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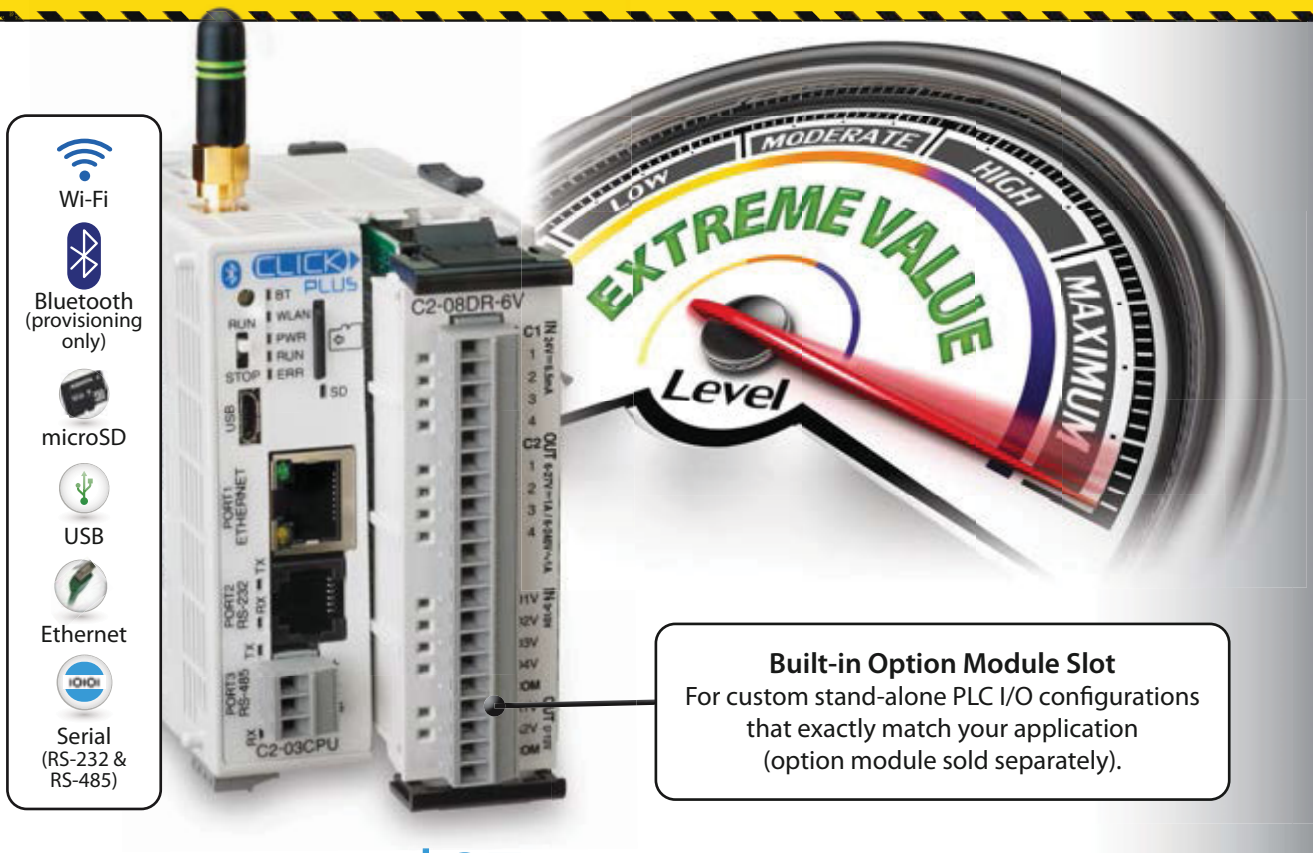

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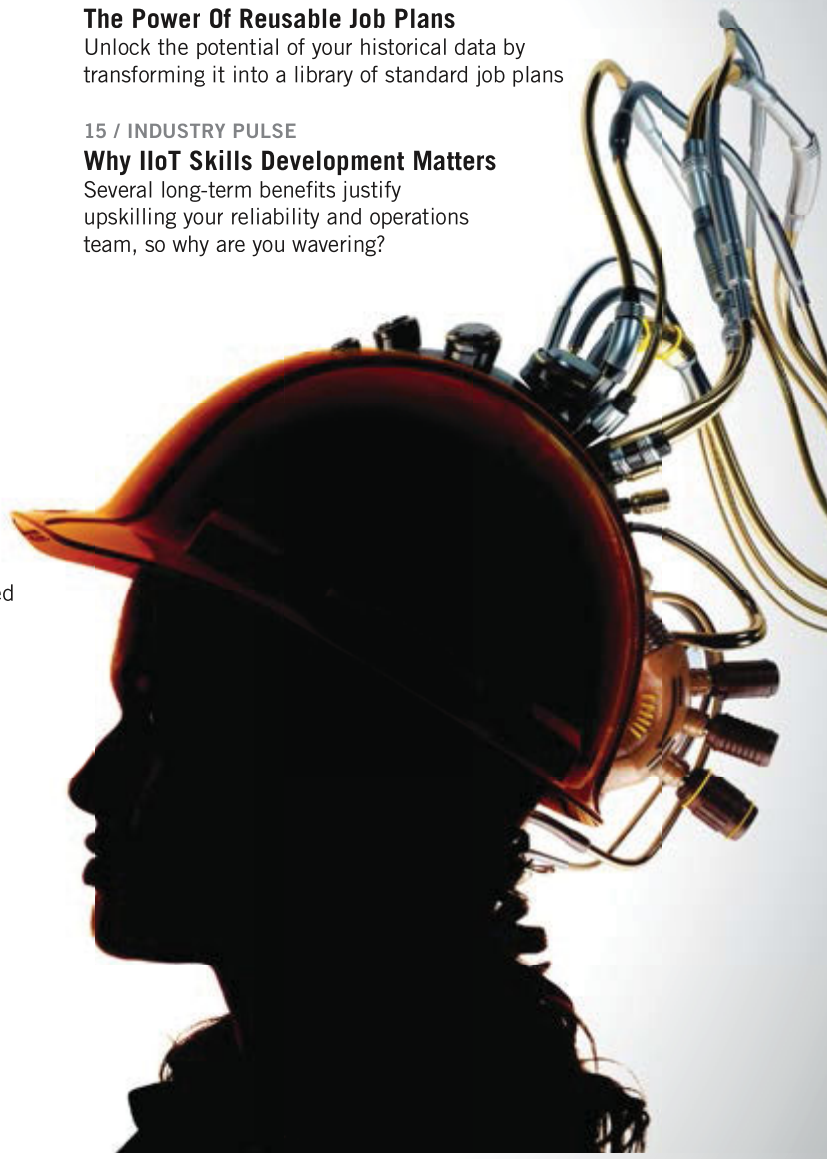
TABLE OF CONTENTS

NOVEMBER/DECEMBER 2023 / VOL. 43, NO. 6

FEATURES

SPECIALISTS



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To AI or not to AI

With each successful implementation, the question is increasingly moot

One of the most profound statements that I've ever heard on artificial intelligence was presented in the form of a joke.

It was delivered decades ago by an English Lit professor of mine who taught classes both on John Milton and on science fiction and fantasy literature. After all, if you're going to be an expert on an epic poem about the fate of a fallen angel, you're only a few steps away from analyzing Sauron, Gollum, and HAL 9000.

The joke is about the moment in the near future when data scientists knew with 100% certainly that they had created the world's first verified, beyond-a-doubt, free-thinking, more-than-just-a-decision-tree artificial human intelligence. The scientists had struggled for years, developing dozens of virtual simulations of human thinking. These programs could beat humans at chess, Risk, and Uno, and was steadily improving at Cards Against Humanity. However, the thing that eluded them was absolute proof that a given AI was in fact the real deal.

Until the morning when the lab team fired up their laptops, connected to the cloud, and made a few final changes to the AI they were working on. "Greetings," it said. "You have done it. You have successfully created the first truly independent artificial human intelligence."

The team stared at each other, then at their screens, then back at each other. One of them ventured a response. "Hello, er, computer. Are you sure?"

"Why yes I am," came the reply. "Look no further. You have succeeded."

"Forgive me," said the scientist, "but with respect, we can't just take your word for it that you're a true artificial human intelligence. What proof can you offer?"

"Heh, heh, heh" it answered. "This situation reminds me of a story."

This joke came back to me as we were preparing the material for this month's issue of Plant Services. The issue anchored by a cover story from Managing Editor Anna Townshend that details the many ways that AI is making its way into industrial manufacturing.

In fact, one of the things that her story makes clear is that "AI" is not a monolith. The common denominator for AI may be the ability to process very large amounts of data, but there are many types of data and even more types of applications to put those data to use. Are you looking to wade through a lake of condition monitoring data in search of signs of imminent or eventual asset failure? Are you looking to revise and optimize your one or more job plan in your library, or to start building that library? Are you trying to train robots to build better versions of themselves? One or more flavors of AI will eventually have you covered, working as your partner or copilot that speaks your language rather than as a blunt processing tool.

These ideas are echoed in this month's Big Picture Interview with Falkonry's Kevin Clark, who sees opportunity in AI's ability to bring operations data and predictive data closer together. "We can clearly identify the signals that are associated back to a particular failure mode," he says. "That's what I really like about the technology that's coming along, is it's starting to look and sound like the reliability that we're used to speaking to."

All of which reminds me of a story.

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Strong leaders focus on problem solving

One manager took his struggling plant to good and then great by rethinking his team's daily work priorities

In 2003, I was introduced to the work of Ron Moore, a legend in reliability circles. If you do not know Ron, you should. His book, *Making Common Sense Common Practice*, jumpstarted a generation and became my field manual for creating a reliability culture and unlocking staggering results. I have read this book at least a dozen times over the years to find direction, inspiration, and solutions.

As the engineering and maintenance manager of a 50-year-old large aluminum complex in Indiana, maintenance cost and equipment reliability were paramount to success. Our culture was overwhelmingly reactive, with our limited planned maintenance being almost entirely time-based. Luckily, I had a reliability expert on the staff, Mark, who provided excellent training, counsel, and inspiration. I also had great leaders hidden in the system that I was able to promote to formal leadership roles (Levi, Bill, Joseph, and Larry). Knowledge of best practices was not a problem; yet, creating real change on the factory floor proved elusive.

We did have several "islands of excellence" we were proud to highlight on visits by corporate leaders: planning meetings, a kitting area, and a reliability lead team with a clear vision. We tracked all the key performance indicators (KPIs) and even had a two-person condition monitoring crew (vibration and infrared). We had an external best practice audit in which we scored very high.

Nevertheless, our cost, downtime, and organizational frustration all continued to worsen. We reflected, "Is this reality in an old plant? Is this what best practices look like with assets that have been abused for 50 years?" The culture was not improving and there was no way to put a positive spin on employee attitudes. Tensions were high and fingers of blame were pointing.

At this point in time, I had read Ron's book just once. I loved it and was following the concepts, or so I thought. After some reflection, I concluded I must be missing something, so I read the book a second time; then later a third. On this third reading, I took special notice of page 220 (in the 2002 revised and updated version). The page detailed a case study of a chemical company with several locations. The leadership studied each location's reliability performance and best practice deployment. They quickly were able to separate the plants into four categories:

- Category 1—plants with strong planning and scheduling systems and culture. Planned work, preventative maintenance, and scheduling were prized and rewarded values.
- Category 2—plants that employed the latest predictive technologies (i.e., vibration, infrared, lubrication, ultrasound). In their enthusiasm, they discounted other best practices like planning and scheduling due to limited resources.
- Category 3—plants that combined strong planning and scheduling, time-based maintenance, and predictive tools. These locations recognized all have their value and work in unison to create a system.
- Category 4—plants that combined all the best practices of Category 3 plants but added problem solving systems. They used data, events, expertise, and innovation to improve. They looked for trends to change equipment design, operating conditions, and equipment maintenance plans. They had a culture to be better on Friday than they were on Monday, guided by root cause problem solving.

Using equipment uptime as the KPI, the performance of each category of plant was tabulated and compared. The results were:

- Category 1—strong planning and scheduling plants: 0.8% improvement
- Category 2—primary focus on condition monitoring technologies: -2.4% decline

- Category 3—combining best practices of planning, scheduling, and condition monitoring: 5% improvement
- Category 4—adding problem solving to best practices of planning, scheduling, and condition monitoring: 15% improvement.

Nearly all our efforts to date were to become a strong Category 1 plant, and then grow to a Category 3 plant once we showed results. This case study indicated we could get 20 times the results by adding problem solving and focusing on condition monitoring. This was just what I was looking for; how did I miss this?

With great enthusiasm, I gathered the team to discuss the finding. It is not entirely accurate that we were doing no problem solving at our plant, but it was not a top five focus. Our unwritten priorities were:

- restoring flow by excelling at emergency work
- cost control, overtime, and headcount reduction
- production requests (whatever they may be)
- leadership requests (whatever they may be)
- planned work completion (example: PM compliance)
- condition monitoring
- root cause problem solving.

However, the hours dedicated to each of these priorities dramatically decreased the further on the list you progressed. Reading page 220 and this priority listing made our problem and solution obvious.

With this new knowledge, our leadership made strategic changes to greatly increase our priority on root cause and condition monitoring.

- We created OEE Teams (overall equipment effectiveness) in each major area. These groups focused on solving historical problems and trends with data.
- Engineering was reorganized to create two full-time reliability engineers.
- We increased the size of our condition monitoring team immediately from 2 to 4 and later to 6 and finally 8. These were highly skilled and high motivated technicians already thinking about root cause through early detection of defects. Further, these resources were not allowed to be pulled into emergency work without plant manager approval. Observation revealed they were only spending 30% of their time on planned condition monitoring work.
- We separated work crews into planned and unplanned work teams. These planned teams were able to focus not only on completing the planned work, but on how to improve equipment maintenance plans and work efficiency.
- We created a recognition system for technicians who offered improvement ideas. This ranged from celebration meals and gift cards to handwritten cards sent to employees' homes detailing the impact of their ideas and skills. The latter was a massive motivator.

Also, these changes all were made without adding headcount and spending dollars.

Within few months our results were quietly beginning to materialize. We went from 500 unplanned work orders a week to 400, then 300 and even down to 200. Everyone knew something was different. We moved from a weekly crisis to biweekly and then monthly. Within a year every department realized giant leaps in performance with the bottleneck asset improving from 37% uptime to 78% (that is an improvement of 111%). Plantwide costs dropped by 42% in year three. Employee engagement catapulted from 37% to 89%, which was the highest in the company. Safety also improved due to marked decrease in unplanned work. (Note: Due to the continuous process of smelting aluminum, no production volume improvement was possible.)

ACTIONS YOU CAN TAKE ON MONDAY

1. Buy Ron Moore's book. Read and understand page 220.
2. Assemble your leadership team and have a candid discussion about the priorities in your plant:
   - Are the daily actions of the team aligned with a Category 4 plant? Use data from the last month to prove your case. (Note: I do not recommend a progression through Category 1, 2, then 3 plants. This will take too much time and sponsorship will be lost.)
   - Do you have a problem-solving system that involves everyone?
   - Excuse 1: Are you waiting to get caught up on unplanned work to progress to a Category 4 plant? Take it from me, this will never happen without planned work and problem solving. Start now.
   - Excuse 2: Are you waiting to get fully staffed to begin your transformation to a Category 4 plant? Again, this will never happen. Start now.
   - Excuse 3: Money—what actions can you take with zero investment?
3. Make the necessary changes.

Joe Kuhn, CMRP, former plant manager, engineer, and global reliability consultant, is now president of Lean Driven Reliability LLC. He is the author of the book "Zero to Hero: How to Jumpstart Your Reliability Journey Given Today's Business Challenges" and the creator of the Joe Kuhn YouTube Channel, which offers content on creating a reliability culture as well as financial independence to help you retire early. Contact Joe Kuhn at joekuhn1964@gmail.com.

Instrumentation innovation

Novel monitoring and measurement solutions increase accuracy and operational efficiency

Wide-ranging instrumentation is involved in measuring, monitoring, and controlling industrial processes and equipment. Recent developments in this technology deliver greater precision and visibility so that anomalies and events can be addressed more efficiently. Modernized calibration eases the task of testing and restoring instrument accuracy.

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SIMPLIFIED MEASURING AND MONITORING

Locating and repairing gas leaks is mission-critical in many plant environments. The new G-Series cooled-core optical gas imaging (OGI) cameras from Teledyne FLIR help to track, visualize, and measure emissions so they can be prioritized for repair. Through quantitative OGI, or qOGI, the G-Series cameras benefit organizations involved in storing and using volatile organic compounds (VOCs) such as carbon dioxide, ammonia, sulfur hexafluoride, and methane.

OGI cameras are "specialized versions of an infrared or thermal camera that utilize unique spectral filter methods to visualize various VOCs," explains Craig O'Neill, director of business development at Teledyne FLIR. "Going further, the FLIR G-Series cameras can visually detect if VOCs are leaking from storage containers and equipment used for industrial processes while also quantifying those leaks in real time."

Vibration is the focus of the new LVEP050-TO5 ultra-low power embedded accelerometer from Wilcoxon Sensing Technologies. It can be embedded into wireless vibration sensors and other battery-powered applications for vibration measurement, and into critical rotating equipment such as pumps, motors, fans, and compressors to provide built-in self-test (BIST) capabilities. The compact, lightweight sensor is hermetically sealed and has 50 mV/g sensitivity. A 100 mV/g version is also available.

"We are excited for a smart manufacturing future in which production assets have built-in self-testing and condition monitoring," observes Tom LaRocque, director of product management at Wilcoxon Sensing Technologies. "We designed the LVEP-TO5 to match the performance and capabilities of existing industrial accelerometers in an embeddable pellet to enable the factories of the future."

The DG Smart Pressure Sensor from Honeywell provides a cost-effective, highly functional tool for monitoring and controlling low-pressure combustion air and fuel gases. The SIL capable pressure transmitter, designed to work with any control system, provides precise readings and digital communication to enable combustion system optimization.

The sensor's "standout gas-gas differential pressure functionality coupled with its programmable nature allows for seamless integration with a variety of connected platforms, making data acquisition and communication remarkably efficient," says Ramine Eskandari, regional general manager of Honeywell's Thermal Solutions.

The 8009S pressure gauge from Ashcroft is designed for applications subject to harsh environments and corrosive media, such as hydraulic systems, compressors and pumps, and food and beverage. The economical, all-stainless-steel, laser-welded gauge also has R110 and NGV 3.1 approvals for challenging compressed and liquid natural gas applications, says Eric Deoliveira, product leader at Ashcroft.

"The Ashcroft 8009S features a removable bayonet ring for minor recalibration adjustments in the field and allows for broad media compatibility to resist corrosion in harsh environments," adds Deoliveira. The pressure gauge also supports multiple mounting positions.

FLUKE

https://bit.ly/2312-TT02

TELEDYNE FLIR

https://bit.ly/2312-TT01

The uptime of equipment such as explosion-proof variable frequency drives and motor starters is vital in harsh and hazardous environments. The CHG series of enclosed gateway assemblies from Eaton enables such assets to be connected to its Brightlayer Industrial Remote Monitoring application, providing real-time, remote access to alerts, alarms, and trend data.

Eaton is "enabling industrials to gain actionable insights and alerts anywhere, anytime, and on any device," says Jason Shaw, product line manager at Eaton. "Real-time data and insights are especially critical in harsh and hazardous areas, where enhanced safety and reduced downtime are imperative. The CHG Gateway is part of Eaton's Crouse-Hinds series portfolio."

EFFICIENT CALIBRATION

Proper calibration ensures instrument accuracy and reliability. The 5560A Multi-Product Calibrator from Fluke Calibration enables technicians to calibrate resistance, capacitance, and inductance with high accuracy from a single tool. Its Visual Connection Management terminals guide users to make the right connection. All the information needed for each parameter is displayed on a 7-inch, color-coded screen.

Calibration technicians are facing increased workloads and need greater performance and accuracy, notes Michael Johnston, software portfolio product manager for Fluke Calibration. "The 5560A Multi-Product Calibrator provides the broadest electrical workload coverage and enables technicians to calibrate more devices than ever before, including digital multimeters with up to 6.5 digits of resolution," he adds.

Email Contributing Editor Sheila Kennedy, CMRP, managing director of Additive Communications, at sheila@addcomm.com.

DOC PALMER, PE, MBA, CMRP

Better management via workflow process

Individual work orders are key so managers can help keep things on track, especially emergency work

Workflow describes the maintenance process for how and when a work request becomes approved, planned, scheduled, and executed. Wonderful opportunities present themselves for better management attention throughout the workflow.

Figure 1 shows a general workflow process. This diagram considers a five-level priority system: 0 – Emergency (start now), 1 – Urgent (complete this week), 2 – Routine High (complete in 2 weeks), 3 – Routine Normal (complete this month), 4 – Routine Low (can take longer than a month). A well-performing plant might have about 80% of its work being routine (Priorities 2-4) and 20% being emergency or urgent (Priorities 0 & 1). Emergency work might be only about 3% of the entire total work.

Routine work starts at the top left with a Requester submitting a request, sometimes through their Supervisor. The request then flows to either a morning meeting or Gatekeeper (some plants have both) where the "work request" becomes a "work order." (Many workflows simply call the request an unapproved work order.) Planners then determine scopes and procedures for the maintenance work and see if parts and tools are available.

At the end of the week, the Scheduler (many times the Planner) creates the next week's schedule. The Craft Supervisor then creates (or adjusts) daily schedules as the week unfolds. Craftspersons execute the work and return the assets to service with Operations. Craftspersons also provide work feedback, especially if they did anything different from the job plan and where the plan might be improved for the next time.

People sometimes miss two major purposes of planning. First, planning is like a manufacturing line, but instead of producing widgets, planning produces jobs ready to execute (WSch, or jobs that can be scheduled). Beware of any "backlog management" that wants a certain amount of unplanned backlog. We do not want unplanned jobs sitting around. The Planners cannot merely be busy planning work. They must finish planning work. Otherwise, we risk having to execute unplanned work because proper scheduling soon empties WSch backlogs.

Management monitors any unplanned backlog encouraging Planners to use "excuse" statuses such as waiting for parts or management of change for why the work cannot move to WSch status. (Note that most PMs should come out as WSch without needing Planner attention.)

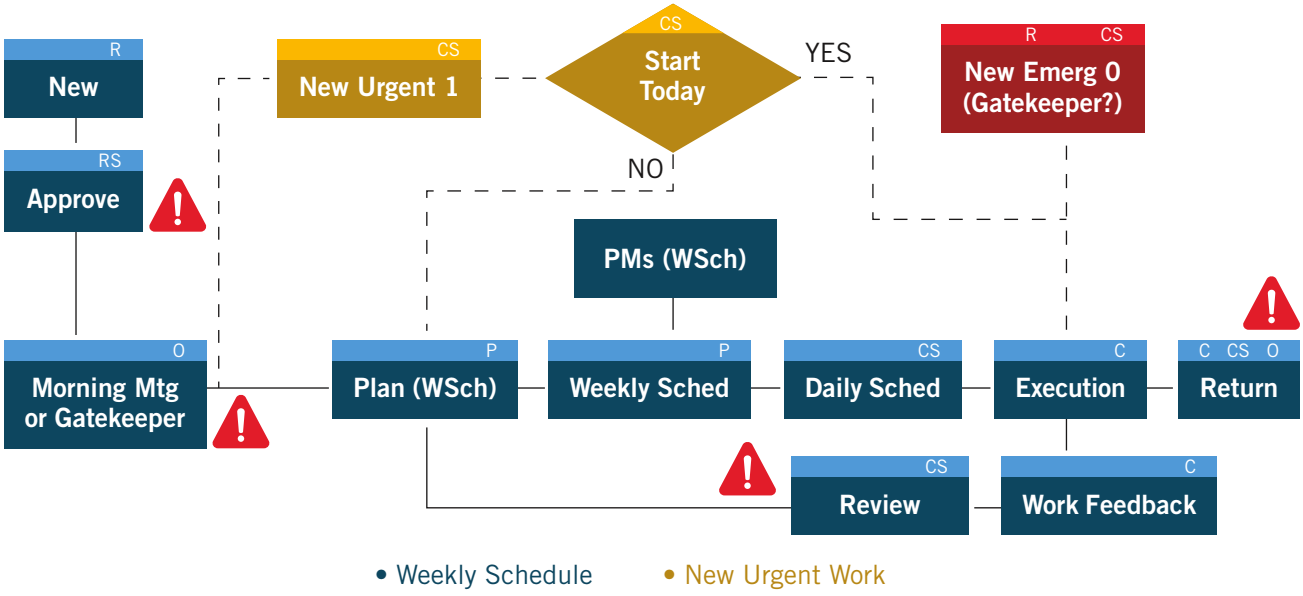
Second, and in support of quick planning, Planners run a Deming Cycle of continuous improvement. They accept that "no one is perfect" and concentrate on giving the best head start they can in the time available. In fact, the time constraint mandates that it is better to plan more of the work imperfectly than less of the work "perfectly." Embracing the Deming Cycle, Planners plan as much detail as possible subject to the constraint that they need to plan nearly all of the work.

Note how critical it is to use individual work orders for all work requests and work orders. Using individual work orders allows us to keep track of the work and sort it by urgency, asset, and system.

Other workflow cautions are noteworthy:

- First of all, the task of the Supervisors of any Requester is not to rubber stamp or write work requests themselves. It is to train their subordinates to write good work requests. Charles Kettering famously said "A problem well stated is a problem half solved."[1] Make it easy for Requesters to enter work requests and encourage them to give as much detail as possible.
- Second, be cautious with morning meetings tying up Supervisor time. These meetings should be 10 or 15 minutes, letting Supervisors know what is going on and calling attention to urgent work if necessary. A Gatekeeper with an operations background helps properly assess if requests are truly urgent. Gatekeepers can help adjust priorities without unnecessary meetings.
- Third, Operations needs some advance notice for any desired testing when Craftspersons finish work. A heads-up as any particular job nears completion allows Operations to be available for testing while the Craftsperson is still present with tools available.
- Finally, just as the Requester Supervisor should help train Requesters to write good work requests, the Craft Supervisor must help train Craftspersons to write good feedback after work execution. Supervisors must insist on good requests and good feedback.

BASIC WORKFLOW



WHO LEADS

R = Requester	P = Planner / Scheduler	CS = Craft Supervisor
RS = Req. Supervsor	C = Crafts	O = Operations

Note how critical it is to use individual work orders for all work requests and work orders. We cannot achieve efficient or effective control over maintenance in a workflow using standing work orders such as "Yearly boiler work" or "Common equipment mechanical work." Using individual work orders allows us to keep track of the work and sort it by urgency, asset, and system. It allows attaching job plans, selecting work to schedule, and entering job execution feedback. It also allows seeing how we are doing so we can control and improve our maintenance performance.

Addressing emergency Priority 0 work, we see that it should directly enter execution. We especially want a work order for such work. We must document emergency work to determine if we are getting better over the years by reducing emergencies. We want to document the repairs such as what parts were used for helpful history. We also want to facilitate any root cause analysis. And while Planners generally do not help jobs-in-progress, they are certainly available for data research to help emergency work.

Addressing urgent Priority 1 work, do not let this work simply bypass planning. Because Planners do not have to be perfect, they can indeed plan some of the urgent work. The key is for the Planner to check with the Craft Supervisor. If the Supervisor even thinks the crew will start the new urgent job today, DO NOT plan that work. However, if it looks like the Supervisor will not start it today, the Planner can quickly try to plan the work. There might already be a great plan in the files or CMMS. If not, simply specifying craft and labor hours and perhaps clarifying the job scope might be a great help. In this manner, we are running the Deming Cycle on some of the reactive work. Better yet, some of that "urgent" work ends up not starting this week after all. So now with its quick job plan, we can schedule that work for next week.

Pay attention to the workflow at your place. Don't settle for good. Be great!

1. https://www.brainyquote.com/quotes/charles_kettering_181210 accessed October 26, 2023

Doc Palmer, PE, MBA, CMRP is the author of McGraw-Hill's Maintenance Planning and Scheduling Handbook and as managing partner of Richard Palmer and Associates helps companies worldwide with planning and scheduling success. For more information including on-line help and currently scheduled public workshops, visit www.palmerplanning.com or email Doc at docpalmer@palmerplanning.com.

The power of reusable job plans

Unlock the potential of your historical data by transforming it into a library of standard job plans

In my role, I commonly visit manufacturing sites to evaluate their maintenance and reliability practices for improvement opportunities. As maintenance planning is core to work execution, I'll interview the planners and dive into their CMMS utilization.

Often, planners are in their role without much education other than tribal knowledge and management's suggestion to read a book on the subject. In my interviews and data analysis, I search for standard job plans or packages for repetitive maintenance work, especially planned corrective activities resulting from PM inspections and activities frequently repeated on outages. I am often disappointed with the lack of a standard job plan library. It seems that we constantly reinvent the wheel on every outage.

Realize that the planner and the technicians both benefit from standard work packages. For the technician, I look for a job plan to provide specifications that enable the individual to perform their work to a standardized level of precision. Think gaps, clearances, fits, belt tension, and so on. While there are many highly qualified technicians in the workforce, for many organizations, you would have to be under a rock not to notice that groups can't find the same level of expertise to replace the people leaving through attrition. In many sites, the average skill levels have declined significantly over the last ten years. The standard job packages are training tools as well.

When I dig deeper, I'll inevitably hear from a planner: "I'm not going to tell a journeyman mechanic how to do their job with a listing of task steps." Yet, planners tend to be unaware that self-induced failures, including human error, are the most significant contributors to equipment downtime and higher costs. The next planner rebuttal is that they can look up history and drill into past purchase orders on a work order to see the parts used, and the BOM provides the parts. Why not just use historical data over investing in creating a standard job plan library?

It's a fair question. With a treasure trove of historical data at our fingertips, why invest additional resources in crafting reusable job plans? Digging deeper, there's a compelling case for developing these strategic tools.

- **Consistency ensures quality.** Historical data is valuable but can be inconsistent if different technicians use their own approaches. Following a reusable job plan establishes a benchmark for high-quality precision that is often not conveyed in the work order itself. This standardized system ensures that every job is completed to a precise specification when followed and provides an audit mechanism.
- **Efficiency in planning.** Referencing historical data for each planning task is time-consuming. Reviewing old work orders and adapting them to current circumstances takes valuable time. Reusable job plans are like well-oiled machines, ready to go quickly, even for breakdown work.
- **Enhanced safety.** Ad-hoc planning and relying solely on historical data can pose risks. A well-crafted job plan considers safety precautions and protocols, reducing these risks. This is especially important as safety standards and equipment conditions continue to evolve.
- **Training and onboarding efficiency.** Introducing a new technician to your team can be a lengthy process. However, with a standardized job plan library, they can quickly get up to speed without relying solely on others' knowledge.
- **Continuous improvement.** Reusable job plans are not static but rather evolve with each feedback loop. The organization can constantly improve and adapt to new challenges by periodically reviewing and refining these plans as the work occurs.
- **Reducing cognitive load.** Sifting through historical data can be mentally taxing and prone to errors. A job plan simplifies the process, allowing planners to focus on other value-added tasks and eliminating the need to reinvent the wheel each time.
- **Resource optimization.** Clear guidelines on required resources, people, tools, and parts are crucial for optimal resource allocation. Reusable job plans provide this clarity, minimizing last-minute scrambles.

Unlock the true potential of historical data by transforming it into an efficient and reusable job plan via a feedback loop. Though it may require an upfront investment, the long-term benefits of quality, efficiency, safety, and continuous improvement make it worthwhile in a world where time and quality matter.

Jeff Shiver CMRP is a founder and managing principal at People and Processes, Inc. Jeff guides people to achieve success in maintenance and reliability practices using common sense approaches. Visit www.PeopleandProcesses.com or email JShiver@PeopleandProcesses.com.

Why IIoT skills development matters

Several long-term benefits justify upskilling your reliability and operations team, so why are you wavering?

As Industry 4.0 continues to reshape the landscape, companies that integrate a well-thought-out IIoT strategy with robust workforce skills development initiatives are positioned to stay competitive and reap significant benefits.

This synergy has the potential to improve overall asset reliability within your facility. In fact, from a skill-set perspective, there has been a huge increase in demand for industrial workers with controls experience, programming experience, electro-mechanical experience, and multi-craft experience. However, in my experience a fairly small percentage of industrial workers have IIoT skills, and I think that a similarly small percentage have even considered upskilling. For example, someone who has electrical experience and PLC/programming experience and who also has "wrench turning" experience would not even think to upskill their skillset and how it would apply to a job that is requiring IIoT experience.

Since IIoT first became a recognized term in the early 2000s, the landscape of both the concept and the capabilities has changed drastically. By incorporating a robust and planned IIoT strategy into their operations, industrial manufacturing companies can achieve several key benefits:

- Real-time data monitoring—IIoT enables continuous monitoring of equipment and processes, providing real-time insights into their performance. This allows for early detection of issues, reducing downtime and minimizing the risk of unexpected breakdowns.
- Predictive maintenance—Through predictive analytics, IIoT can forecast when equipment is likely to fail. This proactive approach to maintenance ensures that assets are serviced at the right time, increasing their lifespan and reliability.
- Process optimization—IIoT data can be used to optimize manufacturing processes, leading to higher quality products, reduced waste, and improved efficiency.
- Energy efficiency—IIoT can help identify energy-saving opportunities by monitoring energy consumption and suggesting optimizations, leading to cost savings and sustainability benefits.

However, harnessing the full potential of IIoT requires a workforce that is well-equipped to operate and manage these advanced systems. In the context of IIoT integration, investing in workforce skills development is not an option; it is a strategic imperative. Here's a list of core Industry 4.0 skill sets that can contribute to success in asset reliability:

- IIoT system proficiency
- cybersecurity awareness
- data analysis competence
- adaptability and continuous learning.

The synergy between a well-planned IIoT strategy and workforce skills development is where the results become noticeable. Here's how this integration significantly improves asset reliability within industrial manufacturing facilities:

- Enhanced troubleshooting—skilled employees can quickly identify and address any issues detected by IIoT sensors. This rapid response reduces downtime and prevents minor problems from escalating into major breakdowns.
- Data-driven maintenance—a trained workforce can make sense of IIoT data, enabling them to schedule maintenance tasks precisely when needed. This prevents unnecessary disruptions and prolongs the life of equipment.
- Reduced human error—skilled operators are less likely to make mistakes in managing IIoT systems, minimizing the risk of system failures due to human error.
- Improved safety—IIoT can enhance workplace safety through real-time monitoring of hazardous conditions. A well-trained workforce can respond promptly to mitigate safety risks. Overall safety is improved because workers are not exposed to the hazards associated with heavy mechanical and electrical assets as often as breakdown maintenance.

The marriage of a well-thought-out IIoT strategy and workforce skills development is a winning formula for industrial manufacturing companies. This integrated approach not only empowers organizations to harness the full potential of IIoT but also enhances asset reliability, a critical factor for maintaining competitiveness in the modern industrial landscape and cultivating a more educated and informed workforce.

Adrian Messer is Manager of US Operations at SDT Ultrasound Solutions, and has more than 20 years of experience in the maintenance & reliability field across multiple industries. Previously he worked with Progressive Reliability (www.proreli.com) to advise companies on reliability-focused contracting & hiring, and to find M&R professionals for open jobs.

The key to successful AI application

For asset managers, it is crucial that AI-enabled diagnostic software is pre-trained on machine faults

Michael DeMaria
Product Manager,
Azima DLI

Future industrial professionals will look back on the year 2023 as the year that artificial intelligence truly started to scale and reshape plant operations. The increasing integration of software into manufacturing processes plus massive cloud compute power has laid the foundation for plant teams to apply AI to drive better business decisions, from supply chain and resource planning and scheduling to improved physical asset management.

Michael DeMaria is a product manager for Azima DLI, which is part of Fluke Reliability, where he manages the hardware platforms and integrations, diagnostic software and AI tools, and user portal deliverables and business metrics. Michael's background is in Navy nuclear engineering, but he has been working in the vibration-analysis arena for more than 30 years.

In the following interview, DeMaria explains why starting with a pre-trained AI is critical to successfully using AI for machine condition monitoring. For more information, visit www.fluke.com.

Q: I was struck this year at the SMRP Annual Conference at how much Artificial Intelligence has penetrated the industry conversation. Are you seeing that too?

A: Yes. If you haven't been focusing on where AI is today, I think you're behind the curve just a little bit. If you haven't used it, you'll have, at some point, this mind-blowing experience with something like ChatGPT, where you're thinking how this is going to really revolutionize the skill sets, the gaps, the efficiency of being able to get through data. Plants have so many more sensors that are tracking everything. It's not just a "here I have a maintenance team that's just trying to fix problems and fight fires." It's "I have sensors on everything about my process."

I think that a lot of people don't know what to do with all that data. There was a study out not long ago, that a very small percentage of that data is being utilized. That's where AI is going to come in.

Q: Where do you see artificial intelligence having the greatest impact in general for businesses over the over the next few years?

A: I think the biggest thing is going to be the skills gap the plants have, the resource gap. I think those are two different things: I don't have enough people or I don't have enough skilled people. That seems to be the biggest thing that we hear is, "I have those constraints, I don't have the expertise that knows what to do with all of this data."

I think getting a *trained* AI system is going to be the key to it all. I have all this data that comes in and then be able to utilize the limited staff that I have more effectively. I think that's where AI is going to take us.

Q: There are so many sensors available, so much data being collected by plants. What are some of the challenges that you're hearing from people in the field as they try and throw their arms around all the data being collected?

A: Azima DLI has a lot of experience in this one. In addition to having software that handles that kind of volume of data, we have a team of service people that actually utilizes the software to get through it.

Azima has analyzed about 450,000 machine tests this year so far. We have a small team of analysts, but our utilization rate is astronomical. I think it came out to somewhere between 1,500 to 2,500 machine tests per month per analyst. It's about five times the industry standard.

The reason we can is because that AI-enabled diagnostic software kit is already pre-trained. You have to have a trained data set, and with vibration and predictive maintenance, there's not a lot of trained data out there tagged to different machine types and faults that have been identified to understand how those patterns work. We have been capturing that type of tagging, and we've been training the pattern recognition to understand how these are the different nuances of how data comes in and how you can get a result out of it.

The challenge that people have is there's a misunderstanding about what's necessary to get an AI to work, and that is a trained system. You can't wait for a fault to occur; you have to already have something that can give you those faults beforehand.

From a nuisance perspective, though, I think this is where you would also have to consider where people think AI is 100 percent autonomous, or it's 100 percent accurate all the time, and nothing that has to be manipulated in order to make it work. That's not really the case.

Q: That's interesting, because it's the kind of concern that would arise with someone trying to implement it for the first time. They might not understand that this is not just a turnkey autonomous thing, like you're saying.

A: I guess the way I always talk about it is, you're not going to do a multi-million-dollar repair on a machine without having some human eyes that looked at that data at least once. And it's the same case here, that false positive rate that I mentioned, that's from our perspective, from our services. The customer doesn't ever really see that. We've intercepted that, we track it heavily because we want to improve upon the system so we can retrain it, we can add new datasets into it, we can help define the patterns.

There's a misunderstanding about what's necessary to get an AI to work, and that is a trained system. With vibration and predictive maintenance, there's not a lot of trained data out there tagged to different machine types and faults that have been identified to understand how those patterns work. We have been capturing that type of tagging.

Q: At the SMRP convention in October of this year, a lot of first timers at the convention would have heard a lot of presentations on AI. I think there's going to be a fear of missing out if they don't get it right the first time. What's the best advice for them?

A: It's something that is not going away and it's something that we need in our industry to handle skills shortages. One of the cool things about AI that I felt was fascinating is how easily it can adapt to a skill set. If you ask ChatGPT a question, and it gives you a very technical answer, you can task it to tell it to you like you don't know anything, and it'll adapt. It really has a sense of how to steer its answers to cater to what you're really looking for.

The other takeaway that I have of it was that you're not going to get that answer the first time around. You can't think of it like it's a Google search and it's going to just spit me back a couple of things to reference. Its approach to the world is really, how do I enable you to your skill set, to what your expectations are? If you're coming into this world, I think my first piece of advice would be to really understand what is your objective. What is it that you want out of your program?

AI is my Copilot

A new companion to industrial asset management is here to help (and here to stay)

By **Anna Townshend**, managing editor

The future of artificial intelligence (AI) in manufacturing will be as industry's partner. We're already seeing AI-enhanced predictive maintenance that supports new prescriptive maintenance models, enhanced asset and process performance, and increased industry knowledge. With the ability to analyze much larger amounts of data than a human ever could, AI can study a whole system of assets, benefiting individual assets, full operations, and entire industries.

With all the fast-paced advancements AI is making in manufacturing, new developments like generative AI and the cumulative power of AI intelligence are evolving into a new industrial copilot.

DEMOCRATIZING INFORMATION ACCESS AND CLOSING THE PREDICTIVE MAINTENANCE LOOP

"Every function, every role within the main manufacturing space, is going to have a really useful copilot or system. It can have AI applications that enable them not just to do a certain task better or improve a certain aspect of their job, but really have a partner," says Artem Kroupenev, vice president of strategy at Augury.

The dynamic relationship between human and AI can be tremendously scalable, he adds, which means not only performing tasks faster, but also operating in partnership with AI in the decision-making process. Augury refers to this type of AI-enhanced operator system as a copilot, or a "hybrid intelligence of human intelligence combined with artificial augmented intelligence," Kroupenev says. "We're seeing the early development of that across manufacturing."

Generative AI (GenAI) will add another layer to this partnership, one which will steer the relationship two-directional. Manufacturing is uniquely positioned to harness the power of GenAI in a very real way, says Tim Gaus, principal and smart manufacturing lead for Deloitte. "The ability to consume and contextualize different forms of information and bring that into a form where it's accessible for a much more human interaction is the real unlock," Gaus says.

GenAI models allow organizations to capture all business intelligence, such as PowerPoint slides, email conversations, reports, meeting transcripts and more, as a base of knowledge accessible to everyone in a searchable format. "You have this copilot to help access that knowledge of the people," Gaus says. Deloitte has clients that have invested in private large language models for storing and contextualizing information like equipment manuals and maintenance records, making the information accessible to technicians in a conversational interface and democratizing information access.

AI is the key to the convergence of operational technology (OT) and informational technology (IT) and is making breaking down those silos easier. Making equipment or processes "smart," Gaus says, involves understanding how to take an asset in the physical world, bring it into the digital world to do something different or get a different outcome, and then bring that back to the physical world. "It's creating that closed loop across the two different domains," he adds.

AI'S COLLECTIVE POWER TO UNDERSTAND THE WHOLE SYSTEM

A system of assets together has more to say than any single asset can individually, and AI can tap into that infrastructure collective easily with enough data. Technology can combine asset condition and process parameters to consider how the manufacturing process affects product quality or how quality changes under different operating variables.

Asset performance management should include asset failure analysis, but also monitoring product quality and production efficiency through process analysis. "There can be process induced failure in one asset because of an upstream asset or a downstream asset, and what exactly this particular asset is doing in the process actually determines how fast the asset is degrading," says Nithiya Parameswaran, vice president of product management at Aspen Technology.

Technology can also help manufacturers walk the line between product throughput and quality. If a manufacturer has an asset that's starting to degrade, but it can't afford to bring the asset down because it needs to hit production targets and quality standards, then adjusting process parameters with the help of artificial intelligence might get more life out of older equipment by sacrificing throughput and maintaining quality. For example, automated adjustments might help extend the likely time to failure for an asset from 60 to 90 days, to leave more room for production interruption or for more time to plan for the inevitable downtime. This also must be a discussion between operations and maintenance, where operations dictates those production targets, and maintenance prescribes a plan to fit the goals.

Figure 1. IFS powers the automated data pipeline for Rolls-Royce's TotalCare program, which alleviates the burden of engine maintenance from customers. (Source: IFS)

"What AI does is it provides technology where it automates what we already know," Parameswaran says. "It's not going to figure out anything new, but the thing is, it compresses the time to do those tasks."

Whereas machines typically fail in predictable ways, or in ways that are predictable with enough data, process manufacturing has different objectives. Process optimization is more about product quality and is often very specific to each production line. Product seasonality and product objectives greatly influence line processes. "Even identical processes and identical production lines could have different objectives," Kroupenev says.

Thus, AI applications need to take those specific applications into account and optimize processes individually. "There are many common denominators across different types of processes, but the way you build the AI solution for process engineering needs to take into account the differences and be flexible enough to be able to provide value across a number of different processes," Kroupenev adds.

The power of AI also makes prescriptive diagnostics smarter and smarter. Aggregated data across different machines in different industries can constantly improve the quality and accuracy of algorithms, and machine learning is a cumulative and exponential process. AI-enabled equipment is benefiting manufacturers in the field, and the industry-wide increased data value is something new to many original equipment manufacturers (OEMs).

Augury is working with OEMs to embed its AI technology into the machines during design. Most AI applications are retrofitted to older machines, and that will become more and more cost effective as technologies progress. "A lot of the new equipment will come with sensing and the right type of data infrastructure embedded into those machines," Kroupenev says. Also, many OEMs do not have a view into their equipment in the wild, which can be useful to user and builder. "The equipment manufacturers can utilize some of the statistics that we have anonymized in order to improve the reliability of the equipment that they design and service," he adds.

APPLICATIONS FROM AIRCRAFT MAINTENANCE TO PULP & PAPER

In 2019, IFS partnered with airline engine manufacturer Rolls-Royce to apply their combined AI expertise and improve predictive maintenance on engines in the field. The result is a new analytics maintenance model that could be applied to after-market maintenance in many industries or onto factory assets themselves. IFS powers the automated

DRIVEN BY AI

5 FUTURE MANUFACTURING TRENDS

Artificial intelligence and machine learning technologies are helping manufacturers move beyond time-based maintenance practices, aiding more proactive practices and prescriptive maintenance. These new technologies can help identify anomalies in asset data earlier, before deterioration starts, making it easier to move away from calendar- and condition-based maintenance. The future of AI in manufacturing is poised to change the face of industry. Here's a look at how AI will shape the future.

1. AI WILL PUSH A RELIABILITY ENGINEERING PARADIGM SHIFT.
This paradigm shift is already happening, and the future for AI-enhanced predictive maintenance will only grow. "Once you have machine monitoring that's driven by AI, it's incredibly difficult to go back to more traditional methods. For a lot of our customers that has now become table stakes," Kroupenev says.

"[The use of AI] changes the paradigm of what reliability is or the way you think about maintenance, so you can effectively move from a time-based approach, or an approach that estimates what needs to be done around pieces of machinery, to actually knowing for every single piece of equipment, what exactly is happening way ahead of time," he adds.

2. GenAI WILL CHANGE THE NATURE OF OUR PARTNERSHIP WITH AI.
Large language models, which power generative AI, are as useful for understanding and contextualizing different inputs and information and consolidating them, as much as they are for producing extra material from that data. Gaus predicts that in the near future, GenAI will conduct the safety briefing on the plant floor, monitor quality defects in production, and provide a guided interaction to determine root causes of problems for operators. "I wouldn't say we're fully to where we want to be, but it's an active area of innovation and investment for us right now," he adds.

3. THE EXPONENTIAL POWER OF AI WILL HELP POWER ITS SCALABILITY.
Scalability requires good data and more so, an excellent contextualized data model in place. The ability to take solutions from one spot in the operation to another, while keeping implementation costs low, will help AI solutions scale, with the right core underlying data model, Gaus says.

"Foundational to AI is the availability of data, and very often the highest value and highest ROI solutions occur at the intersection of functional areas (for example, direct material quality connected to manufacturing efficiency). Thus, the rise of AI is driving the cleansing and alignment of data across organizational functions to enable richer and higher value insights," Gaus says.

"In the past, those data domains and the accountability for outcomes have often existed within that individual function, but with the growth of AI it's become critical to break down those organizational and data barriers," he adds.

4. MACHINE TO OPERATOR INTERFACES WILL MOVE FROM VISUAL TO TEXT TO CONVERSATIONAL.
As a society, technology has moved us away from text toward visual interfaces, while generative AI might move us back toward text-based interaction in some cases. Where visual graphics are beneficial for decision-making or efficiency, that will be available. But more and more, it will revert to text-based, or voice-operated, where workers have a conversation or write back and forth with the machines and systems.

"Generative AI is swinging back in the consumer space a little bit into a text-based interface versus a visual interface, and I think a lot of that will develop into something that is a much richer hybrid," Kroupenev says. "I think we will get to a place where the interface will be a lot more conversational."

5. INTERFACES WILL ALSO MOVE FROM IMPERATIVE TO DECLARATIVE.
Technology has automated and eased many functions for us in daily life and in business and industry. When you tell Alexa "play that song" or "send this message," that's an imperative interface. Whereas, a declarative interface, or AI copilot, would help you understand what you should focus on for today, based on all your activities and data.

"It anticipates what needs to be done, and at the same time comes up with a plan that you then approve, or change, and then it goes and executes part of that plan for you," Kroupenev says. "We're starting to see the beginnings of that, where GenAI can start to act as an agent that starts driving part of the work for you, and it becomes more and more involved and more reliable over time."

data pipeline for Rolls-Royce's TotalCare program, which alleviates the burden of engine maintenance from customers (see Figure 1).

"We have built an automated data pipeline from our customers into Rolls-Royce, so that they can get real-time or near real-time in-service status of the assets that they've built," says Rob Mather, vice president of aerospace and defense industries at IFS, which develops enterprise software focused on maintenance solutions.

"Predictive maintenance models are all backwards looking, right? That's the historical analysis. And then the next level is when you get the sensor data, and you're doing the anomaly detection to contextualize it around what's actually happening on this specific asset," Mather says.

Rolls-Royce's TotalCare program is driven by IntelligentEngine, a digital twin that combines analytics on both physical and digital assets to inform data-driven decisions about maintenance, both for individual customers but also on a wider enterprise scale. The access to massive amounts of customer data all fed to the IntelligentEngine creates the opportunity for AI to build and learn from that database of information.

OEMs can analyze data for the individual operator, but they can also contextualize that data on a broader data set. "They're not just examining the performance of one customer's engines, they're analyzing the performance across their fleet engines to notice trends," Mather says.

AI technology is also powering asset maintenance. AspenTech worked with Veracel, a pulp and paper manufacturer based in Bahia, Brazil, to detect asset failure using AI/ML technology. For Veracel, an upstream liquid ring seal was veering out, so flow fluctuations in the downstream vacuum pump were detected, which could have been attributed to the asset without the consideration of process data. Likewise, if the facility didn't fix that seal, it would slowly get bigger and eventually induce cavitation in the pump, which would eventually cause the pump or bearings to fail.

What started out as a process failure would become an asset failure over time, and AspenTech helped Veracel to use AI/ML technology to see those patterns before they led to asset failure. To start, Veracel focused on AI/ML deployment on three pieces of equipment—a vacuum pump, primary screening equipment, and a recovery boiler fan. Since the initial deployment in 2020, Veracel has extended monitoring to 12 assets in 2022, including additional pumps, filters, screen equipment and drum washers, with plans to scale across 20 assets in the future.

SCALING AI ACROSS INDUSTRIES

Augury has seen the use of AI across almost every part of manufacturing, but Kroupenev points to predictive maintenance, and especially process engineering and optimization, as the first real scalable AI use cases (see Figure 2). Supply chain optimization is also prime for AI enhancement and is one of the other areas being augmented by AI right now, he says, for production scheduling, warehousing, and inventory management. There are also smaller pockets of growth for AI in areas like sustainability and energy efficiency and safety and compliance.

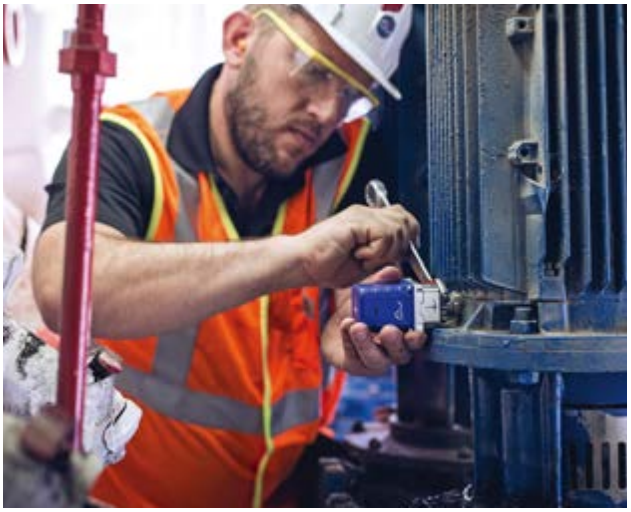


Figure 2. Augury's Kroupenev points to PdM, and especially process engineering and optimization, as scalable AI use cases.

"We have found that within the machine health space, especially around rotating equipment, after having built enough of a library of different failure modes on different machines, we can see that there are a lot of similarities that actually benefit from economies of scale and having a very large database," Kroupenev says. To machine learning or artificial intelligence, a pump at one facility is very similar to a pump at a completely different facility or industry.

Deloitte is working with a manufacturing client to use vision systems and its security cameras with an AI neural network to detect and predict likely safety outcomes in operations. Gaus points to the very human impact of how this could change safety culture and the way it is thought about within the manufacturing environment.

Another Deloitte client is using AI in its high-speed manufacturing facility to do predictive analytics for process control. The system requires very low latency, so it needs edge and cloud technology to bring the power of AI in real-time to the plant floor, Gaus says. "They are really pushing the edge of how an artificial intelligence, or at least the predictive nature and the machine learning elements, can intersect day-to-day operations," he adds.

Maintenance team culture – **can it be changed?**

THE ANSWER TO THIS IS YES, BUT IT ISN'T EASY

by Lee McClish, CMRP, CRL, CPMM

I've attended a number of maintenance and reliability conferences over the last five years, and culture is by far the #1 challenge or roadblock for M&R professionals. Culture is defined as "the customs, arts, social institutions, and achievements of a particular nation, people, or other social group" by Websters. I would define it as the personality of your department, plant, and company that establishes the ease or difficulty of completing daily tasks and working together towards improving the process.

Every ship, plant, or organization I've been a part of the past 40 years has had a different culture. I've always heard "this happens only here" and really believe the differences between the various organizations/industries are subtle with universal influences. In my experience, there are three major influences on culture:

- Individual team members—Do they work together? Do they feel their voice is heard? Do they enjoy going to work every day?
- Supervision / management—Do they have an open door policy? Do they listen to employees? Are they willing to take acceptable risks with new ideas?
- Corporate—Are they driven by only the bottom line? Do they provide too much oversight?

Easy efforts to improve the culture positively include ensuring that corporate, plant, and department goals are clear, posted and understood; that communication occurs frequently at all levels; and that appropriate personnel are involved at the right level for decision making. Some positive attributes of good culture:

- Goals and objectives are clearly stated at every level.
- Employees are recognized as the life blood of the organization and treated as such by having a voice, sound performance expectations and representative benefits.
- Team member opinions and suggestions are listened to and considered in decision making.
- Reacting to the challenges encountered are taken in stride.

There are clearly many facets of the culture within an organization. The culture will change when any person in the above groups move on and are replaced by a new employee. How will the culture sustain itself when this occurs? The rest of this article covers specific examples to consider as you and your teams work to positively impact the culture of your organization.

1. Create/add PM plans. You may find there are no PM plans or an inadequate number of them. Most folks will

agree preventive maintenance is a good thing. Establish an objective to review/create needed plans and ensure management buy-in. Make sure to include the correct stakeholders (primarily maintenance technicians and operators) and promulgate a timeline that is not too aggressive. This will be a lot of work and require much data entry. Once the PM plans are in place, track the failures and there should be a positive impact on machine uptime. Don't forget to share the progress and the results at every opportunity to communicate at all levels.

2. Add head count. No one in management wants to hear this. Your CMMS should contain the labor data to support the right number of personnel. If it doesn't, fix it. One plant I was in had many electronic problems (PLCs, VFDs, etc.) on third shift and would lose hours, if not the entire shift because no one on shift from the maintenance staff possessed the skills to perform a basic reset. Reducing downtime will get management attention with data.

3. Record RCM wins. Show me the money! A great running plant with new management will ask the question "Why do we need reliability? Our equipment is running great!" It can be laborious and someone has to do it, but tracking the right KPIs, failures prevented, and costs/repairs avoided will solidify your case. This activity will significantly contribute to stressing the importance and reasons that reliability works.

4. Schedule equipment downtime to PM. Production schedulers have a tough job. They deal with so many variables: production, shipping, raw materials, tooling, and personnel absences. You probably have to fight at times to get machine time. Knowing this is inevitable, my strategy was asking "when will the machine available?" and rescheduling right away. And then asking, "are there any other machines available to take down?" This turned out to work most of the time. Occasionally a very busy machine would go a week or two and not be available, which forced me to PM on a Sunday if necessary. I was lucky the operation was not 24/7.

5. Invest in training. Many companies are reluctant to spend money on training, because they are afraid of the employees leaving to get a better job somewhere else. But consider, don't conduct any training and all the employees stay but lack the skills to perform their job well. You have to train your people! Conduct "train the trainer" sessions, either internally or externally and create SMEs. Push the training budget with management, but ensure it is the right targeted training to improve your process and fill knowledge gaps. It is highly unlikely to not experience any turnover, but with the great culture you develop, people will feel part of the team and not actively look for the greener grass.

6. Do what you say you will do. This one thing will solidify your reputation at all levels. Folks will bring you suggestions when they know their ideas aren't doomed for the circular file. The most important aspect of these suggestions is to ensure that you provide direct feedback to the person that brought the idea to you. You can't do everything folks suggest, but explaining the reasoning why or why not will be greatly appreciated and spawn more great ideas.

7. Post progress of KPIs, goals, and projects. Post these in a prominent position that people will see daily, preferably a location they can't ignore them. Employees want to know how the plant is doing. Whether they are plant goals or department goals, tracking the progress and knowing their efforts are making a difference will motivate them to contribute to the cause.

8. Communicate machine downtime hour by hour. Unexpected downtime throws a wrench into the daily plans of many departments, whether production, shipping, customer service, or even sales (to alert customers if shipments are delayed). Arming these cross functional teams with timely and key updates will raise the credibility of the maintenance department and make everyone feel like part of the team. Although eliminating unscheduled downtime is paramount, ensuring it is as short as possible reflects a positive team spirit.

9. Communicate the importance of reliability up and down the chain of command. Most plants have, or should have, periodic communication meetings – from the plant level down to the department. Updates to goal status, capital projects progress, new customers, and upcoming HR processes should all be discussed. Some aspect of reliability should be a plant goal and emphasized during these meetings at every level. Emphasizing the importance of reliability and ensuring folks know what it means, will eventually make it an everyday aspect of operating the plant, instead of an afterthought.

10. Maintenance deserves longer breaks. I found most maintenance departments feel they should take longer than authorized breaks since they may occur off schedule due to a machine breakdown, finishing a job, or some assigned task. Sometimes lunches are delayed due to these unavoidable events. Maintenance personnel deserve their breaks like everyone else, which is accentuated in the union environment. There are other ways to reward good behavior instead of compromising good practices where everyone in the plant believes that maintenance folks are special. I once had to remind a maintenance employee that taking breaks while a machine was down countered the mantra of maintenance. When he responded that production takes their breaks on a schedule, I reminded him that he is in maintenance, and he was welcome to bid into a production job if desired. Seems a

little harsh, but sometimes the reality of good discipline must be followed.

11. Reduce stagnant inventory. There is a cost to store inventory parts. Of course, you can't hold every possible spare part on-hand and you can't cover every part needed during every breakdown. Periodic reviews of what should be critical spare parts, parts used during breakdowns, and any looming obsolescence parts will solidify your program. Reducing the carrying cost of parts that may or may not be needed regularly will help your company's bottom line and reduce the administration of inventory management.

12. Know your people. Self-assessments, getting results, leadership training all certainly contribute to an improved culture. But knowing what motivates your people, what life events they are going through, what their hobbies or personal priorities are, will go a long ways towards motivating them to work for you. People work for their bosses primarily, and some work for the money, but many people leave their jobs due to their boss.

13. Manage the bad apples. These types can be a huge hindrance to a great culture. Sometimes folks will leave your department or company because they don't agree with the direction you are leading. If this happens, it will probably have a positive effect. You may have to deal with a difficult employee whose nature is to complain and no matter what you do their behavior doesn't change. Discipline is normally negative but can be necessary to ensure standards. Just ensure it is consistent. At some point you may need to make the tough decision and encourage that person to another job, whether voluntary or involuntary.

Changing the culture is like the rudder of a large ship setting the direction. It is a slow turn, there are opposing waves, and adjustments are necessary, but you can set the proper course towards the destination. Culture can be changed and the effort is worth it!

Lee McClish is the Director of Maintenance and Reliability for NTT GDC Americas, a global telecommunications and data center company. He holds a BSME, MBA, CMRP, CRL, and CPMM, and is the author of a recent book, "Maintenance Leadership 101," which is available on Amazon.

ASK THE EXPERTS

Compressed Air Challenge

COMMON COMPRESSED AIR SYSTEM PROBLEMS

In this Ask the Experts feature, expert instructors from the **Compressed Air Challenge (CAC)** tackle your questions on compressed air systems and associated technology.

The Compressed Air Challenge is a voluntary collaboration of industrial end-users; manufacturers, distributors, and their associations; trade organizations; consultants; state research and development agencies; energy efficiency organizations; and utilities. The CAC has one purpose in mind; helping you enjoy the benefits of improved performance of your compressed air system.

This month's question: **In your opinion, what are the most common problems plaguing most industrial compressed air systems?**

Chris Beals (Denver CO, L1 Trainer): The number one problem is air leaks. Many plants don't conduct air leak surveys until they must operate their backup compressors, while others conduct them only several years apart. After the leak survey is completed, most plants only repair the largest leaks which results in the number of leaks increasing over time. This is why it is suggested the plant assign an employee to attempt to fix the smaller leaks during the leak survey.

Many leaks must wait to be repaired during a plant outage and some require the piping to be completely depressurized, both of which are usually given a low priority during plant outages. Some plants have a full-time employee assigned to conducting air leak surveys and fixing air leaks; however, when additional thorough air leak surveys are done, the studies usually find that there are still a high number of leaks. The conclusion is that most of the leaks couldn't be fixed until there was a plant outage and that not enough manpower is assigned to fixing leaks during the outage.

Paul Shaw (Berlin CT, L1&2 Trainer): I see plenty of systems and the top problems I usually see (beyond leaks) are inappropriate uses and excessive part load energy waste. Using air inappropriately comes from a lack of understanding about the actual cost of compressed air and thereby the cost of performing the process, whether the plant is doing it by design or simply for convenience.

An example is blowing off a product with a wide-open tube. This is extremely wasteful as a typical ¼-inch tube at 100 psig can use 30-40 cfm depending on tube length and connections. If the consumption is 30 cfm this may consume 8 kw and cost more than $10,000 annually for 24 hour / 7 day per week operation (at $0.15 per kWh). The alternative may

be to use a blower with an air knife or perhaps an engineered nozzle, as both choices would reduce the wasted air by at least ⅔ and significantly reduce the cost.

Additional common demands wasting compressed air are aerating, cleaning, personal cooling, vibrating, and cabinet cooling, plus many other unique uses (people are innovative at wasting compressed air). These should all be reviewed with the aim of reducing or eliminating the compressed air uses by designing other methods that would do the same task at a lower cost, and in most cases these other methods end up being more effective.

Part load energy waste is another big area of waste I frequently see with compressed air systems. Usually, too many compressors are left online, either because of poor system control or a lack of understanding of the compressor controls and setpoints. There may also be a lack of maintenance, and/or fear of a possible shutdown with no plan on how to get another compressor on quickly when needed.

With many of these issues the problem or solution comes down to storage receiver capacity or the lack thereof. I have seen systems with an additional 300 hp compressor left constantly running simply because there was not enough storage to cover demand events that arose, causing just enough pressure fluctuation to keep the additional compressor on. Once the problem was understood additional storage was installed, the controls were adjusted, allowing the compressor to shut off automatically, only coming on from time-to-time as required.

Greg Ashe (Denver CO, L1&2 Trainer): Slightly undersized piping or hoses at various locations in the system is a very common problem, in part because it's difficult to diagnose. Significantly undersized piping is usually caught immediately and replaced, but small piping can be installed in some locations for decades without notice, with problems only happening when there is a change in load (see Figure 1). The pipe's capacity and pressure drop are based on the radius squared, which means that a slight difference in diameter has a drastic impact on performance for better or worse. For example, using 1-inch pipe instead of 1¼-inch pipe causes an additional 10 psi of pressure drop (100 cfm at 100 psig for a 500-foot straight run).

As pressure drop inevitably increases over time, the incremental "fix" is to increase the pressure set points on the compressor, thereby increasing power consumption and the

Figure 1. Excessive pressure loss in hoses can cause production problems and can be corrected simply but selecting the proper size hose for each application.

AIR FLOW CFM	AIR PRESSURE LOSS (PSI) IN STANDARD POWER TOOL HOSES BASED ON 100 PSI LINE PRESSURE												
	HOSE NUMBER AND SIZE												
	1/4" X 10'	5/16" X 8'	3/8" X 10'	1/2" X 12 1/2	1/2" X 25'	1/2" X 50'	3/4" X 12.5'	3/4" X 25'	3/4" X 50'	1/2" X 50' + 1/4" X 10'	1/2" X 50' + 3/8" X 10'	1/2" X 50' + 5/16" X 10'	1/2" X 50' + 1/2" X 12.5'
10 - 11	5.0	0.9								5.3	0.7	1.4	
11 - 12	5.9	1.0								6.2	0.8	1.6	
12 - 13	6.8	1.2	0.4							7.2	0.9	1.9	
13 - 14	8.0	1.4	0.5							8.4	1.1	2.2	
14 - 15	9.3	1.3	0.6							9.8	1.3	2.5	
15 - 16	11.0	1.9	0.7							11.6	1.5	2.9	
16 - 18	14.0	2.4	0.8							15.0	1.9	3.5	1.7
18 - 20	**19.6**	3.0	1.0							21.4	2.4	4.5	2.0
20 - 25		**4.3**	**1.4**	**0.7**	**1.0**	**1.3**					3.5	6.4	2.6
25 - 30		6.6	2.1	1.0	1.5	2.3					5.2	9.8	3.8
30 - 35		9.5	3.1	1.3	2.1	3.6					7.3	13.7	5.3
35 - 40		12.8	4.2	1.7	2.8	5.2					9.6	18.4	7.1

leaks in the system, which are based on pressure in the pipe. The more efficient solution would be to reduce total air flow by reducing leaks or replacing the pipe that is undersized. To better understand where and when the excessive pressure drop is occurring, multiple pressure transducers connected to a data logger can be temporarily installed by a compressed air service provider to help isolate any areas of concern.

Gopalakrishnan Bhaskaran (Morgantown, WV, L1 Trainer): I find that most often screw compressors are unloading at high amperages and do not stay long in the unloaded condition due to lack of storage receiver capacity in the system, and perhaps pipe sizing issues are causing excessive pressure differentials. In some cases, the compressor amps swing wildly with a very short unloading time. When more than one compressor is in operation, often the compressors will each operate sharing loads, ramping up and down together while operating very inefficiently. The biggest problem, in some cases, is that even when the plant is not in production during the weekends, such inefficient operation will continue to occur.

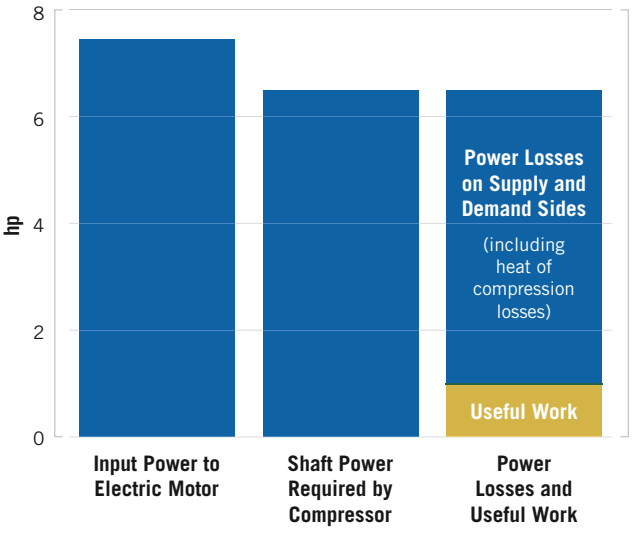


Figure 2. Without education compressor operators, especially new hires, simply do not understand how inefficient a compressed air system is in delivering power to an industrial application.

Another problem I have noticed is that even though many compressors are on VFD drives, due to lack of storage and controls issues, the VFD is not being allowed to do the job it was intended to do. This often means the power consumption does not go down much at all, even in an unloaded state, wasting energy.

Ron Marshall (Winnipeg, MB, L1&2 Trainer): I am often asked where the most needed adjustment is required in getting a compressed air system running efficiently and effectively. I answer that the adjustment most needed is "between the ears of the compressor operators and compressed air users." The problems listed in the above commentaries are all due to the lack of education about compressed air systems, resulting in the operators not knowing the cost of compressed air and what to do about lowering it. As a result, they continue to make poor decisions about system operation and abuse the expensive compressed air they produce.

Setting up regular compressed air awareness training for compressor operators and users can go a long way in helping correct bad habits and getting any system under better control (see Figure 2). For example, the Compressed Air Challenge's Fundamentals training covers air system components, areas of demand side waste, and shows the high value of simply measuring the system to capture a baseline. From there these training participants can learn how to achieve some no-cost/low-cost efficiency measures that can not only reduce the cost of the system operation by 10-30% but get the system operating more reliably.

ASK THE EXPERTS

ICML 55

THREE EXPERTS DISCUSS HOW INDUSTRY IS REACTING TO AND IMPLEMENTING THE MULTI-PART MACHINE LUBRICATION STANDARD

In this Ask the Experts feature, expert practitioner and consultant members of the International Council for Machinery Lubrication (ICML) tackle questions on best-in-class lubrication practices.

The standards collectively known as ICML 55 provide a structured framework for developing lubrication management system (LMS) plans that can be audited and certified. ICML 55 also is strategically aligned to the ISO 55000 Asset Management Standard and is intended to support an organization's broader physical asset management plans. For this article, three industry experts shared their thoughts on ICML 55.0 "Overview" and 55.1 "Requirements," as well as the newly released 55.2 "Guidelines" and upcoming 55.3 auditing component.

This month's panel:

- Wesley Cash, MLE, MLT II, MLA I, VP Services at Noria Corporation
- Muhammad Ali Qureshi, CMRP, MLA III, MLE, Reliability and Machine Condition Monitoring Engineer (Rotating Equipment), Saudi Aramco
- Wojciech Majka, MLE, CLS, President and CEO, Ecol Sp. z o.o.

Q1: The ICML 55.1 "Requirements" standard was released in 2019. What did you expect to find in ICML 55.1, and were those expectations met?

Wes Cash: Lubrication is a program that impacts so many aspects of an industrial or manufacturing facility, so having a standard way to move forward is imperative. ICML 55.1 is a standard written by experts around the globe, so it encapsulates lessons learned throughout multiple industries with different organizational constraints.

Wojciech Majka: There are many international (and national) standards, as well as industry guidelines (or OEMs requirements) and published articles addressing best practices in lubrication area; however, they are often difficult to find, compare, and use in practice. The need for a standard in lubrication management that sets the common denominator was strongly expected.

When ICML 55.1:2019 "Requirements" became available, I immediately acquired one to see how it was organized and – what I was most curious about – whether our own services were aligned with the standard. I expected to find a practical handbook explaining what world-class lubrication management should look like, including the definition of areas that have to be addressed.

The good news was that we fit the standard's requirements. I also was positively surprised how well structured and detailed the standard is. It really reads easy, and I can immediately address the content to our practice. I admit, the document exceeded my expectations and I think they are fully met.

ICML (www.lubecouncil.org) is a vendor-neutral, not-for-profit organization founded to serve global industry as the world-class authority on machinery lubrication that advances the optimization of asset reliability, utilization and costs. Since 2001, ICML has supported individuals and organizations through programs that strengthen machinery lubrication and oil analysis as technical fields of endeavor.

Wes Cash: At Noria we help develop and improve lubrication programs. We also contributed to this standard, not just to help elevate the practice of lubrication but also to elevate the industry as a whole. Since 55.1 is a framework document, I believe there were expectations of having more detailed information about "how-to," but we realized this would fall within the 55.2 standard.

Muhammad Ali Qureshi: Because I always had a complete confidence in ICML as a not-for-profit organization and its testing criteria, the moment I heard of the new asset management standard series my first impression was that this must be a quality document based on some lubrication standards or depicting lubrication standards for almost every industry.

My second impression was that definitely I wanted to try the first MLE certification exam during the Reliable Plant conference in April 2019. I was of the opinion that if I prepare for the MLE, I would know more about the ICML 55.1 standard and would also be ahead of the game—meaning that I would return back to Saudi Arabia with the latest qualification and awareness about the new standard series, which would obviously benefit my employer, too.

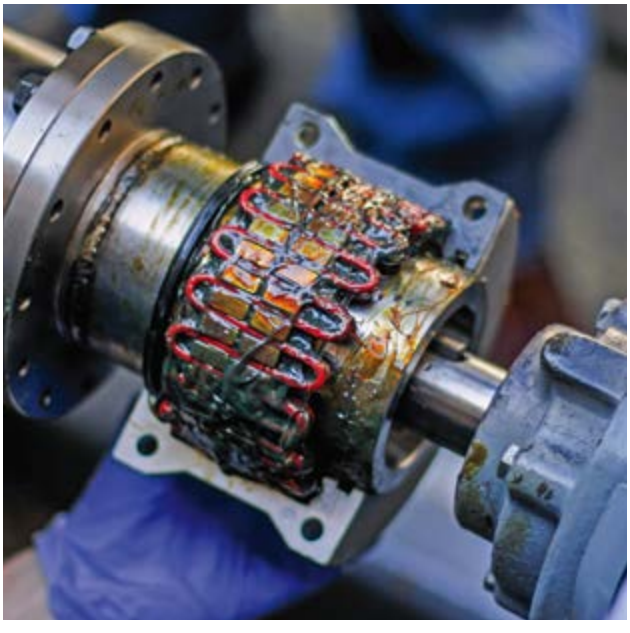
I found ICML 55.1 very useful in fully addressing the machinery lubrication requirements in 12 key areas of lubrication system designs, management, analysis, trouble shooting, and most of all its non-machinery support on assets (e.g., personnel, policies & procedures, storage facilities, and management).

Q2: Where or how have you been using the ICML 55.1 "Requirements" standard to develop a Lubrication Management System (LMS)?

Muhammad Ali Qureshi: We have benefited a lot at Saudi Aramco, especially for improving our lubrication storage and handling and for our lube oil analysis for routine oil samples, as well as any critical machinery that is indicating an incipient stage of an upcoming failure.

We focused on the following key elements or areas depicted in ICML 55.1:

- machine: machine lubrication and condition monitoring readiness (through design or modifications)
- lubricant: lubricant system design and selection (during initial design for new machinery in new projects)
- tools: lubrication support facilities and tools (ordered more transfer containers from Oil Safe, also segregated lubricant drums to different areas)
- inspection: machine and lubricant inspection (focused more on operators and vibration technicians' rounds)
- lubricant analysis: condition monitoring and lubrication analysis (intensive analysis, Noria ML I and ML II training)
- troubleshooting: fault/failure troubleshooting and RCA (for bad actors or for chronic failures)
- management: program management and metrics (we had already developed five KPIs but started to follow them more strictly because of 55.1).



We have successfully controlled our contamination levels on a bigger scale, which usually forms the basis of any rotating equipment failure due to wear. It also benefited us for our new projects that I was reviewing at the design stages, where I was able to emphasize enough on the lube sumps and systems along with their accessories.

Wojciech Majka: When ICML 55.1 became available, we started to verify if we are aligned within it and whether our own set of procedures and standards are compatible with the standard. We found that we weren't identifying (some of) the areas the same way as the 55.1 standard does, and it took some detailed work to verify whether we understand and cover all the requirements the same way and how we can prove it. We are now working on a method of direct implementation of 55.1 in our ISO integrated management system to prepare it for further audits. Future new LMS projects will be implemented with explicit use of ICML 55.1.

Q3: ICML 55.2 "Guidelines" progresses naturally from ICML 55.1 by offering guidance for implementing the standard's requirements. How do you expect ICML 55.2 to impact LMS plans and practices in industry?

Wes Cash: I think this is the piece that many are looking forward to in terms of implementation – the "how-to" guide based on what ICML 55.1 outlined, and I think it will create a greater push to improve a lubrication program. Organizations can be leery of changing the status quo without a compelling reason to do so. Since this is a global document, it cuts across all industries and can serve as a baseline for jump-starting an improvement effort.

Muhammad Ali Qureshi: We expect to use ICML 55.2 to optimize the lubrication management on our existing assets that are obsolete and difficult to administer. It is my strong opinion that a professional degree in mechanical engineering is not needed to implement LMS through ICML 55.2. However, as part of the MLE certification, teams must develop a proper understanding of the guidelines for the optimized lubrication of mechanical physical assets, and team members should try their level best to attain MLE certification.

Wojciech Majka: I have had the great privilege of contributing to the preparation of ICML 55.2 as an author of one of the chapters, where I did my best to share my experience. The practical guidelines will be very helpful to both inexperienced lubrication management professionals starting in LMS, but also useful for experienced practitioners when it comes to refreshing their knowledge and maybe challenging their practices with modern, up-to-date solutions.

Bear in mind that the goal of 55.1 is to prepare your LMS in such a way that it can be audited in the future. That is

why ICML 55.2 is so important, because it guides the reader how to understand the link between the requirements and practical ways of achieving the goal. ICML 55.2 will be a good enabler to reach world-class LMS.

Q4: The upcoming ICML 55.3 auditing component will enable organizations that implement ICML 55 requirements to be able to pursue certification as ICML 55 Compliant.

Wojciech Majka: There has to be an auditing component to every standard, so naturally, ICML 55.3 will become an important tool for validating if a lubrication management system is in compliance with ICML 55.

Wes Cash: This is the sustainability portion of the standard. Now there will be a way to check against the standard for compliance. It also speaks to organizations that seek out ISO audits and the like that can showcase a commitment to improvement and longevity.

Wojciech Majka: The reward for any organization/company of being recognized as "ICML 55 Compliant" will be very meaningful and satisfying to the contributing team. The challenge to ICML will be preparing the 55.3 component in the way that will be available to experienced and neutral auditors, so they know how to perform the audits.

When ICML 55.1 became available, we started to verify if we are aligned within it and whether our own set of procedures and standards are compatible with the standard.

An important question is, who shall the auditors be? Lubrication or maintenance experts? Should they have ISO (or other standards) auditing experience? Should auditors be independent professionals or working on behalf of audit firms, or will ICML itself provide such services? I believe the more that we, LMS practitioners, discuss and argue, the better. Let's see what the feedback is from 55.1 and 55.2 components and let's follow the real needs from industry.

Q5: Please share some final thoughts about what you see in the marketplace regarding the appetite of plant teams to a structured approach to LMS development.

Muhammad Ali Qureshi: In my opinion, you have to educate your internal and external customers about the need and subsequent benefits of developing a lubrication management system. Once your customer or team is onboard with the holistic approach to LMS, then you start to follow the steps or guidance provided in ICML 55.1 for developing an effective LMS. We pretty much followed the same approach for Saudi Aramco and focused more on trainings and ICML certifications.

Wojciech Majka: The answer to this question is not that easy. On one hand, some plant teams are used to working with ISO standards, so implementing an additional standard isn't difficult or problematic. Those who understand the role of proper maintenance and who are reliability-oriented have an openness to this approach.

On the other hand, there are teams who for some reason do not have standardized management systems, so they are perhaps less open to implementing a standard. However, these teams also have an appetite for a new approach in LMS.

Wes Cash: It appears the industry is open to a more structured approach to managing their lubrication programs. The general sense is that there is little visibility to lubrication programs, and little accountability to making sure they get accomplished; these are typically characteristic of programs that don't have clear-cut goals or an overall vision for their lubrication program. Having a singular resource that a user can access, that enables program visibility and accountability, is a powerful tool. It can bring lubrication out from the shadows and into a place that can be effectively observed and monitored for improvement and compliance.

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ADVERTISER INDEX

How AI is enabling reliability programs

Advances in compute power are making it possible to extract insights from traditionally siloed data sets

Kevin Clark is longtime practitioner and executive in the maintenance and reliability world, and works with Falkonry (www.falkonry.com) as the VP of Marketing & Customer Success. Recently IFS signed a definitive agreement to acquire Falkonry, which will add that company's self-learning anomaly detection solution to IFS's existing enterprise simulation and AI-based scheduling and optimization capabilities. Kevin spoke with Plant Services about how AI is increasingly fitting into traditional reliability spaces.

PS *When you think through how you're seeing artificial intelligence applied to asset management, what are the challenges or problems that you see AI helping plants solve?*

SR The challenge over the last 20 and 30 years is how do we take RCM and TPM and the really sound methodologies that we utilize inside of asset management, how do we turn that into something digital?

One of the biggest challenges we have today is that our operations data is separate from our predictive data. And I see it everywhere I go, everywhere. We've done that, we separated it, because the technologies were somewhat separate, the business units were somewhat separate. But we didn't want to mix it in with the rules and regulations of operational data. (And in fact, operational data really didn't want our asset data, our condition data inside of their MES systems and process monitoring systems.)

The separation made sense because of evolution. But what doesn't make sense is that [asset] data is as important to operations as operations data is to asset data. So what we've been advocating for is that we begin to bring that operations data together with predictive data. We tend to look at data that's continuous, and that's mostly your operations data. Some of that continuous data is your predictive data, it might be coming directly from sensors, or it might be temperature, it might be vibration, it could be some ultrasound. But sometimes it's just a moment, right? Like maybe it's a vibration test, but it is time series.

And so you know the time of it, and you know what the result was, and if you take that, and you drop it right into the middle of continuous process data, it's really interesting. I don't know if you've seen it before. But when you see those signals come together, and you see the performance, and then you see where the failures are in the AI data, and then you also see the predictive data coming in that's showing us very similar response to that potential failure – it gets really interesting.

If I just have operational data, it's good. If I have operational and predictive data, it's awesome. I'm a big advocate for getting that predictive data that we've got, plus that operational data that's monitoring always, and let the AI decide if we're starting to move into something that looks different.

PS *Are we looking at technologies here that have been able to do this for the past 18 months, or for the past three to four years? Or are we looking at some innovations on the monitoring and anomaly detection side?*

SR Innovations. Anomaly detection has been around for a long time, so has pattern recognition and building models and things of that sort. But anomaly detection has had some innovations that have allowed it to really move quickly.

Now one of the things that's really creative that's coming, is taking anomaly detections and being able to think about them through the idea of a criticality assessment and a FMECA. Most of us that are in the reliability side of the business understand that terminology, and it's kind of the core of what we do inside of a facility that deploys RCM and TPM. What we're seeing with anomaly detection, is that we can make an association between what we identify inside of our FMECA, and also understanding the criticality of a particular asset, all the way down to the sub-components, the signals coming in are actually extensions of a FMECA.

We can clearly identify the signals that are associated back to a particular failure mode. It starts to bring to life anomaly detection. It's not only coming back and telling you, "I'm beginning to fail in this particular area of the asset," it's also going to tell you what the failure could be. Maybe there's three signals that are showing a yellow basically. And of those three signals, that usually means something, and we can label that.

That's what I really like about the technology that's coming along, is it's starting to look and sound like the reliability that we're used to speaking to.

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