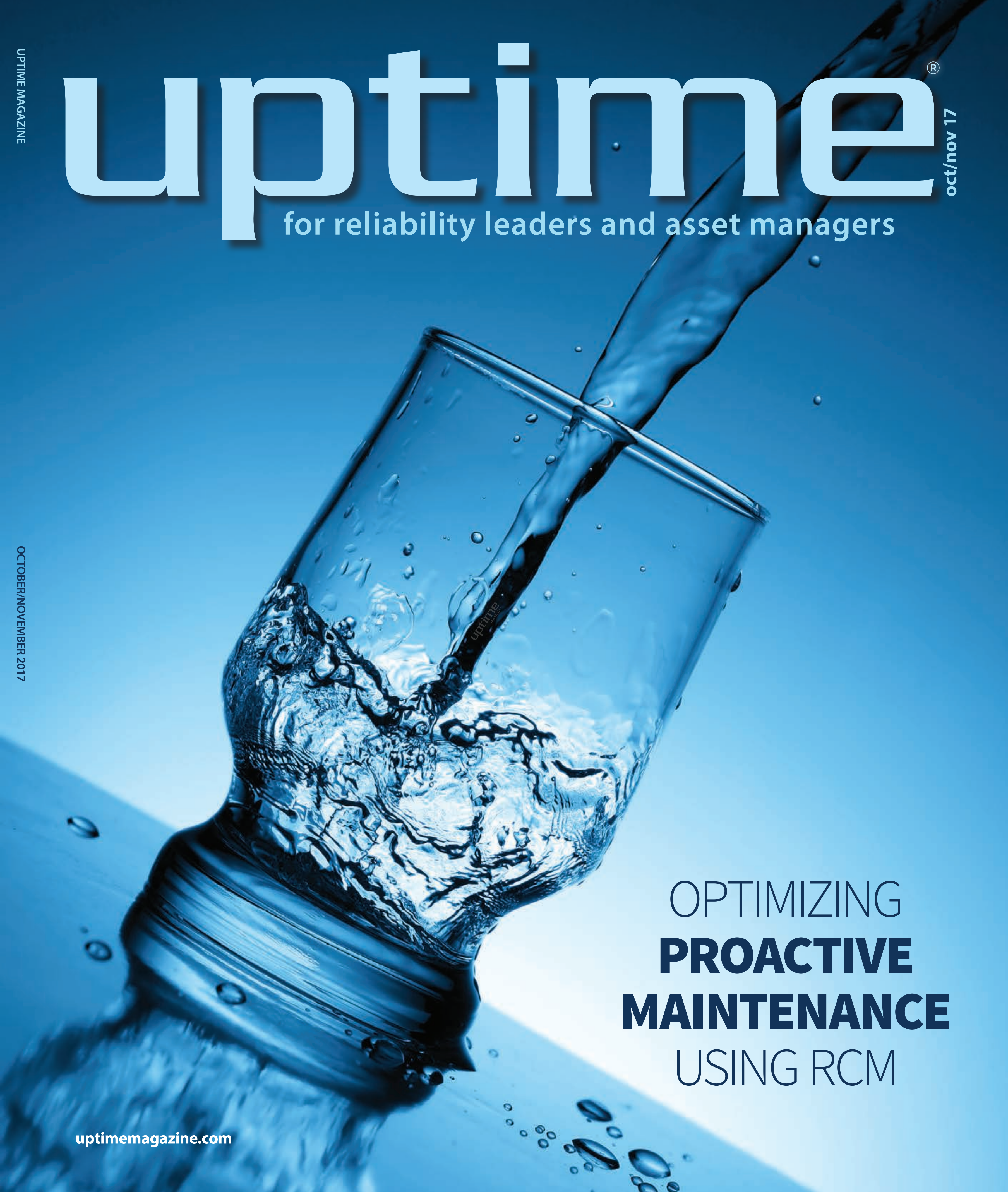
UPTIME MAGAZINE

uptime®

oct/nov 17

for reliability leaders and asset managers



OCTOBER/NOVEMBER 2017

OPTIMIZING **PROACTIVE MAINTENANCE** USING RCM

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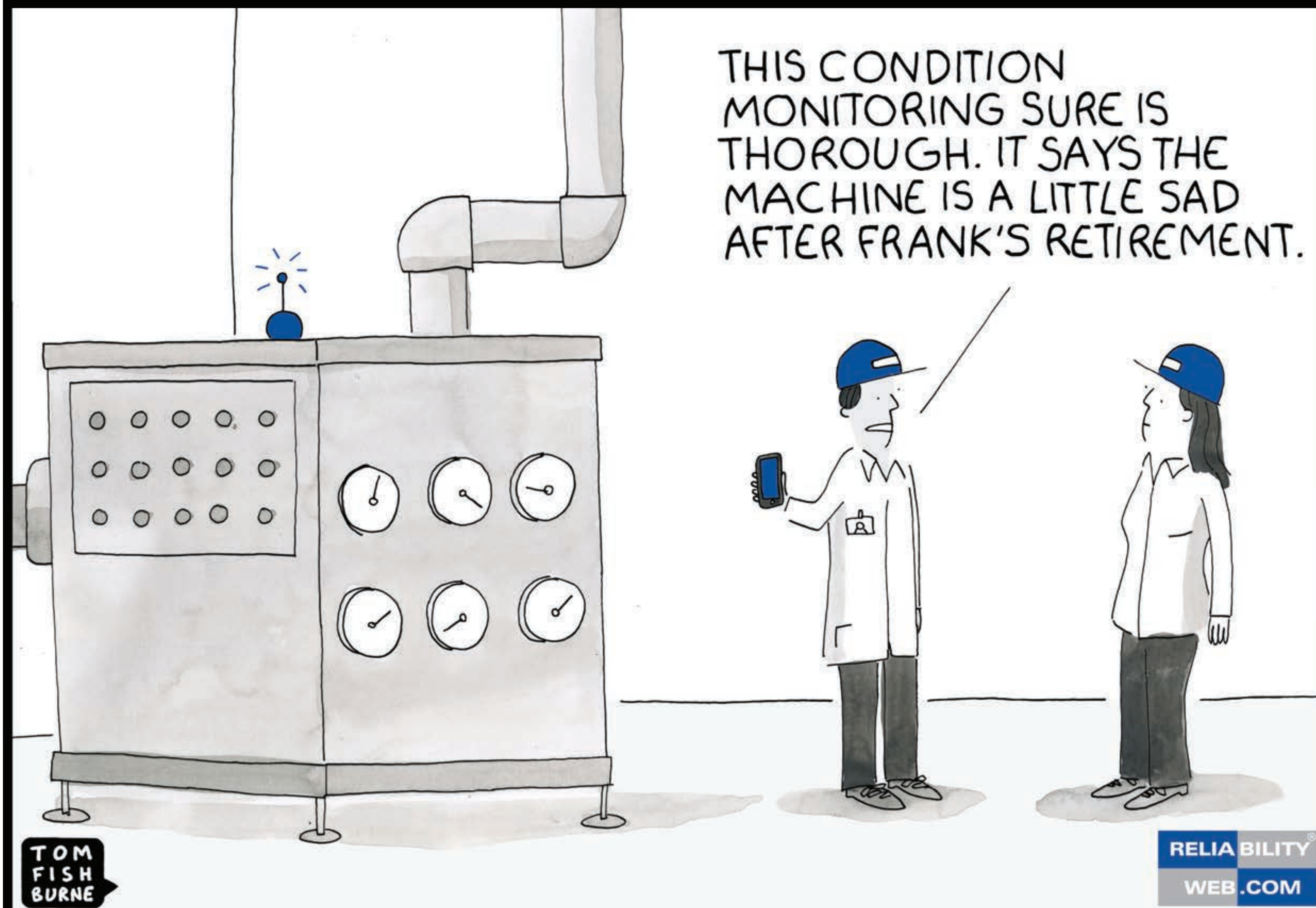
Featured Uptime® Cartoon

Tom Fishburne, Marketoonist



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

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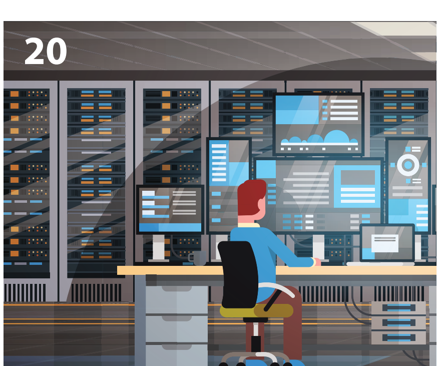

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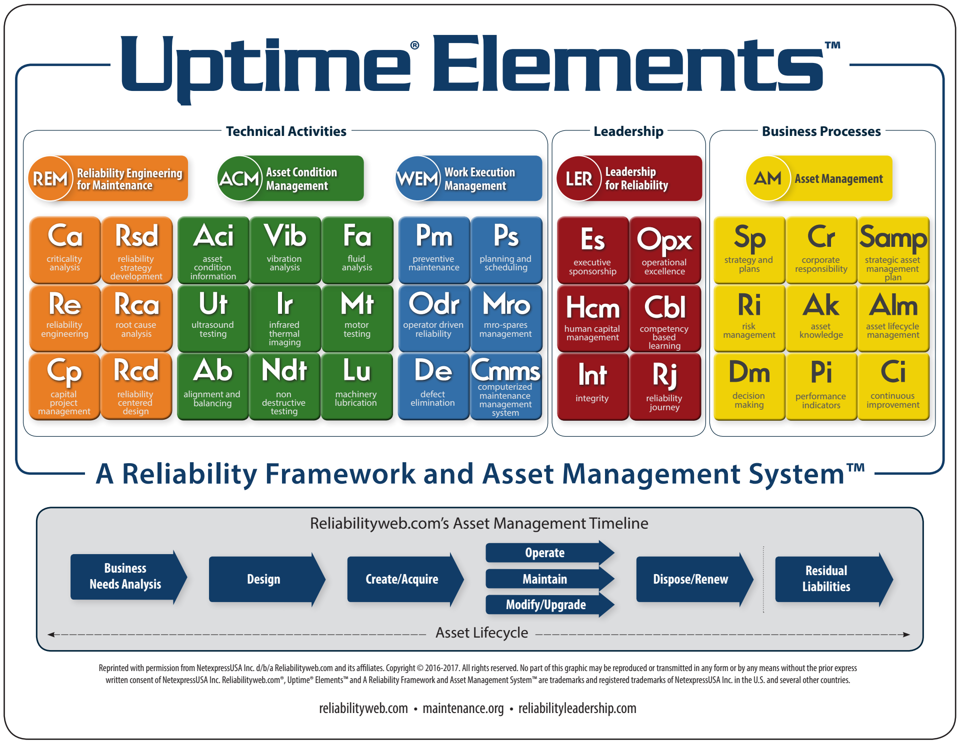

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THE DIFFERENCE BETWEEN RELIABILITY LEADERSHIP AND RELIABILITY MANAGEMENT

In our work to advance reliability and asset management, we know there is a direct connection between reliability leadership and asset performance. The same is true for the 93 percent of *Uptime®* magazine readers who participated in the *Reliability Leadership* benchmarking study completed in August 2017 and indicated the positive impact that leadership has on asset performance.

Combine that data with our *2014 Asset Management Practices, Investment and Challenges* study, which reported the number one challenge for asset performance is organizational culture.

Culture is created through leadership. Performance comes from culture. No wonder more than 70 percent of reliability performance improvement efforts fail as project managers overlook leadership as the leverage needed to deliver a successful improvement.

If you study Uptime®Elements™– A Reliability Framework and Asset Management System™, you know that "being" a reliability leader is defined as ***realizing*** *a future that wasn't going to happen anyway*. It is not about becoming a reliability leader – it is about "being" a reliability leader.

Most people confuse having a certain title, being in a "leadership" position, or having authority with being a reliability leader or with the exercise of reliability leadership. While it is true that reliability leaders sometimes have titles, are in a leadership position, or have authority, none of these make anyone a reliability leader, nor does it mean they are exercising reliability leadership.

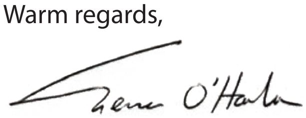
To be a reliability leader, you must be able to lead and exercise reliability leadership effectively with no title, no position, and no authority. For example, you will fail as a reliability leader if you cannot lead up – that is, if you cannot exercise reliability leadership in dealing with those you report to.

Here is some insight for you about reliability: If you are in a situation where you could "figure out" an answer, you do not need reliability leadership. Competent management is fully sufficient for such outcomes and often this is adequate for certain situations. Reliability leaders know when a situation calls for leadership and they know when a situation requires management.

Reliability leaders create outcomes that are NOT going to happen anyway. I truly enjoy working with these leaders as they create a new future with their teams.

I hope you will find this issue of *Uptime®* as valuable for learning as I did. If so, please let us hear from you, or better yet, share your knowledge and experience in reliability leadership on the pages of a future issue.

Warm regards,



Terrence O'Hanlon, CMRP
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"To be a reliability leader, you must be able to lead and exercise reliability leadership effectively with no title, no position, and no authority."

RELIABILITY

IN THE NEWS

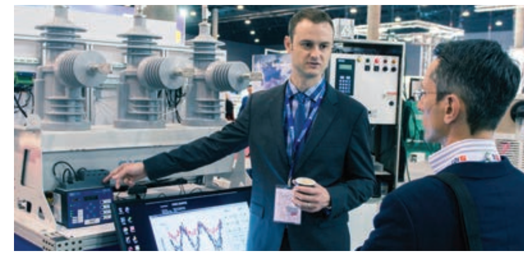
Hurricane Irma

The team at Reliabilityweb.com is overwhelmed by prayers, concern, offers of support and the good nature of so many friends who reached out during a very stressful few weeks. Although some minor damage was experienced, in addition to major inconveniences (no electricity, cell service, Internet, gas, etc.), none of our team was injured before, during, or after the storm. Thank you to all who wrote and called.

Southwest Florida is once again open for business, with the best Gulf of Mexico sunsets, welcoming hotels and restaurants, and a carefree, sun-filled lifestyle to make your winter season more bearable!

We look forward to seeing you at IMC-2017, December 11-15, 2017, in Bonita Springs, Florida!

For more details: www.imc-2017.com



IoT Solutions World Conference - Barcelona

Uptime® magazine is honored to participate in the IoT Solutions World Congress, October 3-5, 2017, in Barcelona, Spain. This 3-day event hosts the world's leading Industry IoT Congress, where over 250 of the most innovative and influential IoT thinkers will gather together to share knowledge, present visions and discuss the affects of IoT in the industry.

Executive Operational Certainty Roundtable

Emerson Automation and Reliabilityweb.com recently collaborated on the Executive Operational Certainty Roundtable held in Minneapolis, Minnesota, on October 4, 2017, in conjunction with the Emerson Exchange Conference. The objectives are to explore the challenges and solutions related to:

- Asset management as a business and performance strategy;
- Executing on the promise of the Industrial Internet of Things;
- Empowering human capital: The secret weapon for asset management and reliability.

Additional support was provided by DuPont Sustainable Solutions and Solomon Associates. A published white paper summarizing the discussed solution strategies will be available to participants or through the above mentioned event sponsors.

MaximoWorld Hosts WIRAM

MaximoWorld 2017, held August 1-3, 2017, in Orlando, Florida, hosted the Women in Reliability and Asset Management (WIRAM) face-to-face group meeting. More than 50 leaders attended a special breakfast and discussion. Topics included the role of women in the field of reliability and asset management, and the unique challenges they encounter. The next face-to-face meeting will be held December 11, 2017, at IMC-2017.
For more information, contact:
maura@reliabilityweb.com.

CRL Workshops

Hilmar, CA - August 29-30

Queretaro, MX - September 6-7

Additional 2017 Workshops

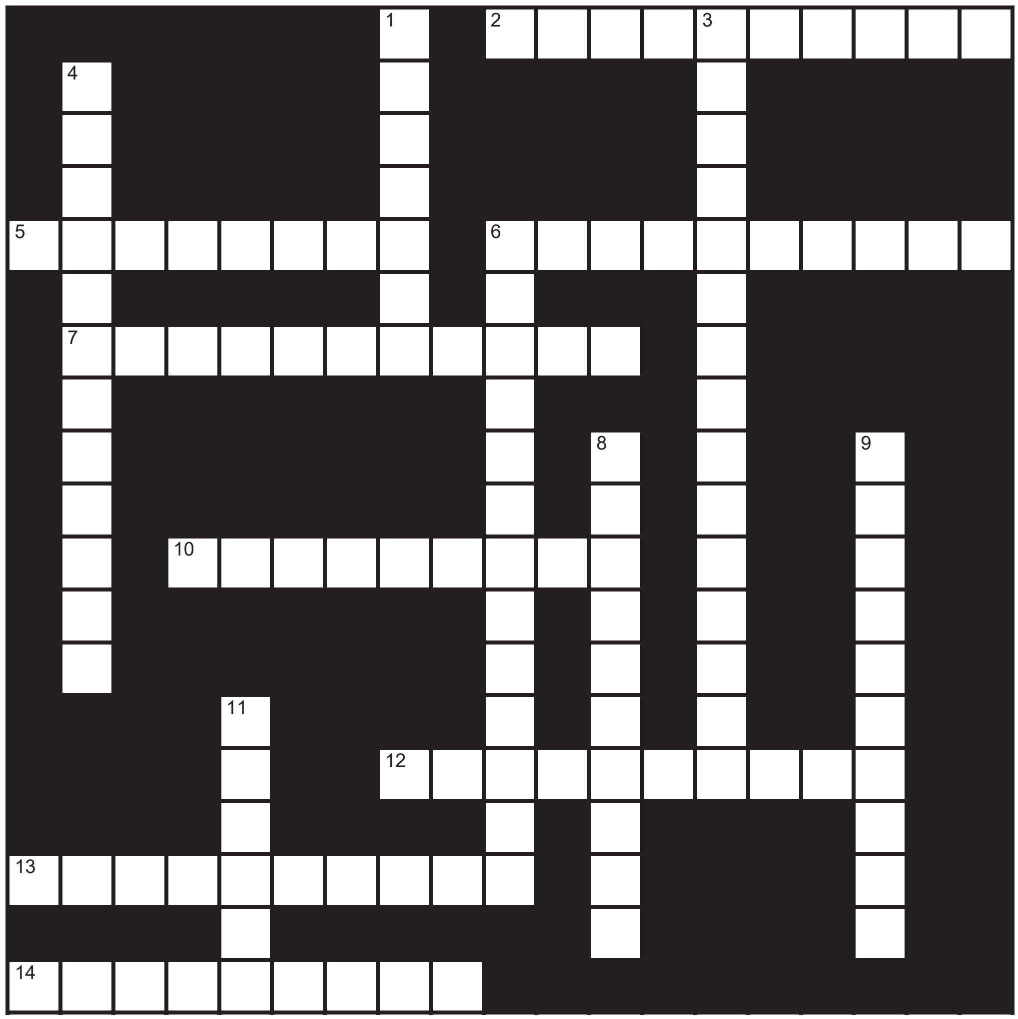
July 25-27 St. Paul, MN	August 9 Galveston, TX	September 11-14 Albany, OR	September 20-21 Lebanon, OR
August 2 Orlando, FL	August 16-17 Washington, D.C.	September 18-19 Monterrey, MX	September 25-29 Fort Myers, FL

uptime® Elements™

Uptime Elements Dictionary for Reliability Leaders and Asset Managers

Crossword Puzzle

Created by Ramesh Gulati



ACROSS

2. The use of sonic technology to discover asset problems
5. An established norm or requirement, generally presented in a formal document that establishes uniform technical criteria, methods, processes, or practices
6. A phenomenon that occurs when the absolute pressure in a pump intake line is reduced below the vapor pressure of the liquid
7. Something that follows from an action or condition
10. An item or subassembly of an asset, usually modular and replaceable, sometimes serialized depending on the criticality of its application, or interchangeable with other standard parts
12. A basic problem-solving tool that uses unbiased ideas of group members to generate a list of possible options
13. The ability to apply knowledge and skills to achieve intended results
14. The period from an asset's conception to its end of life; Also referred to as cradle to grave

DOWN

1. A Japanese word for output optimization
3. An organizational process to maximize value from an asset during its life (two words)
4. The series of activities in a project network diagram that determine the earliest completion of the project (two words)
6. An area with limited access and a potential respiratory hazard requiring a special permit to enter (two words)
8. An information extraction activity whose goal is to discover facts contained in databases (two words)
9. Fulfillment of a requirement
11. A condition that causes deviation from design or expected performance and leads to failure

Answers for this issue's crossword puzzle will be published in the December/January issue.

Rsd
reliability strategy development

OPTIMIZING PROACTIVE MAINTENANCE USING RCM

Anthony M (Mac) Smith,
Neil Meyer, Clint Shima

THE CRITICALITY ISSUE

A major challenge currently confronting plant staff and management is how to deliver cost-effective and sustainable business practices based on plant performance requirements over the lifecycle of the assets. This can be especially challenging when it comes to recruiting and retaining skilled technicians who can operate and maintain an industrial complex. While it is recognized that a primary cause for this challenge is a shrinking pool of newly qualified technicians to replace the retiring workforce, a second and substantial cause is the inefficient allocation of resources that are here TODAY. What can be done to address this inefficiency? This article suggests a ready solution exists when you stop to recognize that not everything in your plants is of equal importance to achieving your objectives. Think return on investment (ROI). How can you identify those systems and equipment that are most responsible (think **critical**) for the loss of ROI? In the operations and maintenance (O&M) world, the selective application of reliability-centered maintenance (RCM) to your plants can optimize the use of available resources. This article describes a real-world application of RCM to focus the optimal use of your available resources.

> "How can you identify those systems and equipment that are most responsible (think **critical**) for the loss of ROI?"

PLANT BACKGROUND

Since 1946, Central Contra Costa Sanitary District (Central San) has been providing safe and reliable wastewater collection and treatment for residents in central Contra Costa County, California. Today, Central San serves over 481,600 residents and 3,000 businesses in 147 square miles. Its services include a complex treatment plant, 19 pump stations, recycled water for parks and golf courses, operation of a household hazardous waste collection facility and running a sophisticated water quality laboratory.

During 2017, Central San piloted an RCM approach on two systems as part of an overarching asset management implementation plan. The plan is part of the strategic goals, with clear line of sight objectives from vision and mission to success measures.

The objective of this pilot is to establish a framework for Central San to improve maintenance efficiency and functional reliability of assets. The project aligns with its strategic plan, specifically to:

> "Be a fiscally sound and effective water sector utility, to develop and retain a highly trained and innovative workforce, and to maintain a reliable infrastructure."

RCM ORIGIN

Historically, RCM was invented in the 1960s by a United Airlines (UA) team headed by then Vice President, Maintenance Planning Tom Matteson. It was in response to a serious concern about operating maintenance costs for the new 747 "jumbo jet" airplane. The team's creative approach first addressed defining the airplane's systems, then called functionally significant items (FSIs), and then mandating that the functions of flight critical FSIs be preserved. Only then did the team turn to determining which specific component failure modes could defeat those functions. This new step in the maintenance decision world provided a logical focus on where to specify maintenance actions that could prevent or mitigate the loss of flight critical FSIs (and, by the way, also revealed that many of the then maintenance actions on the operating jet fleets were totally unnecessary or ineffective). The obvious outcome of this logic also identified the equipment in noncritical FSIs, thus introducing the potential for cost-effective run to failure (RTF) decisions.

The team's solution was so successful that it became the standard for defining the preventive maintenance (PM) program for virtually all new commercial airplanes. The details of that solution were first recorded publicly in the 1978 U.S. Department of Defense sponsored book titled, "Reliability-Centered Maintenance," coauthored by two members of the original UA team, Stanley Nowlan and Howard Heap. In the 1980s, the RCM process was widely introduced to industry and several RCM books were written, most notably by Anthony (Mac) Smith and John Moubray. (See References for these publications.)

In summary, the RCM methodology is basically these four features:

1. Preserve Function;
2. How Are Functions Defeated (failure modes)?
3. What Are the Failure Mode Priorities?
4. For the High Priority Failure Modes:
   - Define applicable task candidates,
   - Select the most effective (i.e., least costly) one.

THE CLASSICAL RCM PROCESS

Today, virtually all RCM practitioners incorporate the four features in their analysis work. The "classical" descriptor was bestowed by the Electric Power Research Institute for the specific form of analysis used by Mac Smith in his facilitation work because it follows as closely as possible to the original UA creation (see Reference #1).

Classical RCM has a 7-step system analysis protocol as shown in Table 1. This was formulated years ago via a trial and error process to assure it captured all the salient features used by the UA creators. These seven steps also form the basis for the RCM WorkSaver software that was introduced in the late 1990s. Today, it is the only known software devoted completely to the 7-step system analysis. These seven steps also were the basis for the project reported in this article.

Step 1 in Table 1 is used to select the 80/20 "bad actor" systems in a plant or facility and is the industrial equivalent of the FSI used by the UA team. (More details on the "Selecting System Criticality" process follows in a separate section.) Steps 2 and 3 assure the classical process clearly identified and recorded in the software the boundaries for the critical 80/20 systems, then the

Table 1 – 7-STEP SYSTEM ANALYSIS PROCESS
Step 1: System Selection – agreement on system priorities
Step 2: System Boundary Definition
Step 3: System Description and Functional Block Diagram – what is in the box
Step 4: System Functions and Functional Failures – agreement on functions
Step 5: Failure Mode and Effects Analysis (FMEA) – hope to strategy, predictable day
Step 6: Logic (Decision) Tree Analysis (LTA) – what is important as opposed to everything is important
Step 7: Task Selection – select the best appropriate practice

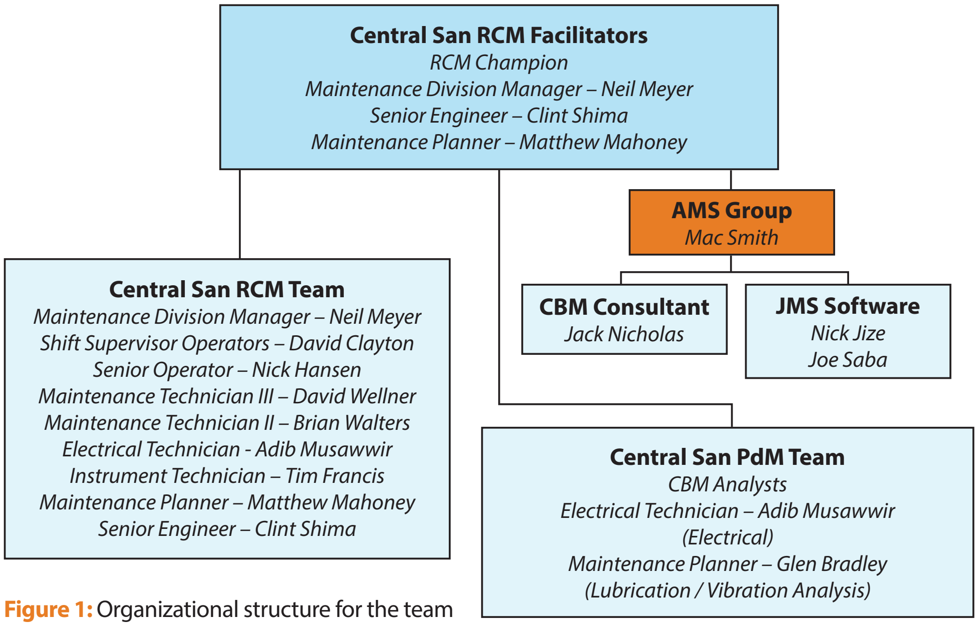


Figure 1: Organizational structure for the team

THE TEAM

A successful RCM project requires two organizational considerations. First, since the RCM process is relatively new to most organizations, an RCM project requires leadership and facilitation by someone who is well versed in the basic RCM methodology. This person must be a good teacher who can explain the details of the 7-step system analysis and all the ground rules associated with its application.

Second, it requires the commitment of a dedicated team of highly qualified technicians who know the equipment and plant systems and how they operate together to produce the product. The team must share their personal expertise as they are almost always the exclusive source of the data to "fill in" the questions and the format of the analyses' steps. This team also needs a leader who is respected by the team members and can assume the role of the RCM champion for this and subsequent RCM projects. Figure 1 shows the A-Team organization that produced the results discussed in this article.

components inside and finally the functional block diagram and description for the selected system.

The four features of the RCM process are captured in the analyses performed in Steps 4, 5, 6 and 7. Step 4 is crucial to a successful project as it is the step that captures what the selected system does and must preserve so it will not experience a functional failure. Step 5 combines information from Steps 2 and 3 and with Step 4, specifically pinpoints the failure modes that should be prevented or mitigated. Step 6 takes the criticality issues to the failure mode level and characterizes whether it is the source of a safety or environmental, outage, or hidden failure, with the default issue being an insignificant failure. (The upcoming section on "Selecting Component Failure Mode Criticality" describes this assignment process in detail.) Step 7 then addresses the failure modes with a critical label as the culprits needing a realistic PM task.

SELECTING SYSTEM CRITICALITY

As previously suggested, a major issue today is how to best utilize the limited plant resources that are usually available. One could further suggest that not all plant assets are equally important in achieving the plant's mission and goals. So, how can you identify those assets most critical to those goals? In the O&M world, criticality is most

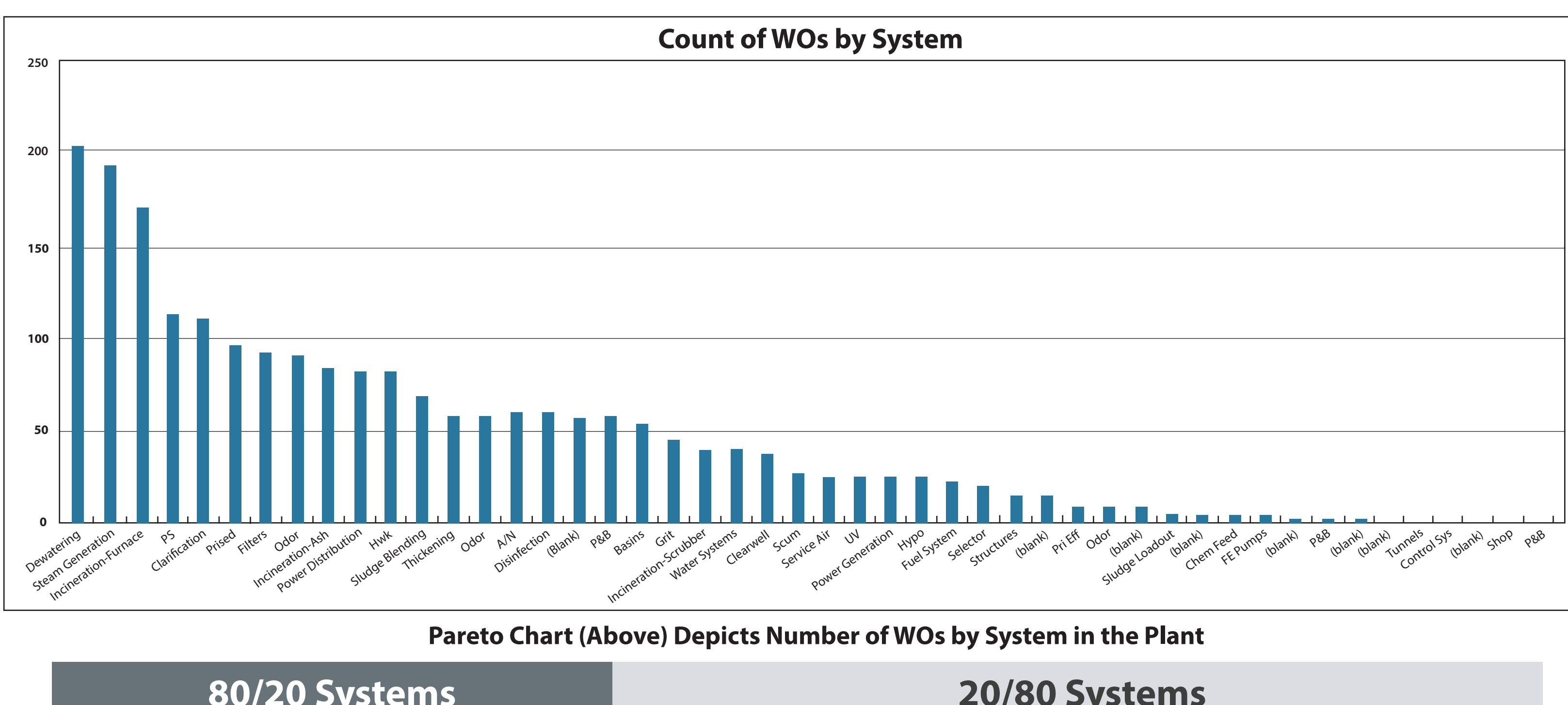


Figure 2: Pareto diagram

commonly associated with costs and system availability. So, what parameters can be used to best measure this?

Step 1 in the Classical RCM process directly addresses this question by illustrating a factual approach that will identify the bad actor systems in the plant. It does this by employing the Pareto diagram technique to rank, from worst to least, the individual plant system contributors to one of these rather easily measured parameters: corrective maintenance work order (WO) counts, corrective maintenance costs (labor plus materials), or unplanned downtimes. All three are usually assessed over a previous 24-month period. In the study for the Central Contra Costa Sanitation District treatment plant, the prior 24-month WO counts history was used for each of the 33 systems that comprise the treatment plant. The resulting Pareto diagram is shown in Figure 2. Looking back over some 60 Classical RCM projects, the pattern shown in Figure 2 ALWAYS existed. One can rather easily determine by visual inspection just which systems are doing the least good to the plant. Also, as a rule, it had been common to see the diagram reflect either an 80/20 or 70/30 pattern (80% of WOs occur in 20% of the systems, etc.). In this study, the top two bad actor systems, dewatering and steam generation, were initially selected for the two pilot studies. Within those system boundaries, several subsystems existed, so the same data was used to select the worst subsystems in each for the details conducted in Steps 2 to 7 of the 7-step system analysis process.

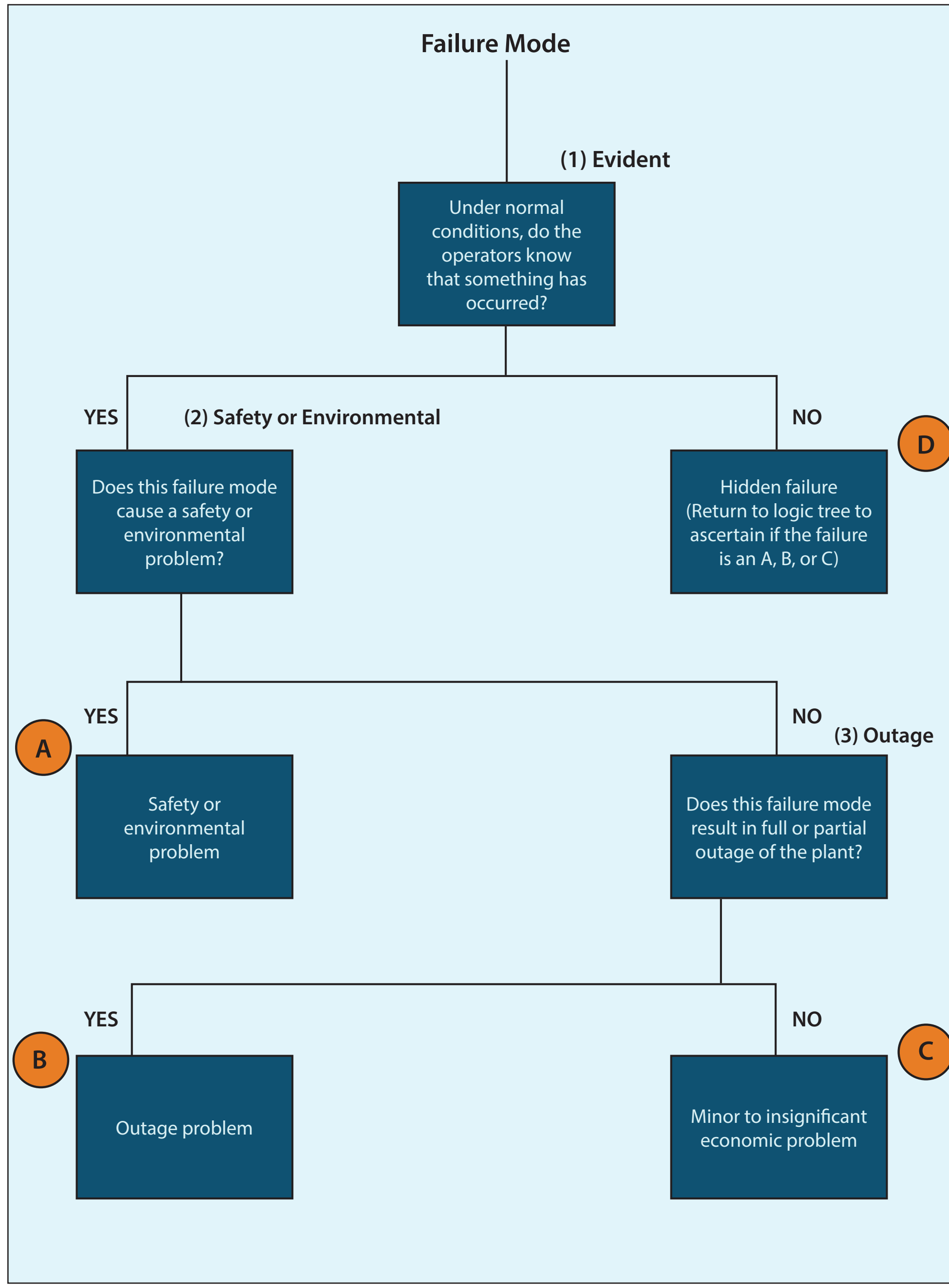


Figure 3: Decision logic tree

SELECTING COMPONENT FAILURE MODE CRITICALITY

Steps 4 and 5 in the 7-Step Classical RCM system analysis process provide the details for how the selected system or subsystem can develop component failures that may degrade or eliminate the system's functions. Step 5 is one of the most detailed steps in the analysis process as it systematically addresses each component inside the system and lists specific failure modes that could do this (some of which may have already occurred in the plant's WO records).

The next step in the criticality discovery chain takes place in Step 6, shown in Figure 3. The decision logic tree passes each failure mode listed in Step 5, one by one, through this three question "Yes or No tree," which pinpoints the nature of the failure mode consequence. A "Yes" answer serves to identify the role of the failure mode in creating a safety, outage and/or hidden failure condition (coded with the letter A, B and/or D), with the default condition being a failure mode that has little to no impact on system performance or criticality (coded with the letter C). The A, B and D failure modes pass to Step 7 for assignment of a PM task that will hopefully eliminate or mitigate their occurrence. The C failure modes become candidates for a run to failure (RTF) decision that delays any expenditure of resources until it is convenient and cost-effective to do so. However, such RTF decisions are subjected to a sanity checklist in Step 7 that first must be considered. For example, redundancy is lost, so this would be a risk that should not be taken. The results of Step 6 and 7 then become the recommended PM tasks for the system or subsystem. The final analysis in Step 7 is to then compare for each failure mode in Step 5 the current PM action versus the RCM recommended PM action. This comparison is shown in the upcoming section, "Analysis Results – Task Comparisons."

Notice that this process between the Step 1 and Step 6 analyses has defined *two* levels of criticality decisions: system and component failure mode. This provides a detailed road map for where the maintenance resource can be effectively applied – no more guessing at it!

Table 2 – Statistics from RCM System Analysis Profile		
RCM Systems Analysis Profile	**Centrifuge Subsystem**	**Waste Heat Boiler Subsystems**
Subsystem Functions	6	7
Subsystem Functional Failures	9	11
Components in Subsystem Boundary	16	25
Failure Modes Analyzed · Critical · Non-Critical · Hidden	46 29 (63%) 17 (37%) 13 (28%)	63 28 (44%) 35 (56%) 7 (11%)
PM Tasks Specified (includes Run to Failure)	62	70
Active PM Tasks	53	58
Items of Interest	30	16

ANALYSIS RESULTS – SUBSYSTEM PROFILES

After the final step in the RCM 7-step system analysis process for each subsystem, typically 50 to 60 pages of detailed information have been recorded in the RCM software as the final report. The team's action at the end of Step 7 is to summarize a group of statistics that provide an overview of both the content of this report and the highlights of the findings. Table 2 presents the statistics for this RCM system analysis profile. This profile contains information that is very descriptive with the details the team has examined and discussed. Here are some observations.

- **FROM STEP 4** – System/Subsystem (S/S) Functions and Functional Failures: Each S/S is commonly thought to have one, maybe two, functions. They usually have more than two to fully perform their intended role. Such is the case here. Also, notice there are more functional failures than functions; this is because a S/S may have more than one way *not* to do its complete job (e.g., it would not stop altogether, but is in a degraded mode).
- **FROM STEPS 2 AND 3** – S/S Components: The numbers here are about average, but many S/Ss do have numbers that are two times or larger.
- **FROM STEPS 5 AND 6** – Failure Modes Analyzed: This is the heart of the analysis' findings because a) it is the failure mode that causes all the trouble, and b) it is the failure mode that needs to be addressed via preventive maintenance or other corrective actions. Notice that on average, every component had about three failure modes per component and the clear majority of them (63% and 44%) are critical, that is "A" and/or "B" categories from Step 6. It is those failure modes that made these S/Ss critical in the first place. Also, notice that some of them are hidden from the operators (23% and 11%). In comparison to many other studies, these percentages are low.
- **FROM STEP 7** – Active PM Tasks Specified: Notice that some failure modes have more than one active PM task specified. The introduction of predictive maintenance (PdM) technology and tasks specific to the hidden characteristic may be the reason.

All this information represents input from the team's technicians. It involved collective team agreement, with frequent discussions and additional research to accumulate all the data over about a staggered 20 day, seven hours per day, period.

ANALYSIS RESULTS – TASK COMPARISONS

In Table 3, another very important part of the analysis shows a comparison between the current PM task program and the PM task program recommended by the Classical RCM study. There are six different comparison categories shown. The 62 PM tasks for the centrifuge subsystem and the 70 PM tasks for the waste heat boiler subsystem have been assigned to the appropriate category descriptors shown in Table 3. The final analysis in Step 7 also assigned current PM tasks to each appropriate failure mode in the study to obtain the comparison statistics.

CATEGORY I: Referring back to the Pareto diagram in Figure 2, the two subsystems in the study came from the #1 and #2 bad actor systems, dewatering and steam, respectively. Thus, before the study was done, it was known that these two subsystems would likely need some major overhaul in their PM programs. The data in Category I reflects that expectation. In the centrifuge subsystem, not one current PM task was recommended to stay completely "as is," and in the waste heat boiler subsystem, only 16 percent were recommended for retention.

CATEGORY II AND III: Given the results for Category I, it is not surprising to see the results in these two categories!

CATEGORY II: The results for both subsystems are larger at 34 percent each than the average numbers most frequently seen in many other studies and provide a very valuable lesson learned for the team. What these statistics made visible is that while a current PM task is generally the right thing to do, it is not clearly stated or written just what specific actions need to be done. For example, the task may be, inspect the widget quarterly, but no details are provided on just what to inspect, measure, clean, tighten, etc., or record for the file. The term for these missing details in such a task is "tribal knowledge." In other words, to assure

Table 3 – Current and Recommended PM Task Program Comparison			
PM Task Comparison(By Flure Mode)		**Centrifuge Subsystem**	**Waste Heat Boiler Subsystems**
I	RCM Task = Current Task	0 (0%)	11 (16%)
II	RCM Task = Modified Current Task	21 (34%)	24 (34%)
III	RCM Specifies Task, No Current Task Exists	29 (47%)	24 (34%)
IV	RCM Specifies Task, Current Specifies Different Task	3 (5%)	0 (0%)
V	RCM Specifies RTF, Current Task Exists	1 (1%)	0 (0%)
VI	RCM Specifies RTF, No Current Task Exists	8 (13%)	11 (16%)

the PM is properly accomplished, an organization relies only on the knowledge and thoroughness of an individual technician to do a complete job without spelling out what that is. The problems with using tribal knowledge are: a) the tribe is retiring and all the details of the task procedure are walking out the door with them; b) the tribe takes vacations, sick leave, etc.; or c) the tribe has a new member who is not totally familiar with the widget. This tribal knowledge problem is common and without RCM, tends to go unnoticed.

CATEGORY III: This is often called the "ho-hum crasher" category! In the centrifuge subsystem, nearly half (47%) of the failure modes currently receive **no** PM and in the waste heat boiler subsystem, one third of the failure modes receive **no** PM. Basically, this situation is why these two systems are at the top of the bad actor list and generate a large amount of corrective maintenance activity. They also are the culprits behind unintended large resource expenditures, since corrective maintenance can be ten times the cost of a PM task that could have prevented them. The knowledge obtained from the Category III data, if acted upon, can easily reduce your reactive costs by 50 percent or more.

CATEGORY IV AND V: No special meaning or value in this study. However, in other studies, Category V has seen data in the 10 percent to 20 percent range, which signifies that PM resources are being wasted on failure modes that are of little consequence.

CATEGORY VI: This category indicates that without any formal RCM decision process, the current PM program is **not** wasting resources on some small percentage of the failure modes. In other words, you lucked out, but did not realize it until you did this RCM study.

SUMMARY OF SIGNIFICANT FINDINGS

Both subsystems in Pilots #1 and # 2 reflect the need for four very important, beneficial actions:

- Upgrade the selected PM tasks in the existing program to eliminate tribal knowledge as the basic procedure or modus operandi;
- Add PM tasks to many components that currently have no coverage to prevent possible failure modes;
- Better knowledge of the assets and how they can fail;
- Need to progressively replace the large percentage of time-directed intrusive (TDI) PM tasks with nonintrusive PM technology available with predictive maintenance (PdM) methodology.

Other significant findings include:

- Several items of interest (IOIs) were identified;
- Emphasis on the importance to integrate with a computerized maintenance management system (CMMS);
- New and updated standard operating procedures (SOPs);
- Fault, cause, action codes;
- Update asset attributes;
- Review spares and warehouse inventory;
- Metrics.

OTHER STRATEGIC CONSIDERATIONS

Figure 2 suggests a broader issue that the 20/80 systems also may be harboring a few failure modes that could be serious (i.e., "showstopper") disruptions to the plant. Three additional methods were examined to address such a possibility. The following three methods typically take 4 to 8 hours per system to flush them out.

Risk Threshold Identification (RTI)

While not 100 percent bulletproof, the idea here is to have special brainstorming sessions with your subject matter experts (SMEs) who must list the functions of a selected system and then list their experiences on where specific components could manifest a problem that may cause one or more serious consequences to the plant. To date, there have been some previously unknown "finds" that needed immediate corrective actions.

Defect Elimination (DE)

The methodology and rationale for including DE in addition to root cause analysis (RCA) is to eliminate known defects caused by aging, wear and tear, careless or poorly executed work habits, changed operating conditions requiring more robust components, or inadequate replacement parts that don't meet current stress levels present in an asset. DE analysis meetings typically can be completed in a day because they deal with known defects.

Root Cause Analysis (RCA)

An in-depth investigation of why a specific failure occurred is more the result of an actual failure that had very large consequences (e.g., shutdowns, safety, regulatory violations, etc.) and less about a clear understanding of the "why" question not being satisfactorily ascertained. In a way, RCA may be considered a special form of DE coupled with the large consequence situation.

These three methods are the subject of a future *Uptime* article.

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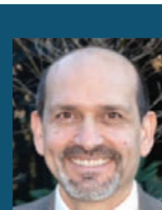

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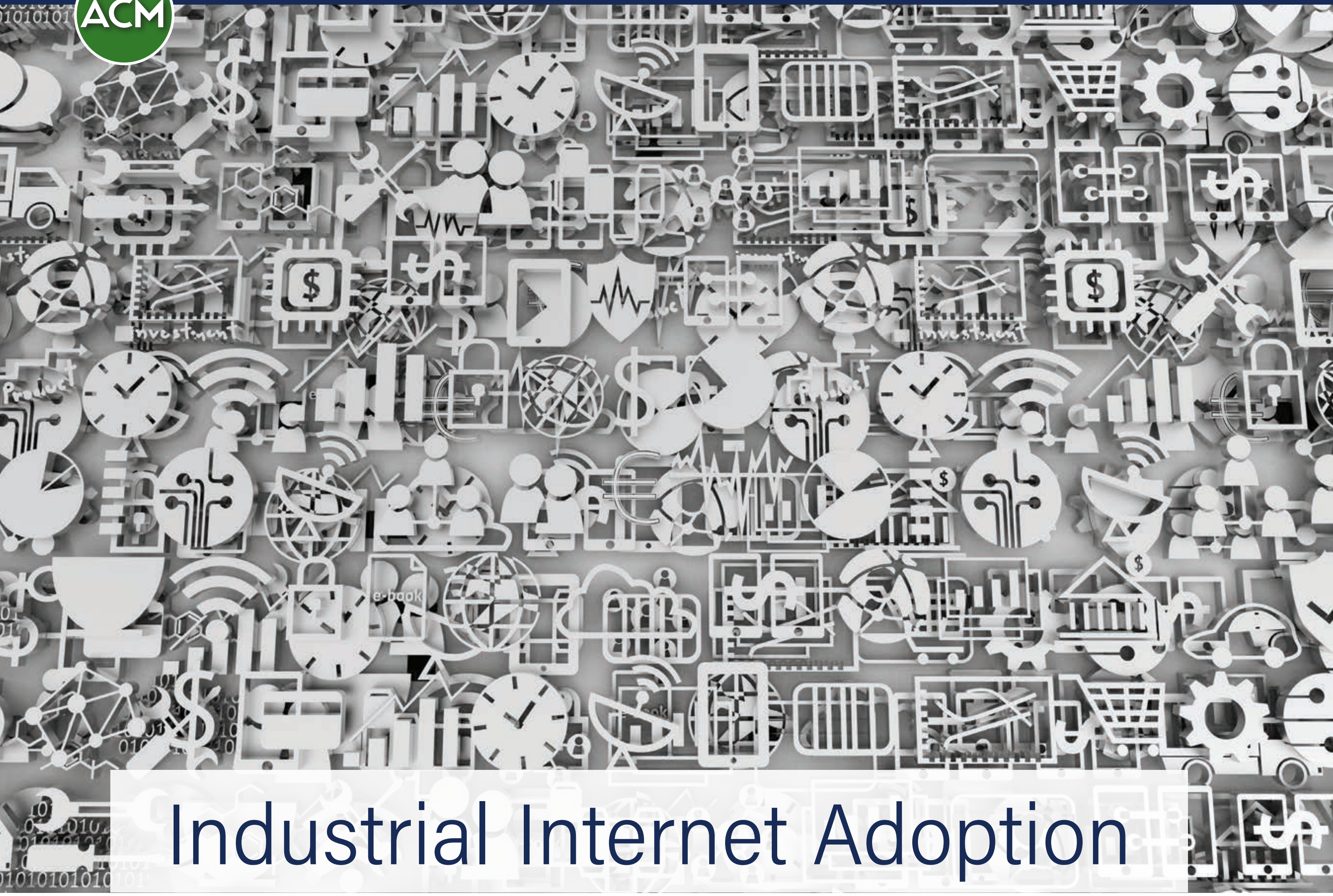

Industrial Internet Adoption

Senior Leadership Sought

John Murphy

For a successful condition monitoring program, you have to have an overall Industrial Internet of Things (IIoT) plan. Sure, you can put monitoring devices on your equipment and extract significant value, but without an overarching plan, over time you will spend unnecessary capital funds, run into scalability issues, and underestimate the impact IIoT will have on your organization.

A recent study finds that three out of four companies do not have a clear IIoT strategy. Additionally, an article's headline states, "While Most Execs Find IIoT Strategy Critical, Only 25% Have One in Place." Finally, a spring conference speaker referenced "over 50 percent of industrial companies have no plans to create an IIoT strategy."

At this stage in the IIoT lifecycle, it boggles the imagination to understand how C-suite/executive level leadership in any public or private company could not have plans developed or at least underway to address the impact of the industrial Internet. Have they not seen the impact of the smartphone in the business place? Are they not observing Amazon's transformation of the service sector? Can they not extrapolate to their own industry and business the impact of the IIoT technologies experienced in electric cars, wind power, jet engines and water utilities? Don't most board of directors have to review risk to their organizations? Don't they understand how much IIoT can improve service and how much they can save?"

Of course, many reasons exist for an organization to not develop an IIoT strategy yet. Several executives blame their last major shared services initiative as having worn the organization down and they "need a breather." Sure, major platform replacements can be challenging, but this perspective is dangerous and suggests limited organizational bandwidth and a lack of confidence in the chief information officer (CIO).

More legitimate rationale ranges from limited cash flow to personnel deficiencies to mergers and acquisitions activity to competing strategic initiatives. Certainly, strategic plan development by its very nature is time-consuming, challenging and requires layers of consensus and approval before being enacted. Once set, organizations typically follow the implementation of these multiyear programs with discipline to achieve the desired outcomes. But, what do you do when *disruptive* change enters the business environment? Time has shown most organizations are slow to recognize these business changes, even slower to adapt and many simply falter.

Does the industrial Internet qualify as a disruptive? With investment outlooks in the trillions, the multitude of start-ups in the IIoT supply chain, rapid technological tool development, and a boatload of conferences on the subject, it seems reasonable to assume that IIoT is a disruptive initiative. Any doubts can be erased if you look deeper into those more competitive, emerging, or safety industries, like auto, air transportation, and wind generation. These telltale signs of substantive change are exactly the reason why organizations should be assessing IIoT's impact.

So, what should C-suite/executive level leadership be doing to assess the impact? Certainly, starting with an organizational risk assessment makes sense as a first step, but to do that, senior leadership has to prepare for that journey by:

Educating Themselves

- Conference attendance (not supplier conferences, which are really product demonstrations);
- Benchmark – go to the best IIoT in other industries, see and hear case studies firsthand (at least a half dozen visits to include the chief executive officer, vice presidents and key strategic leaders);
- Participate in IIoT supply chain discussions – have suppliers present case studies of success, not just product demonstrations;
- Assess what your competitors are doing through industry organizations or digital media (LinkedIn is a great source).

Evaluating the Organization's Current Capabilities

- Look sharply at your business anew through industrial engineering eyes with a combination of internal and external resources. How productive is labor? How many handlings per product? How many maintenance, repair and operations (MRO) resources and what are they "really" doing? What is the utilization, availability and cost of all your assets?

"These telltale signs of substantive change are exactly the reason why organizations should be assessing IIoT's impact."

- Go down to your factory floor and listen to your employees. Where are the opportunities? Where are the problems that aren't being resolved? Take action immediately where it makes sense.
- Review your supply chain activities. Focus on material usage and supplier efficiencies. Listen to the supply chain and how it's dealing with IIoT.
- Quantify your workforce management situation. Look at attrition projects, skill set gaps, the impact of labor agreements on productivity, people development programs, etc.

Performing a Risk Assessment
Define the IIoT opportunity with the new knowledge base

- Review scenarios of the impact of IIoT technologies on all aspects of the business, including production, MRO, customer service, facility management, workforce management and future growth goals.
- Assess the impact IIoT will have on the organization's key performance indicators (KPIs).
- Quantify the competitive and risk aspects of doing nothing versus investing in IIoT technologies.

Yes, this takes time and resources, but the investment is worth the effort. The industrial engineering self-awareness assessment alone should provide adequate return on investment for the time invested, as well as build a fact-based foundation for future IIoT investment. At the end of this journey, every C-suite/executive leadership team will sharply realize the need to rethink their organizational strategy and incorporate IIoT investment into their planning, which will schedule out over multiyear investments in platforms, including asset management systems, sensors and condition monitoring software, and machine learning/artificial intelligence (AI), so they integrate to optimize your investment, organizational goals and profit and loss statement (P&L).

Just as the Internet of Things (IoT) is having a profound transformational impact on consumers, IIoT will have the same, if not greater, impact in the industrial environment. Those who plan and welcome change will thrive, those who don't, won't.

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www.reliabilityweb.com

Alm asset lifecycle management

The GOLDEN RULES for Machinery Reliability

Mike Barkle and Ron Moore

You are probably familiar with life's golden rule: Do unto others as you would have them do unto you. But have you ever wondered how any given machine, if it could express itself, would feel about this rule? What would it say? This article offers some speculative thoughts from the machine's point of view, presented as the golden rules for machinery reliability.

GOLDEN RULE 1

With regard to design and fabrication, I am sized and designed for a specific purpose, mostly process parameters, so they need to be correct and for that purpose. I want to deliver my capability and be viewed favorably by both operations and maintenance. If I have a say and am pressed, I would reluctantly accept some purchasing compromises for the sake of price, but never lifecycle cost.

GOLDEN RULE 2

I need to be stored so I can maintain my like new condition. Some of my friends have been stored poorly, so when brought out for installation, they are really ready to go back to the hospital or even the boneyard. I hope you won't do that to me. I really enjoy working hard for you, so please store me so I can be ready when called upon.

GOLDEN RULE 3

I will try really hard to withstand substandard installation practices, but please excuse me if I make more noise, generate excessive heat, consume more energy and cost more than you were expecting. After all, I can't work well, run quietly and be energy efficient if defects were introduced during installation. By the way, many of my friends died shortly after a poor installation effort. It was so sad, not to mention expensive. I will miss them.

GOLDEN RULE 4

I really want to live a long life and make you happy during that life, but if I fall short of my expected lifecycle, please conduct a thoughtful review of why I died so early. I hope my autopsy would reveal any oversights with the original design, purchase, storage, installation, operation and maintenance. Most of my friends could benefit from that and live longer than me. They would likely appreciate that and you would, too.

GOLDEN RULE 5

During my life, if I need any work or repairs, I hope the maintenance technicians treat me kindly. I'm only as good or bad as their efforts dictate. Hopefully, they won't shorten my life and create a situation that needs an autopsy.

GOLDEN RULE 6

In order for me to live a long time, precision installation and adjustment must take precedence over brute force. You should know I abhor hammers and appreciate things like micrometers and lasers. They help me to feel loved. You wouldn't go to a doctor for a good beating, would you? Wouldn't you want to be treated with care and respect? I'm the same way. For example, I just love to be in perfect balance, not to mention colinear or parallel shaft alignment. I also like to be securely mounted without any housing distortion. I'm really not a very good mover and shaker, except for the process stream, and dancing is totally out of the question.

GOLDEN RULE 7

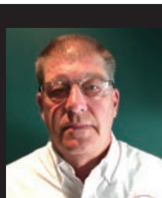
All my fluids must be kept clean (oil is particularly dirty, even when it is brand new) and at the proper level, and neither too hot nor too cold. Like Goldilocks, my fluids must be kept just right. And, if I happen to be a pump, I much prefer operating at my best efficiency point or BEP. To do otherwise is a bit like you trying to run with a rope and weight tied around your belly or, alternatively, like running against a hurricane wind. You'd get tired and worn out pretty quickly. So do I.

GOLDEN RULE 8

While I really don't like being the center of attention, especially if something is wrong with me that could have been avoided, I appreciate an occasional visit to check on my well-being and correcting the little things so they don't turn into big things. Starvation, in the form of cavitation, is really a stressful thing if I was a pump. It just wears my heart out really quickly. I don't want to die before my time.

GOLDEN RULE 9

Finally, I'm not as dumb as you think; I respond well to kindness and care. If you follow all these golden rules, our relationship with be reciprocal. I'll take care of you if you take care of me. I've been trying to tell you all this for a long time. We're partners, even though you make the decisions and I can only respond. Take my advice: **Apply Life's Golden Rule!**



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Tracy S. Smith

EAM/CMMS
Know the Difference

Today's market is crowded with hundreds of software systems, each trying to position itself as the perfect maintenance and asset management solution. But, they're not all created equal. Understanding the difference between an enterprise asset management (EAM) system and a computerized maintenance management system (CMMS) and knowing how to tell them apart under all the marketing hype are key to sorting through the herd and finding the asset information system that's right for your business.

Aren't EAM and CMMS the Same Thing?

The market for maintenance and asset management software is primarily dominated by two types of products: enterprise asset management systems and computerized maintenance management systems. The two terms are thrown around a lot, but it's not always clear what the difference is, especially when you're trying to decide which software system to purchase for your business. The confusion is not helped by the fact that many true CMMS products have started advertising themselves as EAM systems, or as EAM/CMMS hybrids.

On the surface, these products all make similar claims and seem to do similar things. They're all geared toward maintenance; they all offer cloud-based subscriptions; and most of them provide additional features like inventory management and asset tracking. Some CMMS software packages even offer features that have traditionally been the domain of EAM systems, such as purchasing modules or multisite management tools. This raises two important questions. In today's market, where web architecture and mobile apps are par for the course and multisite support is becoming more and more common, is there any noticeable difference between an EAM system and a CMMS? Have we reached a point where the lines are so blurred that they're basically the same thing?

The answers are yes, there's a difference, and no, they're not the same thing. Let's be clear: not every product that claims to be an EAM system has real EAM functionality. While it's true the line between EAM and CMMS is not as clearly defined as it was 20 years ago, these two types of software still have big differences in approach and functionality.

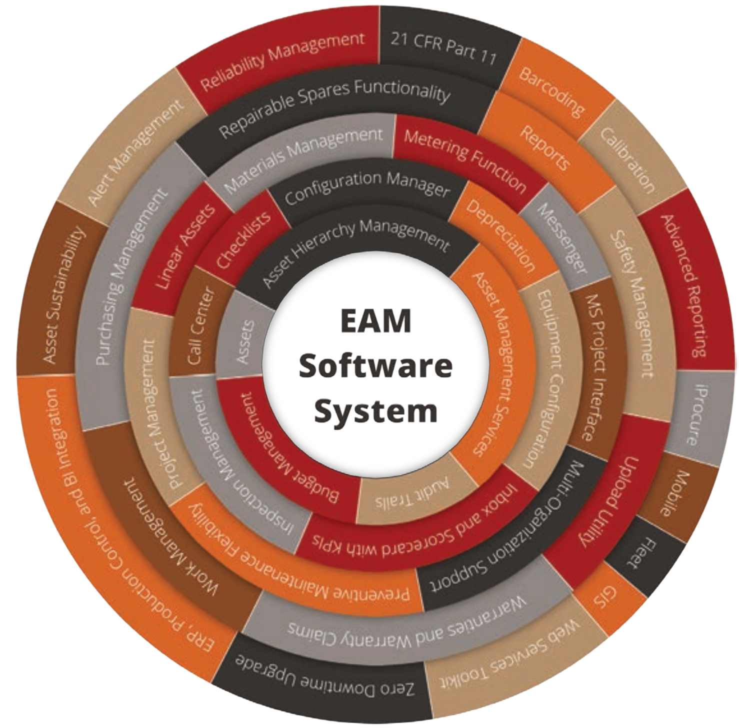

Figure 1: Anatomy of an EAM software system

What Is a Computerized Maintenance Management System?

A CMMS is designed to be exactly what the name says: a computerized maintenance management system. These systems came into being in the 1960s as technology for managing work orders with punch cards instead of paper and filing cabinets. They emerged as a computer software in the 1980s. As these systems evolved, more features were added to support a wider range of business needs. These days, most computerized maintenance management systems have some form of preventive maintenance, asset and inventory management, and mobile functionality. Many boast additional features, such as project management, multisite support, or the ability to purchase maintenance, repair and overhaul (MRO) parts from an online catalog without leaving the CMMS.

Despite their growing range of capabilities, maintenance management remains the heart of a CMMS software package. Smaller CMMS products focus exclusively on work orders and equipment records. Even the largest aren't designed to provide much functionality outside of maintenance and MRO materials management. This limited focus makes sense given their history and, in some situations, it can even be seen as an advantage. Computerized maintenance management systems are dedicated, streamlined tools for managing maintenance operations. They aren't supposed to service the asset management needs of the whole organization. This leaves gaps, but businesses can fill them by integrating their CMMS with other software systems that provide services, such as scheduling, purchasing and accounting.

A CMMS is an attractive solution for small maintenance operations that need a simple way to manage work orders, equipment records and spare parts. These systems can't do everything, but they often have a smaller price tag than their larger and more powerful cousins—the EAM systems.

What Is an Enterprise Asset Management System?

As the name suggests, enterprise asset management systems were designed to be unified platforms for managing an organization's physical assets across the enterprise. They came on the scene after computerized maintenance management systems, once network technology gave companies the ability to link computer systems across multiple sites. EAM systems include maintenance management capabilities, but they consider the total cost of ownership (TCO) for a company's physical assets and provide a wider range of features to track, manage and analyze asset performance and costs through the whole asset lifecycle, from acquisition to decommission and everything in-between.

Because they are designed for the enterprise, EAM systems serve every facet of an organization that pertains to asset management. This includes functions like maintenance and MRO inventory, but also spans MRO procurement, engineering and project management, accounting, operations, reliability management, safety and compliance, and even business intelligence (BI) to support strategic planning at the enterprise level.

The result of this comprehensive design is a single system that contains all the information about an organization's physical assets. Repair histories, energy usage, lifecycle costs, warranty records, parts catalogs, purchase orders, audit trails and more are all stored in the same system and accessible to any department. Maintenance can use the EAM system to manage work orders and equipment records. MRO materials management can use it to manage storerooms and inventory. MRO procurement can use it to manage requests for proposals (RFPs), contracts and purchase orders. Accounting can use it to manage MRO budgets and invoices. Because it's a single system, everyone is accessing the same data—data that is aggregated from a multitude of sources across the organization and updated in real time.

Since they debuted in the 1990s, EAM systems have been the solution of choice for asset intensive organizations that need to manage a large portfolio of physical assets across multiple locations. However, in the last decade, these systems have seen increasing use by small and medium-sized businesses (SMBs) that want the added performance optimization and cost management features that EAM systems offer. With the rise of software as a service (SaaS) deployment models, the cost of owning an EAM system has become competitive with a CMMS and because of its additional features, an EAM system is often the most cost-effective choice, even for small operations.

FEATURES	EAM	CMMS
Asset Hierarchies	✓	⚠
Asset Tracking	✓	⚠
Automatic E-mail Alerts	✓	✗
Budget Management	✓	✗
Calibration Management	✓	✗
Condition Monitoring	✓	⚠
Customizable Configuration	✓	✓
Document & Image Management	✓	✗
Energy Monitoring	✓	✗
Fleet Management	✓	✗
Interactive Maps, Floor Plans, and Schematics	✓	✗
Inventory Management	✓	✓
Linear Assets	✓	✗
Maintenance-as-a-Service	✓	⚠
Mobile Platform	✓	✓
Multi-Site Management	✓	⚠
Preventive Maintenance	✓	✓
Process Management	✓	✗
Project Management	✓	⚠
Purchasing & Requisition Management	✓	✓
Reliability-Centered Maintenance	✓	⚠
Repairable Spares & Rotating Assets	✓	✓
Reporting, Visual Dashboards, and KPIs	✓	✗
Role-Based Security Controls	✓	✓
Safety & Compliance Management	✓	✗
Warranties & Warranty Claims	✓	✗
Work Orders & Requests	✓	✓
Work Planning & Scheduling	✓	✓
Zero Downtime Upgrade	✓	✓

Table 1: Side by side comparison of EAM and CMMS software features

Figure 2: An EAM system serves all business functions that play a role in asset management.

EAM and CMMS: Different Approaches to Asset Management

As you have seen, CMMS and EAM systems have similar purposes and some of the same functionality, although EAM systems offer a broader range of features. What really distinguishes them is philosophy and scope. A CMMS focuses on maintenance, while an EAM system takes a comprehensive approach, incorporating multiple business functions. A CMMS starts tracking after an asset has been purchased and installed, while an EAM system can track the whole asset lifecycle, starting with design and installation. A CMMS is designed to manage a single location or offer limited multisite support, while an EAM system comes with extensive features for managing multiple sites and businesses.

An EAM system is more than just a beefed up CMMS. It's a comprehensive tool for managing physical assets and maximizing their performance across the business. It's a CMMS combined with an inventory management system, a purchasing management system, a document management system, an accounting system, a project management system, multisite management tools, performance management tools and BI tools, all rolled into a single, integrated piece of software.

Organizations that are serious about asset management rely on EAM systems to get the job done because they offer the broad, powerful, unified feature set that asset intensive operations need to make the most of their physical assets. This is also why it's misleading to describe a CMMS as an EAM system; the difference between them is more than just a few extra features. They are two different kinds of software products that represent two different approaches to how an organization manages its assets.

Which One Is Right for Your Business?

For large organizations with multiple sites and many assets, EAM systems are the obvious choice. They're the only tool on the market that combines powerful maintenance and asset management capabilities with advanced features for lifecycle cost tracking and analysis, enterprise grade support for multiple locations and businesses, and functionality for non-MRO departments like accounting and engineering. EAM systems also offer a wider range of integration options than computerized maintenance management systems, connecting the enterprise from BI systems at the top to supervisory

> A CMMS focuses on maintenance, while an EAM system takes a comprehensive approach, incorporating multiple business functions.

control and data acquisition (SCADA) systems and building automation systems (BAS) at the bottom.

For SMBs, however, the choice isn't always so clear. Most computerized maintenance management systems are more than capable of handling maintenance management needs and even MRO inventory requirements of smaller operations. They are generally priced lower than EAM systems. If you are just looking to put in a preventive maintenance (PM) program, a CMMS may be your best choice. But even for smaller operations, there are strong reasons to consider an EAM system.

If you have plans for growth, you need a tool that can grow with you. A CMMS is great for small operations, but not as good in supporting the needs of a growing business. If you're thinking about adding another site, for example, you need the enterprise functionality of an EAM system. Or, if you decide next year to implement a reliability-centered maintenance (RCM) program, you're going to want the failure analysis tools provided by an EAM system. A CMMS may serve your immediate needs, but an EAM system will give you tools to keep improving performance over the long term.

If you want to take a comprehensive approach to asset management—one that considers TCO and seeks to maximize value throughout the asset's lifecycle—then you need the deep functionality and enterprise mentality that come with an EAM system. Asset management is not just about maintenance, but about all business functions working together. You need a software platform that serves the needs of the whole operation, not just one function. An EAM system provides the tools to track costs, manage resources and optimize performance across the whole organization.

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OPERATING AT CAPACITY:

WHEN PDM IS NOT OPTIONAL

Burt Hurlock

Imagine a large, global industry that competes on hair thin margins for the opportunity to deliver products continuously, requiring just-in-time (JIT) to process and other nonstop production operations. Combine the urgency of delivery with the fact that many production sites are unmanned and downtime disrupts the customer's production operations and triggers heavy contractual penalties. Put it all together and you have all the ingredients for the perfect unplanned downtime storm.

This is the competitive environment in which major industrial gases companies operate. Many of their production operations are colocated with the manufacturing sites of customers because they're supplying ingredients that are critical to customers' production processes. Uninterrupted on-site delivery is a key industry success factor.

"…. Every unit of available capacity can be turned into revenue if they can just operate at capacity full time."

The Last Frontier

Global industrial gases suppliers squeezed out the last penny of operating efficiencies a decade ago. The only remaining significant opportunity for both cost and strategic advantage in the bare-knuckled contest to serve some of the world's largest process manufacturing operations is reliability. It is the last frontier, the holy grail of operators who know that every unit of available capacity can be turned into revenue if they can just operate at capacity full time.

To succeed in the global industrial gases market, there's no room for reliability roulette. Reliability is the last best place for competitors to distinguish themselves. As with many fiercely competitive industries, imitation in the industrial gases sector is the sincerest form of flattery because no competitor can afford to ignore innovations that become part of what marketing strategists call "the reference set," that combination of features and capabilities representing the bare minimum requirements for prospects to consider buying. Consider the auto industry and the prevalence of airbags, Bluetooth® and USB ports. Would you consider buying a new car today that didn't have them?

Companies in fiercely competitive markets have to maintain parity when it comes to proven innovations. This explains the pervasiveness of ingrained predictive maintenance (PdM) cultures in the industrial gases sector. PdM is a staple because reliability is expected.

The Financial and Performance Imperative

Industrial gases is a highly consolidated industry, which means only a handful of large global players vie for increasingly contested market share. Wins are scarcer and losses more costly. The financial and performance imperatives demand reliability.

But, financial and performance imperatives are not unique to the industrial gases sector, so PdM adoption rates should be broadly similar across industry. Curiously, that's not the case. In fact, anecdotal data suggests PdM adoption may be as much as five times higher in the industrial gases sector than elsewhere in industry generally. Why has one industrial sector concentrated on a practice that few others have? Is the financial and performance imperative among industrial gases companies greater than in other sectors?

Managers, board members and investors from other industries would very likely cry foul at the insinuation, even though they would be hard-pressed to argue the data suggests otherwise. It could be that PdM is like flossing or completing your daily 10,000 steps – you probably should, but you can't be bothered and there's no discernible, real-time cost to ignoring your dentist or doctor, respectively, until the visit at which you reckon with the toll of cumulative neglect.

Reliability Is Binary

Companies operating in tight markets can't wait for their vulnerabilities to show or for machine failures to strike. Reliability is binary, a one or a zero. Zeros represent lost market share, which takes years to claw back and often at great cost.

Interestingly, the ingrained PdM cultures of industrial gas companies are present among leaders in other highly consolidated, fiercely competitive markets, but not with the same consistency across companies. It's hard to explain the disparity, except to speculate that these may be sectors in transition. To be sure, industrial gases companies did not draw the same conclusion about the criticality of PdM all at the same time. As the industry evolved, one, or perhaps a handful of companies, the so-called "first movers," outperformed their competitors by distinguishing themselves on the basis of reliability. The "second movers" had no choice but to follow.

This may be the sequence of events playing out in other global industries, especially as the Internet of Things (IoT) facilitates predictive analytics. The first movers are already in motion, securing competitive advantage by distinguishing themselves in the areas of higher capacity utilization, higher return on capital and lower operating costs, with their customers and shareholders benefiting.

How likely is it that the concentration of PdM being seen in industrial gases will be repeated in other sectors? It may be too early to tell, given the relative novelty of the Industrial Internet of Things (IIoT) and the paucity of proven applications. What is clear, however, is that at least one fiercely competitive industry has added PdM to the reference set of operating strategies required to be competitive.

If financial and performance imperatives give reason for the pattern to repeat itself in other industries, then wherever first movers have surfaced, second movers will surely follow, especially where they have lost at reliability roulette and performance failures have shown that PdM is not optional.

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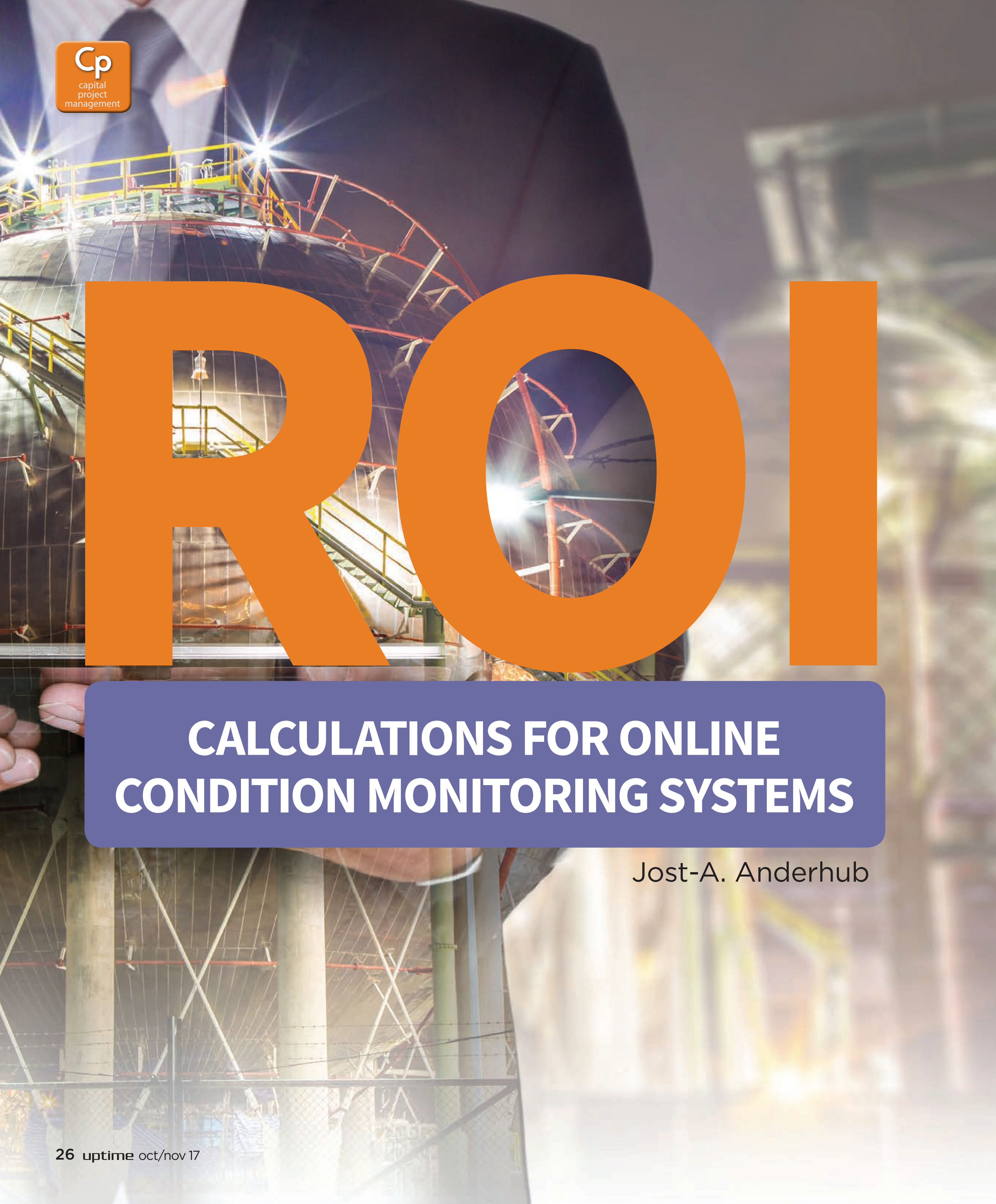
Cp capital project management



ROI

CALCULATIONS FOR ONLINE CONDITION MONITORING SYSTEMS

Jost-A. Anderhub

Continuous condition monitoring (CM) is advised for those assets that run continuously, perform functions that are crucial to the production process, have grave failure consequences, are expensive to maintain, or pose a risk to personnel safety and the environment.

Before launching a CM program, though, plant operators have to identify the goals, such as increasing machine uptime, preventing failures of critical machines, protecting workers from the consequences of machine damages, or enhancing product quality.

Operational Benefits

In terms of operational benefits, a CM system will positively affect: equipment uptime, mean time between maintenance (MTBM), component lifetime, production rates and overall operations effectiveness (OOE) of the process and plant. In particular, a CM system allows the machine to operate until scheduled shutdowns, although some values (e.g., vibrations) are less than perfect. Performance diagnostics enable process managers to save energy costs and increase asset efficiency. Early detection of leaking valves, seals, or piping saves penalties for environmental pollution.

Remote access from the system vendor allows expert support based on the customer's systems data and avoids expensive traveling to the site(s) where the system is installed, an important element for offshore applications, such as floating production storage and offloading (FPSO) units, LNG carriers and others.

Maintenance Benefits

A CM system positively affects maintenance campaign costs, with less work orders and more targeted activities. It can replace preventive, offline measurements, possibly executed from costly external service companies, and reduce labor time and associated costs with shorter mean time to repair (MTTR). Moreover, the knowledge of the failed component allows targeted repairs instead of trial and error campaigns, with less capital commitment for spare parts inventory

Risk Avoidance

Risk is the product of two factors: consequence and probability, or frequency. For the purpose of this article, the consequence factor is presented in monetary units. Let's say, for example, a compressor fails catastrophically, with a potential consequence of $200,000 in production loss, labor costs and spare parts. If this event occurs at a frequency of once every 10 years, this represents an annual risk of $20,000 per year. But, if it occurs every two years, the annual risk is $100,000.

A Worthwhile Investment?

Condition monitoring can substantially reduce the cost of consequence (i.e., avoidance of catastrophic and consequential damages), as well as the frequency (i.e., real time and continuous diagnoses of bad actors and all relevant components).

The risk of machine failures has several severity steps that need to be considered when starting return on investment (ROI) calculations: normal loss (i.e., cost for production loss and maintenance campaigns during scheduled shutdowns); probable maximum loss (i.e., cost for massive maintenance or a new machine with associated production losses); and maximum possible loss (i.e., massive machine damage, loss of product, health, safety and environment (HSE) issues, environmental pollution, fire, business interruption).

When it comes to the financial justification of investments in CM, many studies assume that the system is perfect and will always inform the user ahead of any impending failure. However, this is not always the case and false alarms, as well as missed failures, will produce costs. These imperfections and their effects on operations and maintenance have to be part of the equation as the payback periods increase.

When investing in a predictive maintenance system, two methods of assessing the economic incentives can be used. First, the payback period, which gives information as to whether the investment in the system pays for itself within a defined period of time. The result is expressed in time (i.e., years, months).

$$\frac{\text{Investment (\$)}}{\text{Annual profit of Investment (\$)}}$$

CHART 1

$$\frac{\$110{,}000}{\$75{,}000} = 1.4 \text{ years}$$

Figure 1: Payback period

Second, the return on investment (ROI), which measures the amount of return on an investment in a specified time period relative to money spent. To calculate the ROI, the return or benefit of an investment within a time frame is divided by the cost of the investment and the result is expressed as a percentage or ratio.

$$\frac{\text{Return (\$) in time period A}}{\text{Investment (\$)}} = ROI_A$$

$$\frac{\$360{,}000 \text{ in 12 months}}{\$280{,}000} = 1.29_{12m}$$

$$= 129\%$$

Figure 2: Return on investment

In both cases, operators have to precisely sum all costs and efforts associated to each detected failure to perform the equations. Adding up the investment is the easy part of the profitability assessment. More challenging, but of same importance, is the realistic calculation of the benefits earned from the CM system.

Here, four categories should be considered: lost production, labor, spare parts and drive power consumption.

Lost production is the cost that is perhaps most difficult to determine. Yet, on average, reduced downtime is responsible for 60 to 70 percent of a company's savings in this regard. These savings depend on the type of machine. Consider, for example, a machine that produces $10,000 worth of products per hour. By preventing a bearing failure on this machine, you could eliminate five hours of downtime and a $50,000 loss in production.

Labor savings are the easiest to calculate by checking the particular machine's repair records in the previous year. The number of hours spent on planned and unscheduled repairs gives a realistic indication of how much time a company can save after implementing the CM system.

For spare parts, the machine's maintenance records are a good way to determine the cost of replacement parts, such as valves, bearings and gears.

The drive power consumption factor is a little harder to evaluate because it's usually not included in maintenance records. However, improving machine efficiency can substantially reduce drive energy costs.

The rate at which companies recover an investment in CM depends on the type of products manufactured, the amount of experienced downtime and how well they implement and use the system.

In some cases, companies can recover their investment in monitoring equipment and training within months after initial start-up. Within a year, they can obtain as much as a four to five times ROI.

There are operators with full-scale CM systems that pay for themselves within weeks after their implementation due to the avoidance of only one major consequential damage on a reciprocating machine.

Experience shows that CM pays back significantly fast, especially during the initial start-up of new machinery or after major overhauls or main process changes.

In other cases, there may be little or no return during the first few months. Moreover, maintenance costs may increase during these early months because many new, unknown machine issues are identified, diagnosed and corrected in a short time period. Once these initial problems are corrected, however, maintenance costs drop dramatically and remain low.

If the system is not providing a return after several months, it should be reviewed in terms of how it was implemented. Some factors may need to be changed, for example: the training status of the system users, the proper adjustment of all warning thresholds, the full utilization of all system features and capabilities, and whether diagnostic outputs are not delivered to the right destination and, therefore, get ignored.

Finally, operators must build confidence in the notifications and diagnostic results issued by the system. When the system detects uncritical, but maybe unusual, wear development, operators should stop themselves from wanting to stop and open the machine. Rather, they should have an eye on the trend data and keep the machine running as long as possible, that is, until the next scheduled shutdown.

"This is what condition-based maintenance is all about: taking action only when required."

Another example to the contrary is brand new parts and components failing in the first hours of operation. In this case, an immediate stop might be necessary to avoid consequential damages. This is what condition-based maintenance is all about: taking action only when required.

Continuous monitoring requires a larger investment for online data acquisition and analysis equipment, plus installation. To precisely assess the total cost of ownership, operators have to consider the following investments: system engineering and installation; field instrumentation (e.g., sensors, cabling); monitoring and diagnostic system (e.g., hardware and software, installation, software licenses); user training and customer support, if required; system maintenance (e.g., sensor replacement, software updates); and necessary external expertise and support.

But, besides all the calculations, the most important question to answer is: "What system fits our needs at best?" Condition monitoring systems have been around for decades and range from handheld devices to online diagnostic systems with neuronal network features. The ongoing development of new technical features, system capabilities and, finally, the reliability of diagnostic results, increased the prices for such systems. However, the number of production assets that qualify for continuous online monitoring increased, as well.

Debottlenecking campaigns and high product output plans require more machines to be productive; former redundant machines are now onstream and an essential part of the production process. With less backup machinery available, plant operators are more than ever becoming dependent on those machines that are required to meet production goals. This means condition monitoring systems and programs are mandatory in industries nowadays.

Machine criticality is one factor to start with in identifying the proper monitoring technology and scope. One factor of the criticality definition is the well-known risk matrix. Again, you see the previously mentioned factors: consequence and probability. Risk assessment is a challenging and complex task, and in terms of criticality, you also have to consider aspects, such as: process layout (e.g., single line or multiline); list profits per hour in case of production loss; availability of product reserves to keep the process running downstream of the failed machine; time and cost for shutdown and start-up caused by the failed machine; equipment redundancy (i.e., backup machinery); average MTTR of the evaluated assets; failure history of the machinery; and availability of maintenance experts and tools.

Machine Criticality	Monitoring Technology	Financial benefits per detect
High	Diagnostics	☆☆☆☆
Medium	Online Monitoring	☆☆
Low	Offline	½☆

Figure 3: As the probability and severity of consequences of an incident increase, risk and the need for condition monitoring increase

"Experience shows that CM pays back significantly fast, especially during the initial start-up of new machinery or after major overhauls or main process changes."

One way to show dependency between criticality and the CM system's scope is shown in Figure 3. The more critical the asset, the more advanced the CM technology should be to detect all impending failures and avoid costly consequential failures.

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THE EFFECTS OF Hydrogen Sulfide Gas on Electrical Components

Samuel Starnes

Having a reliable predictive maintenance program at your facility is crucial to the health of your machinery. One cannot stress enough the cost saving benefits of detecting an issue early and being able to repair it versus the cost of fixing it after a catastrophic failure has taken place. For electrical components, infrared thermography is a great technology to incorporate into any predictive maintenance program.

Electrical systems emit heat as the electrical current flows through the connections, components, equipment, etc. When a problem exists, the resistance to the flow of electrical current increases, thus causing an increase in the amount of heat that is emitted from the component. This variance in temperature of the electrical components can be detected and measured with the use of infrared thermography.

Performing infrared surveys can help a facility detect problems with its electrical systems before they reach the point of having a costly or catastrophic failure. One such example is a routine infrared survey conducted at a plant that detected excessive heating on an LA-1600 group breaker. This particular breaker typically carries a load of 900 to 1,000 amps. An initial inspection of the group breaker from the front side of the panel showed the B-phase was heating through the breaker's contacts and arc shoot (See Figure 1). The B-phase had a delta of 28° F at this location.

Due to previous experiences of this heating being an indication of a more severe problem, it was decided to put on the proper personal protective equipment (PPE) and remove the back panels of the switchgear and complete an IR survey of the bus bar connections. On this particular group breaker, the B-phase showed to be significantly hotter than the other phases on the line side. The B-phase had a delta of 160° F at this location (See Figure 2).

The plant site was able to remove this breaker from service on a scheduled down day two days after the problem was detected. Upon inspecting the group breaker, it was noted that the B-phase showed a significant amount of heat discoloration on the line side pole projection. It was also noted that the finger cluster was plated, which would damage the springs. Once the spring tension is compromised, it results in an

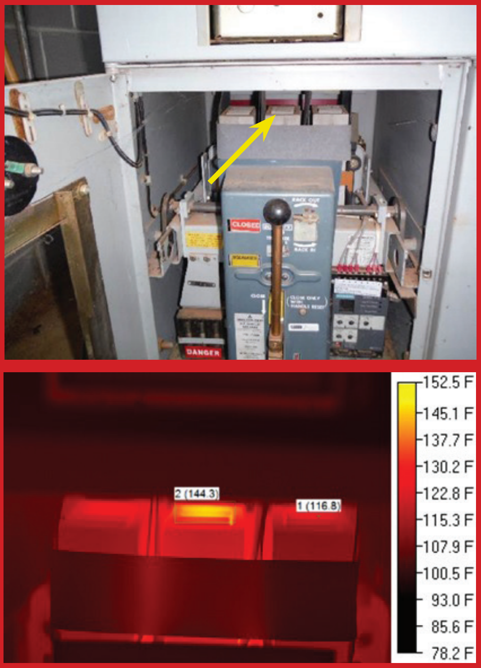


Figure 1: Group breaker arc shoot

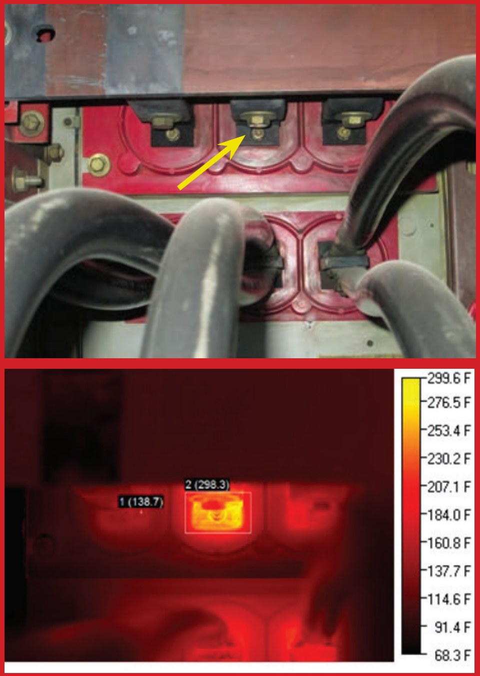


Figure 2: Group stack breaker bus bar connection

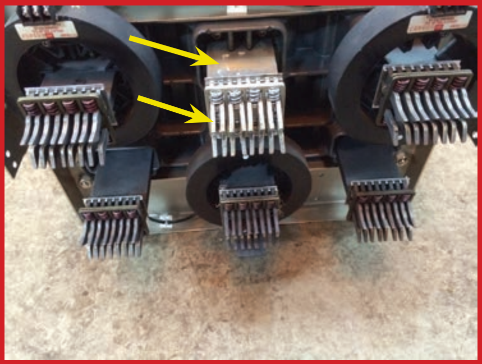


Figure 3: Group breaker pole projections

Figure 4: Silver filaments

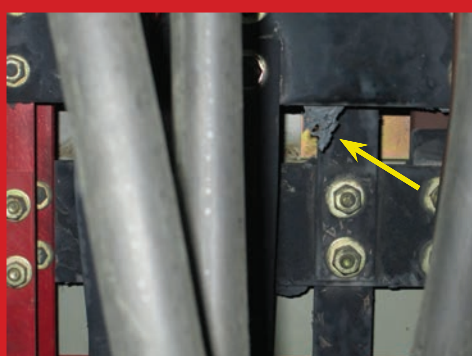


Figure 5: Flaking on bus bar

Figure 6: Metallic dust buildup on components

Figure 7: Bus bars with insulating epoxy coating applied

> When the contact surfaces of an electrical component begin to corrode, the result is an increase in the contact resistance and a rise in temperature.

increased contact impedance, which generates more heat, etc. (See Figure 3).

Further inspection of the group breaker showed silver filaments on the B-phase, which is indicative of the heating occurring there. (See Figure 4). There were no silver filaments on the other pole pieces. A visual inspection of the switchgear showed the bus bars had severe scaling and flaking in some areas. (See Figure 5). The start of a metallic dust buildup could be seen on the wire insulation and other components in the switchgear. (See Figure 6).

The switchgear is located in a corrosive atmosphere that contains low concentrations of hydrogen sulfide (H_2S) gas. At the time of the infrared survey, the air was tested inside of the motor control center (MCC) and showed the H_2S gas concentration to be at 2.3 ppm. The presence of H_2S gas played a significant role in the growth of the silver filaments on the breaker and the bus bar flaking noted on the switchgear (Figures 4 and 5).

H_2S corrosion typically occurs on electrical components by the chemical reaction of the H_2S gas coming into contact with metals, such as iron, copper and silver. Studies have shown that the presence of H_2S gas, even at low concentrations, leads to the corrosion of silver and copper components in electrical switchgears and can result in a catastrophic failures if not properly addressed. This phenomenon has been documented as early as the 1920s.

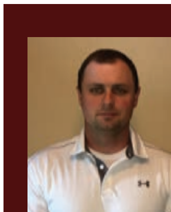
Silver plating is widely used on electrical contacts and other conductive parts because of its conductivity and longevity. It is used in circuit breakers, bus bars, relays and switches. When the contact surfaces of an electrical component begin to corrode, the result is an increase in the contact resistance and a rise in temperature. Once a thick enough layer of silver sulfide has formed, the silver filaments begin to grow. They grow more intensely in areas with elevated temperatures, such as contacts and bus bar connections. If not properly addressed, the silver filaments will continue to grow and result in electrical component failure due to overheating or a short circuit, which can be a catastrophic failure.

This particular LA-1600 group breaker provided power to the plant's wastewater process. If this particular process area loses power, the entire plant site has to be shut down. A month prior to this infrared survey, the plant site had 32 hours of unplanned downtime due to a group breaker in this same process area, causing a catastrophic failure that resulted in an arc flash. According to calculations completed by the plant's reliability manager, that particular incident cost the plant approximately $1.2 million in lost production, parts and labor.

Since this issue was detected on the LA-1600 group breaker during a routine infrared survey, the plant site was able to remove the breaker from service and make the necessary repairs before a catastrophic failure occurred again. This resulted in the plant saving a considerable amount of time and money.

The repairs that were made included replacing the LA-1600 group breaker and performing a thorough cleaning of the switchgear in order to remove all flaking, silver filaments and dust from the electrical components. After the switchgear was cleaned, a corrosion resistant insulating epoxy coating was applied to the bus bars to help control the rate of corrosion due to the presence of H_2S gas (See Figure 7). Repairs also were made to the structure of the MCC room to reduce the concentration of gas inside of it.

By detecting the problem at this facility, infrared thermography was able to save the plant hundreds of thousands of dollars in repairs and lost production, as well as avoid the potential for someone to have been injured.



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Hcm
human capital management

ENGINEERS NEED A NAP

Christopher Lindholst

The overwhelming majority of industrial accidents result from human error. Engineers who sleep less than eight hours per night are less productive and almost 10 percent more likely to cause an accident, and many don't get enough sleep. The solution: take a short nap.

Engineers can be heroically dedicated to their work, like the group that banded together for a marathon brainstorming session to figure out how to save the Apollo 13 crew. Or, in more modern times, the army of engineers who are battling sleep deprivation to upgrade the Large Hadron Collider (LHC) at CERN. But while desperate times call for desperate measures, daily operations require a well-rested workforce.

Research shows that fatigued, distracted employees are at a significantly higher risk of being involved in an accident. Eighty of every 100 workplace accidents are attributed to the person who is injured. The American Society of Civil Engineers published a 2009 study entitled, "Sleep Deprivation and Its Consequences in Construction Workers," that showed employees at construction sites who sleep less than eight hours per night have a nine percent increase in accident risk.

> A Harvard University research study estimated that sleep deprivation costs the U.S. economy **$63.2 billion in lost** productivity annually

Accidents are the most serious issue, but productivity suffers when engineers and other employees don't get enough sleep. The bad news is, most aren't getting the rest they need. The National Sleep Foundation reports that almost half of the employees surveyed said insufficient sleep at night affects their daily activities. Most people don't get the recommended seven to nine hours of rest the majority of adults need.

The good news is, there's a simple solution. A quick daytime nap of up to 20 minutes can help mitigate insufficient nighttime sleep and ramp up engineer and employee productivity. However, before that can happen, workplaces need to overcome the stigma of sleeping on the job.

Getting caught nodding off at work in the past was embarrassing at best and a firing offense at worst. But, the world has changed. People are suffering from information overload. They work longer hours and sleep less. The ability to take a guilt-free nap on company time is a workplace perk that not only improves employee morale, but helps teams be more effective.

There's scientific evidence behind the new workplace napping trend. Multiple studies show that even a short nap of 10 minutes or less improves brain function, enhances concentration and creativity, and even reduces the risk of chronic disease. Here are four benefits of a short rest policy at work:

- **IMPROVES ALERTNESS:** A U.S. Department of Veterans Affairs study conducted at the Northport VA Medical Center in New York found that short rest sessions improved cognitive functioning and alertness, resulting in a 30 percent decline in attention failures from the baseline measure. This is especially significant in environments focused on safety — frequently the type of environment in which engineers work. Short rest can improve focus by 30 percent, which, in turn, improves adherence to safety regulations.
- **INCREASES PRODUCTIVITY:** Tired employees typically perform at suboptimal levels. A Harvard University research study estimated that sleep deprivation costs the U.S. economy $63.2 billion in lost productivity annually. A restorative nap can keep engineers and other employees working at desired productivity levels for longer periods of time.
- **ENHANCES WELL-BEING:** Employees who are more satisfied are more productive. Research conducted by Hiroshima University's Department of Behavioral Sciences shows that naps improve employees' confidence when performing tasks. The study also showed short rest can mitigate the type of stress fatigue that often occurs in fast-paced production environments. Allowing engineers and other employees to nap helps them cope with overload and stress.
- **HEIGHTENS LEARNING:** Engineering is a profession that often requires ongoing learning, and well rested engineers are better equipped to learn new best practices and professional standards. A University of Düsseldorf study found that even short naps heighten knowledge retention, which allows employees to perform current tasks more effectively and learn to operate new tools, systems and technologies.

In addition to improving the ability to stay alert, productivity and readiness to learn, short-term rest on the job generally improves morale, making interactions between coworkers more pleasant and productive, and even improving customer relationships. It has a trickle-down effect across the job site.

Workplace napping became a trend when it was adopted by start-ups looking for ways to keep employees with difficult to find skills focused and satisfied with their jobs. But while it might have begun as a start-up perk, short rest solutions have grown into a worldwide workplace phenomenon.

Some of the most well-known corporations now encourage napping, including Google, HuffPost (formerly The Huffington Post), Salesforce, Uber, Zappos, Capital One Labs, Ben & Jerry's and PwC. Other organizations have gone even further, providing napping pods for employees, including NASA, Cisco and Procter & Gamble.

Napping pods, with specially designed ergonomics, timed waking and privacy visors, make it easy for employees to take a catnap on the job and get the benefits short rest provides. Managers who are thinking about ways they can boost their engineers' workplace safety, productivity, knowledge retention and well-being should wake up to the benefits of a short nap.

Do you agree? Do you have a story about a workplace accident that occurred due to lack of sleep? Please share your thoughts and comments: terrence@reliabilityweb.com

__Christopher Lindholst__ is CEO and Co-Founder of MetroNaps. A pioneer in corporate fatigue management solutions since 2003, Christopher has built a client base and established partnerships on four continents. An avid napper, having amassed nearly 5,000 naps over his 13-year sleep career, Christopher takes a 14-minute nap every workday afternoon. www.metronaps.com

RELIABILITYWEB.COM 2018 EVENTS

CONFERENCES

From the full conference experience to focused, two-day events, Reliabilityweb.com offers options that are designed to meet objectives based on your time, budget and needs. The full conference experience is five days and includes workshops, short courses, learning sessions, expo and ample opportunities to network. Training symposiums provide all the same great options, but condenses it all into two days!

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The RELIABILITY Conference Las Vegas
April 23-27
Las Vegas, NV

maximo world
August 7-9
Orlando, FL

IMC 2017 The 32nd International Maintenance Conference
December 10-14
Bonita Springs, FL

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Lima, Peru

June 6-7
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New Orleans, LA

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Honolulu, HI

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March 26-30
Fort Myers, FL

The RELIABILITY Conference
April 24-27
Las Vegas, NV

June 18-22
Fort Myers, FL

September 17-21
Seattle, WA

International Maintenance Conference
December 11-14
Bonita Springs, FL

IOCM MEETINGS

The Internet of Condition Monitoring (IoCM) is happening. Join the early adopters, the technology pioneers, the start-ups, the underdogs and the individual innovators in regular meetings for discussions and demonstrations.

Special Invitation - Request Your Seat

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April 23
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July 16
New Orleans, LA

September 5
Honolulu, HI

September 24
Antwerp, Belgium

International Maintenance Conference
December 10
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ASSET MANAGEMENT BENCHMARKING ROUNDTABLES

Leaders in rail, water and life sciences come together for two-day discussions and industry benchmarking.

Special Invitation - Request Your Seat

April 4-5
Rail Asset Management

May 2-3
Life Sciences Asset Management

July 11-12
Water Asset Management

RELIABILITY LEADERSHIP ROAD MAP

Leadership on the road! These introductory, one-day events allow attendees to learn and engage with those carving the path to true reliability leadership. Limited seats available, so register early to guarantee your place.

January 16 Denver, CO	**April 12** Chicago, IL
January 18 San Jose, CA	**May 8** Houston, TX
February 6 Atlanta, GA	**May 10** Nashville, TN
February 8 Detroit, MI	**July 24** Minneapolis, MN
March 27 Boston, MA	**July 26** Indianapolis, IN
March 29 Baltimore, MD	**August 14** Phoenix, AZ
April 10 Jersey City, NJ	**August 16** Seattle, WA

RELIABILITY LEADERSHIP INSTITUTE COMMUNITY OF PRACTICE (COP) MEMBERSHIP FACE-TO-FACE MEETINGS

Organizations from all industries join to enhance the business effectiveness and sustainability of reliability and asset management through peer-to-peer collaboration, active project management, research, related initiatives and industry alliances. Four face-to-face meetings are held annually. Membership required.

Febuary 28-March 1 Pheonix, AZ	**August 28-29** Chicago, IL
April 22 Las Vegas, NV	**December 9** Bonita Springs, FL

Vib vibration analysis

VIBRATION CASE STUDY: "CRACK"ING THE ROOT CAUSE

Chris Hobbs

At Inter Pipeline Ltd. (IPL), a petroleum transportation, storage and natural gas liquids processing company based in Calgary, Alberta, Canada, a cracked weld on the suction side of a three-inch, schedule 80 balance line of a four-stage MSD mainline pump was discovered during routine monthly vibration routes. As a result, all seven identical pumps were inspected in situ using magnetic particle examination.

Figure 1: Balance line leak

A second identical failure was discovered at a different IPL facility, indicating the problem was potentially systemic in nature. This particular failure, being in a nontraditional vibration survey or inspection location, emphasizes the importance of diligent visual inspection while performing condition monitoring tasks.

The IPL reliability department was engaged to investigate and determine the root cause of the issue. The unit was removed from the field and returned to the original equipment manufacturer (OEM). IPL's engineering department was requested to assist in the failure assessment.

Observations and Possible Root Causes

These observations were noted after the paint was removed and the area more closely inspected:

1. The crack was approximately 1/4 of the pipe's circumference in length in an area where welding access was restricted.
2. Stray arc strikes were observed above the weld joint to the pipe. The crack appeared to originate from one of the arc strikes.
3. The weld had undercuts and a potential lack of fusion in some locations of the crack. Everywhere else, full penetration of the weld was observed.

Based on the inspection observations, two potential root causes were identified.

1. Weld Quality: The geometry at the location of the crack inhibited an ideal weld angle access and lent itself to potential arc strikes, weld undercuts and a lack of fusion between the pipe and pump case. Any one of

Figure 2: Left image, balance line weld as found, showing restricted weld access and location of lack of fusion and crack initiation; Right image, arc strikes

these defects or a combination of them could have been the root cause of the initiation and subsequent propagation of the crack.

2. Fatigue Crack Due to Vibration in the Balance Line: The balance line could potentially have been resonating, resulting in a fatigue crack failure mechanism.

Upon the removal of the balance line from the pump case, a fatigue crack was observed to have propagated within the balance line itself. Despite the predisposition of both the OEM and IPL that a relatively short length (i.e., 42 inches) of three-inch schedule 80 pipe was unlikely to be susceptible to resonance, combined with a lack of history supporting this finding for identical installations, the presence of this crack indicated it was, in fact, a vibration induced failure. In order to strengthen the certainty of this conclusion or root cause, the failed section was sent for a formal failure analysis and investigation by an independent third party. The third party determined through its assessment of the crack's characteristics that the weld quality was not a contributing factor to the failure.

Simultaneously, vibration spectrums were collected on the balance line at the suction side weld, center point and discharge side weld locations to get a representative vibration profile of the balance line. Readings are illustrated in Figure 3. In addition, pump vibration readings were collected under the same process conditions to observe if the vibration signatures of the pump

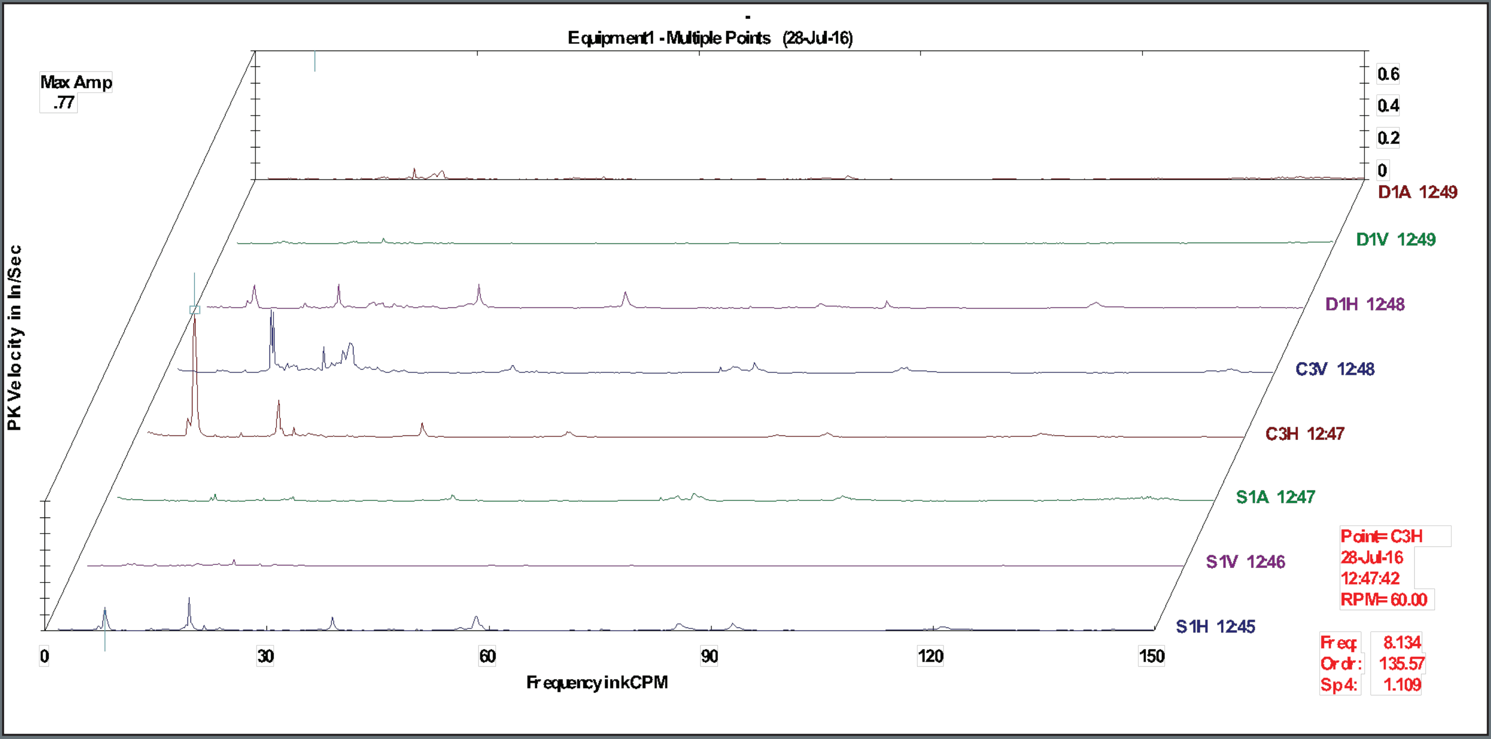

Figure 3: Vibration readings of balance line S1 (suction side of balance line in horizontal, vertical and axial orientation), C3 (midway length of balance line in horizontal and vertical orientation) and D1 (discharge side of balance line in horizontal, vertical and axial orientation) at a speed of 3,565 rpm and steady state / balanced operation; Represents typical vibration levels that could be inferred on balance line

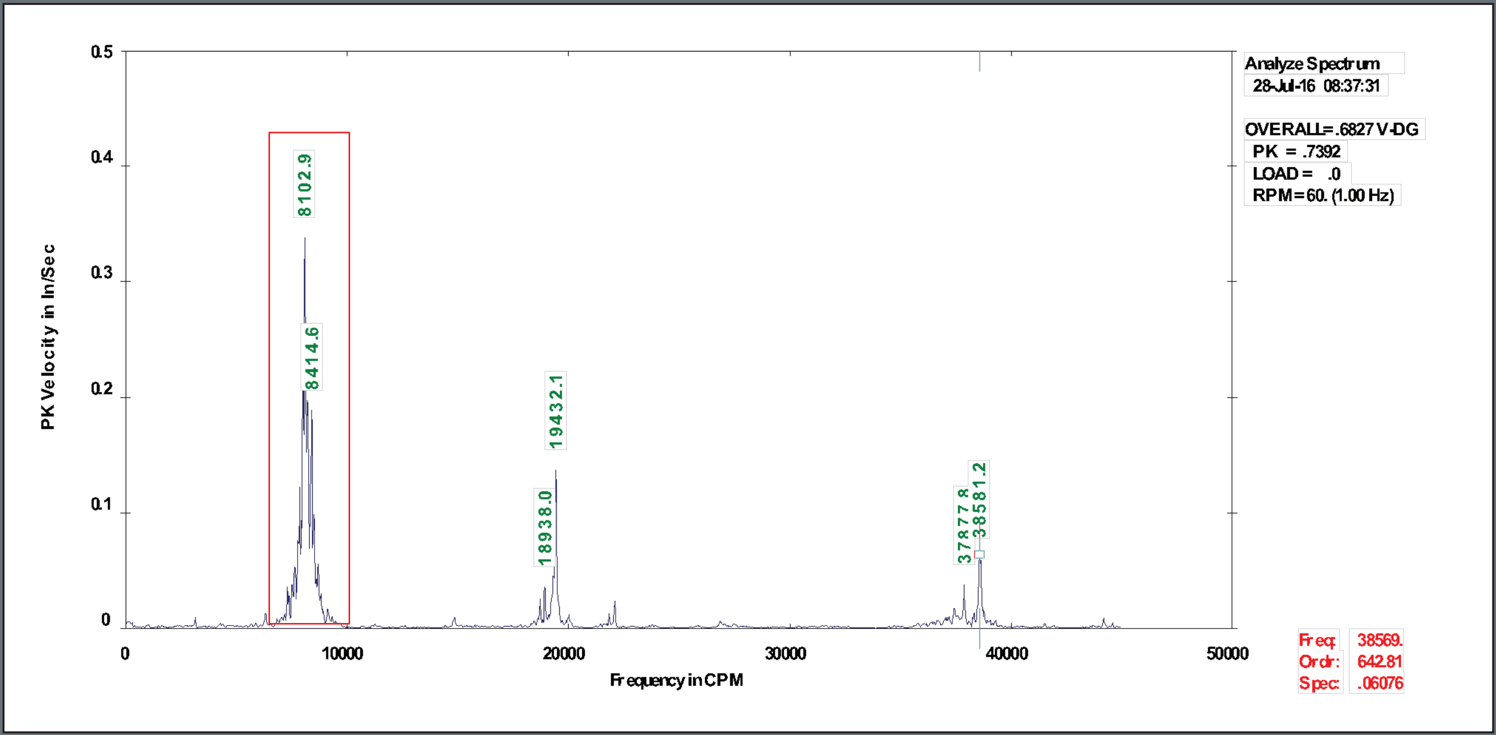

Figure 4: Zoom in measurement of C3H (centerline location of balance line in horizontal orientation) and largest source of vibration on balance line; "Haystack" appearance (within red highlighted box) indicates a resonant response, which could provide amplification or excitation of any frequency ranging between 7,300 rpm to roughly 8,700 rpm

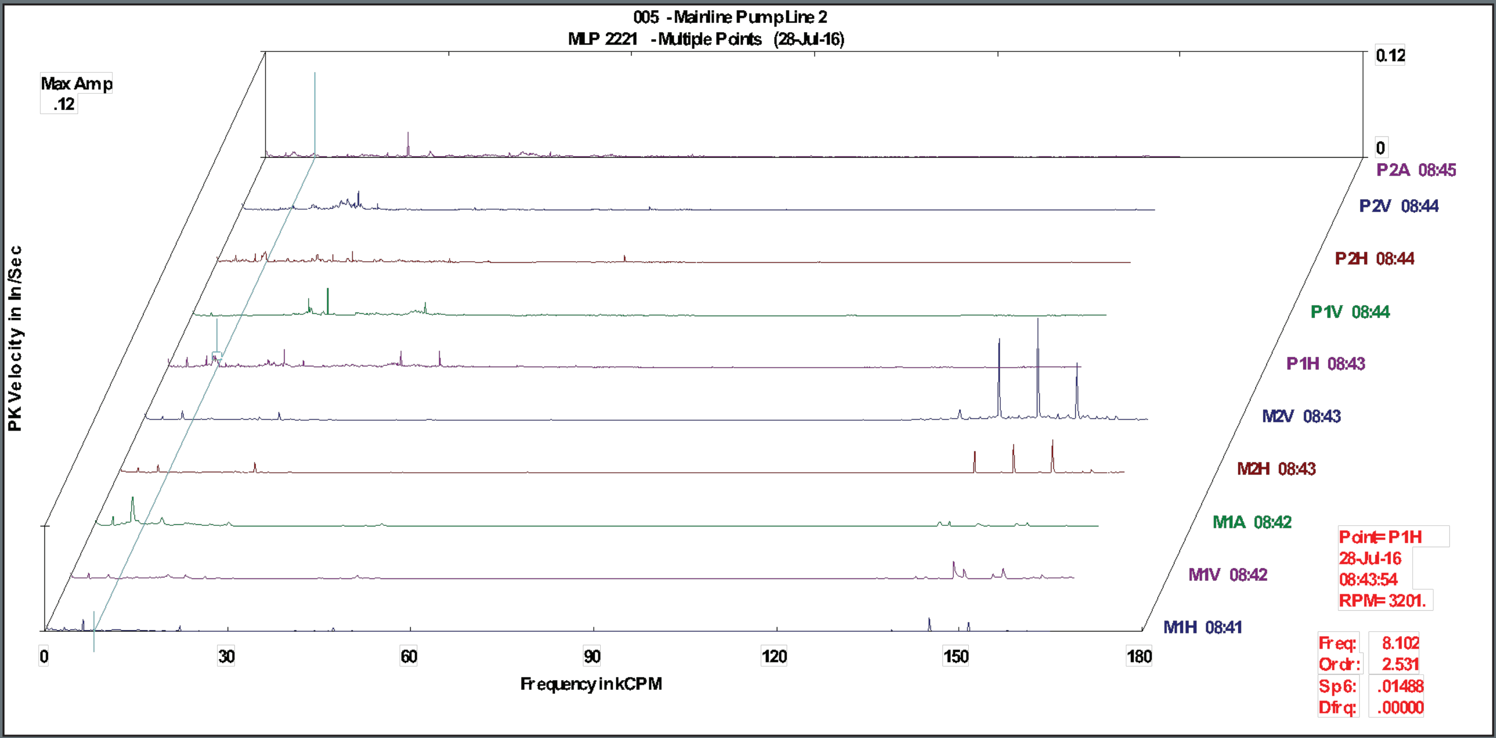

Figure 5: Standard measurements on motor and pump equipment train indicate no appreciable adverse vibration coinciding with frequency of excitation observed on balance line; Red line across all readings represents forcing frequency of balance line in horizontal direction

and balance line correlated. The pump vibration signatures are illustrated in Figure 5.

Validating Hypothesis

As can be interpreted from the Figure 4 and Figure 5 comparison, the pump bearing vibration and the balance line vibration signatures do not correlate (i.e., balance line forcing frequency (8,103 CPM) was independent of equipment running speed at a nonsynchronous integer of 2.27 x running speed). Simply stated, the resonance was caused by hydraulically induced forces as opposed to mechanically induced forces from the pump. The pump was a variable frequency drive (VFD) and tests were conducted at five percent (i.e., 180 rpm) VFD increments. The balance line vibration worsened at higher flow rates and began to transfer load from the max vibration observed in the center of the balance line to the horizontal weld locations at these higher flow rates, as can be inferred through S1H and D1H vibration signatures in Figure 3.

In order to conclusively prove the hypothesis drawn of resonance being the root cause of weld failure on the balance line, an impact or bump test was independently conducted on an identical in situ pump. This impact test would verify the presence, or lack thereof, of resonance, as well as quantify the frequency range of excitation, as applicable. This information then could be used as input in the determination and design of a solution to mitigate the detrimental vibration. Results are presented in Figure 6.

The resonance test demonstrates conclusively that there is a balance line resonance in a range of roughly 7,500 rpm to 9,000 rpm in the horizontal direction (see top red highlighted box in Figure 6) and 14,250 rpm to 15,150 rpm in the vertical direction (see bottom red highlighted box in Figure 6). Resonance is indicated when there is a rounded haystack in the bottom plot, in combination with a coherence greater than 0.7 and a phase shift ranging from 150 to 210 degrees.

In addition, as demonstrated in Figure 7, the response of the balance line to the impact doesn't decay significantly over time, meaning the balance line is likely to remain in resonance based on the lack of dampening characteristics of the piping's configuration. Also, it can be observed that the balance line is very sensitive / susceptible to any vibration excitation forces present, based on the amplification of the impact. This finding is perhaps the most significant in the design of a solution as it signifies that, with the presence of limited forcing frequency, the line is easily excited, excessively amplified and

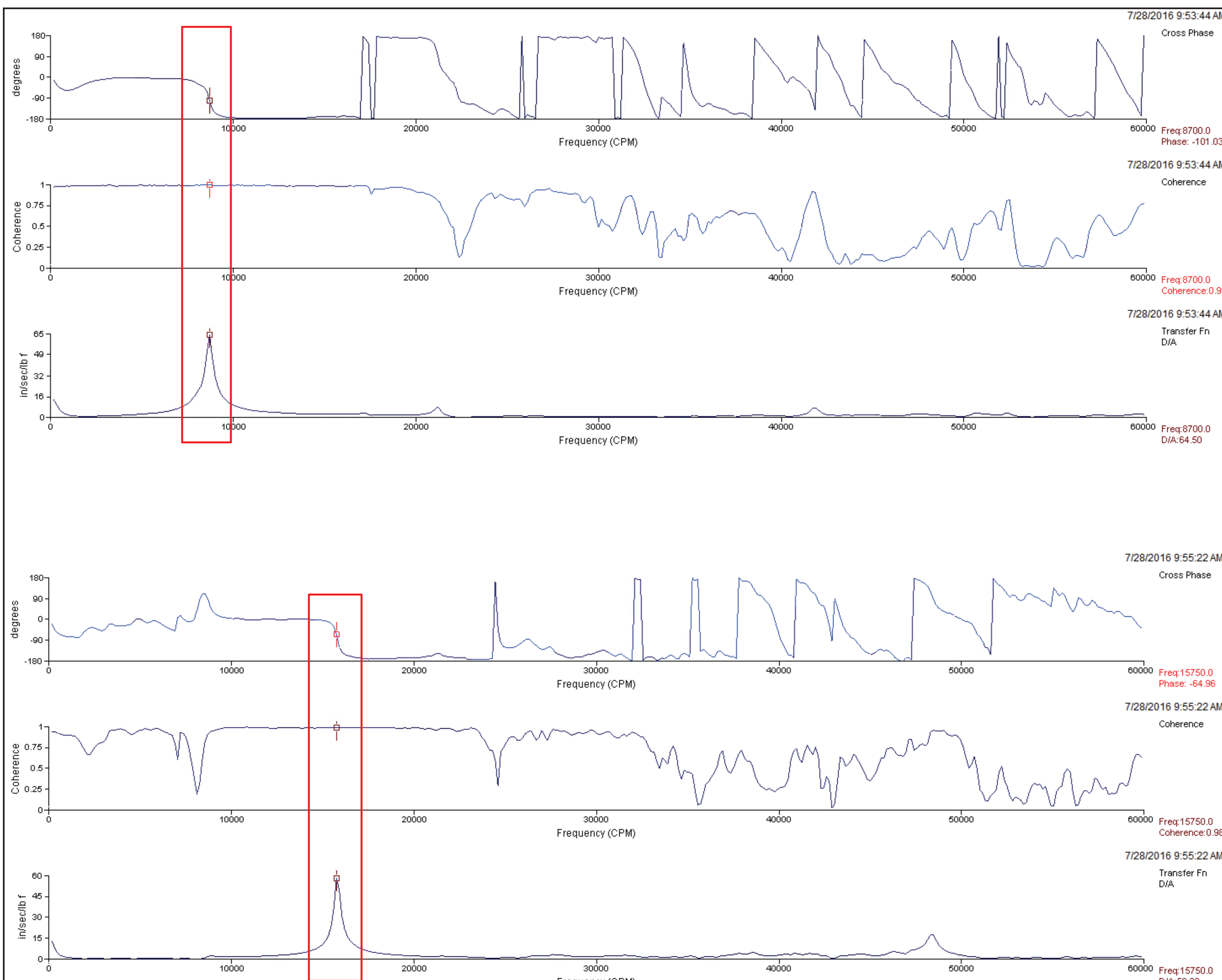

Figure 6: Resonance bump tests of balance line in the horizontal (top) and vertical (bottom) direction

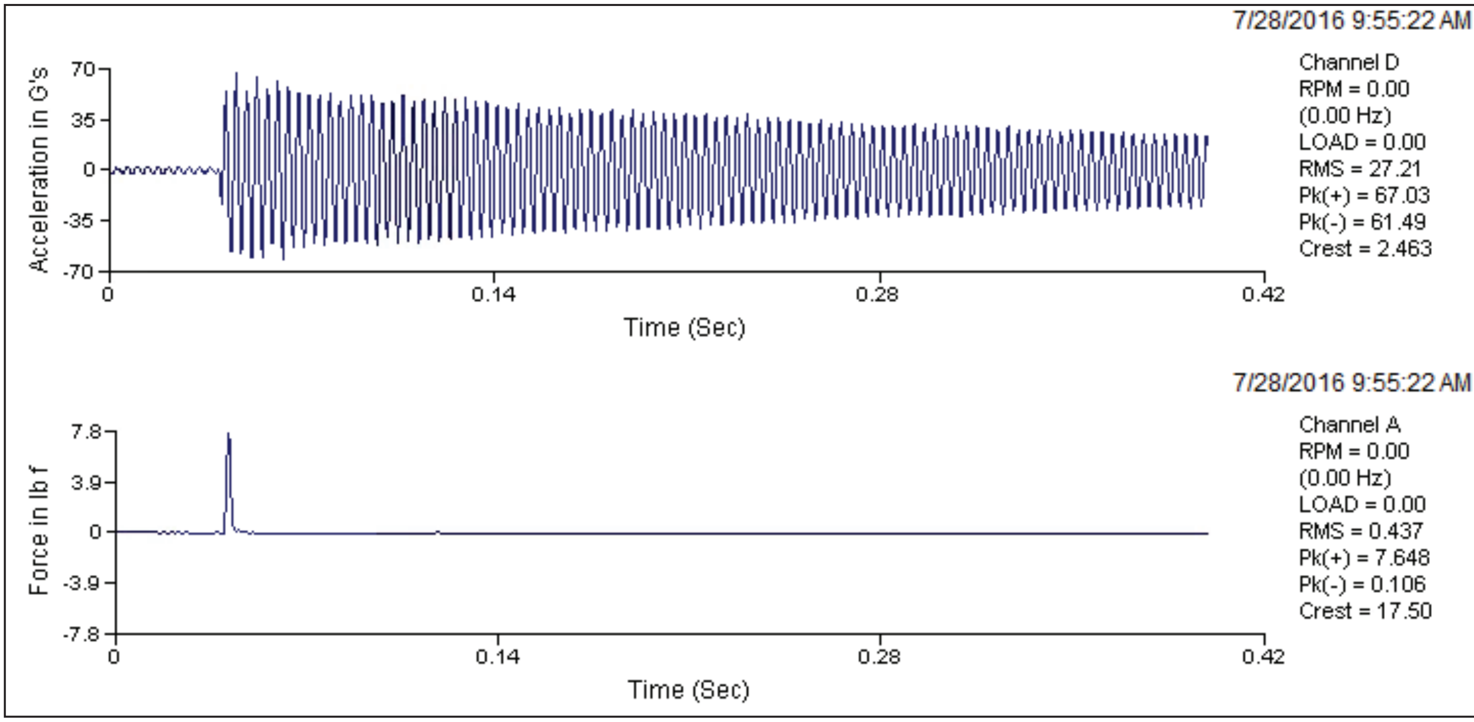

Figure 7: Undamped response of balance line impact

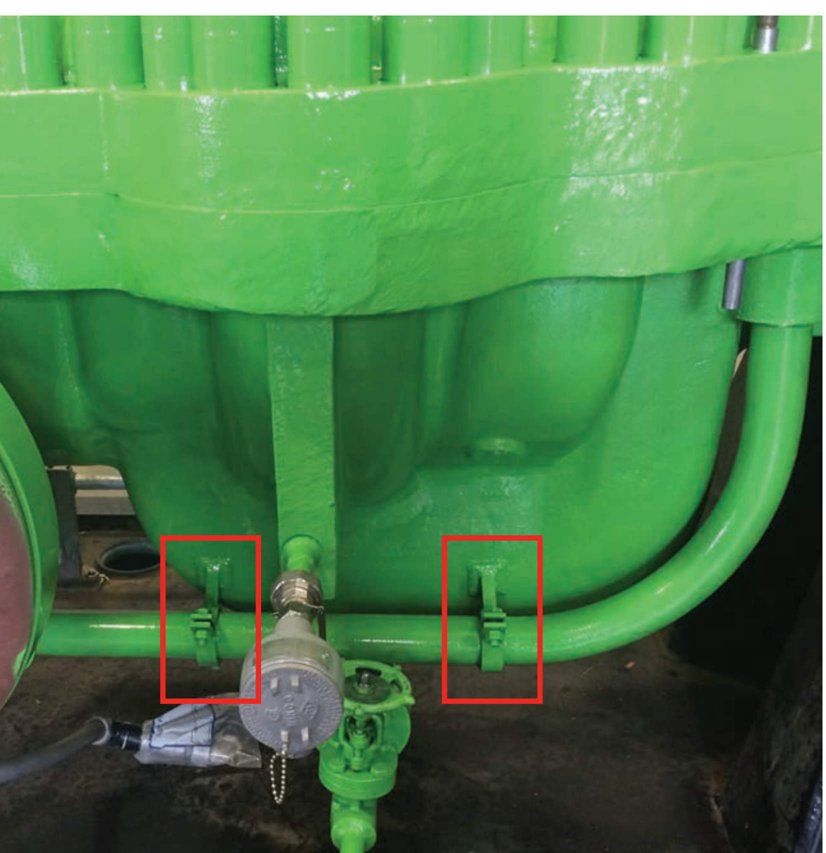

Figure 8: Installed clamps, complete with rubber inserts on balance line to address resonance

will remain in vibration over an extended period of time. Changing the natural frequency of the line itself likely would not have completely addressed the issue. These resonance tests are verified to be repeatable based on a separate impact test conducted on another identical in situ pump that was not in operation at the time of the impact.

The results of the impact test, as well as the pump and balance line spectrums collected, were supplied to the OEM for determination of an appropriate OEM endorsed recommendation to mitigate the resonance of the balance line.

Despite weld quality being exonerated as a contributing factor to the failure in this instance, the OEM recognized that any of the defects noted could have potentially caused weld failure, even in the absence of vibration. The arc strike could have resulted from a localized brittle zone, the undercuts could have introduced stress risers, while a lack of fusion could have created a leak path which, in turn, may have allowed the crack to propagate into the undercut. In response, the OEM took it upon itself to modify its welding procedure in an attempt to mitigate the defects observed in this installation. In addition, the OEM has modified its design assessment methodology to examine whether supports may be required for shorter length, schedule 80 balance lines.

Remediation

The balance line was replaced and reinstalled. The welding was completed using the previously referenced new weld procedure, inspected using magnetic particle examination, and it also passed a hydrostatic test by the OEM.

Based on the observed vibration amplitudes on the balance line, the recommendation was to weld two clamps onto the pump case to secure the balance line, hence increasing the stiffness and reducing the natural frequency. In addition, based on the lack of system dampening, rubber inserts were incorporated into the clamp's inner diameter to the balance line piping. After

"...The presence of this crack indicated it was, in fact, a vibration induced failure."

an impact test by the OEM following installation of the clamps, the natural frequency or resonant response was reduced from 8,400 rpm to 837 rpm. The impact test also revealed a significant improvement in the system's dampening characteristic, as the rubber linings effectively dampened the "ring time," indicated by a prompt dissipation of the vibration energy after the impact.

Conclusions

Figure 6 demonstrates that the balance line of the pump was being excited at resonant frequency between 7,500 rpm to 9,000 rpm in the horizontal direction and 14,250 rpm to 15,150 rpm in the vertical direction at its center point location. The vibration in the horizontal direction of the balance line was of the highest detriment. It was adequately braced and the balance line dampened to move the resonant amplification from 8,400 rpm to a frequency of 837 rpm. It was the resonant vibration that imparted loading on the balance line to the pump case weld and eventually resulted in a fatigue failure of the weld.

Vibration monitoring alone would not have detected this leak, based on both the nontraditional failure location of the fault and the low vibration levels of the pump unit and bearings. Instead, it was the hidden and indirect benefits of vibration routes, combined with the diligence of the technician performing the route collection, that captured this failure before it significantly escalated.

Having open channels of communication and a good working relationship with the OEM enabled IPL to quickly and accurately determine the root cause of failure and put in corrective actions to prevent repeat occurrence. Upon verification of an effective solution, clamps were proactively installed on the remaining identical in situ pumps to mitigate an increased probability of failure of the balance line welds due to resonance.

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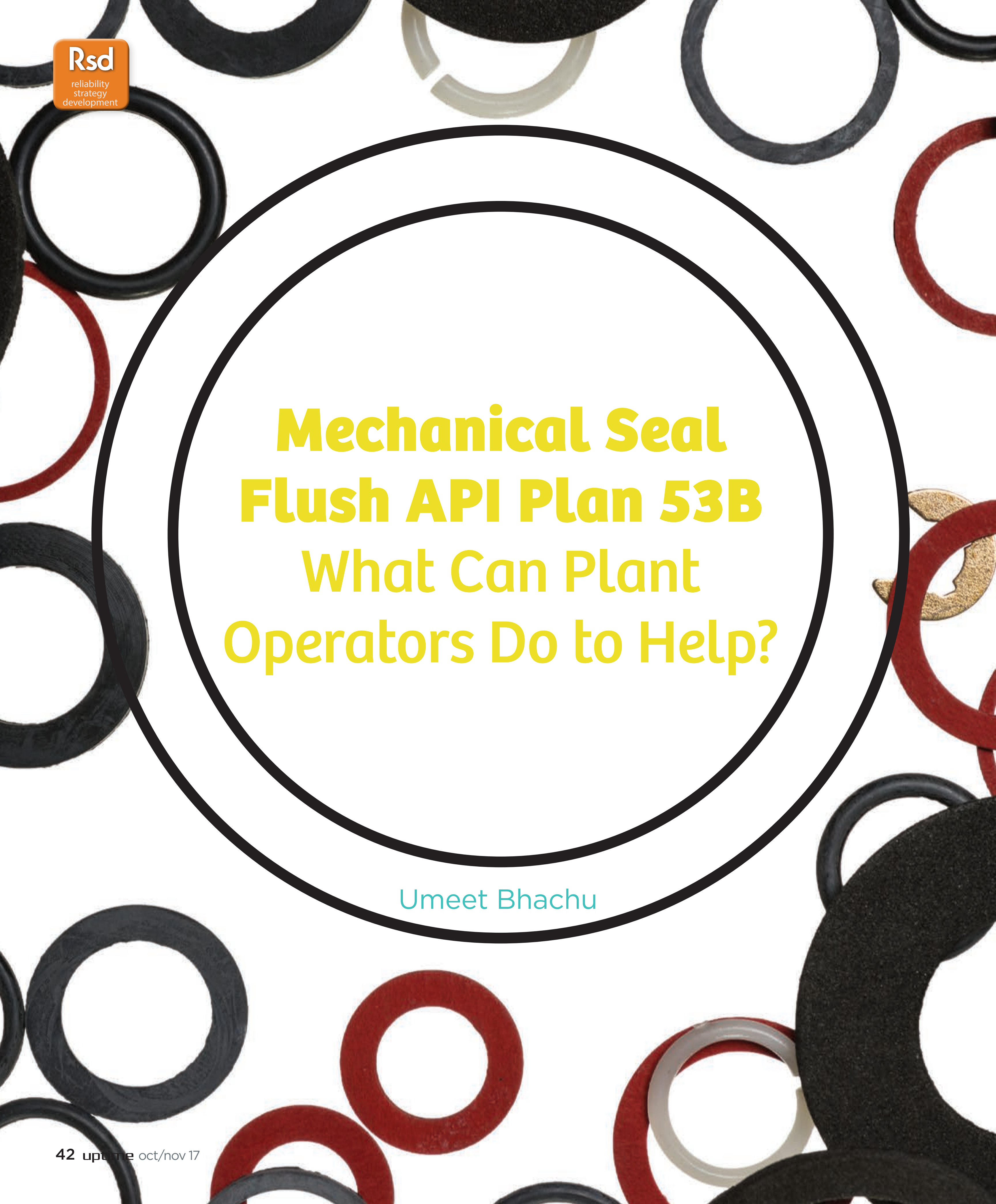

Mechanical Seal Flush API Plan 53B

What Can Plant Operators Do to Help?

Umeet Bhachu

Mechanical seals are a great cause of concern and failures in many operating plants. This is especially true of systems that are pumping or compressing dirty fluids. Some examples include bottoms pumps, sulfur pumps, or equipment that is handling abrasive or challenging process media. Mechanical seals are often redesigned, replaced and repaired simply because of the challenging conditions these seals face during operation. This has continually led to excessive costs in terms of repair or redesign, not to mention production loss and cost associated on a critical unspared asset.

While seals have to be properly selected and designed for the application during the project's engineering stages, it is equally critical to select the right and most cost-effective seal plan to help support the seal's operating environment. The seal flush plan is as equally critical and perhaps more so to help establish a reliable operating mechanical seal. API Standard 682 from the American Petroleum Institute provides various seal plan configurations, their advantages and disadvantages and a good description of each of the plans. To gain an in-depth understanding of the various types of applications and plans available for selection, refer to API 682. In addition, a lot of seal vendors publish handy booklets that contain good, brief and quick references and explanations of the different API seal plans.

This particular article looks at API Plan 53B and how paying careful attention to some aspects of this plan can ensure a proper and reliable running seal in many applications. Of course, the mechanical seal should be correctly and most optimally designed for the particular application at hand.

Figure 1 shows a basic overview of what a 53B seal flush plan looks like. It is a pressurized flush plan that gets used with a dual seal (i.e., two seals) configuration. The accumulator contains a bladder that is pre-charged at a certain calculated bladder pre-charge pressure value through the bladder charge connection shown in Figure 1. Next, the barrier fluid, which can be royal purple or another process compatible based media, is injected into the system at a certain calculated hydraulic charge pressure through the make-up barrier fill or a similar port provided on the piping setup. The idea is that when the seal fails (leaks are more than expected since all seals leak to some extent), then the barrier fluid, being at a higher pressure, will push the leakage back into the process rather than letting the process media leak outside into the ambient. This helps prevent environmental release and avoids wastage of costly process media to the atmosphere. It is quite clear based on this that such plans are best suited for applications that are toxic and hazardous and where negligible leakage is allowed into the atmosphere due to such concerns. Consider reading ample literature available from various sources to gain a deeper understanding of this particular plan.

One of the key advantages of this particular plan is the cost associated with implementing it in a given plant compared to other similar options (i.e., Plan 54 or others). However, it is imperative to realize that the reliability of a 53B plan and the mechanical seal it supports is highly dependent on the plant operator who maintains this and checks on the system on a regular basis. While a number of seal failures can be attributed to incorrect designs or other issues, equally, if not more, causes can be attributed to how a plan 53B is operated and maintained on a running asset.

Here are a few important points that should be considered while working with any plan 53B in a maintenance and operating organization.

- It is important to vent a 53B through the appropriate vent points provided to ensure there is no vapor entrapment prior to seal start-up. Attention should be paid to horizontal versus vertical heat exchangers provided on the system. Based on experience, it is easier to vent out vertical heat exchanger configurations versus horizontal systems. However, horizontal systems are provided or should be provided with block valves to help ensure proper venting.

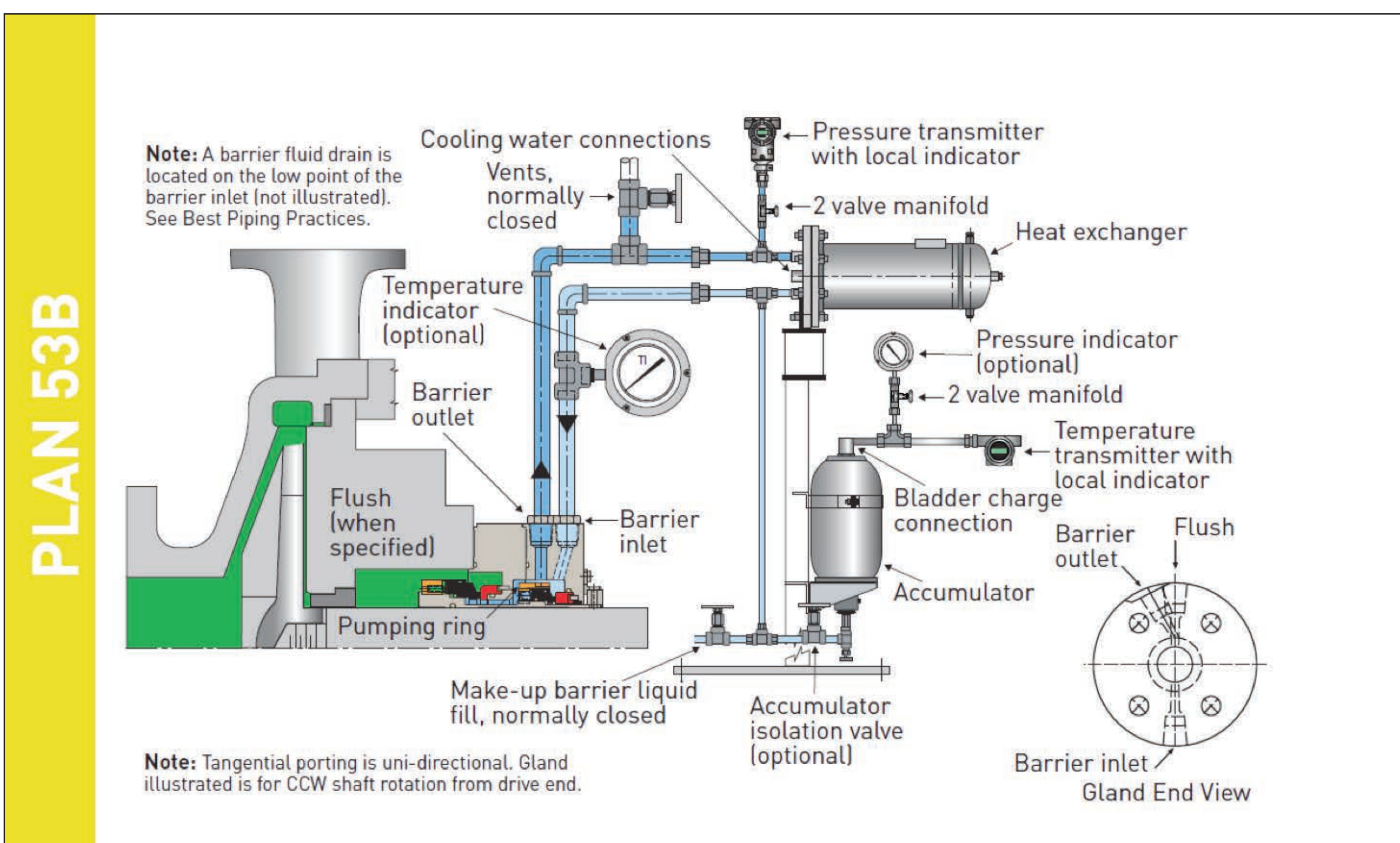

Figure 1: API 53B seal flush plan (Courtesy of John Crane)

Rsd reliability strategy development

"(Plan 53B) is a pressurized flush plan that gets used with a dual seal (i.e., two seals) configuration."

- In colder climates where a plan 53B is installed outside, the system should be properly heat traced and winterized. This includes the seal flush piping, the accumulator and the exchangers. The accumulator contains a nitrogen bladder with a pre-charge pressure as previously indicated. Fluctuations in the ambient temperature can have a dramatic effect on system pressure and lead to seal failures and loss of seal system reliability.
- Operations should confirm and check with engineering that the right calculated values are provided for the pre-charge pressure for the bladder and also the hydraulic system charge pressures. These are quite critical to ensuring system and seal reliability. Any discrepancies in these calculated values can risk reverse pressurization (i.e., seal reversal) and subsequent failure of the sealing system. It is important to note that some plants consider playing around with the pre-charge and hydraulic charge values to buy more time between system failure and low-level alarm of the barrier fluid so the operator has sufficient time to fill and make up the loss of barrier in the system. However, experience has shown the best way to address this issue is to procure accumulators of higher volumes to provide for this as opposed to modifying pressures to buy more volume in the system. The latter seems to have much smaller effects compared to sizing the accumulator correctly in the first place. Also, if consideration is being given to changing pre-charge and hydraulic pressures, this should be in discussions with the original equipment manufacturer (OEM) seal vendor since excess pressures on a given seal can compromise and affect seal leakage rates, thus reducing the time and volume present in the system.
- It is equally important that the operator only charge (i.e., make-up fill with hand-pump) the system when the low-level alarm pressure is initiated. Charging the system at every minor occasion when the barrier pressure and level drops is not warranted. This, on the contrary, will lead to a poor seal system and seal reliability as a result of multiple pressure charging in short intervals.
- Operations should keep a log of charging frequencies, depending on the low-level alarm. This, along with visual inspections, can provide a good clue to seal failures and acceptable leakage rates. The question most often asked by an operator is: What is considered an acceptable leakage? While engineering, along with the seal OEM, can provide acceptable leakage rates, to get a very good measure of seal reliability, the operator can keep an eye out for the frequency of fill and also, if correctly done, the volume filled during the initial fill cycle.
- Since the pump throat bushing controls the stuffing box environment, it would be beneficial to incorporate the throat bushing on the seal cartridge itself to help with maintenance, as opposed to locating it within the pump. This holds true not just for the 53B seal plan, but for others as well.
- Having a temperature gauge located on both the inlet and outlet of the seal helps in establishing a temperature gradient between the seal's in and out flow. A difference of around 20 to 30 degrees C is acceptable; any more delta T changes can point to possible issues with the seal, cooling water, or other variables. This can help the operator make on-site decisions to engage or escalate the issue to engineering in the event of a potential problem.

While there are many individual experiences connected to running a 53B seal flush plan, these important points most certainly can help the operator make an informed decision to help seal reliability and mean time between failures (MTBF) in a running plant. Engineering should perform a detailed root cause analysis on complex seal issues and provide the appropriate solutions sought to address repeated failures. This will help the plant's bottom line: Cost and Revenue.

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Part I of II:

ULTRASOUND FOR SAFETY... IF NOT FOR ANYTHING ELSE!

Jim Hall

All through the late 1980s and 1990s, ultrasound was literally the all-purpose tool. Vibration and infrared (IR) were too expensive for most organizations to afford. Yet, you could purchase an infrared thermometer gun for $100 and an ultrasound instrument kit for between $750 and $7,000 and perform a multitude of applications on motor bearings, gear boxes, pumps for cavitation, leak detection (pressure/vacuum), steam traps and acoustic lubrication (introduced in early 1990s). You could hook up an ultrasound instrument to a vibration analyzer and utilize the contact or magnetic sensor on bearings to easily detect an outer race defect, sometimes missed by earlier vibration boxes unable to go above 20,000 Hz. Into the mid-1990s, ultrasound inspectors added electrical switchgear and substation inspection for arcing, tracking and corona discharge. A new era of ultrasound inspection had begun, dealing with SAFETY.

Figure 1: Air leak audit, chemical plant, Waco, TX

Figure 2: Electrical arcing heard within closed 480v panel at a power generation plant

> "A new era of ultrasound inspection had begun, dealing with SAFETY."

Figure 3: Oil platform in Gulf of Mexico

Ultrasound for Safely Finding Electrical Failures

This example demonstrates why using ultrasound for safety is so important. Many years ago at a Southern California military supplier of fins (i.e., wings) for heat seeking missiles, heat treat ovens were located in a room just a few feet from the 480v switchgear. The smell of minute gas leaks were present in the area. But then, intermittent arcing and a sizzling noise could be heard. Arcing from what appeared to be aluminum wiring was evident from a half open 480v electrical panel. (Creep-wire was another name for the soft aluminum wiring in those days. It was named so due to its tendency to creep out of its locked down position. Nowadays, it's all copper wiring.) Of course, loose wires can arc and heat up. Well, needless to say, everyone exited the premises immediately for safety's sake.

The facility did not have an ultrasound instrument. But, if ultrasound technology was available, the technician could have used it to first scan the switchgear panels before opening them. Then, once opened and reenergized, ultrasound could be used as a complementary tool to both infrared and corona camera inspection. Why? Infrared and corona cameras require line of sight, but ultrasound does not. So, learn to use them all in combination with each other. Become familiar with the sounds of electrical anomalies. Get some training. Do it in the name of SAFETY, if nothing else!

Ultrasound for Safety in Remote Locations

Oil platforms in the middle of the ocean use compressed air and gases of different types. Some may even be vented overboard. On one particular oil platform, there was a lack of compressed air in a production area, most likely due to a leak in the system.

While scanning for possibilities with an ultrasound instrument, the technicians located a high amount of compressed air being vented from a drain that should not have been opened. This was only spotted while moving down an outboard stairway leading from one deck to the one below it. The technicians were scanning with the ultrasound and a long-range horn attachment. They located the leak 50 to 60 feet away.

The gas was not just manufactured compressor air; it was, in fact, nitrogen (N2) gas. Most of today's oil rigs use onboard nitrogen generators, but still, this is a costly gas to manufacture. Nitrogen has many uses on an oil rig, too many to list here. Although not volatile or caustic, too much nitrogen could cause nitrogen asphyxiation. An oxygen concentration that falls below 19.5 percent is considered unsafe for workers. When the oxygen content drops to about eight or 10 percent, you haven't much chance of survival. Nitrogen is a silent killer.

Ultrasound is sound above 20,000 Hz. It detects sounds above the human hearing range. It also detects friction, which can be a disturbance in the air. For instance, leaks of air or compressed gases, either a positive or negative pressure, produce friction in the air. Some instruments are capable of detecting a 5 psig leak of .005 inches at 50 feet. Having stated that, ultrasound cannot distinguish between a compressed air, nitrogen, or hydrogen gas leak. However, leaks to the atmosphere produce friction and since this friction is a disturbance of the atmosphere, it can be detected using ultrasound.

Ultrasound for Safely Locating Gas Leaks

Within the military, safety is of the highest priorities. In the early 1970s, the U.S. Navy trained cryogenics technicians to produce liquid nitrogen and oxygen, as well as work-around and handle other gases that were primarily used for airfield facility maintenance, on aircrafts, or aboard aircraft carriers.

Figure 4: Leak on a liquid oxygen supply system

Liquid oxygen ***demands*** respect. As a cryogenic liquid, it is very volatile and highly explosive. Cryogenic liquids are liquefied gases that have a normal boiling point below –130° F (–90° C). Liquid oxygen has a boiling point of –297° F (–183° C) and has an expansion ratio, liquid to gas, BP to 68° F (20° C), 1 to 860. Oxygen has no warning properties!

To find leaks on storage units or supply lines, cryogenics technicians were taught how to use an ultrasound translator or receiver. The U.S. Navy supplied its cryogenics technicians with an ultrasonic translator unit that consisted of a wand with a piezoelectric sensor at the end and a microphone built into the box. Effective, but not so much in today's industrial market.

The ultrasonic translator receives the high frequency and heterodynes or demodulates the high frequency to a low frequency signal below 20,000 Hz. This is also known as Ultrasonic Down Conversion™ (UDC)[1]. UDC is what *all* ultrasonic translators perform.

Through UDC, the user of the instrument can discern a leak either afar or nearby, depending on the sensitivity of the translator being used and the application.

Ultrasound for Safety in Industrial Plants

Besides the military, there is an *abundance* of opportunities to use an ultrasonic translator or instrument in most industrial plant environments for safety purposes. However, only a few of the ultrasonic instruments manufactured today are ***intrinsically safe*** or **IS** rated, meaning if the unit has the appropriate rating, the instrument may be used in an explosive environment.

Some ultrasound instruments manufactured today have an ATEX IS rating, while another popular ultrasound instrument manufacturer has an IS rated instrument with an ATEX EX and Mb Ex ib I for underground mining.

There's also the factory mutual (FM) IS rating, Class I, Groups A, B, C, and D. Here's an example of what these FM IS ratings means:

Class I: Locations are areas where flammable gases may be present in sufficient quantities to produce explosive or flammable mixtures.

Div I: Area where explosive or flammable materials usually exist under normal conditions.

Group A: Atmospheres containing acetylene.

Group B: Atmospheres containing hydrogen, gases, or vapors of equivalent hazard, such as manufactured gas.

Group C: Atmospheres containing ethyl ether vapors, ethylene, or cyclopropane.

Group D: Atmospheres containing gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzyl, lacquer solvent vapors, or natural gas.

WARNING

When using ultrasound, use *ONLY* an approved "IS rated" ultrasound receiver/translator and review local safety recommendations and specific classifications authorized for local usage.

Ultrasound Inspections for Safety

Ultrasound inspections may include:

- Hydrogen Leaks – Power generating plants use hydrogen to cool the generator;
- Electrical Transformer – Internal and external for arcing, tracking, corona and partial discharge;
- Boilers – Natural gas leaks around them and boiler leak of the horizontal flame box releasing toxic carbon monoxide;
- Electrical Inspection – Switchgear and substation for corona, tracking, or arcing and partial discharge;
- Underground Electrical Vaults – For corona, tracking, or arcing of transformers and electrical cables;
- Underground Utility Vaults and Tunnels – For various gas leaks (e.g., nitrogen, natural gas, etc.);
- Aviation Applications – For compressed gas or cryogenic gas leaks;
- Aviation Fuel Leaks – Using either positive or negative air on wings and fuel cells to locate leaks;
- Cockpit Pressurization – Ultrasound used on cabin doors, windows, fuselage and other areas that might create a loss of cabin pressurization;
- Marine Applications – Watertight hatches and manways for water or gas intrusion on a sealed door;
- Marine – To detect fugitive emissions at a manufacturing plant or aboard ship;
- Clean Rooms and Labs – Negative pressure leaks and cryogenic gas (inert and toxic) leaks within the false floor beneath the lab;
- Underground Utilities – Natural gas lines, electrical cables and transformers.

Of course, these are just some of the thousands of applications within the industrial manufacturing, transportation, military, power generation and other utilities where ultrasound can be used for safety purposes.

What is your ultrasound SAFETY application?

Watch for Part II of Ultrasound for Safety….If Not for Anything Else! in an upcoming issue of *Uptime* Magazine.

Reference

1. Ultrasonic Down Conversion™ is a registered Trademark, Reg. No. 4,377,926, Registered July 30, 2013.

Jim Hall, *CRL, is the Executive Director of The Ultrasound Institute (TUI). Jim has been in the ultrasonic market for over 25 years and has trained many Fortune 500 companies in the use of airborne ultrasound, including the electrical power and generation, pulp and paper, automotive and aviation industries. Jim has been a contributing writer for Uptime® Magazine's (ultrasound segment) since the magazine's inception. www.theultrasoundinstitute.com*

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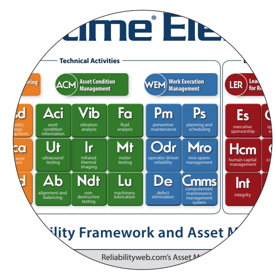
WOULD YOU PREFER TO PARTNER WITH SOMEONE WHO:

SHARES THE SAME
VALUES

SPEAKS THE SAME
LANGUAGE

USES THE SAME
FRAMEWORK



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4. **AIM**
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WORK WITH SOMEONE YOU TRUST

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MAKE YOUR ERP IMPLEMENTATION A SUCCESS

Richard Foster

You probably have your own list of top items to address when implementing a major enterprise resource planning (ERP) project. But, depending on a person's role in an organization, the perspective of what is necessary for a successful ERP implementation is likely to change. For example, an implementer may have a very different view than a maintenance planner responsible for planning upcoming work on key success factors for a project.

Often, the complexity of effectively managing all the moving pieces can cause ERP projects to go off track. It is helpful to remain focused on the bigger picture or main components that impact the success or failure of a project on a regular basis.

The creation of this list of factors is based on years of implementing enterprise-wide systems. Listed in no particular order, these factors can lead to project success or, if not done well, depressing failures.

COMMUNICATE, COMMUNICATE, COMMUNICATE

Communication almost always makes any top 10 list related to successful business practices. When implementing complex software in an already complex business setting, clear and direct communication is a must.

During a project, are all impacted personnel given regular updates? Do all key parties have a clear understanding of the software and its impacts? For that matter, does everyone have a clear understanding of the goals of the implementation? You should strive to overcommunicate with the theory that too much communication is better than too little.

DOCUMENT AND AGREE

After a successful project implementation, you'll always find loads of documentation. Key documents include signatures from all key project team members. With so many moving parts, it's important to have a record of impactful decisions and conversations. You may have functional design documents, technical design documents, agreed upon business processes, agreed upon report designs, and more. Obtain signatures on all of these designs. This may seem overly formal, but as you approach go live with a system, it becomes very clear why formal agreements matter.

UPPER MANAGEMENT SUPPORT

Everyone understands that a large-scale implementation succeeds or fails based on upper management support. Without it, nobody will take your project seriously and the implementation will be undermined. This support needs to be voiced loudly and frequently. You should have formal mechanisms that drive this support in a visible manner to all involved parties.

EMPLOYEE BUY-IN (CHANGE MANAGEMENT)

This factor can be called the "What's in it for me" question. This question needs to be answered regularly. Involving employees in various phases of the project is one way to answer the question. Quite often, your front line maintenance personnel will see these systems as an unnecessary hindrance to getting the job done. Knowing this, take that challenge head-on and discuss with them the benefits of the system and their concerns. You're driving change in the organization. Many will resist.

STRONG PROJECT MANAGEMENT

For a project to succeed, there must be a strong project manager (or two) ensuring all the moving parts are aligned. The project manager is focused on each of the items in this list and much more. It's this manager that ensures that your change strategies, communication strategies and much more are followed fully and accurately.

STRONG PROJECT TEAM

What makes a strong project team? There are many factors. Yes, you need knowledgeable and competent members. But, these members need to work well together and communicate frequently. For a large project, you likely will have the following members (and more): functional lead, technical lead, project manager, integrator, report writer, project coordinator and a data specialist. Because most things that happen in a large project impact across team members, it is important that the team is one cohesive unit. Lone wolves don't work very well on these projects.

STRONG PROJECT PLAN

So much stems from the project plan or project charter. Each aspect to be addressed during the project is listed. Costing for each phase is included. Costing a project can be especially daunting when you're predicting all costs across all phases for a project that can last for multiple years. The project plan needs to be well understood and agreed upon by all key project team members. Each member needs to have full input in their areas of expertise. This is one of the first steps that will determine project success or failure.

FULL UNDERSTANDING OF BUSINESS PROCESSES

All too often, the results of an ERP project are delivered with little understanding of business processes. The cookie-cutter approach to large project implementations just doesn't work. Each organization is different. Defining and understanding business processes prior to developing solutions is another key early step to project success.

KEEP IT SIMPLE

Don't customize the system unless you have no other choice. There's a reason why you chose the solution you did, so why the need to massively change it? Only change the system if a strong, valid reason for the change is presented. And no, wanting the system to look just like the one it's replacing is usually not a valid reason. You need input from all involved parties, but all inputs won't necessarily be implemented. This is where a good consultant with years of experience becomes necessary. The consultant should know the implications of each change to the overall system.

INFRASTRUCTURE

Before moving to any other aspect of implementing a major system, ensuring the infrastructure is more than sufficient to support the system is a must. If you skip using key features in an application because the infrastructure won't support it, perhaps it's time to address the infrastructure. If end users spend loads of extra time waiting for your system to respond, they're likely to either use the system poorly or not at all. Make sure your infrastructure meets and exceeds minimum requirements recommended by your software vendor.

There are many other important aspects to an implementation. The Information Technology Infrastructure Library (ITIL)) standards can help meet project goals. ITIL's foundation comes from a need for a systematic process to deliver projects on time and under budget.

Of course, many other important factors can be added to this list. Perhaps you consider full training and coaching as something to add. Even the evaluation process for determining which system best meets your company's needs could make the list. What main factors have you encountered that either undermine system implementation or help the implementation succeed?

Richard Foster *is a Systems Analyst for the consulting firm A&A, helping NASA with its Maximo implementation. Richard has spent the last 11 years implementing and instructing others on implementations related to Maximo. Mr. Foster holds a Master's degree in Organizational Psychology focused on team building and work performance. www.adincorp.com*

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IMPROVING SAFETY:

10 TIPS, TRICKS, RULES AND SUGGESTIONS

Matt Wastradowski

According to the U.S. Bureau of Labor Statistics, workers sustained a collective 2.9 million workplace injuries and illnesses in 2015, and nearly 5,000 workers were killed on the job—an average of 13 employees every day.

As employers try to curtail those shocking numbers and improve safety throughout their facility, it's important to examine the relationship between a safer workplace and ensuring uptime, reliability and quality asset performance.

These 10 health and safety tips for safety managers easily translate to the reliability and uptime maintenance sectors, and show you how they can help your company. Asset managers, in particular, can use these tips to acquire, operate and maintain assets in a safe, efficient manner.

1

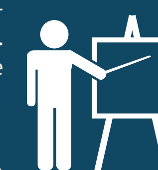
Take Steps to Mitigate Hazards

You can't fix what you don't know is broken. Coordinate with your facility's safety manager and members of safety leadership to conduct a job hazard analysis (JHA), which offers a systematic process for uncovering, mitigating and accounting for workplace hazards.

A JHA allows you to recognize a potential hazard, identify any triggers or consequences associated with that hazard and find solutions that encourage a proactive culture of safety. With a JHA, you aren't just applying a bandage to your facility's hazards, you're finding out *what* caused those risks, *why* they exist and *how* to prevent them going forward.

2

Provide Proper Training



The Occupational Safety and Health Administration (OSHA) outlines dozens of requirements for training employees to understand the risks associated with their work and establish best practices that lead to a safer workplace.

As you train your employees, keep in mind industry specific resources, tips and processes, including these questions:

- Which hazards should you watch and plan for when acquiring and maintaining physical assets?
- Do your employees know the relevant OSHA regulations for their work processes and how to comply with those standards?
- Which hazards may be present when performing maintenance and what steps can you take to minimize those hazards?
- Should your employees know certain processes when machines break down or when maintenance is performed?

3

Keep Your Workplace Clean and Organized

At first glance, most people don't associate neat and tidy workplaces with a safe facility. The 5S system, however, offers one popular method for cleaning a work area, organizing work systems and establishing routines that increase productivity and improve safety.

How can 5S help your facility? In a nutshell:

- By discarding seldom used and unnecessary tools and organizing whatever's left, maintenance workers can find exactly what they need *when* they need it.
- Standardized work procedures can save time, establish routines and create good safety habits.
- Safety managers can hold ongoing meetings to track progress, develop safety goals and revisit the workflow to look for additional areas of improvement.

5S even applies to wasteful *processes*, as well. For instance:

- Are certain preventive maintenance tasks redundant or unnecessary?
- Should certain maintenance tasks be reassigned or performed with more or less frequency to improve uptime?
- Will weekly or monthly safety meetings help refine maintenance processes and encourage employees to think mindfully about safety?

Use 5S to locate and mitigate these inefficiencies for a more streamlined, safer workflow.

4

Establish Lockout-Tagout Procedures

It seems obvious: Who *wouldn't* take precautions when performing lockout-tagout (LOTO) maintenance procedures? The harsh reality, though, is that electrical hazards pose dangerous risks far too often. Failure to follow proper LOTO procedures accounts for nearly 10 percent of all serious accidents in numerous industries.

Stay safe when performing routine maintenance and minimize downtime by establishing and following a LOTO procedure. You should have a documented process for notifying employees when equipment will be locked out, identifying energy sources, shutting down and locking out the impacted equipment, and resuming normal operations once work has been performed.

5 Be Ready for the Unexpected

Are your workers ready if the power shuts down or fire breaks out? Whatever industry you're in, your employees will benefit by being prepared for the unexpected. Doing so demonstrates a commitment to safety and encourages employees at all levels to follow suit.

As a safety manager, you should consider these actions:

- Conduct a fire risk assessment to determine hazards and establish exit routes;
- Develop an emergency action plan that keeps employees safe;
- Ensure all outside exits, emergency exits, egress paths and stairways are fully accessible and clearly marked with phosphorescent signs, labels and floor marking;
- Provide phosphorescent signage to warn employees about hazards posed by physical assets in the event of power outages and other dangerous situations.

6 Improve Organization with Floor Markings

Keep your shop floor organized with a color-coded floor marking system. Doing so separates workers from forklifts, heavy machinery and other hazards; clearly outlines storage and maintenance areas; keeps employees away from exposed edges; and more.

How does all this improve uptime and maintenance procedures?

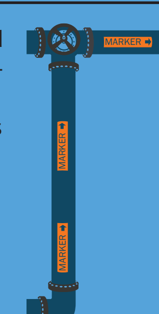
- By setting aside an area specifically for maintenance, you're keeping workers safe and improving organization.
- Workers can streamline maintenance procedures if floor markings set aside and clearly label certain areas for parts and tools.
- Aisles and walkways can create a level of separation between employees and hazardous assets that improve safety, cuts down on injuries and increases profitability.

7 Meet Key Pipe Marking Requirements

Even small facilities may have miles of pipes snaking through their plants, each carrying water, acids, oils and other liquids. In an emergency, properly labeled pipes can assist first responders and ensure clear communications that keep workers safe.

Which pipe marking requirements are right for your facility? Here's a breakdown of the popular standards and when they come in handy

- **ANSI/ASME A13.1:** General pipe labeling
- **IIAR Bulletin No. 114:** Ammonia refrigeration piping identification
- **ISO14726:2008:** Ships and marine technology identification of piping systems
- **NFPA99C and CGA C-9:** Labeling of medical gas piping in healthcare facilities
- **10 States Standards:** Water and wastewater treatment plants



8 Provide Proper PPE at All Times

Whether you're climbing ladders to scope out an electrical box, working on wet or slippery surfaces, or working around materials, such as dust, sand, or grit, you must provide employees with *all* necessary personal protective equipment (PPE) and train them to properly use it.

Safety managers should ask these questions before issuing PPE:

- Which hazards are present and what kind of PPE will protect against those dangers?
- How can employees properly use PPE and what do they protect against?
- Where and how should an employer communicate PPE requirements in certain work areas or throughout a broader facility?

9

Schedule and Perform Routine Inspections

Establishing safe practices and putting safeguards into place are just the first steps in developing a culture of safety throughout your facility. Safety inspections and safety audits provide two systematic approaches for bolstering your facility-wide efforts.

- **Safety inspections** identify hazards and unsafe practices by ensuring safeguards are in place, looking for hazards (e.g., faulty equipment and machinery) and observing and identifying unsafe work practices.
- **Safety audits** take a bigger picture approach to safety by evaluating an organization's established safety programs and practices. Audits usually measure a safety program's efficacy, analyze whether those programs meet the company's goals and see if other training efforts might be warranted.

10

Expand Visual Communications Throughout Your Facility

No matter the field, your facility can benefit from improved visual communications. Whether you want to warn workers of arc flash risks posed by electrical hazards or promote PPE use in a manufacturing environment, signs and labels can keep workers safe and on the job, boost productivity and improve morale.

DOWNLOAD

the complete 10 Health and Safety Tips for Safety Managers info graphic:

www.graphicproducts.com/10safetytips

***Matt Wastradowski** writes for Graphic Products, makers of the DuraLabel line of industrial label and sign printers. For more information: www.GraphicProducts.com*

Joel Levitt

YOUR ORGANIZATION'S AIM **PROVIDES THE ROCKET FUEL!**

> Leading organizations use the AIM to give their employees, from the shop floor to the C-suite, something to work for that is bigger than themselves.

How many companies organize themselves to take advantage of their AIM? Is your organizational mission stated in a poster on a wall like other bland corporate displays or is it the pulsing lifeblood of your organization?

During a visit to the NASA space center in 1962, President John F. Kennedy noticed a janitor carrying a broom. He interrupted his tour, walked over to the man and said, "Hi, I'm Jack Kennedy. What are you doing?"

"Well, Mr. President," the janitor responded, "I'm helping put a man on the moon."

What a great story! Probably not true in fact, but certainly true in action. Historians argue that the original story came from England about 300 years earlier.

Following the Great Fire of London in 1666, Sir Christopher Wren supervised the rebuilding of St Paul's Cathedral. One day in 1671 during an unannounced visit, he spoke with some of the stone masons and received a variety of responses to the question, "What is your job here?"

The first said, "I am cutting this stone." The second answered, "I am earning three shillings, six pence a day." The third man straightened up and, still holding his mallet and chisel, replied, "I am helping Sir Christopher Wren build this great cathedral to the Almighty."

Whichever story you like, there is some wisdom there because finding meaning in what you do is a large contributor to the satisfaction you'll experience during your career. For organizations, finding meaning is also the lever to elevate your reliability effort to its highest expression.

One of the central roles of leadership is to create a context that explains why they are doing what they are doing. "Context" is defined in the Oxford English Dictionary as, "the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood."

The key word is "understood." There is a human need to understand what is going on so people can give meaning to everything around them. Events and circumstances don't just happen, they happen for a reason. That reason is the context of the event.

Some have said that people are meaning making machines. Since work is at the center of people's lives and the context of the work has a major impact on who they say they are and how they feel about that, it behooves people to make the activity at least motivational and, at best, uplifting.

In the Great Fire of London example, the first person is cutting stone – not much there to create a motivational, uplifting activity, or even a reason to get up and go to work.

For the second person, his salary might be more powerful since the money is used to feed his family, care for a loved one, or pay for his child's medical care.

Money is typically a short-term motivator. What people need is a reason that commits them to fighting for something bigger than themselves and even bigger than their own family.

The third worker is serving his God. As for many people, it is a powerful context that gets him out of bed every morning and motivates him to take care in every swing of the hammer. He is creating a home for his faith. His mission to rebuild the cathedral took 26 years.

But organizations are not building cathedrals. So, what about their AIM?

Leading organizations use the AIM to give their employees, from the shop floor to the C-suite, something to work for that is bigger than themselves.

Take a look at some of these AIMs:

Google: "To organize the world's information and make it universally accessible and useful."

Honda: "Maintaining a global viewpoint, we are dedicated to supplying products of the highest quality, yet at a reasonable price for worldwide customer satisfaction." Honda is clearly a product oriented company. Its mission makes clear the organizational priorities.

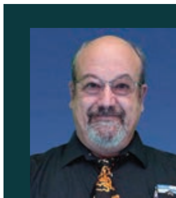
Walt Disney Parks and Resorts: "One of the world's leading providers of family travel and leisure experiences, giving millions of guests each year the chance to spend time with their families and friends, making memories that last a lifetime." Wow, doesn't that sound like something you can get behind?

IBM: Since 2013, the company has had no mission statement. Instead, it operates with a set of values:

- Dedication to every client's success;
- Innovation that matters – for our company and for the world;
- Trust and personal responsibility in all relationships.

From the moment individuals are hired at each of these organizations, they learn the AIM. It is the organization's reason for being in business. Each of these organizations uses its mission to not only choose policies, but to make decisions and motivate people.

So, how important is context? Context is decisive. Go get your organization's AIM statements and see if working on them makes you feel uplifted, empowered, or like you are working toward something bigger than yourself.



Joel Levitt, CRL, CPMM, is the Director of Reliability Projects for Reliabilityweb.com. Mr. Levitt has 30 years of experience in many facets of maintenance, including process control design, source equipment inspector, electrician, field service technician, maritime operations and property management. He is a leading trainer of maintenance professionals and has trained more than 17,000 maintenance leaders from 3,000 organizations in 25 countries in over 500 sessions. www.reliabilityweb.com

LER

Q&A

WIRAM
Women in Reliability and Asset Management

S. Kay Bourque, CMRP
Director – Maintenance Strategy and Services - Phosphates
Mosaic Fertilizer, LLC

Uptime® magazine had the opportunity to speak with Kay Bourque, Director of Maintenance Strategy and Services – Phosphates at Mosaic Fertilizer, LLC. Kay began her career in the phosphate industry in 1980 as a maintenance engineer in Louisiana at Mosaic's Uncle Sam Plant. During the last 37 years, she held various positions in phosphates production, maintenance and procurement. In her present role, Kay is responsible for the strategic direction of Phosphates Business Unit's asset integrity. She leads the maintenance services team as it partners with facility management in their improvement efforts to deliver safe, cost-effective and reliable equipment performance to drive operational excellence.

Q: You are an accomplished leader in a challenging industry. What have been the biggest challenges in reaching your current position?

I started my career as an electrical engineer in 1979 when I was one of a few women in engineering. In 1980, I moved into the reliability and asset management field as a maintenance engineer with Mosaic. I quickly realized there was much to be learned that was not taught in my college classes. I have been blessed over the years to work with some really talented teams of people, all of whom helped me fill the knowledge gaps. However, the biggest challenge I had was learning that a large component of leadership is the ability to influence.

Q: Where are you now in your journey to advance reliability and asset management?

For many years, we focused on the use of predictive technology deployment and workflow process improvements. In the past five years, we have adjusted our focus to more proactive activities, including reliability in the design of assets and activities that extend the life of assets, including eliminating defects that cause early failures.

Q: How does your reliability and asset management journey support the business objectives for Mosaic?

Asset reliability improvement drives positive results in all areas of the business – production, quality, cost and safety. It is critical to our success in a global commodity business.

Q: How do you gain executive support?

The goal of an asset management program is to ensure asset availability so the goals of the organization are met. Much of this very important reliability work is foundational in nature and, if it is successful, is invisible. It is important to ensure executives have visibility to those foundational activities, sharing the successes, both immediate and forward-looking, to ensure a good understanding of what drives asset availability.

Q: Is there anything you can tell us about your team that makes it unique compared with groups you have worked with in the past?

I work with an extremely talented team of reliability professionals who are not only subject matter experts, but are also passionate about the reliability journey. It is their influence across the business that helps to capture the hearts and minds of all in the organization to continue to improve on the reliability journey.

Q: What are the three biggest challenges in reliability and asset management that you face? What are the solutions you have discovered?

1) Becoming a process and procedure driven organization – We have made tremendous progress over the last few years, but to have a sustainable program, we will need to move away from the historic dependence on tribal knowledge and individual subject matter expertise to documented, standard processes. We are formally launching the Asset Integrity Program, which includes documented processes for reliability, maintenance workflow, mechanical integrity and turnarounds.
2) Capturing the hearts and minds of the organization – Even though documented processes are foundational to sustainability, engagement of the entire organization is key to a truly successful program. Celebrating and sharing successes, along with empowering team members through training and certifications, will result in continued improvement.
3) Ensuring sustainability for the future – If we are successful in becoming a process and procedure driven organization and capturing the hearts and minds of the organization, sustainability will result. Leadership is key in ensuring success.

Q: What would you recommend to organizations that want to create more diversity on the reliability and asset management team?

Organizations can provide mentoring and networking opportunities for reliability and asset management professionals. Relationships that are formed through these processes can result in confidence, acceptance, respect and an interesting, innovative environment in which to work.

Q: What would you recommend to younger women entering this field?

Be confident in the value that you bring to the organization while always remaining open to others' ideas. Learn continuously. Jump in!

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Maintenance TIPS

What's the Role of the Reliability Engineer?

The primary role of the reliability engineer is to identify and manage asset reliability risks that could adversely affect plant or business operations. This broad, primary role can be divided into three smaller, more manageable roles: loss elimination, risk management and life cycle asset management.

Loss Elimination

One fundamental role of the reliability engineer is to track the production losses and abnormally high maintenance cost assets, then find ways to reduce those losses or high costs. These losses are prioritized to focus efforts on the largest/most critical opportunities. The reliability engineer, in full partnership with the operations team, develops a plan to eliminate or reduce the losses through root cause analysis, obtains approval of the plan and facilitates the implementation.

Find the complete explanation by visiting www.PoweredByRx.com and clicking on the Articles link when you hover over the Reliability Engineering element of the Reliability Excellence® Model.

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Quick Decision Checklist

Sometimes, it is necessary to make quick decisions in the course of the day. There might be no time for research or reflection. There is one thing that you should do ahead of time. Know your organization's AIM (Mission, Vision and Values). Translate that AIM into a work group's set of goals consistent with the AIM. If your work group doesn't have clear goals, be sure to work on this. Clear goals and a clear mission make clear decisions.

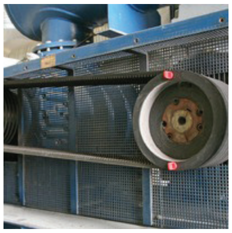
Once done with the goal setting, try this:

- Your choice should alter the work group's goals the least;
- Set aside normal delegation;
- Take control of the situation to ensure clear communications;
- If you make the decision, take full responsibility;
- Get into action.

This is not the time to observe all the niceties of discussion or consensus type supervision. You must take control, take responsibility and act. Maintenance emergencies frequently require this type of decision-making.

Joel Levitt • Reliabilityweb.com

Are You Wasting Time and Money on Quick Repairs?



Many times when equipment fails, there is an incredible rush to get the machine back online due to production. This usually leads to repairs that are inadequate/incomplete. It's important to remember that as long as the machine is locked, it isn't going back into service until it's unlocked. It could take only a few more minutes to allow the machine to be repaired completely, but instead, job is rushed and weeks later the same machine is being repaired for the same reasons again. Some examples that hopefully drive the point home are: Many techs simply roll V-belts on and off for removal or installation. Have you ever noticed a V-belt running upside down? In most cases, it is due to the cords in the backing of the belt being broken, usually caused from rolling the belts on or off the sheave. If "power band belts" are used, their cost is usually higher than the sheaves that the belts are running on. It's a paradox that brand new belts would be installed on worn out sheaves. How many use an indicator to ensure sheaves are square to the shaft after replacement and not just tighten the hub with an impact wrench? How many are precision aligning equipment after replacing belts or sheaves? Poor alignment or incorrect installation are common causes of abnormal wear of sheaves and pulleys. Repairs need to be done in a timely fashion in cooperation with production to minimize downtime and reduce any effects on quality.

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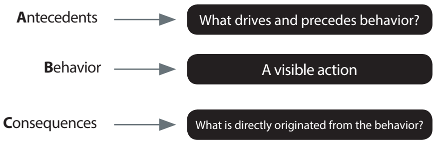
The ABC Model for Behavior

The ABC model for behavior provides a simple step-by-step approach to understanding the process of behavior so it will be used to do just that from this point forward. In this model, each letter has a meaning:



ABC model for behavior

A: The letter "A" stands for Antecedents, which refer to something that precedes and stimulates behavior.
B: The letter "B" stands for Behavior and refers to any act or action observed by others.
C: The letter "C" stands for Consequences, which arise directly from the behavior.

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Created by Ramesh Gulati **ANSWERS**

Crossword Puzzle

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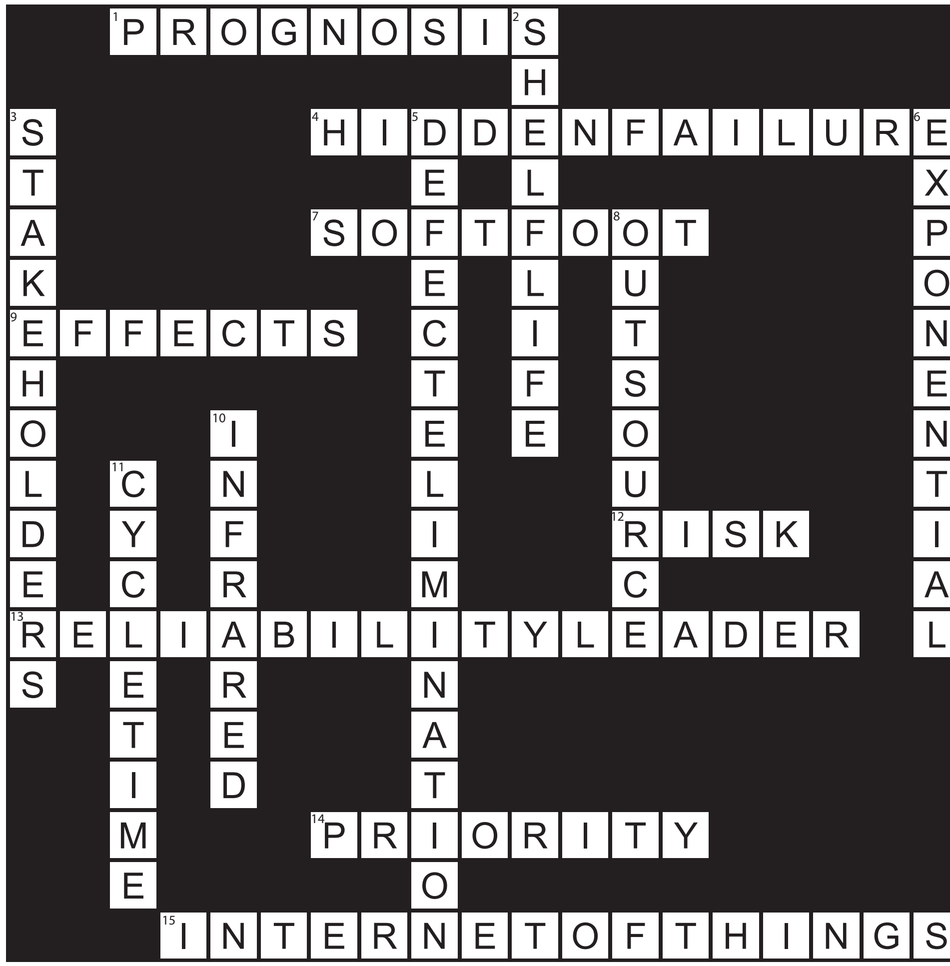


ACROSS

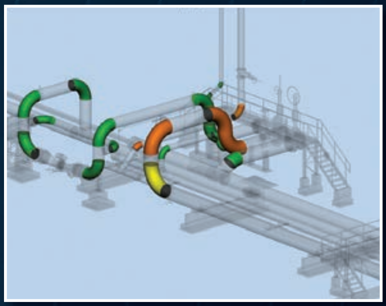
1. A forecast or prediction of outcome, such as how long an asset or component will last or its remaining life left
4. A failure mode that will not become evident to a person or the operating crew under normal circumstances (two words)
7. A condition in which one of the feet on a machine does not sit flat on the base; The foot or base may have been damaged causing misalignment and initiating vibration when tightened (two words)
9. Consequences of failures
12. A future event that has some uncertainty of occurrence and could have negative or positive consequences if it were to occur
13. Anyone who helps another person, a machine, or a gadget to do a better job to improve reliability (two words)
14. The relative importance of a single job in relationship to other jobs based on equipment condition, operational needs, safety, etc.
15. Network of physical objects, such as devices, components, machines, using embedded technology to communicate with each other with minimal human intervention (three words)

DOWN

2. The amount of time an item may be held in inventory (MRO store) before it is no longer fit for use (two words)
3. A person or organization that can affect, be affected by, or believe to be affected by a decision or activity; Also known as interested party
5. The identification of a nonconformance and its removal (two words)
6. Something that is increasing very rapidly
8. An arrangement where an external organization performs part of an organization's function or process
10. A predictive technology that detects thermal energy emitted from an object and displays an image of temperature distribution
11. The elapsed time from the start of an activity/process until it's completed (two words)

Your Roadmap to Operational Readiness and Superior Asset Performance

Assess risk based on failure severity, likelihood scores and confidence assessment.



Visually navigate assets.

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