital plan. The 5-year capital plan is populated by asset replacements flagged for reaching the end of their useful life, business needs projects, or an approved change in existing assets.

In 2006, the Management of Change (MOC) process was created by the merging of two different processes pertaining to continuous improvement: Improvement Reports and the Change Management section of our Process Safety Management (PSM) process. The backbone of our asset management is our MOC process.

This MOC process is documented with defined roles and responsibilities and covers all project and asset requests. The main inputs to the MOC process are from our root cause analysis process, existing asset changes, business needs, and PSM items.

In 2015, we established a Strategic Asset Management Plan (SAMP) that is presided over and reviewed by executive management. As prescribed by ISO55000, this plan is in accordance with our company's objectives and policies. Our 5-year capital plan, asset list, and MOC process are parts of our SAMP.

The results of our asset management program continue to yield benefits, with a reduction of total plant costs by 11.5% over 18 months, total maintenance costs by 16.9% over 18 months, emergency work by 25% over three years, required staffing levels by attrition 15% over 12 months, and project completion increased by 16.5% over 12 months.

Uptime® Awards

Best Lubrication for Reliability Program

AB INBEV LUBRICATION TEAM

AB InBev is a company of owners. Our headquarters are in St. Louis, MO, and New York, NY. We brew two of the best-selling beers in the world: Budweiser (introduced in 1876) and Bud Light (introduced in 1982). We partner closely with our wholesalers to promote alcohol responsibility. We focus on managing our environmental impact from "seed to sip," including water, energy, recycling and packaging. We provide financial contributions and volunteer with charitable organizations that support education, the environment, economic development, disaster relief and military personnel.

Our successful lubrication program has been implemented in many locations around the world. The program consists of a set of guidelines to show the lubrication teams how to organize areas, implement error proofing tools and perform oil analysis. Eight sections of compiled information were designed to create a lubrication tool kit that serves as a master guide. Progress is measured with a set of evaluation questions in a lubrication "Good Operation Practices." The evaluation visualizes opportunities and develops actions with accountability. In conclusion, the program's success provides us more production stability, contributes to equipment reliability, controls costs and reduces lubrication issues.

Think about the importance of teaching lubrication. Equipment reliability depends on best lubrication practices. Our systems need lubrication programs to enable sites to operate safely at the optimum efficiency and reliability.

Uptime Awards

Best Green Reliability Program

ENGINEERING DIVISION, MALAYSIA AIRPORTS HOLDINGS BERHAD

Malaysia Airports' Engineering Division is responsible for the maintenance of the group's airport infrastructure, worth billions of ringgits, to ensure we continue to offer the most efficient and secure service to our airline partners, as well as to the passengers who use our facilities. In line with our green commitments and our support for the national goal of reducing 45% of carbon emissions by 2030, we are working to reduce energy consumption and ensure more of our power is derived from renewable sources. Already, we have been able to reduce electricity consumption by 9,510,583kWh/year – equivalent to 1,463 homes electrified per year. The installation of light emitting diode (LED) masts has created a significant energy savings of 69% or 782,784kWh/year and also reduced carbon emissions at Kuala Lumpur International Airport (KLIA) by 1,951 tonnes CO2e per year. The e-Energy Management System (EnMS), a globally accepted framework for managing energy, has been in use since and allows us to monitor and adjust the energy performance, profile and building energy index of each facility.

We are proud of our employees as we continue to strive for excellence by recognizing their forward-thinking capability locally and internationally with these following accolades:

- ACI Asia Pacific Green Airports Recognition 2017: Platinum – KLIA;
- 3-Star Gold Award at the International Convention on Quality Control Circles, Bangkok (2016);
- 3-Star Gold Award at the Malaysia Productivity Centre on Technical Excellence Convention: Baggage Handling System Team, Electrical Power Supply Team & Building Services Team;
- Best Facilitator for Technical Excellence – Amran Abdul Razak & Mohd Fauzi Ismail;
- Best Complaint Management Category at SPAD Land Public Transport Symposium, KLIA;
- Honorable Mention by ACI Asia-Pacific Young Executive Award 2016 – Mohd Khairulfatin Zulhaimi;
- Special Recognition Award for Best Culture of Reliability - Uptime Awards, USA, (2015).

To conclude, we, the Engineering team in Malaysia Airports Holdings Berhad, are committed and dedicated to serve our stakeholders and also to promote best practices in engineering operations and maintenance throughout the group. We will continue our best and may God bless us all.

Uptime® Awards

Special Recognition Award Safety in Maintenance

CINTAS CORPORATION

Cintas Corporation helps more than one million businesses of all types and sizes get ready to open their doors with confidence every day by providing a wide range of products and services that enhance our customers' image and help keep their facilities and employees clean, safe and looking their best. With products and services, including uniforms, mats, mops, restroom supplies, first aid and safety products, fire extinguishers and testing, and safety and compliance training, Cintas helps customers get **Ready for the Workday®**.

HIGHLIGHTS OF THE CINTAS MAINTENANCE SAFETY CERTIFICATION PROGRAM

Due to the nature of the work our maintenance partners complete, it became our desire for each one to become a safety leader. After all, maintenance partners have the potential to be in and touch every area of every facility, including areas where most partners will never step foot. We found it critical that they be highly trained in the knowledge and understanding to perform all aspects of their job safely.

Our team developed a program to address this knowledge and understanding in the effort to develop each maintenance partner to be a safety leader at their location. The program is driven and coordinated by Corporate Engineering field partners with support from the Corporate Safety & Health teams based in the field.

Program elements consist of several segments and activities to guide our partners on their journey to excellence in their daily jobs.

- **Study Guide:** Questions from various existing safety training for the partners to study and know.
- **Weekly Training Calls:** Partners must attend a weekly training call during which the questions on the study guide will be reviewed.
- **Q&A:** Partners will be tested on many questions from the study guide. The certification panel will consist of the location's General Manager, the Corporate Engineer, Safety Coordinator, and others.
- **Scenario Questions:** Real-life situations will be discussed for each partner to prove they know how to practice the skills and knowledge they have learned.
- **Demonstration:** Where the rubber hits the road—the partner is required to successfully complete a live demonstration of the skills, involving confined space entry procedures, live electric panel access, and Logout-tagout.

Upon successful completion of these steps, the partner is certified, presented a trophy, and deemed a safety leader in their organization.

Uptime® Awards

Special Recognition Award Best Reliability Centered Design

THE MOSAIC COMPANY

With populations rising while land devoted to farming shrinks, Mosaic's mission is helping the world grow the food it needs by producing quality fertilizers that increase crop yield. The Mosaic Company has nearly 9,000 employees across the globe and is the world's largest producer of phosphate and potash fertilizers. Mosaic's phosphate business unit operates mines in Florida and processing plants in Florida and Louisiana, which produce concentrated phosphate crop nutrients.

In 2013, Mosaic collaborated with Allied Reliability Group to improve reliability elements of its capital project management (CPM) process. Prior to that time, there were vague references to reliability and maintainability, but the CPM process lacked definition and the results were frequently not satisfactory. Over the next couple of years, Mosaic pulled together specific guidance for numerous reliability elements within the CPM process. In essence, Mosaic raised expectations of an acceptable deliverable from a capital project to include:

- Design considerations for maintainability and asset reliability over the total lifecycle;
- CMMS updated with hierarchy and asset attributes;
- Failure mode based asset strategies developed through RCM or FMEA analysis;
- Equipment maintenance plans developed and implemented prior to start-up;
- Asset bills of materials populated in CMMS and critical spare parts inventoried;
- Enhanced QA/QC and commissioning programs.

Once Mosaic had implemented the improved CPM process, employees leveraged the enhancements by applying them on a major capital project. The outcome of this crucial project met nearly every project measure, in addition to having a "vertical launch" start-up in terms of delivering expected production quickly. Mosaic continues to refine the RCD process and leverage it on capital projects across the company.

Uptime Awards 2018

NOMINATE YOUR PROGRAM FOR THE 2018 UPTIME AWARDS

The Uptime Awards recognize the best and most innovative reliability professionals in the world. Get the exposure and acknowledgment for your reliability and asset management program.

HURRY! Submissions due by April 30th.

uptimeawards.com

BENEFITS OF PARTICIPATING IN THE UPTIME AWARDS PROCESS:

- **CREATE** an opportunity for external assessment and comparison.
- **DEFINE** the business case for a sustainable program.
- **FOSTER** teamwork and acknowledge all stakeholder contributions.
- **SHARE** program details and best practices with the global reliability and asset management community to create external knowledge sharing and benchmarking relationships.
- **RECEIVE** internal recognition, program validation and organizational support.

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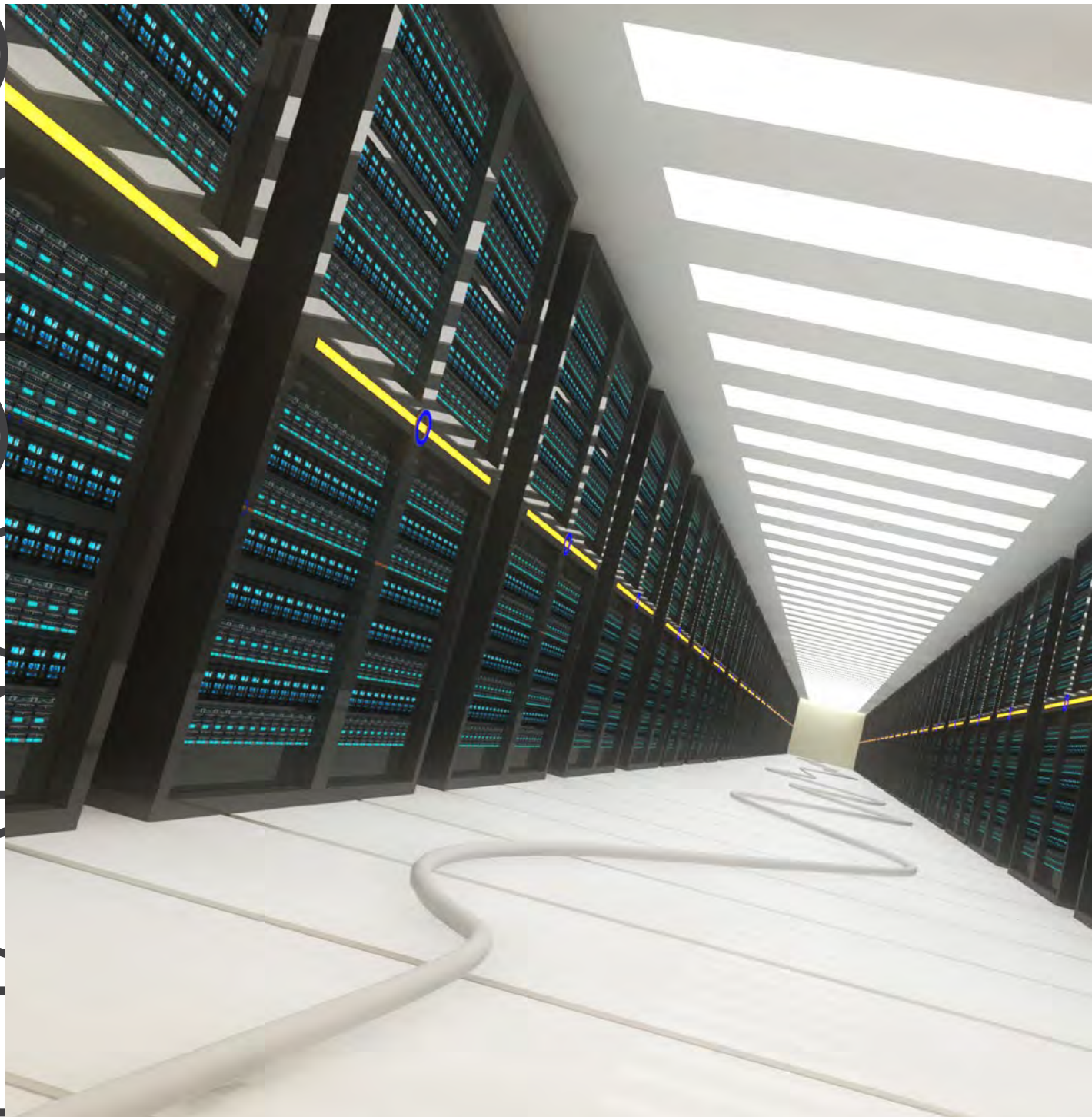

Mark Gaydos

The hyperscale data center segment is growing as the never-ending onslaught of data continues to require new and more agile transport systems. This need is creating a unique challenge for teams tasked with the management of assets and their lifecycles in these dynamic and sometimes dispersed hyperscale data center environments.

Hyperscale is a term usually associated with facilities on a massive scale. It also means an environment that is complex, constantly changing and dependent on scalability as demand grows. Operating hyperscale facilities at peak efficiency and using resources as responsibly as possible brings on a whole new infrastructure management era, especially when asset lifecycle management (dock to decom) is taken into account.

Dock to decom refers to asset management from the point at which the equipment is received on the loading dock throughout its useful lifecycle, all the way through to decommissioning. Due to the sheer scale of hyperscale environments and their evolving growth, these data centers constantly require streamlined workflows and rapid application response times to support hundreds of instantaneous changes. Without a complete and consistent dock to decom strategy, hyperscale organizations can't operate efficiently. However, data center infrastructure management, (DCIM) solutions are helping and quickly becoming a vital part of hyperscale data center operations.

With a DCIM system in place from the day an asset enters the system, its location is tracked so management is aware of:

- What the asset is connected to;
- How much power it is drawing;
- The work it is performing;
- Its temperature, its redundancy;
- The risks involved if the particular piece of equipment should fail.

In addition, a DCIM solution allows data center operators to manage changes to the asset, including physical location, as well as its place in the workflow. A rich set of information is provided, including who has worked on the equipment, as well as when and what type of work was performed.

It is the data center manager's job to know:

- Where the asset is in its lifecycle;
- The maintenance schedule;
- Warranty information (i.e., whether keeping the particular asset will be more expensive than replacing it);
- When it should be decommissioned.

Managing complex, highly dynamic data center environments requires a distributed enterprise architecture that can scale across multiple physical servers for a real-time, interactive user experience. The DCIM solution should offer features to ensure:

- Rapid application response times under massive load to enable deployment of new applications and equipment with high levels of service while reducing IT costs;
- Efficient scalability to enable services, such as backup, restore, resiliency, redundancy and load balancing;
- Connectors to support integration with existing management frameworks for virtualization, configuration management database (CMDB) and service desk and inventory management applications for goods receiving.
- A "single pane of glass" view of the entire organization that enables a consistent approach to managing assets, capacity and energy use.

> "Dock to decom refers to asset management from the point at which the equipment is received on the loading dock to throughout its useful lifecycle, all the way through to decommissioning."

Figure 1: DOCK TO DECOM

This type of management is particularly challenging with facilities that are geographically dispersed. Each location typically has its own system for tracking assets and infrastructure, and if these systems don't interoperate, each department or location might become silos, making it difficult to extract and combine data. A unified view across all facilities is needed to prevent misunderstanding, errors and repetition of work.

Additionally, the DCIM solution must provide the following:

1. The ability to handle the sheer volume of equipment and constant change; with large numbers of assets involved that are constantly changing and on the move, all the data needs to be accurately tracked, hence, the DCIM solution must be flexible and uniquely nimble.
2. Real-time data for informed decision-making, greater energy efficiency and disaster prevention.
3. A holistic, real-time view of what is going on in the entire data center to allow operators to make the best business decisions quickly. In addition, it allows for adjustments to avoid situations such as an overload or overheating incident. Real-time data also simplifies the deployment of new assets or the rearrangement of equipment for greater efficiency, as well as stranded capacity discovery.
4. Discovery of the power draw of each piece of equipment for load balancing.
5. Long-term trending data for future capacity planning; trending data is important for advanced planning to accommodate future needs, as well as analysis of what equipment may be underutilized so consolidation or retirement of these assets may be considered. Capital expenditures can be delayed or even canceled if present space, power and cooling capacity can be used to its most efficient potential.
6. The ability to communicate with all types of equipment, regardless of age or manufacturer; another unique challenge present in the hyperscale environment is the number and variety of types of equipment from different suppliers and vintage. The DCIM solution should be able to communicate with and gather data from a greater variety of sources, either natively or through the use of connectors.

A data driven world requires data centers to operate at a rate and scale never before imagined. Data center operators must meet these demands if they are to remain competitive and be able to increase the speed at which they can deploy new applications, all while remaining cost-effective. Hyperscale data centers are fast becoming the norm and solutions that manage and optimize these facilities must meet these specific demands to ensure rapid application response times at any scale.

Mark Gaydos *is Chief Marketing Officer for Nlyte Software, the leading data center infrastructure management (DCIM) solution provider for seamlessly automating data center operations and infrastructure into an enterprise's IT ecosystem. www.nlyte.com*


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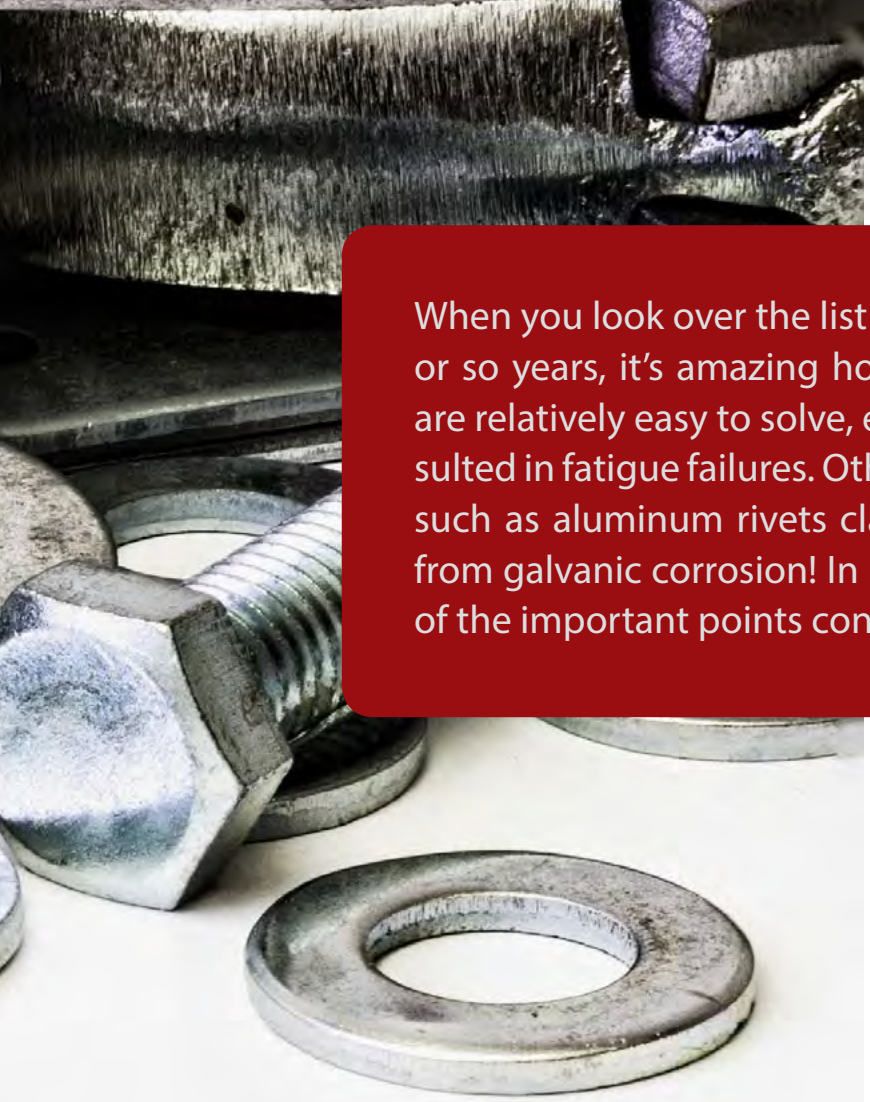
SOME PLAIN TALK ABOUT NUTS AND BOLTS

Neville W. Sachs



Part 1 of 2

When you look over the list of projects you've worked on in the last 20 or so years, it's amazing how many involve fastener problems. Some are relatively easy to solve, especially where careless practices have resulted in fatigue failures. Other problems are much more sophisticated, such as aluminum rivets clamping aluminum sheet metal that failed from galvanic corrosion! In Part 1 of this series, a Q&A addresses some of the important points connected with common bolting practices.

> "...Being consistent in tightening practices is more important than the specific torque."

Q. Why do bolt torque charts frequently vary with their torque values? As an example, for a certain size bolt, one chart may say to use 45 ft-lbs (61Nm), while another, for the same conditions, will say to use 55 ft-lbs (75Nm).

A. Understanding how torque charts are developed will help you see that the differences really aren't that significant. And, good practice says that being consistent in tightening practices is more important than the specific torque.

The way designers and manufacturers usually develop a torque spec is to take a group of fasteners, say a lot of 10, and very carefully tighten each of them until they begin to permanently stretch. This essentially happens a little below the yield stress of the steel and is considered the proof load of the fastener. Then, they look at the torque needed to just begin that stretching. As an example, let's say that was 100 ft-lbs (135Nm).

Next, to ensure there is adequate clamping force without any of the bolts breaking, the normal tightening torque is set at some percentage of this 100 ft-lbs (135Nm). If the designer is very conservative, it may use a factor of 55 percent and say the bolts should be torqued to 55 ft-lbs (75Nm). On the other hand, another designer may be far less conservative and specify that the bolts in its design be torqued to 80 ft-lbs (108Nm). The result is a range of tightening values. However, it is really important to use uniform tightening practices.

Also, if you are dealing with anything other than very thin gaskets or a metal to metal joint, the type of gasket material has to be considered in specifying a torque value.

Q. Why is being consistent in tightening practices more important than the specific torque value?

A. Obviously, you have to tighten the joint enough to prevent leakage or movement, and most mechanics are very good at that. The problem with uneven tightening is that it will cause distortion, leading to all sorts of other problems. In one production application, for example, a simple change in the tightening procedure cut the leak rate by 80 percent. Maintenance had been going once around an eight-bolt pattern at 100 percent of the specified torque. When that was changed to the first pass at 50 percent and the second pass at 100 percent, the number of leaks dropped substantially. In

a continuing effort to improve, the tightening procedure was also tried in three steps, 40 percent, 70 percent and 100 percent, which dropped the leak rate by another 50 percent. However, the plant decided the additional cost wasn't worth it.

Q. Can nuts and bolts be safely reused?

A. Yes, as long as you're intelligent about inspecting them. (Though sometimes, it is less expensive to throw out the old bolts.) Some bolt manufacturers say never reuse any nuts and bolts. They emphasize this with demonstrations at technical events, but the conditions in these demonstration aren't realistic or practical for the real world. As such, in most cases, you shouldn't hesitate to reuse nuts and bolts. For reassurance, ask your fastener salesperson if he or she changes the wheel studs along with the vehicle's tires.

Two things to be concerned about with reused fasteners are whether they still have their initial strength and whether they've been affected by corrosion. If the bolt threads haven't been stretched, if the bolt hasn't been heated to high temperatures, if it hasn't been exposed to leaking steam and if the bolt isn't rusty, you can reuse it without hesitation.

This raises additional questions:

1. How do you check to see if the threads have been stretched?

   Run a nut down the bolt. If the bolt has been overstressed, the threads will bind and the bolt should be trashed.

2. How hot can a bolt be heated before the metallurgy is changed?

   For most bolts used in industry, you wouldn't get concerned until they have been well over 600^{0}F (315^{0}C).

3. Can you remove light rust with a wire brush and make the bolt as good as new?

   If the bolt is a Grade 1 or 2 (not a heat treated bolt), the answer is yes. However, if the bolt has been heat treated and has rust on it, the safe course of action would be to throw it out.

Q. How do you find out what grade a bolt is?

A. Look at the head of the bolt. If there is no marking on it other than a trademark, it is a low strength, U.S. thread bolt. All strengthened, general purpose bolts, whether heat treated or strain hardened, must have the manufacturer's trademark and an approved grade symbol. Be very careful because a small difference in the symbol may make a huge difference in the strength. As examples, a **Grade B8** is almost three times as strong as a **B8** (Note: underline is critical to describing strength levels), an **F593C** is made from a different stainless steel than an **F593D,** and a **Grade B7** is substantially stronger than a **Grade B7M**.

Q. Should nuts and bolts always be lubricated before assembly?

A. It depends on the manufacturer's specifications. There are some applications where lubrication is frowned upon. For example, car manuals say to never lubricate wheel lugs and nuts. This is to reduce the chance of a lug nut working loose. Also, many structural applications, like the bolting used on structural steel, don't need a lubricant because they are tightened to the point where the steel has yielded. However, for most mechanical applications, fastener lubrication is important for improved reliability.

As a nut and bolt are tightened, some of the torque goes into stretching the bolt, some goes into overcoming the thread friction and some goes into friction between the rotating piece and the bolting surface. The more control you have over the amount wasted on friction, the better you can control the clamping force. By lubricating the threads and the face of the rotating member, the typical variation in clamping force can be cut in half.

The real benefit of fastener lubrication is that more uniform clamping force reduces component distortion and improves the life of mechanical components.

Q. When should high strength bolts (e.g., Grade 8, A490, or metric 10.9) be used?

A. Hardly ever.

Many pieces of industrial and commercial equipment are designed using SAE Grade 1 or Grade 2 bolts, their ASTM equivalent, A307, or metric 4.8 and 5.8 bolts. These are bolts made from mild steel and are very tolerant of abuse. Others are designed using SAE Grade 5 bolts, one of their ASTM equivalents, or metric 8.8 bolts.

Very few pieces of equipment, other than hydraulic systems, are designed with SAE Grade 8 fasteners because, with high strength bolts, the trade-off for higher strength is greater sensitivity to corrosion and embrittlement problems.

There is good data showing that atmospheric corrosion will cause occasional hydrogen cracking and fracturing of some Grade 8 bolts. This means if Grade 8 bolts are used in an atmosphere that results in corrosion, some of them will crack and fail because of the corrosion.

Grade 5 and ASTM A325 and ASTM B7 bolts are also subject to hydrogen cracking, but are much less sensitive to the environment. They usually crack only when used around acids and compounds containing sulfur. However, there have been instances where they have cracked and failed from exposure to steam leaks.

So, a more detailed answer to the question would be: As seldom as possible and never in a critical application where corrosion is present.

In Part 2, there will be more about bolting practices, plus why washers, especially hardened washers, are a good idea.

Neville Sachs *is a graduate of Stevens Institute of Technology and a registered P.E. In the last 40+ years, he has worked to better understand materials and mechanical devices, with the goals of improving operating reliability and educating the engineering and maintenance workforce. He has written more than 50 technical articles and two books on failure analysis and has conducted practically-oriented failure analysis seminars across North America and Europe.*

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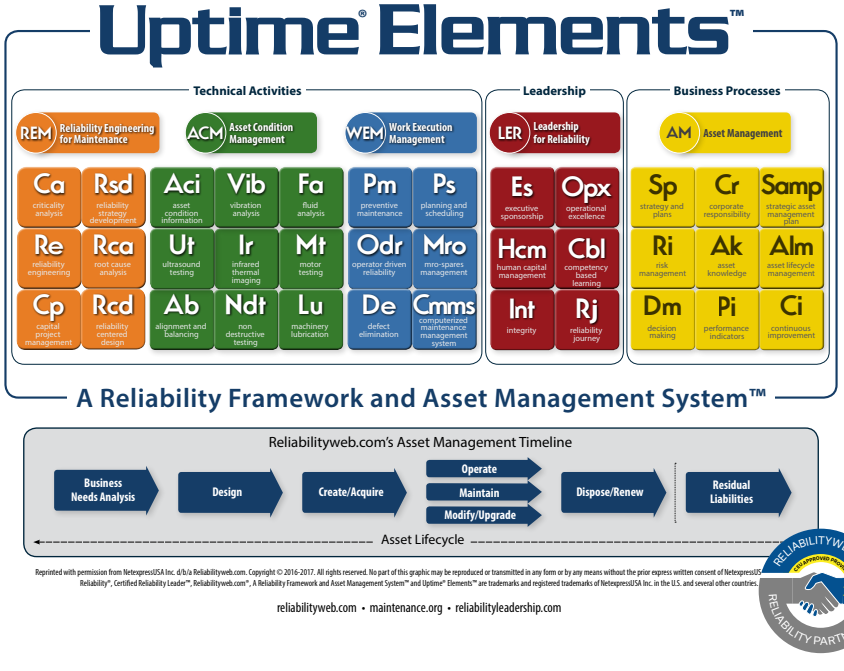

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How to Get the RESOURCES AND SUPPORT YOU NEED

Kent Knight

If you're getting comments like these, you're not alone. For those in the reliability field with a technical background, it can be frustrating. Your response might be, "The numbers in the spreadsheets are clear. Why is it so hard to get support from the executive team?"

Although your work is backed by hard science and a solid body of work, the fact is many others in the company may not have a good picture of what maintenance reliability professionals do to contribute to its success.

This article gives you some ideas on how you can demonstrate the value of your work and that of your team's in order to get acceptance and support from the rest of the organization. As a result, your recommendations get followed, you get the staff and budget you need, and you're seen as a team player.

Learn to Talk Their Language

Each profession has its own terms of reference, values and jargon. One of your first steps is to learn to communicate your ideas in the frame of reference of the person you are working with. Members of the finance department will talk about costs, profitability and other financial issues. Human resources people will want to know about staffing requirements. Operations team members want to talk in terms of availability of equipment, planned versus unplanned downtime, event impacts on production and any way you can help them meet their productivity and quality targets.

And then there's a common language. For example, consider the definition of reliability. Most people will define it as meaning, "What I expect to happen, happens." Most people will recognize that this is only the case if conditions are right. You can use analogies they will recognize from their own lives. For example, with their own car, they understand they can expect it to operate smoothly as long as they don't drive it at the redline all the time or skip service appointments.

Stepping out of your comfort zone and into theirs may be a challenge, but the key is good preparation so that you're confident in your message. Here's an example of this approach in action:

The predictive maintenance (PdM) group of a major oil company worked in the harsh environment of the oil sands of northern Alberta, Canada. The group held regular meetings with people in other departments. These people are responsible for some of the biggest mobile equipment (e.g., trucks, shovels, bulldozers, graders, etc.) in the world. Taking down a truck or other asset for an hour of maintenance is a big deal. So, in the weekly meetings, the PdM group went over the current issues and how they could be addressed, building rapport with the maintenance managers, as well as the frontline staff. These department representatives grew to have confidence in what the PdM group was recommending and this confidence grew as the group incorporated the departments' feedback into its recommendations. They came to see that taking down a haul truck to check some worrisome diagnostic reports, even if nothing wrong was found, was much better than having it fail in the field or in the shop for major repair.

Build Credibility That Comes From Results

The acceptance and credibility you need comes from building a track record of success. Year-over-year statistics help, showing the results of processes followed and how maintenance costs have changed over time. Show that the availability of assets is going up and demonstrate that this is because you're monitoring for adverse conditions and resolving them before they manifest themselves as a catastrophic failure.

While spreadsheets may be easy for you to understand, it's much better presenting this sort of data in chart form. Also, be sure to put the data in terms your listeners will understand, such as availability, dollars saved and staff hours.

> "Why is it so hard to get support from the executive team?"

Proving Your Worth When Things Go Wrong

Generally, many reliability initiatives start when things get bad, such as cost overruns, unplanned downtime, component failures and, sometimes, safety incidents or even fatalities.

However, equipment failures can be some of the best possible opportunities to show your worth. Perhaps you identified the problem before, but the maintenance or operations manager didn't want to bring the equipment down for operations reasons or to meet the productivity target for the month. The equipment continued to operate and the "unforeseen" failure occurred.

You need to make the best of these learning opportunities. Document the course of the failure, including any warning signs that were ignored. Take pictures of what the equipment looks like when torn apart, such as gears missing teeth or a shaft torn in half. Photos and visual indicators really help, particularly when working with people with nontechnical backgrounds. Images and video are easy to take with a standard smartphone and incorporate into your presentations or written communications.

Figure 1: Sometimes visual evidence is best for convincing others in the organization about the importance of a good reliability program, such as this damaged spiral bevel gear (Image courtesy of Fluid Life).

In this manner, you can convey the issue to the technical and nontechnical management team members, showing where the symptoms developed, how the failure progressed and the consequences. Show how the failure impacted the downstream processes and how this affected production. Describe the impact in dollar terms and how this is reflected in payroll and bonuses. Additionally, describe the implications for overtime, safety, the need to bring in contractors and the need to rent equipment.

This helps you to demonstrate your grasp of the situation, show how you could have prevented it and why your recommendations should be followed in the future.

Bring in the Science, Carefully

Many of the people you need to convince have professional backgrounds in nontechnical fields, such as finance, accounting and law. They may see maintenance reliability as a black box.

So, you need to explain to them the science involved in what you do. This helps you deal with comments and questions, like those at the beginning of this article, particularly, "Our equipment doesn't break down much, so how do we know we're not spending too much on reliability functions?" Short of pulling out your hair pointing out that it's your work that helps keep that equipment humming smoothly, you may be able to point to some of the science behind your team's work.

This includes diagnostics, such as oil analysis and showing how laboratory studies of lubricant samples can reveal potential problems, including how much wear material has built up in the oil and contamination from fuel or coolant. A good laboratory can do a comparison between unused lubricant and the sample drawn from your machine, or compare samples drawn from similar equipment elsewhere.

Sometimes, Less Is More

One of the key success factors in implementing reliability measures is striking a balance between too much and too little maintenance. Each time a machine is opened up for servicing, there is the potential for causing new problems, such as dust and grit entering uncapped hydraulic hoses that have been left on the floor, incorrect or worse quality parts being installed, or new parts installed incorrectly.

As such, members of other departments may be surprised if you recommend fewer service related shutdowns than they had expected. But, if you are watching diagnostics, such as run temperature and vibration, closely and using fluid analysis effectively, less service can lead to increased reliability.

In short, it's important for those in the reliability field to have a solid grasp of the technical aspects of success. But, not ignoring the soft skills, such as communication, will help give you the resources needed to do your work effectively.

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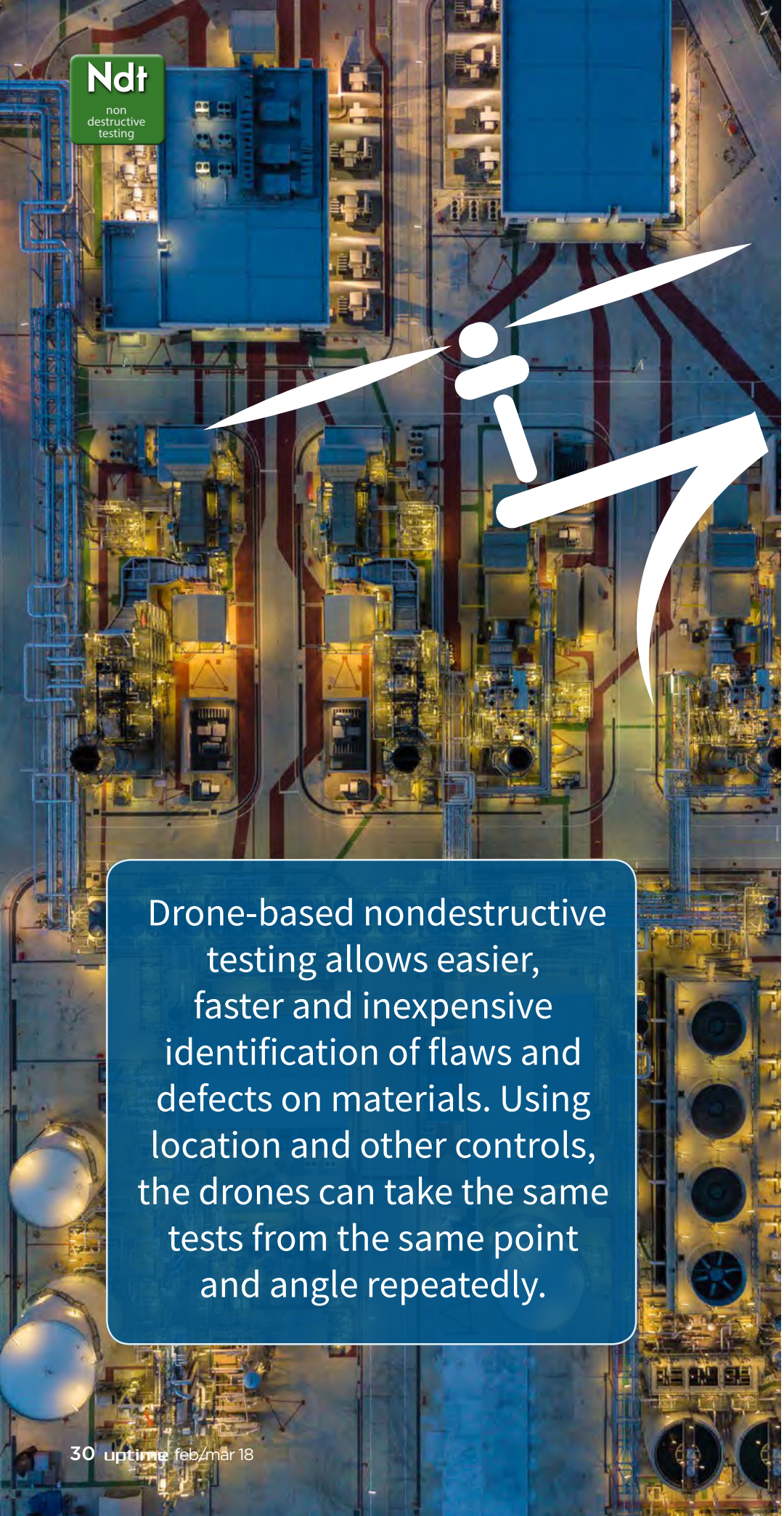

Drone-based nondestructive testing allows easier, faster and inexpensive identification of flaws and defects on materials. Using location and other controls, the drones can take the same tests from the same point and angle repeatedly.

Chris Leightell

Drone-based inspection and maintenance provides a wide range of possibilities that take advantage of the mobility of the drone, as well as the nondestructive nature of the tests. These tests can help oil and gas companies identify defects and reduce the rate of failures and unplanned shutdowns.

The delicate nature of the oil and gas industry requires close and careful monitoring of its systems, such as pipelines, refineries and more. However, some traditional nondestructive testing (NDT) requires shutting down operations, as well as the repair or replacement of the test area or component.

Benefits of Drone-Based Inspections

Drone-based inspections provide a cost-effective, safe and faster solution for most oil and gas inspection needs and do not require shutting down operations. Due to their simple and flexible nature, drone-based NDT inspections can be used to regularly monitor the integrity of the oil and infrastructure throughout its service life.

Here are five reasons why drone-based inspections will be essential in the facility maintenance and inspection industry of the future.

Wide scope and capabilities

New technologies make it possible to equip drones with a wide variety of sensors that perform different kinds of inspections. A drone provides the mobility that allows an inspection of almost any facility, regardless of its design or location.

Combining a drone with a suitable NDT technology increases the ability to perform a wide variety of inspections without destroying or changing any materials' physical characteristics. This helps in identifying most surface and subsurface defects, and can be very useful in the oil and gas industry due to its delicate nature.

THE USE OF DRONES IN THE FUTURE FACILITY MAINTENANCE AND INSPECTION INDUSTRY

Some common tests include visual inspections, eddy current inspections, liquid penetrant inspections, ultrasound inspections, thermal imaging, radiography inspections, and more. Each of these produces a set of results that aid in determining if components are still meeting the required standards and regulations.

Reduce inspection time and costs

Drone-based nondestructive testing allows easier, faster and inexpensive identification of flaws and defects on materials. This enables the maintenance department to carry out prompt repairs of replacements before problems occur.

Each of the technologies plays its individual role in reducing the costs and time it takes to perform an inspection. Further, testing without shutting down operations means the company will save time and avoid production losses.

Only a few workers, if any, need to go to the field to carry out the inspections. Additionally, drone-based NDT inspections greatly reduce the need for large transport vehicles and helicopters to reach remote areas. The technologies reduce the transport, as well as insurance costs. And, since the tests take less time, the company spends less on accommodations and allowances.

Drone-based NDT inspections can quickly identify the majority of defects and provide maintenance personnel with enough information to allow them to fix problems and prevent leaks and pipeline damage.

Improve safety and minimize accidents

Drone-based inspections can significantly increase safety, reliability and the efficiency of the oil and gas infrastructure. In particular, they help to improve on-site safety for workers by avoiding accidents and injuries associated with traditional destructive testing.

The nondestructive inspections provide a safe and effective way to identify defects that may lead to unsafe conditions, malfunctions, or catastrophic failure. Drone-based inspections prevent accidents associated with test procedures where workers need to access difficult to reach areas and hostile environments. In addition, they minimize the possibility of fires and other accidents that may occur during traditional destructive testing, such as those involving welding or using open flames.

By identifying defects in ample time, drone-based inspections allow maintenance departments to fix problems before they occur. This, in effect, prevents failures that can lead to fires and accidents to workers, as well as people in the community near the affected facility.

Improve facility reliability

Tampering with equipment design during destructive testing affects its reliability and, sometimes, its design life. For example, if cutting a certain part of metal is required, welding back the part results in some changes to the material's structure. This will either weaken the welded part or the surrounding area, causing parts of the welded area to respond differently to operational stresses. Drone-based NDT inspections, on the other hand, do not interfere with the structures, so they continue retaining their initial design form.

Drone-based NDT inspections also can be used to determine whether structures meet certain environmental and safety requirements. Most of these regular tests can be carried out effortlessly with drones. If the assets meet the accepted levels, the systems can continue operating, otherwise, repairs or replacements are performed to avoid issues that may lead to unplanned shutdowns or disasters.

Comprehensive, accurate and reliable inspection data

By using a drone to access difficult areas, the NDT can then evaluate the structures and provide immediate comprehensive data that otherwise would have taken several days using traditional access methods. Drone inspections in the oil and gas industry can provide reliable and accurate test data on a variety of properties. The inspection process is usually repeatable and can be very useful when analyzing the effectiveness of any repairs.

Using location and other controls, the drones can take the same tests from the same point and angle repeatedly. This helps maintenance personnel produce accurate results and eliminate errors that would arise from taking tests on different locations.

Conclusion

Combining drones with NDT brings in the advantages of drone mobility and flexibility, as well as the nondestructive nature of the inspection. This increases safety, produces cost savings and does not introduce weak points on the materials tested.

However, the use of drones in facility maintenance and inspection will require an understanding of the task the drone is to perform and what kind of information it will look for. Knowing the capabilities, as well as the limitations, of drone NDT inspections is key. It is also critical to understand the relevant standards and specifications in relation to the test. However, when used correctly, a drone-based NDT inspection can provide valuable information while keeping the structures intact.

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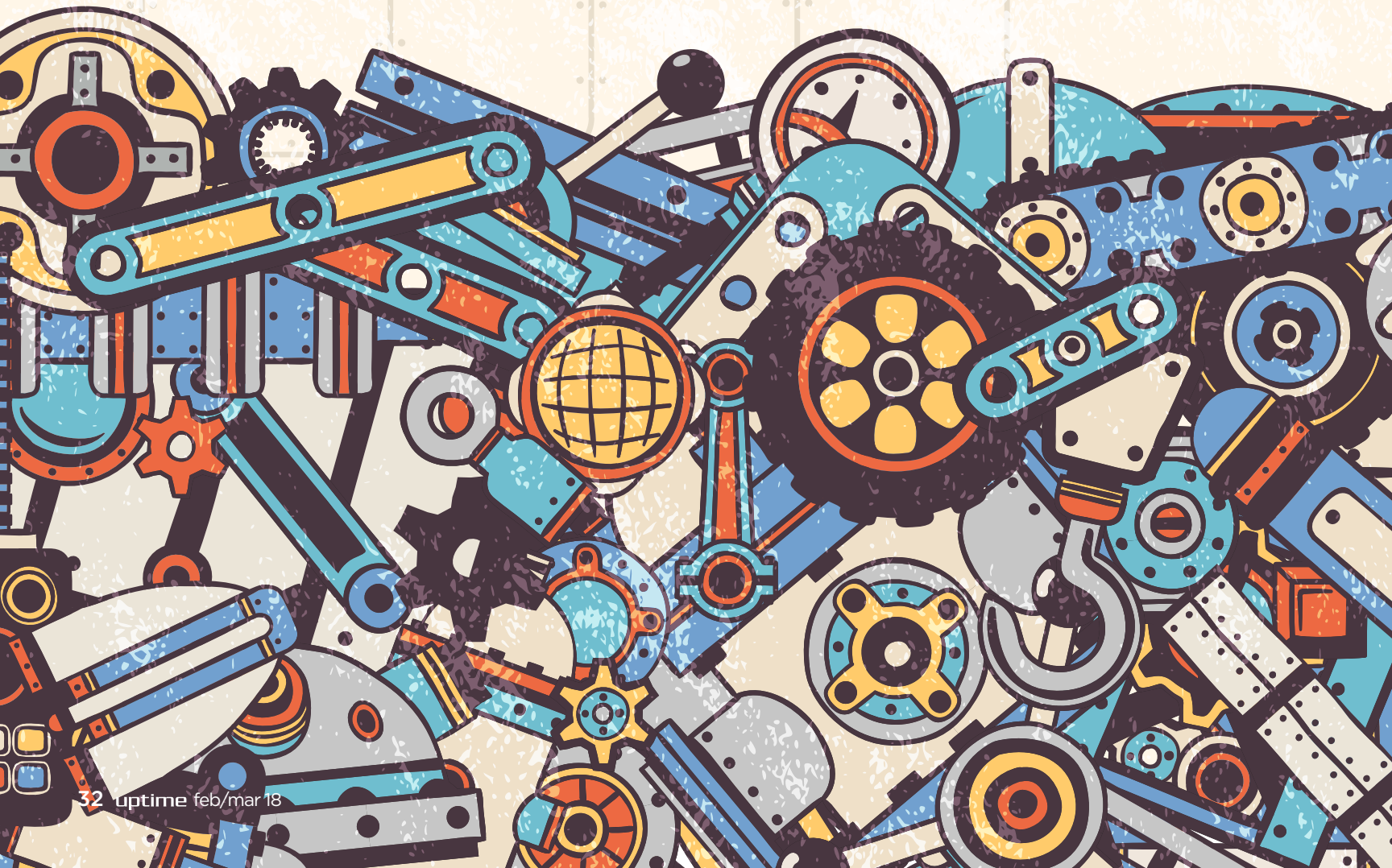

As anyone with a hand in running a household knows, it's important to keep a stockpile of key items. You certainly don't want to find out the hard way that you're on your last square of toilet paper! But in the case of a facility like a power plant, a missing spare part could be more than just a nuisance, it could be downright expensive.

Determining the appropriate spare parts to have on hand in a large facility, however, can be tricky. This is especially true after building a facility from the ground up, when you don't have a frame of reference for which spare parts you're most likely to need first.

Most organizations deal with this in one of two ways: 1) they guess or 2) they purchase according to a spares list provided by an equipment vendor.

A Reliability-Focused Purchase List

There are obvious limitations when it comes to guesswork. Making the wrong guess can result in huge expenses, either in unnecessary spare parts or in costly downtime. An equipment vendor's suggested list probably would be somewhat more accurate, but such suggestions are unlikely to take into account the specific needs of your organization. A better way is approaching spare parts recommendations through the lens of reliability as it applies to each specific operation. As factors change, it's important to reevaluate, making sure to take into account everything that could influence purchase priorities.

For example, recently a utility company sought to review the list of spare parts its equipment vendor had recommended. According to the equipment vendor, the utility needed to purchase $4.9 million worth of spare parts up-front. The utility wanted a second opinion before making such a sizable investment.

> "The investment the utility company made to conduct a spare parts analysis ultimately resulted in a savings of 50 to 1."

Spare Parts Analysis

The external reliability consultant started a spare parts analysis by looking at the list provided by the equipment vendor, then digging much deeper. A series of questions was explored, including: How often is this part likely to fail? What is the cost of the downtime if the part is attached to a critical piece of equipment? What is the unit cost of the spare part? What is the lead time to obtain a spare? Is this part likely to fail at any time throughout its lifecycle or is it only likely to fail at the end of its life? There is no point in purchasing a spare today if you are unlikely to need it for another 20 years.

In all, about 1,500 pieces of equipment were reviewed over 40 days before providing a recommended list of spares. The final list included some of what the equipment vendor had recommended, left off many of its recommended parts and suggested a few additional parts that weren't on the original list.

The final critical spares list that was recommended included a total of $2.2 million in spare parts, a savings of $2.7 million over what the equipment vendor had originally recommended.

Built to Adapt

The reliability consultant's recommended spares list is intended to be responsive to changing needs and new information. When the utility took a second look at its downtime cost and calculated that it was actually $10/megawatt and not the $23/megawatt it had initially determined, the consultant reevaluated the spares list, reducing the utility's recommended purchases by another $200,000.

Conclusion

The investment the utility company made to conduct a spare parts analysis ultimately resulted in a savings of 50 to 1. Beyond the monetary benefit, the utility's reliability engineer felt much more confident in the approach taken and was relieved in being able to avoid grossly overspending on spares.

If yours is like most organizations, you probably run into trouble when it comes to having the right spares on hand. Either you're missing the right parts when something breaks down or you have expensive spares gathering dust and potentially going bad in storage. Getting a second opinion from a reliability-focused consultant takes the guesswork out of developing a critical spares list by taking into account item costs, the likelihood of failure, lead times, downtime costs and all other relevant factors.

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MAINTENANCE STRATEGIES: IS THERE A SIMPLE SOLUTION

Randy Clark

PREVENTIVE
PREDICTIVE
PROACTIVE
RUN TO FAILURE
REACTIVE

No doubt you have heard these terms, read articles and attended workshops and seminars to learn about these strategies. Using this information, you've discovered which ones will make your maintenance program more effective, reduce labor hours, reduce costs, increase equipment availability and ultimately improve production.

Based on experience gained from being around maintenance shops for many years, visiting with people in a variety of industries and talking with maintenance professionals around the globe, the conclusion formed is: There is a right time and a right place for each of these strategies.

Preventive Maintenance

For years, maintenance professionals relied on preventive maintenance strategies to take action on a prescribed interval, such as days, hours, miles or tons hauled. On a predetermined interval, they took action to drain and fill oils or replace an engine, transmission, or gearbox. They did so without regard for

the condition of the oil or whether or not the component was running well. The thought was, if you maintain it on a time based interval, you won't have to work on it tomorrow as an unscheduled event.

Predictive Maintenance

Then came a time when maintenance shifted toward a predictive or conditioned based strategy. This approach requires the use of nondestructive, noninvasive testing, such as vibration analysis, thermal imaging, ultrasound and oil analysis. It also includes monitoring work order history, the number of operator complaints, dollars spent on minor repairs and the frequency of those repairs.

One might look and immediately come to the conclusion that predictive maintenance is the strategy that should be followed. After all, "If it isn't broke, don't fix it!" However, there are times when a predictive maintenance approach might not be the proper method.

Let's look at a scenario of a gear pump in a minor circuit or as a support piece of equipment. In this scenario:

- The oil capacity is minimal.
- Oil changes are easy to perform and are not labor intensive.
- The cost of the gear pump replacement is minimal.
- A replacement gear pump is readily available.
- There will not be a significant impact to production.
- There are no safety concerns associated to the failure.

> Do the benefits of predictive maintenance outweigh the run to failure or preventive approach?

Would following a predictive maintenance strategy be the correct choice, or should you, perhaps, consider a run to failure or preventive maintenance strategy?

In this scenario, it is important to consider the cost of nondestructive testing and the labor hours involved. The question to consider is: Do the benefits of predictive maintenance outweigh the run to failure or preventive approach?

On a side note, a strictly predictive approach offers some challenges, compared to a preventive approach, when trying to forecast and prepare next year's maintenance budget. That, however, is a topic for another day.

Proactive Maintenance

The proactive maintenance approach can be used in combination with any of the other maintenance strategies, although many would argue that this is a "stand-alone" maintenance strategy. With this approach, you look at the root cause of both impending failures and an analysis of failures that have already occurred. You look beyond symptoms and look at root causes, such as incorrect lubricants, faulty rebuild practices specific to the part of the rebuild procedure that was incorrect, contamination control practices, etc. You then focus on a remedy for these root causes for the purpose of extending component life hours and preventing future or catastrophic failures.

Run to Failure

While on the surface it does not sound like a "strategy," run to failure can be the correct maintenance decision in some circumstances. For components that are at the end if their lifecycle, you simply want to get every hour of operation out of the component as you can, and you are not concerned with loss of core. If this is a route you choose, you will want to ensure you are prepared with a replacement already on-hand and willing to accept the risk of the disruptions in scheduled maintenance that is likely to occur when the failure happens. If this is a strategy you choose, keep in mind that nondestructive testing, such as fluid analysis, can still be very useful in helping predict when the failure will occur.

Main & Cam Bearing/Bushing Replacement

Scheduled Repair

Downtime	Cost Per Hour w/ Burden	Total Labor	Parts	Loss of Production @ $600 per Hour	Shipping
16	$55.00	$880.00	$4,000.00	$9,600.00	$800.00
Total Cost				**$15,280.00**	

Unscheduled Repair

Down Time (Scheduled Hrs. x 1.5)	Cost Per Hour w/ Burden	Total Labor (*1.5 factor)	Parts	Loss of Production @ $600 per Hour)	Shipping	Loss of Core
24	$55.00	$1,320.00	$12,000.00	$14,400.00	$1,400.00	$2,000.00
Total Cost						**$31,120.00**

Cost per Oil Sample	$20.00
Samples per Year	12
Total Cost of Program per unit	$240.00

Apparent Savings	$15,840.00
Adjustments	-$240.00
Total Savings	$15,600.00

Figure 1: Cost analysis example of an engine repair in a long-haul truck

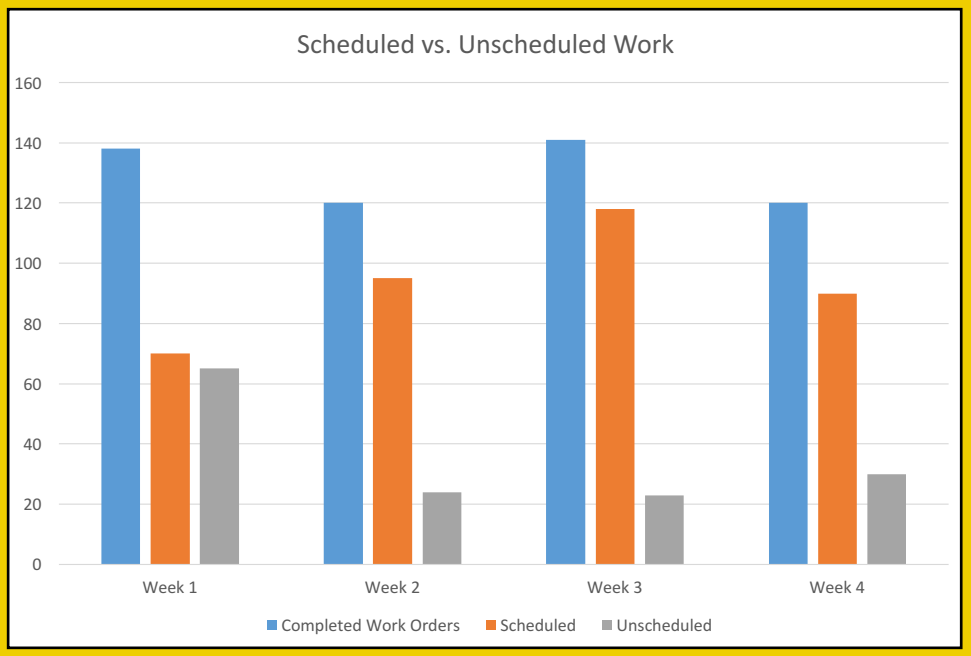

Figure 2: KPI example of scheduled vs. unscheduled work

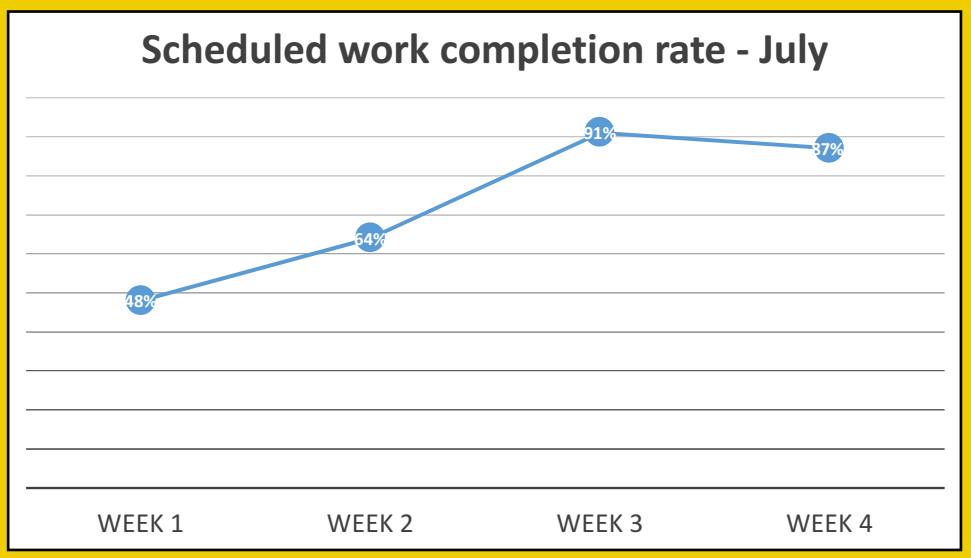

Figure 3: KPI example of scheduled work completion rate

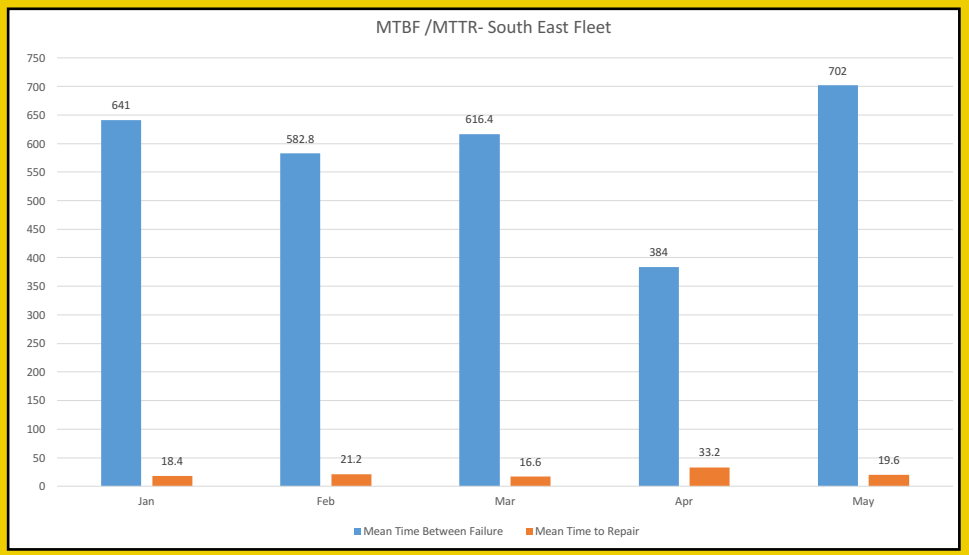

Figure 4: KPI example of mean time between failures (MTBF) vs. mean time to repair (MTTR)

Reactive Maintenance

Every maintenance professional would like to greatly reduce or eliminate reactive maintenance, that unplanned, unscheduled event that catches you by surprise and disrupts everything you had planned for the day. This type of maintenance often leads to a visit from an unhappy owner, operations superintendent, plant manager, or customer. Despite all your efforts of preventive, predictive, or proactive maintenance, these unplanned events happen regardless of which maintenance strategy, or combination of strategies, you decide upon. Reduction in reactive maintenance events is your goal and you should pursue a path of continuous improvement.

How to Decide Which Maintenance Strategy Is Best for Your Organization

First, it is important to do an honest evaluation of how well your current maintenance program is performing and identify the areas that need improvement. Evaluate a few of the major maintenance repairs you routinely perform today. Then, perform a cost analysis of an average cost of repair under a scheduled/planned event in comparison to an unscheduled, reactive maintenance event.

Figure 1 is a cost analysis example of an engine repair in a long-haul truck. Under the scheduled repair scenario, oil analysis results alerted maintenance of abnormal early stage bearing wear. The driver was immediately contacted to return to a local maintenance facility and maintenance repairs were scheduled and performed. The cost of these repairs were then compared to a scenario where the truck continued to run until there is oil pressure loss and the driver notices the check engine light is on, resulting in an unscheduled/reactive maintenance event.

Other considerations when evaluating your current maintenance strategy include:

- Are you experiencing a high number of unscheduled/unplanned maintenance events?
- Are you having difficulty completing all of your scheduled work?
- Do you have cost overruns or are you exceeding your maintenance budget?
- Does production suffer due to equipment being down for reactive maintenance?

If you answered "yes" to any of these questions, then it is definitely time to reevaluate your program. One of the best ways to do this is to create, monitor and share informative key performance indicators (KPIs). Figures 2 through 5 show examples of a few useful KPIs.

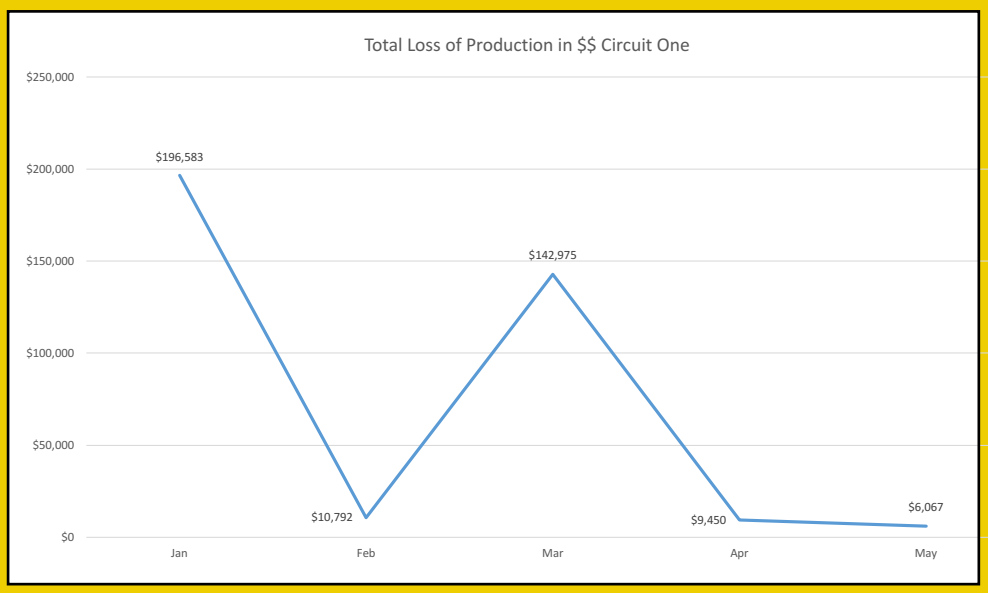

Figure 5: KPI example of total loss of production in cost

Once you have the information in hand and have created a gap analysis of where your program is today compared to where you would like it to be, you will then be able to make a decision on what type of maintenance strategy, or combination of strategies, will best meet the needs of your organization. What worked best for you yesterday may not be the best approach to reach tomorrow's goals.

Randy Clark, Technical Business Consultant at POLARIS Laboratories, has over 30 years of experience in heavy equipment maintenance and maintenance management. Randy's experience includes mining, heavy haul, construction and over-the-road fleets, which he uses to help customers improve their maintenance and reliability practices. He holds certifications as a Machine Lubricant Analyst Level 2 and Certified Oil Monitoring Analyst, Level 1. www.polarislabs.com

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BUILDING A RELIABLE PLANT THROUGH CONSTANT EVOLUTION

Mathieu Fyfe-Leblanc and
Frédéric Thivierge

Greenfield Global's ethanol plant in Varennes, Quebec, Canada, demonstrates the power of maintaining and evolving a strong reliability plan. Reliability is a key term in manufacturing that plenty of people talk about, but often find difficult to tackle in a practical way. Often, when discussing reliability, people imagine it to be achievable only for large scale, high capital organizations with a great deal of manpower. This misunderstanding stems from the misconception that reliability is a goal: just put the right equipment in place, spend enough money and somehow the plant will become reliable. This couldn't be further from the truth.

Reliability is a journey, rather than a simple goal. It is a cultural mindset that must permeate every level of an organization to be truly effective. The goal of reliability is not to reach the end, but rather to constantly evolve, always looking for ways to improve organizational processes and assets with the goal of constantly doing better than before.

Building a Reliability Culture

The Greenfield plant in Varennes manufactures fuel grade ethanol, distillers grains, carbon dioxide (CO_2) and corn oil, running on a lean staff of only 56 people. Over the years, Greenfield has managed to outperform hundreds of similar plants across the continent with larger staffs and bigger budgets. In the face of rising energy prices, the plant has consistently managed higher output at lower costs for years, all because of a focus on reliability. As a result, the Greenfield ethanol facility was chosen as Emerson's 2016 Reliability Program of the Year.

When the plant was constructed 10 years ago, Greenfield knew from the very beginning that a focus on reliability would be essential to the way the company wanted to do business. Because the plant runs a small staff, Greenfield makes a concentrated effort to hire people who have a strong background and belief in the value of a reliability culture. A culture of continuous improvement is essential to operations, maintenance, logistics and production, and all other sectors work together to improve every part of the plant at all times. Even in top-level management, maintenance reliability is not considered an expense, but rather an investment.

Following the Map

From the very first day at the Varennes plant in 2007, it was clear that expansion would be necessary. Management's goal is to increase the feed rate of the plant every year to produce more using the resources already in place. When the implementation team began a reliability program, the common tool for guidance was the reliability pyramid. While that system worked well in the early days, plans have evolved to follow a reliability road map developed in partnership with a local business partner. During an asset's lifecycle, reliability enhancements integrate all the elements necessary to extend and improve its functionality.

> **Reliability is a journey,** rather than a simple goal. The goal of reliability is not to reach the end, but rather to constantly evolve…

> At the heart of any good reliability program are the people responsible for implementing the program.

But, reliability doesn't stop with the initial plan for an asset. The reliability team constantly audits the system, looking at all the road map's elements to see where functionality can be improved for the next year. For example, the thermal oxidizer is the heart of the plant. If the oxidizer doesn't run, the whole plant shuts down. Developing a quality maintenance strategy for this asset was as simple as following the road map. The first step was a failure mode and effects analysis (FMEA) to determine the most common failure modes and their causes and effects.

The plant uses the FMEA information to determine what technologies will achieve the lowest possible risk for a given machine. As with many assets, an early warning of failure on the thermal oxidizer can come from abnormal vibration. Technicians detect such aberrations with portable vibration analyzers, which are used on monthly vibration rounds to ensure maintenance receives early warnings of any impending failures. The collected data is stored, tracked and analyzed.

Based on feedback received in the previous steps, the next step on the road map is to move toward preventive maintenance (PM) to keep the equipment functioning. PM tasks help ensure the plant is never caught off guard with catastrophic equipment failure, delivering peace of mind that unplanned shutdowns will be few and far between. By keeping a close eye on all the failure modes of the thermal oxidizer, it is possible to plan maintenance around scheduled shutdowns, avoiding unplanned downtime.

Finally, management follows up on all work with internal metrics. It is essential to know which techniques are providing results. The problems identified in the first stages of the road map shouldn't be causing plant shutdowns anymore. If they are, the maintenance team knows there is more work to do in analyzing methods and technologies to ensure each plan is optimal for its piece of equipment.

Evolving Criticality

The Varennes plant also takes a few unconventional steps on the road map to reliability. One of these steps is a goal to constantly reassess asset criticality ratings. By continually updating the plant's criticality assessment, maintenance ensures the criticality ratings assigned yesterday are still valid today. It may seem like a device is either critical or not, but in a constantly evolving plant, criticality status can change.

For example, an agitator installed in the early days was labeled non critical and allowed to run to failure (RTF). It was assumed that if the agitator failed, a couple of hours without agitation on the tank wouldn't have a significant impact on production. However, after a couple of breakdowns, operations quickly learned that the device was far more necessary than first suspected. As such, the device rating was changed to allow for regular monitoring during rounds.

Constantly revising criticality ratings also allows maintenance to keep an eye on moving bottlenecks in production processes. Often, a change in one sector of the plant, usually with the goal of removing a bottleneck, will cause a new bottleneck further down the line. When throughput is increased in one sector of the plant, other equipment may become more critical to accommodate the increased feed. Monitoring criticality allows plant staff to make the changes necessary to keep processes moving smoothly.

Ready for Anything

When the Varennes plant opened, the status quo was multiple planned shutdowns a year. By 2010, the reliability team had reduced the number of shutdowns to two and in 2011, the number was reduced to one. Future plans will allow for one scheduled shutdown every 18 months. Much of this improvement is a result of the reliability plan elements that are constantly improving. But, some came directly from new methods put in place in later years.

Thivierge and Fyfe-Leblanc with the Emerson Reliability Program of the Year judges

To keep an eye on critical equipment, technicians began using wireless gateways coupled with transmitters that allow intermittent online monitoring of problem assets. The use of wireless devices allow technicians to keep a piece of equipment running during examination so they can use a monitoring program to get a clearer picture of what is causing any malfunction, as well as avoid process upsets with failures on critical equipment.

A kitting plan speeds maintenance during both planned and unplanned equipment outages. In the computerized maintenance management system (CMMS), all jobs have extensive part lists and clear work orders. The goal is to anticipate all possible steps of the maintenance task. Kits stand ready with a printout of the work order for a maintenance task and all the parts necessary to complete the job. When a planned shutdown happens, these kits are moved in advance to the assets where they will be used. In the case of an unexpected shutdown, everything is in one place, making the kit grab and go, saving critical time.

Before the kitting plan, a common maintenance task, such as a sheave and V-belt replacement, would take significantly longer. Often, a technician would go to the repair with just the belt and no sheave or bushing in hand. Depending on the equipment, it could take five to 10 minutes to travel back to the shop and grab more parts. Before the kitting process, changing a belt and sheave could commonly take two and a half hours. With the kitting process in place, maintenance has cut that time down to one or one and a half hours.

The Value of Constant Learning

Reliability success has not only come from process changes and equipment improvements. At the heart of any good reliability program are the people responsible for implementing the program. Greenfield was lucky to start with a staff that understood the value of reliability, and reliability teams have helped to cultivate that understanding into a culture.

The core of the plant's reliability culture is developed from training. Two times a year, each person at Greenfield undergoes an evaluation. The evaluations determine what kind of training will help individuals be better at their jobs. The goal is for all employees to constantly strive for a higher level of experience and performance.

Both external and internal training play a role in the reliability culture. Greenfield has used outside vendors to help develop and roll out training courses for employees to help them better understand the components they are working with. These experts help operators and technicians get the most out of the equipment they are using.

Greenfield gains even more advantages when those same employees use their training and experience to cross-train other employees throughout the plant. For example, an operator and a maintenance technician on a pump might cross-train each other. The operator learns how the equipment runs, why it does what it does and what can damage the equipment when it is run improperly, leading to better troubleshooting. The maintenance technician learns how the equipment is used and how the process works so it becomes easier to diagnose issues, such as underperformance or intermittent failures. At the end, everyone is speaking the same language, which makes for more efficient and accurate diagnosis and repair of issues on the plant floor.

....Every failure is a learning opportunity
that improves the reliability program.

Turning Action into Results

The ultimate result of a constantly evolving reliability improvement plan has been less downtime and improved production throughout the plant. In eight years, production increased by 80 percent, while maintenance costs only increased by 14 percent. In addition, energy costs have decreased significantly. Overall, energy costs are 74 percent of what they were in the plant's first year of operation, even though energy cost increases should have them at 180 percent.

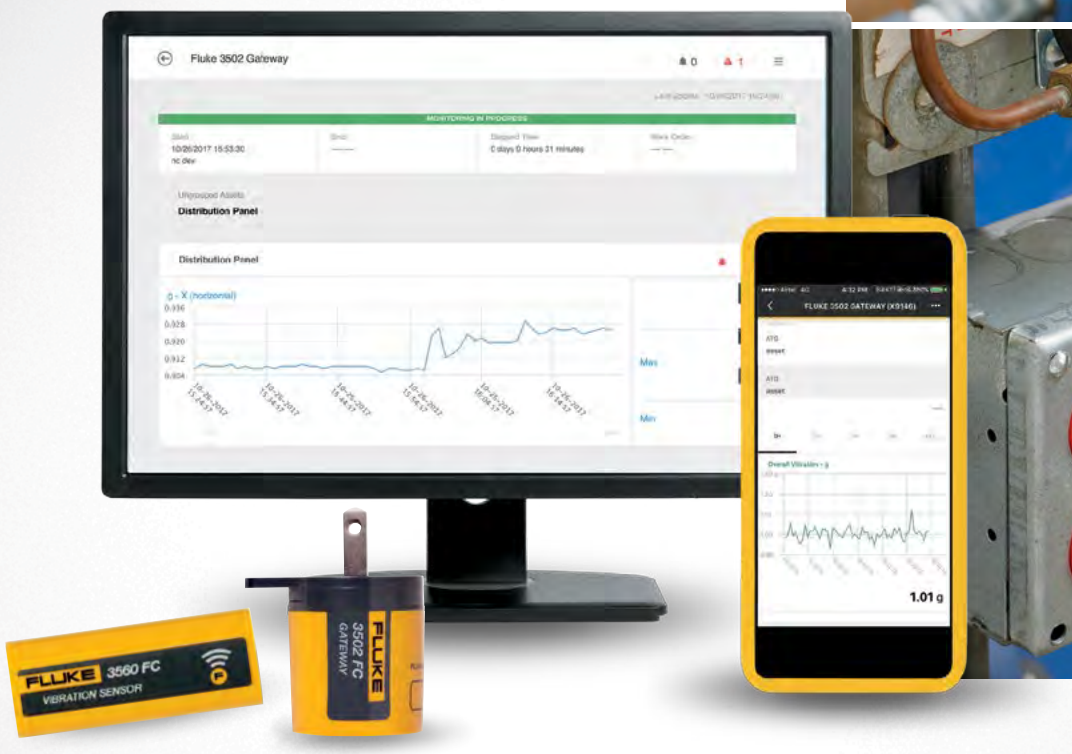
The motivation of the Greenfield team is much higher than it was in the early years. The plant no longer operates in reactive mode, meaning the team can work on improvements rather than constantly trying to put out fires.

The goal is not perfection. Greenfield experiences failures just like every other plant. The difference is, with every improvement, the team's reaction gets faster. At Greenfield, every failure is a learning opportunity that improves the reliability program. Users learn from *everything* and dedicated people make them successful. The reliability team is positive, takes initiative and brings good ideas. Many key improvements came from people on the plant floor. Winning Emerson's Reliability Program of the Year is a direct result of the hard work and innovation of those people. Because of a dedicated and innovative staff and a vision for the future, the Varennes plant continues to improve every day and will only run leaner and with greater efficiency as time goes on.

Mathieu Fyfe-Leblanc is a reliability/maintenance project specialist at Ethanol Greenfield, Inc. in Varennes, Québec. Hired as a millwright for the plant's start-up in February 2007, Mathieu has more than 10 years of experience, and in 2014, he accepted the challenge to be in charge of the reliability improvement. www.greenfield.com

Frédéric Thivierge is an operations manager at Ethanol Greenfield Quebec. Starting as a maintenance manager, Frédéric quickly advanced and only after two years, was placed in charge of production, establishing a strong culture of continuous improvement and world-class maintenance best practices. Frédéric has worked in maintenance for 15 years, and has held positions in maintenance departments for companies in a variety of industries. www.greenfield.com

It’s time to redo the formula on condition monitoring



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HOW DOES CONDITION MONITORING

PREVENT MOTOR FAILURES

Nicole Dyess

MOTORS FAIL. It's a fact of life that's nearly as certain as death and taxes.

Until now, preventing motor failure required early retirement, as in repairing or replacing your rotating equipment on a schedule possibly years before the motor would fail. Fortunately, the declining costs of sensors and submeters, together with the growing big data industry, have made condition monitoring increasingly accurate and affordable. The net result: condition monitoring can decrease your motor operations and maintenance (O&M) expenses by up to 25 percent.[1]

This article describes how condition monitoring detects motor damaging situations and uses that information to maximize the life of your rotating equipment.

> With the Internet of Things (IoT) and rapidly declining submetering costs, the use of energy monitoring is increasing as an affordable method for providing continuous, remote monitoring.

How Condition Monitoring Works

Condition monitoring works by collecting, sorting and analyzing streaming data from sensors on your equipment, as shown in Figure 1. Then, data analysis platforms apply complex algorithms to the incoming values to detect problematic conditions and update the virtual model, also known as a digital twin[2], of how your equipment operates. The platform compares your equipment's current performance to its manufacturer's specifications and historical readings to identify performance nonconformities or items that require action. Finally, the platform generates a report with asset history and sensor data and alerts you to these nonconformities, enabling you to determine the proper intervention, such as correcting a potentially motor damaging stress before it creates a bigger issue or scheduling downtime to replace equipment.

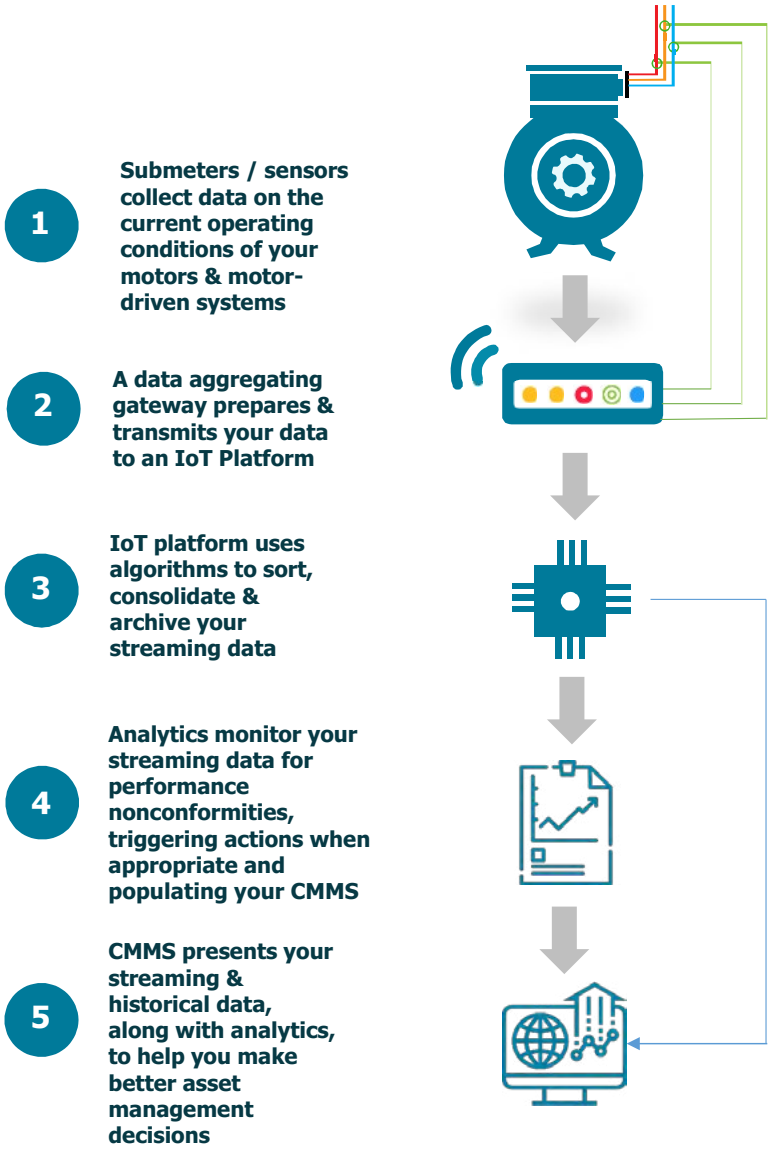

Figure 1: Process of condition monitoring through the use of sensors

Advantages of Energy-Based Condition Monitoring

Much like your doctor tracks your temperature and blood pressure, monitoring your motor's vital statistics, such as its normal operating parameters and stress levels, can indicate an issue long before it's symptomatic of a problem.

Energy-based condition monitoring offers three advantages over more common condition-monitoring techniques, like vibration and thermography. First, it's difficult and expensive to monitor vibration, thermography and ultrasound remotely, so these tools tend to be interval based, such as quarterly or annually. With the Internet of Things (IoT) and rapidly declining submetering costs, the use of energy monitoring is increasing as an affordable method for providing continuous, remote monitoring.

Second, ultrasound, vibration and thermography only identify whether your motor is operating normally or not. In the absence of an issue, they consider a motor healthy. But, energy-based condition monitoring can detect motor damaging electrical stressors, such as a voltage unbalance, as illustrated in Figure 2. With that knowledge, you have a chance to intervene and correct the issue before it harms your asset.

If damage has already occurred, then energy-based condition monitoring provides intelligence that helps you understand your motor's current performance and health. With this information, you can make an educated decision about when to retire an asset that balances its performance, operating costs and remediation costs with the risk and consequences of failure.

Third, energy-based condition monitoring uses energy efficiency as a leading indicator of motor failure. Whether a motor is just beginning to arc between windings or has a bearing issue emerging, the motor consumes more energy to generate the same output. That means its efficiency has declined. Because energy-based condition monitoring platforms continuously monitor your motors and compare new to historical measurements, these platforms detect that your motor needs attention, often before ultrasound, vibration and thermography do.

How Condition Monitoring Saves You Money

By continuously tracking the health of your motors, condition monitoring enables you to maximize your capital investments in your motor-driven systems. Here are six ways this improves your bottom line:

1. **Preserves the health and extends the life of your assets.**

   By detecting and notifying you when situations stress your motors, condition monitoring alerts enable you to proactively correct issues before they irreparably damage your rotating equipment.

2. **Reduces your energy expenses.**

   Since motor efficiency declines with motor health, using condition monitoring to preserve the health of your motors also lowers your energy costs.

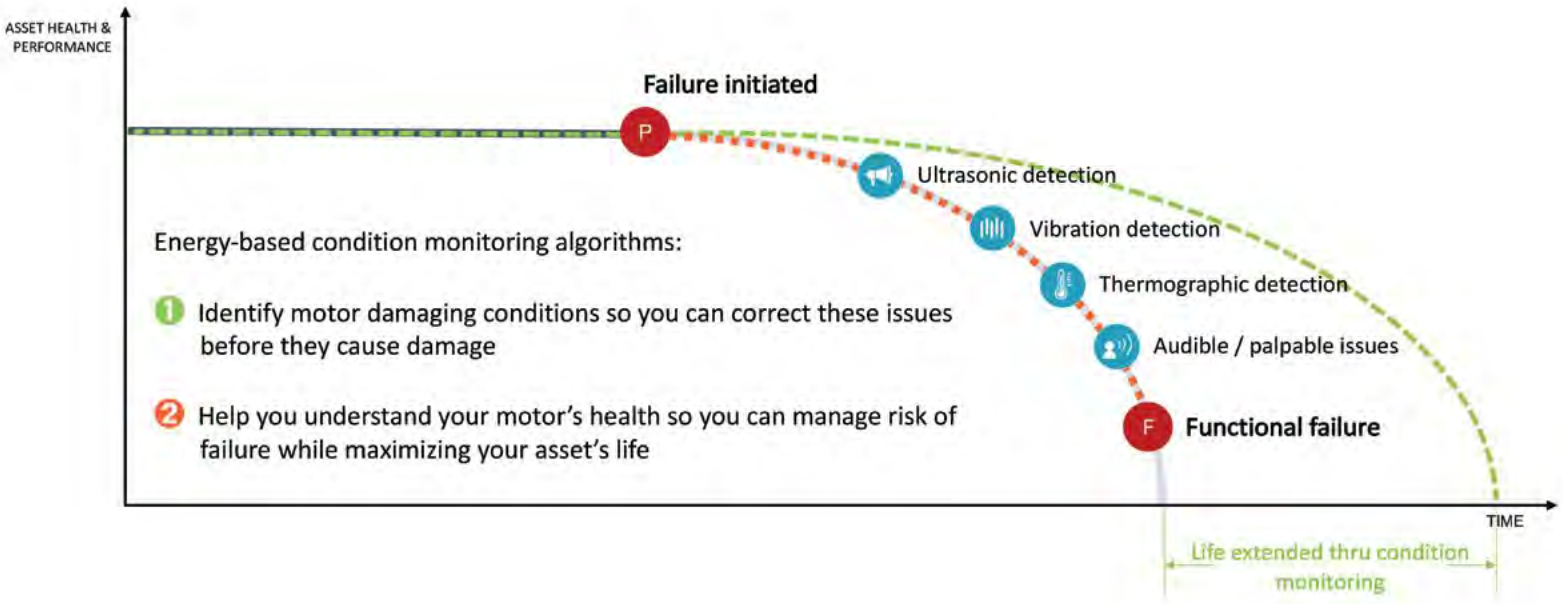

Figure 2: Energy-based condition monitoring continuously watches for motor damaging stresses, such as voltage unbalance, and alerts you when these conditions occur. Taking actions on these alerts prevents damage and extends the life of your asset. Or, if your motor is already damaged, then energy-based condition monitoring supplements other diagnostics to provide insight on the motor's performance so you can balance operating costs, remediation costs and risk of failure in an informed manner.

3 Extends your maintenance staff's reach.

Your staff focuses on the motors only when they need maintenance and can perform other tasks when they don't.

4 Optimizes your maintenance processes.

By intervening only when the asset needs maintenance, condition monitoring enables you to eliminate the 19 percent of preventive maintenance activities that are unnecessary[3] and the 45 percent of preventive maintenance practices that are ineffective,[4] while still achieving high availability and reliability performance.

5 Makes smarter asset management decisions.

Avoiding the premature replacement of a healthy motor extends your capital investment, while maintaining high availability and reliability metrics. Providing operations, maintenance and engineering with visibility on how your equipment is performing helps these teams make more collaborative and better informed asset management decisions.

6 Avoids unplanned outages, minimizes downtime, works safer and reduces defects.

Insight on your assets' health enables proactive, risk- and economic-based asset management decisions about the type and timing of maintenance. By making these decisions proactively instead of in the heat of the moment after the asset fails, you can order supplies, stage equipment and schedule the outage at a time that works best for you. Eliminating catastrophic failures and prepping people and supplies in advance halves the time it takes you to complete maintenance.[1] Studies also show that planned, condition-based maintenance is safer (i.e., results in fewer injuries) and results in up to 70 percent fewer defects.[5]

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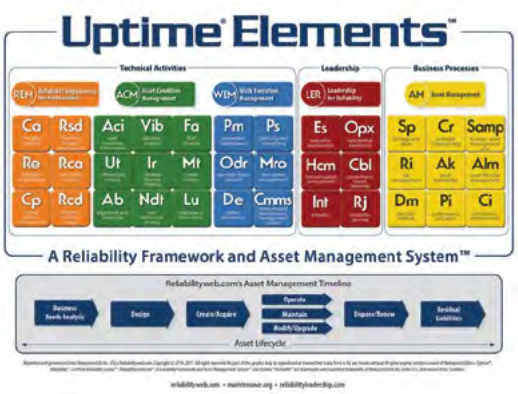

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HOW FAILURE DATA CONTRIBUTES TO THE SUCCESS OF YOUR RELIABILITY PROGRAM

Brian Baldwin

Although more and more industrial plants have been incorporating reliability into their vocabulary, in several cases, something has been lost in translation. More times than not, when asked about their asset reliability program, maintenance reliability organizations do not have a process in place to document asset failures, specifically the utilization of failure coding within their computerized maintenance management system (CMMS). The goal of this article is to shed light on the long-lasting benefits of documenting failure data so that organizations not doing so become the exception rather than the rule.

In this age of the Industrial Internet of Things (IIoT), organizations can sometimes be overwhelmed by all the data produced from multiple sources and how to transform it into meaningful information. Modern diagnostic tools are excellent at detecting process and machinery problems, but this is a short-term benefit. This short-term benefit, although predictive in nature, is still somewhat a reactive approach by itself. Unfortunately, the maintenance role is often solely responsible for replacing failed components only to assure short-term plant production goals are met. What's missing is properly investigating and documenting failures to support the reliability organization's ability to improve long-term plant availability.

When good old-fashioned organization, classification and documentation of asset failure information, whether a simple component failure analysis or a formal root cause failure analysis (RCFA), are performed, it pays huge dividends in the ability to improve your plant's overall reliability. Knowing how equipment fails allows for effective plans to be put in place to eliminate or mitigate future failures and improve equipment reliability. The secondary benefit of these enabling technologies is not realized until the data they generate is analyzed to determine the root cause and the subsequent corrective actions targeting the failure mode(s) are implemented.

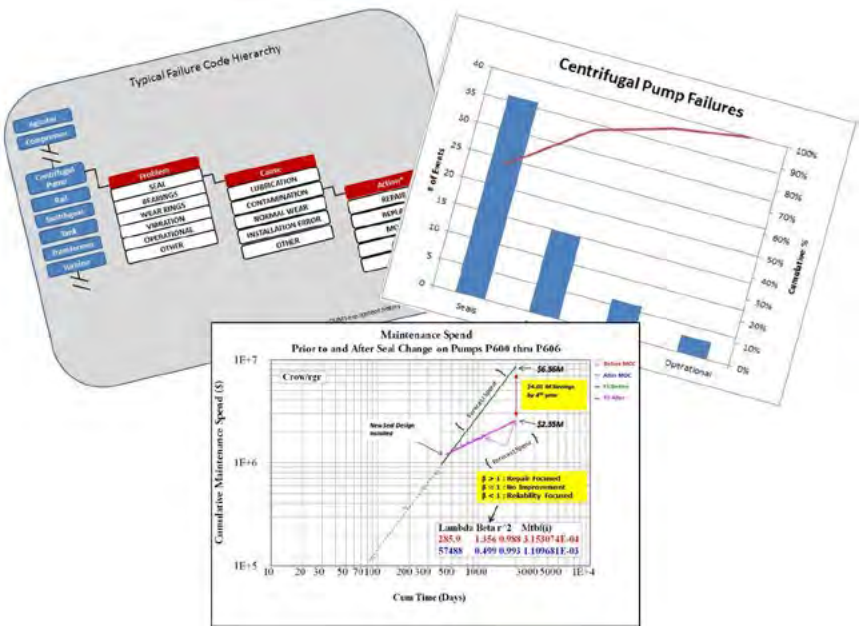
You can leverage your CMMS investment by building an accurate asset hierarchy that is logical and user-friendly for those who need to generate work notifications, but also provides them with equally important asset class specific failure codes. These failure codes help communicate what the apparent cause of the problem appears to be from their vantage point. Failure codes should include a problem, a cause and the remedy to be taken to restore normal design function of the asset. The International Organization for Standardization (ISO) offers ISO14224, a very detailed standard

> "Failure codes should include a problem, a cause and the remedy to be taken to restore normal design function of the asset."

that addresses failure data that you can utilize as a guideline or adopt in full.

It is recommended that each failure code has a detailed text description to explain what symptoms it is intended to cover to ensure proper use. Typically, problem codes are required entries in the CMMS for work order generation, whereas cause and remedy codes are not required fields until work order close out or completion to ensure work process compliance. Wait to finalize failure coding on a work order until failure analysis is complete in order to ensure accurate failure history has been documented.

When building your failure code hierarchy, establish an accurate list of asset types or classes for the top level, followed by the corresponding asset specific problems. Because it is unrealistic to list every possible failure problem, cause and remedy for each asset type, stick to the most common or realistic failures you may encounter in your facility and your operating environment utilizing an "Other" code to capture all others. Be sure to stipulate that details must be documented in the work order comments when using the "Other" code. As you analyze these "Other" coded failures, you will be able to perform a Pareto analysis to see if there is a common failure mode that deserves your attention and should be added to your existing library. Remember, your CMMS is a living program, as is your reliability program. Update and refresh it with current and relevant content based on the analysis of your reliability data.



Ideally, it is recommended to perform failure mode and effects analysis (FMEA) up front during the acquisition of assets to identify all failure modes. The findings from this analysis can be then used to incorporate asset failure codes for those failures you anticipate you will most likely encounter. However, a valuable continuous improvement project for an existing facility would include systematically reviewing critical assets and conducting a FMEA if one has not yet been performed for your facility's assets.

The point is, you should create these failure codes to help proactively tackle the equipment failure issues that exist at your plant. Failure forecasting reliability analytics, whether it be Weibull, Crow-AMSAA, or even a simple Pareto analysis, are only as good as the quality and quantity of the data. The information gathered through failure data analysis can be then used to identify maintenance strategies focused on root cause elimination through early detection/inspection, new component designs, or revisions to operating procedures with the goal of improving safety and reliability. Even better is the fact that this information, when presented with supporting total cost of failure data (e.g., lost production, penalties, expedite fees, etc.), can reveal the true financial impact of asset failure and help you justify continuous improvement efforts to eliminate future failures of this type.

At first glance, this transformation process can seem a bit intimidating, to say the least. Many managers decide that this type of analysis is just too much work and abandon the whole idea entirely. But by doing so, they overlook the fact that on a day-to-day basis, maintenance is really managed at the failure mode level. However, if you build the foundation of your reliability program around disciplined data collection and analytics, it will pay huge dividends in the form of communicating priorities for safety and reliability improvements in your plant. Most importantly, these improvements add real value to the bottom line by focusing on eliminating future failures.

Measuring maintenance strategy effectiveness is one key benefit that comes from documenting failure data. Accurate failure event documentation within your CMMS provides the foundation necessary for accurate analysis of mean time between failures (MTBF), mean time to repair (MTTR) and the total cost of failure when lost production is also accounted for.

It has been observed that several failure analysis/reliability programs supported only by the maintenance department documented annual returns in the range of six to 10 times the program's cost. However, failure analysis/reliability programs supported by the entire organization showed an annual return on investment of more than 50 times the program's cost. This confirms that reliability is ***everyone's*** responsibility. To that point, it is important to educate your entire organization about how the decisions they make on a daily basis impact plant reliability and the company's performance. Incorporating change management tools, like *The Reliability Game*®, to transform the culture of your organization can be very powerful. These tools will help deliver the message that proactive practices, like failure data documentation and analysis, add significant value to companies in a competitive world.

Successful reliability programs have strong plant leadership that is committed to creating a proactive work environment by understanding how vital failure data analysis is to maximizing uptime at their facilities. It can't be overstated how important documentation and analysis of failure data is in creating improved maintenance strategies that target specific failure modes. When this becomes common practice, it is at this stage of your reliability program journey that you have truly shifted your modus operandi to a proactive approach.

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THE VANISHING WORKFORCE AND HOW TO DEAL WITH IT

Dave Abecunas

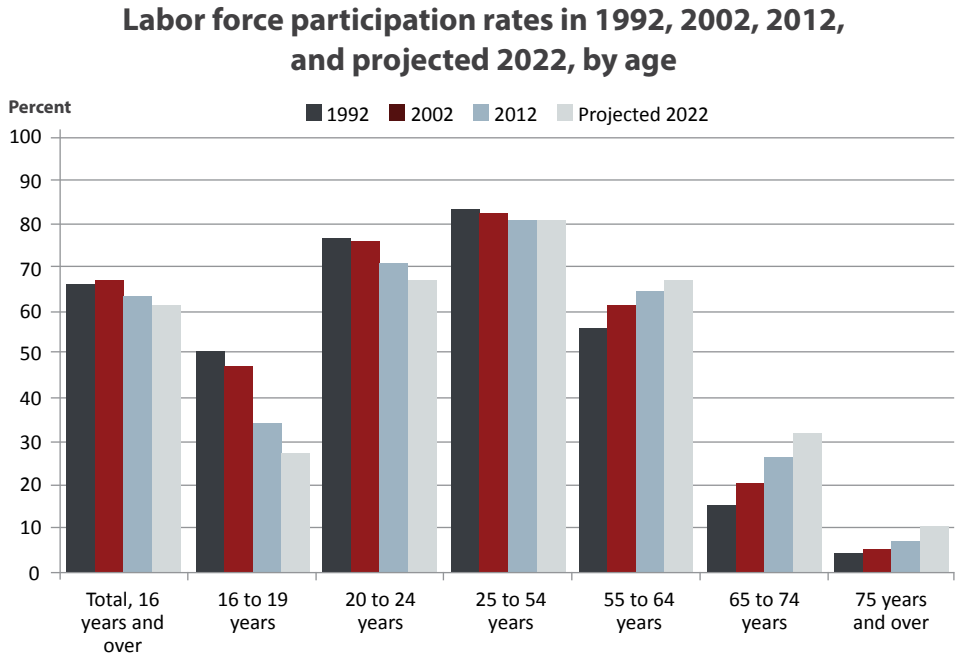
For over 10 years, the country has seen a shift in the workforce. Older workers, known as baby boomers, have begun to leave in droves before younger replacements are trained or, in some cases, even onboard. You keep hearing, "jobs, jobs, jobs," but what should be heard is, skilled workers, skilled workers, skilled workers. That's right, there is a worker shortage more than a job shortage. Why, you may ask? There are several reasons, but more importantly, very little is being done to solve the problem.

The older workforce problem had started even before the recession. Workers between the ages of 50 and 65 started to retire, leaving gaps in the workforce that were not being filled prior to the vacancy. This did not allow younger workers, when and if they were available, to gain some of their predecessors' knowledge. In addition, there were fewer younger workers entering the trades. Many companies were caught between a rock and a hard place; they had jobs, but few skilled enough to do them.

LOOK AT WHAT HAS HAPPENED:

1. Many companies and schools have eliminated apprenticeship programs and/or technical training.
2. The attitude of the trades is "second-class workers," making it hard to recruit.
3. The "you have to go to college" expression has become a firm belief, in that you need a degree to survive in the future.
4. Younger people today do not realize the benefits of becoming a skilled welder, plumber, or millwright.

In addition, the Great Recession actually helped the situation. Many boomers lost thousands in retirement funds, making retirement almost impossible for many. So, these workers started staying longer in the workforce. Also, with companies feeling the pinch, training, including apprenticeship programs, began to disappear. A job shortage began as companies cut back. This gave birth to sayings like, "do more with less," and soon wages became stagnant and unemployment lines swelled. Slowly but surely, the country began to rebound. Retirement funds started to build and soon the boomers started to retire. As the economy started to rebound, the new problem developed, a shortage of skilled workers. Even the White House administration kept pushing education, with all of the programs aimed at college. They did not emphasize opportunities in the trades, nor did they recognize the value of those hardworking Americans who work with their hands, which is a shame because it exacerbated the skilled labor shortage, as shown in Figure 2.



Source: U.S. Bureau of Labor Statistics.

Figure 1: Labor statistics to 2022

> **TRAINING IS A KEY WORD HERE.** Technical training, either before or after hiring, must take a front seat in all companies.

A welder today in most parts of the country usually starts at $50 an hour and looks forward to security for many years to come. Some college graduates get hired for $35K per year, have a mountain of debt and do not know when opportunities for advancement will begin.

Germany had recognized a similar problem and began creating technical programs for the trades, with graduates getting a diploma and a two-year degree, as well as a prosperous future. Over 1.5 million people are participating in these programs. In the U.S., Georgia has started creating similar programs. But, what about the rest of the country?

Training is a key word here. Technical training, either before or after hiring, must take a front seat in all companies. The use of a skills matrix provides a foundation for developing the right training for the workforce, both in the present and for the future. The skills matrix identifies the requirements needed to work in a position, then identifies the training required, as well as the sources. These sources can be colleges, technical schools, or even contractors. Create an internal certification program to develop a healthy competitive spirit and goals that one can pursue and live for. Intern programs are a great way to introduce younger folks to opportunities in an actual working atmosphere. Contact local technical schools and colleges.

Communication needs to be enhanced to make the trades something to be proud of. All positions in industry are important. An "All Vocations Matter" movement needs to begin. Every company must change the culture to make working in the trades palatable and instill a sense of pride. The impression that *only* college graduates will succeed needs to be discarded. Not that there isn't a need for degreed professionals, but college is not for everyone. There are many alternatives to college degrees for high school graduates. There is the military, which today provides some of the best training in the world in a variety of vocations, and opens the eyes of individuals who are undecided. There are technical schools and the government is also now passing legislation to provide the must-have training needed for the thousands of jobs currently available. So, young people not wanting to or not qualifying for degreed programs have numerous alternatives to explore.

As illustrated in Figure 3, a basic skills matrix can be as simple or as complex as needed depending on the company. The purpose of a skills matrix is to have a basis for the training required that can be used as the focus for employee development. This is a tool that supervisors and man-

Figure 2: The shortages in various trades

SKILLS MATRIX

Position	Skills	Description	Training Methods	Training Sources
Planner	Planning and Scheduling	Plan and schedule work orders for technicians	1. Classroom 2. Practical On-The-Job-Training (OJT)	1. Publications 2. Web Training 3. Peer Coaching and Mentoring
	CMMS Super User	Utilize CMMS for Work Management	1. Classroom 2. Practical 3. Computer	1. OEM 2. User's Manual 3. Web Training 4. Peer Coaching and Mentoring
Mechanical Tech 1	Precision Alignment	Ability to use the latest technologies for alignment of rotating equipment, including shaft to shaft and sheave to sheave	1. Classroom 2. Practical	1. Technology OEM 2. Web Training 3. Peer Coaching and Mentoring

Figure 3: A basic skills matrix

agers can use to determine training requirements and develop an annual training plan. Additionally, it can be utilized as a hiring guide.

The labor shortage is affecting all industries, including construction, manufacturing, mining and even refining. If it is not yet seen in your industry, watch out because it is on the way. The U.S. government is not going to do a bailout and, as a matter of fact, matters may become worse when new jobs are created as part of the current administration's goals. Addressing the skilled labor shortage has to be a team effort, with industry and government working together.

The first step has to be awareness. There is a general false impression that the problem is a lack of jobs, but few realize the real problem is resources, namely skilled workers. If the U.S. does not start now, the problem will only get worse. This problem will neither fix itself nor disappear in time. It requires action, and action now!

What action can you do now? Start with your own company. Look for applicable venues and get involved with local government. Soon, you will see a movement, like training institutions helping companies train personnel by forming partnerships, much like intern programs. Soon, you will see the change, with people entering or, in many cases, reentering the workforce as skilled workers ready for the task. What else will change? Attitude! Yes, the workforce will have that "can-do" attitude that hasn't been seen in a while. Why? Purpose, of course! A person with skills and a purpose will become more valuable with every task assigned.

> ***After years of running flat out, U.S. Gulf Coast refiners are lining up repairs to plants in 2017 - but facing a severe labor shortage that could delay work, drive up costs and raise accident risks.***
>
> ***Fuel producers, such as Marathon Petroleum Corp (MPC.N) and Valero Energy Corp (VLO.N), have delayed routine work in the past 24 months amid high margins. Those margins collapsed this year in a global fuel supply glut, providing an incentive for refiners to undertake the shutdowns necessary for maintenance.***

Figure 4: Examples of the labor shortage on industry

"ALL POSITIONS IN INDUSTRY ARE IMPORTANT."

Dave Abecunas, *CMRP, is a Discipline Lead with Commissioning Agents, Inc., and has over 40 years of experience in asset management and reliability. Dave has extensive experience in reliability-centered maintenance, computerized maintenance management systems, root cause analysis and training development. He believes that continuous improvement is the key to every organization's success. Dave has held positions both in the workforce and management, and understands the challenges they face today.*

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TRANSIT

John Murphy

ASSET MANAGEMENT FORUM IMC-2017

December saw another successful International Maintenance Conference (IMC), with over 1,100 participants from 41 countries. Part of the conference included the Transit Asset Management (TAM) forum, held the first day of the conference. Presented in association with the Rail Reliability and Asset Management Roundtable, the TAM forum was designed as an opportunity for agencies to share simple and practical approaches that they can put to work immediately using asset management (AM) and Industrial Internet of Things solutions (IIoT). The forum was well attended and presenters shared some highly interesting progress stories with attendees.

OVERVIEW OF PRESENTERS' KEY SHARES:

Passenger/commuter agencies are facing many challenges that AM and IIoT solutions can address:

- Improving safety
- Managing aging infrastructure
- Improving customer service
- Controlling maintenance costs
- Designing for growth
- Improving reliability
- Driving maintenance fundamentals
- Compliance with TAM/FAST regulations

The American Society of Civil Engineers estimates $4.6 trillion to be spent by 2025 in order to bring U.S. infrastructure to an acceptable standard. Less than half that amount has been allocated so far.

- Much of the Northeast Corridor infrastructure is beyond its useful live. Eighty-five percent of basic preservation and improvement projects are on hold pending funding.
- Transit in the U.S. continues to grow and is adding new lines and networks every year. Yet, the symptoms of overdue maintenance and underinvestment of existing agencies are not being addressed.

Managing the asset obsolescence challenge requires a specific focus by agencies to ensure AM/IIoT designs drive extending existing asset life, as well as improve new asset lifecycle management.

- "The goal of obsolescence (OBS) management is to achieve improved maintainability of services while ensuring best value and overall reduction in whole lifecycle costs." --- John Gariti, Long Island Railroad, IMC 2017
- Successful OBS requires structured design integration into computerized maintenance management systems (CMMS), IIoT and purchasing systems.

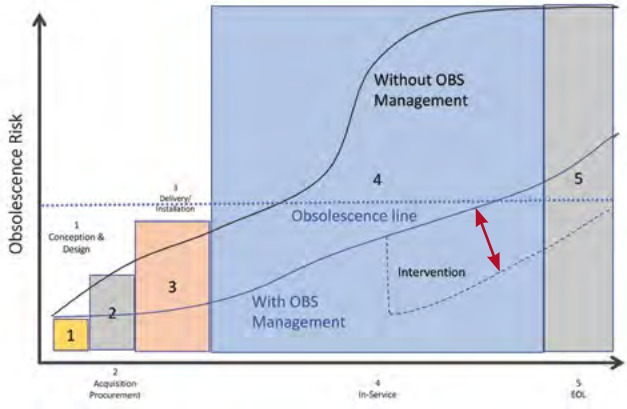


Figure 1: Typical obsolescence risk in the asset lifecycle
(Courtesy: John Gariti, Long Island Railroad and Jesse Rothkopf, Life Cycle Engineering)

> **The marriage of digital technologies and infrastructure has given rise to smart infrastructure.**
> *~ Michael Salvato, MTA*

- Crucial in the OBS assessment is understanding, in measurable terms, whether the asset is capable of performing at its designed level and ensuring an asset does not pose a known unacceptable safety risk.
- Due to the extensive asset aging issue, OBS prioritization and criticality analysis must be completed early in the design process.

A serious issue for transit rail operators is a lack of basic information about their legacy assets, such as their condition, history, criticality, replacement lifecycle and total cost of operations of the asset, in terms that are quantifiable and mutually agreed upon.

- Growing consensus around the benefit of introducing a generational model to address lack of information
- Added benefit of improved management of the long-term investment and related risk expectations of capital replacement within their organizations
- Demand by operators for holistic visual asset "data halos" vs. component level data streams
- Digital configuration enables managing process and information changes from cradle to grave; many new governmental regulations, like positive train control (PTC), now mandate deep, accurate configuration management

Investing in AM/IIoT solutions has seen rapid acceptance by agencies over the last 12 to 18 months, compelled by:

- Compliance with the spirit of TAM/FAST regulation requirements;
- Increasing technology-oriented regulatory and safety environment;
- Driving maintenance fundamentals to include improving the reliability of assets or improving asset availability while optimizing, or at least understanding, the asset cost of operation;
- Local, state and federal governments demanding greater operating efficiency; McKinsey & Company research has shown that emerging technologies could boost productivity by 25 to 30 percent.

Key technologies required for tomorrow's agency management include:

- Asset management (i.e., CMMS) and geographic information system (GIS);
- Program/change management platforms;
- Intelligent sensing and communicating devices in your infrastructure and on your assets;

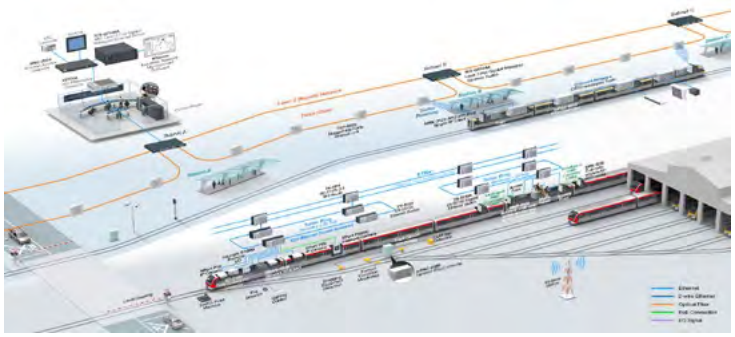


Figure 2: "The marriage of digital technologies and physical infrastructure has given rise to smart infrastructure." --- Michael Salvato, Director and Program Executive, Enterprise Information and Asset Management, IMC-2017 presentation

- Security;
- Mobility/communication systems;
- 3-D virtual design (i.e., digital twin) technologies;
- Machine learning/algorithmic-based, predictive enabled, decision-making solutions;
- Advanced analytics/dashboard data or data visualization.

Increased AM/IIOT technology integration has organizational implications:

- New requirements on workforce planning and new training and skills needed to accelerate the "speed of transformation;"
- New suites of asset management tools and organizational and production structures increasingly realigned to support maintenance fundamentals;
- Broader responsibilities for "tomorrow's" technologically enabled asset manager, who must operate the asset, make the asset safe and long-lasting through good maintenance practices, and make the most out of today's dollar.

The agency AM/IIoT journey requires extensive planning, change leadership and program management:

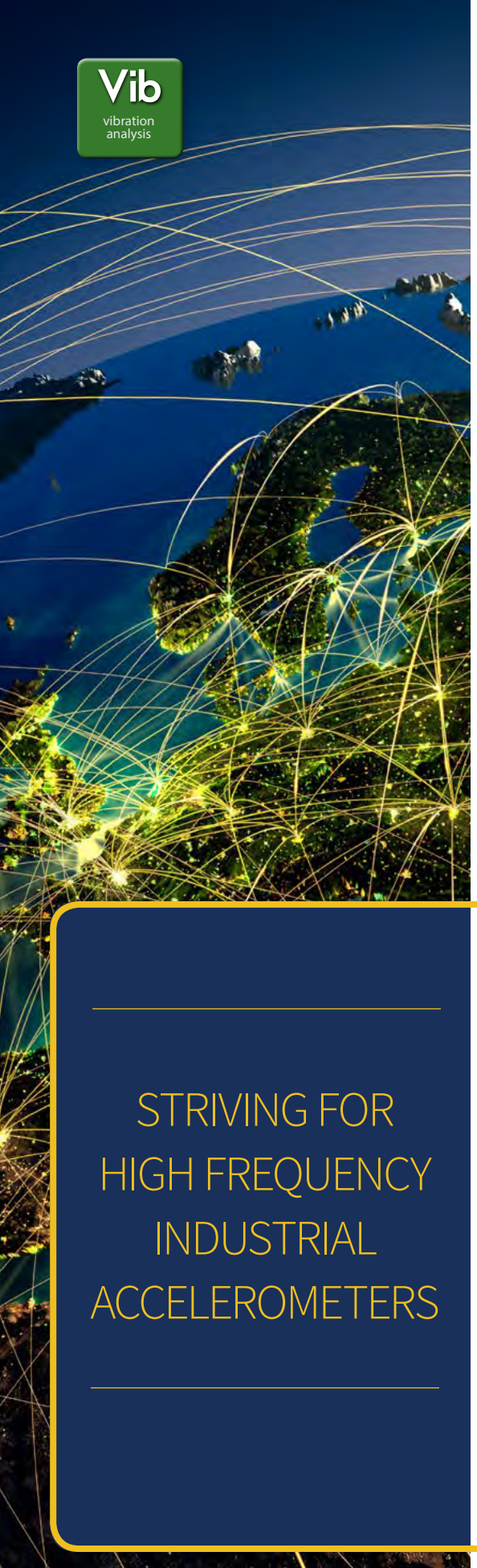
- Needs a shared vision, key performance indicators (KPIs) and a clear understanding across agency personnel of what success means;
- Comprehensive and enterprise approach to system integration beyond maintenance to include all aspects of the customer, the employee and the asset experience;
- Designed architecture that promotes efficiency and effectiveness of its business processes, as well as the utilization of the assets it is managing – this means a strong reengineering or industrial engineering approach embedded into the architecture;
- Formal program and change management teams to ensure delivery timelines are met and communications of progress, plans and changes are known through the organization.

The transit/passenger agency of the future will consist of smart designed stations and platforms, and self-aware and self-managing equipment on connected networks that are all connected into control centers or hubs, thus leveraging artificial intelligence (AI) and learning management systems to deliver high levels of customer service at an optimized cost per passenger.

Thanks go out to the presenters at the Transit Asset Management forum for sharing their thoughts, experiences and visions of how agencies and solution providers are working together to address the issues facing America. As Michael Salvato, director and program executive, Enterprise Information and Asset Management, concluded in his presentation: "The challenges facing America require much more than incremental improvements. They require reinventing the infrastructure industry. Rebuilding America's crumbling infrastructure requires a major paradigm shift."

The 2018 Transit Asset Management Forum is planned for IMC-2018, the 33rd International Maintenance Conference, December 10-14, 2018. If you are interested in learning more or want to be part of the transit management solution discussions at Reliabilityweb.com, contact: crm@reliabilityweb.com.

John Murphy *founded Gallatin Management Services in 2016. Prior to starting Gallatin, Mr. Murphy was Chief Mechanical Officer – Engineering and Strategy at CSX, a leading freight transportation company. In his CMO role, John was responsible for development of locomotive and railcar business intelligence systems, physical infrastructure modernization, creation of asset management and workforce planning strategies, and led the Mechanical, Electrical, and Industrial Engineering maintenance functions.*



Vib
vibration analysis

MAKING IT IN A HIGH FREQUENCY WORLD

Meredith Christman

STRIVING FOR HIGH FREQUENCY INDUSTRIAL ACCELEROMETERS

As predictive maintenance teams in industrial facilities strive for a more complete picture of their equipment's health, high frequency vibration measurements have become a crucial addition for identifying faults, such as motor and pump bearing defects and gear tooth inconsistencies in high-speed gearboxes. As a result, there is an upsurge in demand for vibration sensors with a high frequency response.

HOOKE'S LAW AND THE SPRING-MASS HARMONIC ISOLATOR

What determines the resonant frequency (and therefore high frequency response) of an accelerometer? For that answer, a look into the field of physics and the spring-mass harmonic isolator is required.

A spring-mass harmonic isolator consists of a spring hung vertically from a support structure. A weight is attached to the end of the spring. By pulling the weight down and then releasing it, the weight/spring assembly will oscillate evenly, both in speed and distance, back and forth across an equilibrium position, recreating the oscillation of a sinusoidal wave.

While the amplitude of the resulting oscillations can be theorized using Newton's second law of motion (F=ma), the primary interest of this article is the speed of the resulting oscillations. This speed can be theorized using Hooke's law. In the late 1670s, Robert Hooke proclaimed that natural/resonant frequency is a function of stiffness and mass, as seen in the following formula. In the spring-mass harmonic isolator example, the mass of the weight and the stiffness of the spring are predetermined, so the assembly's oscillation speed cannot be altered unless either the spring or the weight is switched out for an alternative.

$$Natural/Resonant\ Frequency = \sqrt{\frac{Stiffness}{Mass}}$$

As the formula shows, resonant frequency and mass have an inverse relationship, while resonant frequency and stiffness have a direct rela-

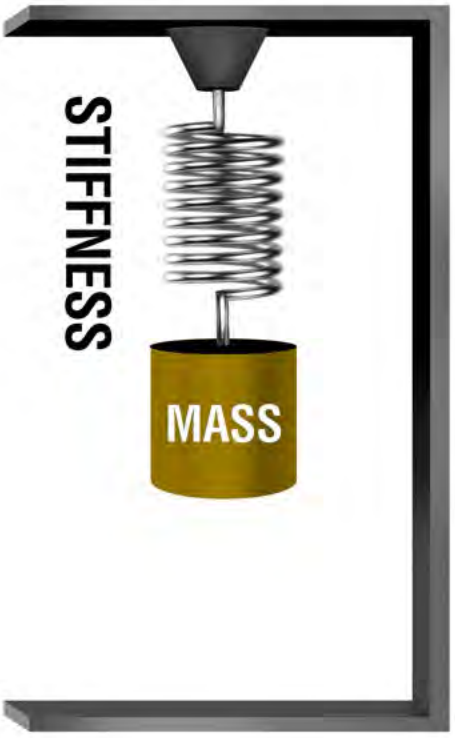


Figure 1: A spring-mass harmonic isolator best describes Hooke's law

Figure 2: Four common mounting methodologies for accelerometers

tionship. In the world of accelerometers, the mass of the weight correlates to the mass of the accelerometer, while the stiffness of the spring correlates to the stiffness of the accelerometer's mounting. To achieve high frequency measurements, an accelerometer must be as small as possible and have as stiff of a mounting methodology as possible. Each of these two factors is explored in detail in the following sections.

FACTOR #1: STIFFNESS OF SENSOR MOUNTING METHODOLOGY

There are several common methodologies used for vibration sensor mounting. These include stud mounting, adhesive mounting, use of a mounting pad and use of a magnet. Here are the characteristics for each mounting methodology:

Stud Mounting

- Maximum Frequency Response: Stud mounting an accelerometer directly to a piece of equipment provides the stiffest possible mounting and, therefore, the highest possible frequency response from the sensor.
- Equipment Modifications/Permanency of Installation: To stud mount a sensor to equipment, it is necessary to spot-face a smooth surface and then tap a pilot hole to fit the sensor's mounting thread. Once removed, there is still lingering evidence of past sensor mounting.
- Can Install on Curved Surfaces: Stud mounting a sensor on a curved surface is not possible.

Adhesive Mounting

- Maximum Frequency Response: Mounting an accelerometer with adhesive directly to the equipment provides the second stiffest mounting methodology. Frequency response is reduced only slightly, about 10 to 15 percent, compared to a stud mounted accelerometer.
- Equipment Modifications/Permanency of Installation: An adhesive mounted accelerometer can be easily removed with the appropriate dissolving agent for the adhesive. Once removed, there is no evidence of past sensor mounting.
- Can Install on Curved Surfaces: Adhesive mounting a sensor on a curved surface is not possible.

Mounting With a Mounting Pad

- Maximum Frequency Response: Mounting pads can be adhesively bonded or welded to the equipment's surface. Then, the sensor can be stud mounted to the mounting pad via the tapped hole in the pad. This type of sensor mounting is considered a midway point between the stiff methodology of stud mounting and the flexible methodology of magnet mounting. Frequency response will be reduced by approximately 35 percent compared to stud mounting.
- Equipment Modifications/Permanency of Installation: While a weld mounted pad is a relatively permanent installation, an adhesive mounted mounting pad can be easily removed with the use of an appropriate dissolving agent for the adhesive.
- Can Install on Curved Surfaces: Mounting a sensor on a curved surface with a mounting pad is not possible.

Mounting With a Magnet

- Maximum Frequency Response: Mounting an accelerometer with a magnet is a very flexible mounting methodology that will significantly degrade the sensor's high frequency response by as much as 80 to 85 percent.
- Equipment Modifications/Permanency of Installation: The lack of required equipment modifications and the temporary nature of the installation are the reasons why magnet mounting is used in many applications. Magnet mounting offers the most convenient method of temporary sensor installation for route-based measurements and data collection.
- Can Install on Curved Surfaces: Magnet mounting a sensor on a curved surface is possible when a dual rail magnet is used.

FACTOR #2: SENSOR MASS

Sensor manufacturers continue to make smaller and smaller accelerometers in order to satisfy customers' requests for sensors capable of high frequency measurements. This effort is challenging because manufacturers must balance the small size with the need for a rugged sensor that can withstand harsh environments.

MOST INDUSTRIAL CUSTOMERS REQUIRE:

- Robust Housing: In the world of industrial accelerometers, the robustness of the sensor's housing is not determined by one single fac-

Figure 3: A triaxial accelerometer with a footprint less than one inch square and a 13kHz frequency response on all three axes

tor. Rather, it is determined by the housing material, the level of seal the housing provides and the electrical isolation of the housing. Most industrial accelerometer housings are 304 or 316 stainless steel and hermetically sealed in order to withstand chemical exposure and wide operating temperature ranges. An isolated case housing allows an accelerometer to be mounted on equipment with poor electrical grounding without running the risk of signal contamination. This isolation is typically achieved with the use of a Faraday cage, a continuous enclosure around the sensor's electronics to repel noise.

- Rugged Connectors: Connectors must be able to withstand repeated use in harsh conditions. Military-style connectors are preferred, as they, along with their mating cables, can withstand extreme conditions.

Despite the challenges, sensor manufacturers have been able to successfully shrink the size of industrial accelerometers to about the size of a quarter. For example, some high frequency triaxial accelerometers measure just 0.95 inch by 0.95 inch and have a 13kHz frequency response on all three axes, isolated stainless steel case housing and rugged connectors.

CONCLUSION

High frequency measurements are gaining prominence as industrial predictive maintenance teams seek ways to get the most comprehensive look at the health of assets. The size of the sensor and the stiffness of sensor mounting methodology are the two most important factors contributing to a sensor's ability to successfully provide high frequency measurements.

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Meredith Christman *is the Product Marketing Manager for IMI Sensors, a Division of PCB Piezotronics, Inc. Meredith is responsible for product development and management of the company's industrial and energy product lines. Prior to her current role, she worked for 10 years as Product Manager of Air Management Products with Roberts-Gordon LLC.*
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Q&A

Chrissy Hedrick

WIRAM
Women in Reliability and Asset Management

Chrissy Hedrick, Wastewater Operator at Cintas Corporation, hasn't let stereotypes or diversity slow her down when it comes to her career. Since her 2011 hire in sorting operation, Chrissy has quickly moved up the company ladder. She has held roles in storeroom utility, human resources and became the eMaint expert, assisting and leading her company in a successful and consistent execution of the program. Chrissy's road into reliability and asset management has been a journey, one that she has learned from and experienced fully. However, as she will tell you, it is not over…it is a continuous journey.

Q: How did you get started in this career?

My journey at Cintas Corporation started from a long period of temporary and part-time employment. During the recession, I struggled finding a full-time job. I started at a factory right out of high school. Unfortunately, that factory moved to Mexico in 2004, giving employees only a six month warning. I was a single mother of two young children, so I needed to find employment of any sort that could pay the bills. I worked any job available, including factory work, roofing and siding, and retail, to survive.

Working in roofing and siding for 18 months was the first time I experienced diversity in the workforce. I had to prove myself and overcome fears of not being strong enough and my fear of heights. I overcame my fears and was accepted on this team because of my determination to provide for my children.

I restarted my life in an unsafe, rent-controlled environment that made me want to obtain a better job so I could move up and out of that place. In 2011, I remarried and my husband was without work, which caused me to keep looking for a full-time position. This is how I found Cintas. Cintas Corporation has changed my life in so many ways and the gratitude I have cannot be explained. Through this career, my family and I were able to relocate to a safer place to live and I obtained an associate's degree in business administration. I am honored at all the wonderful opportunities that have come my way and are yet to come.

Chrissy's Cintas team (from left to right) back row: Joel Huber, Tom McGraw, Eric Seiler, Dwight Weller; front row: Brianna Brough, Chrissy Hedrick, Alex Maye (not pictured: Eric Pravidica)

Q: Women in Reliability and Asset Management (WIRAM) is committed to increasing diversity in teams to advance reliability and asset management. Why do you feel this is important and how does it add value?

I feel diversity plays a huge role in the advancement of reliability and asset management. The current maintenance team at Cintas 355 has people with very diverse experience levels, age groups and backgrounds. As examples, we have team members with decades of experience in machining, the auto manufacturing industry, facility maintenance, and HVAC and automation. I have a background in general assembly and retail. The diversity allows everyone to have a different perspective and enables troubleshooting to go very smoothly.

Q: What are some examples of how you have successfully promoted diversity?

When I was the admin for the human resources manager, I did a lot of training. One of the biggest challenges the Cintas 355 partners face is the language barrier between English and Spanish. So with management's approval, I partnered with the project lead and we translated safety trainings from English to Spanish. This made all partners feel as though they are an equally valued part of the Cintas team and gives them a better understanding of the trainings offered. I was also involved in planning celebrations and congratulatory gifts for partners becoming U.S. citizens. I also organized a job shadow program. For two days, participants shadowed the Reliability Audit team and got to experience a day in the life of a maintenance tech. They gained valuable training in the maintenance field and learned about career opportunities in this field.

Q: What are some of the challenges faced in advancing diversity in reliability and asset management?

Some of the challenges I have faced in advancing diversity in reliability is inexperience in such areas as electrical troubleshooting, limited strength and dealing with suppliers who are not as willing to accept females in this industry. My managers and fellow Cintas 355 partners have always encouraged me to do the best I can and have played an integral part in my career advancement.

Being a woman in reliability has brought about challenges when working with others who are not accepting of me in this position. I am always willing to learn and listen to those who are more experienced, but I still come across individuals who ask to speak with the boss or the "man" of the department when I am sourcing parts. I keep a professional attitude and I understand they may be from a different generation when this was acceptable, but I know it is not. Cintas Corporation has a very diverse culture that accepts everyone in all areas and does not allow any discrimination to take place.

Q: What suggestions do you have for anyone wanting to support diversity in reliability and asset management?

The first suggestion is to never judge a book by its cover. Looking back 6-½ years ago, I would never have imagined that I would be such an important part of compliance and wastewater management, nor would I have thought about asset management. Being a woman in the wastewater management field takes time and study to understand the function and importance to the company. I have had to learn hands-on troubleshooting with the pumps, motors and chemistry of the wastewater system. When issues arise, we don't automatically go to the chemistry; I must understand the mechanical aspect prior to diagnosing a chemical issue. As a woman, I take pride in doing this job to the best of my ability and I have learned the different sounds, feelings of water/sludge and actions needed to take when pumps are not running properly. I need to utilize all my senses, which at times, is not pleasant! Another way to support diversity is to have an open mind to all individuals and allow those interested in this field to do a "tryout" to see exactly what happens on a day-to-day basis. Lastly, believing in yourself and getting rid of self-doubt is crucial to success. I have had many successes and some failures, but I choose to use those times as life lessons to learn from, rather than put myself down. Always strive to be the best at what you do and the sky is the limit.

Q: Who has inspired you as a leader? Is there a quote from that individual that has left a positive influence on you?

I have had several individuals who have inspired me as a leader. Eric Pravidica, General Manager at Cintas 355, has always shared his journey on how he is where he is today. Eric has always encouraged me and recognizes the hard work I put into the job. Dwight Weller, Plant Manager at Cintas 355, is also a big part of my journey. He has always been a hands-on manager, willing to do whatever it takes to assist partners, whether it's loading and unloading trucks, sorting garments, bagging bulk, rolling mats and even assisting in replacing a bearing on a washer. Dwight is one of the hardest working managers I know. He is not afraid of sacrificing his personal time to make sure the partners are taken care of along with the customers. Eric Ayanegui, Director of Operations and Engineering of North Central Group, is the individual who has nominated me to take part in this Q&A. He is a pleasure to work with and is an awesome leader who enjoys visiting the locations and getting to know partners. Jim Gniadek, Corporate Field Engineer North Central Group, inspired me with his willingness to support me on my journey. Keith Carey, Tom McGraw and Joel Huber inspire me with their on-the-job training. These technicians continue to teach me on this journey and they believe in me when I have doubts. Eric Seiler, Maintenance Supervisor at 355, inspired me to get skilled in electrical troubleshooting and organizational skills. He has spent a lot of time with me on schematics and wiring diagrams. I am grateful for all of these leaders; I could not be where I am today without any of them.

Q: What advice can you share with young women who are interested in a career related to reliability and asset management?

My advice is to remember to stay focused and teachable. I overcame my fear of not being strong enough or skilled enough through training and the use of proper tools. Follow your heart and calling in life. Take time to learn from those with the experience in the safe way to do the job. If you work hard at everything you do, it will pay off. I am treated equally in my position and I have earned the respect of my fellow partners because of my willingness to learn and grow in all I do. Women can do anything in this field if they are properly trained and willing to put in the hard work.

Q: Are there any books you would recommend?

I recommend everyone reads, *The Spirit Is the Difference*. This book is the beginning of a company known today as Cintas Corporation. The book explains how it was founded, its corporate culture, the character aspect of Cintas and its partners, and how the management team operates. I am so proud of the history that is behind Cintas Corporation and I remind myself daily that a family with a dream worked hard and turned their dream into a multi-billion dollar operation that it is today.

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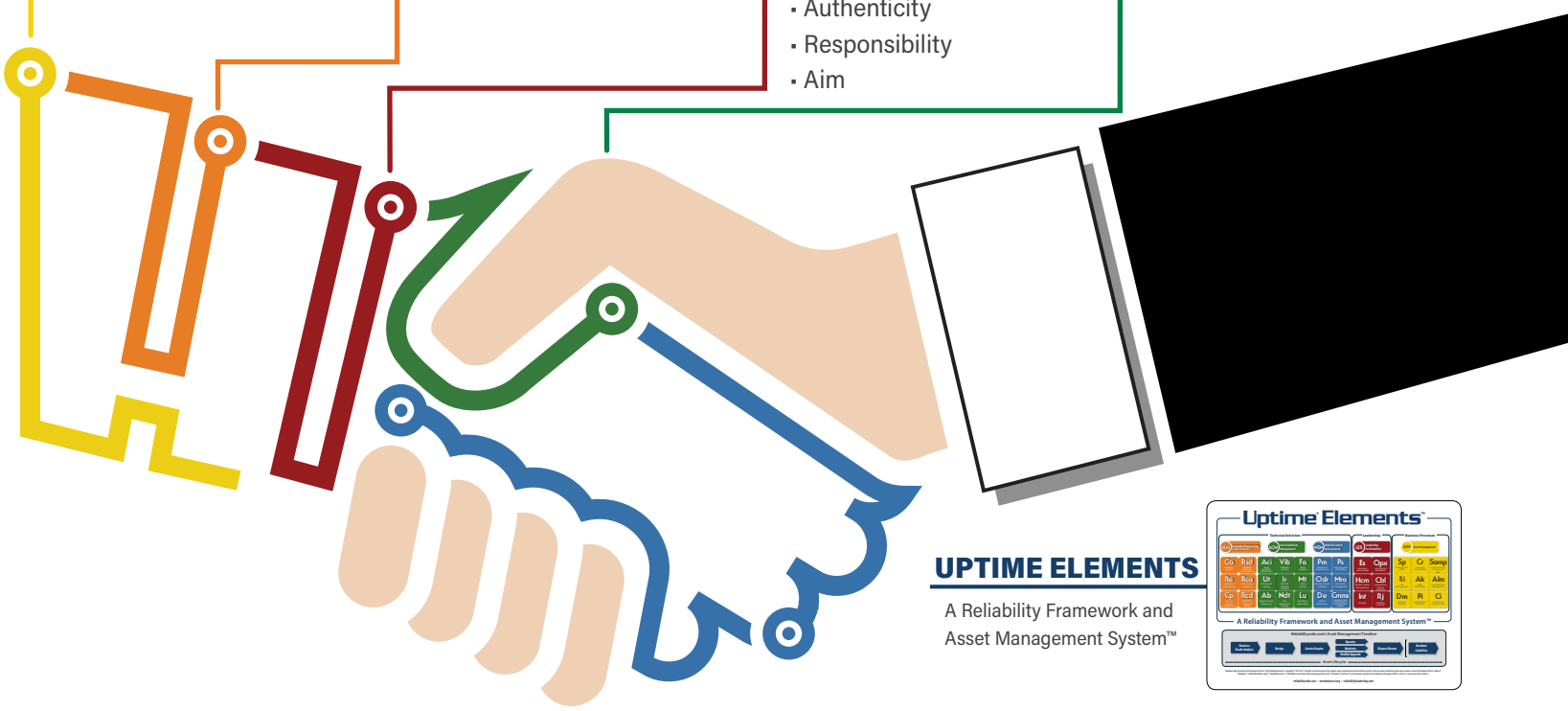

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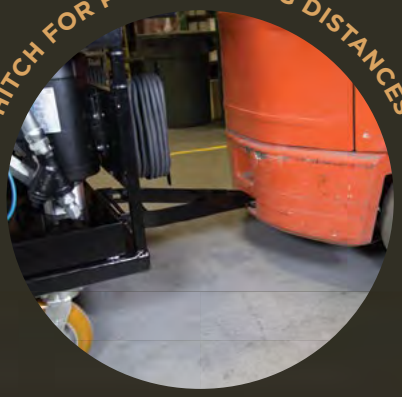

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