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Max Discrete I/O	156 points including option slot modules and expansion I/O		132 points including base, plug-ins, and expansion I/O
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MQTT	✓		X
Wireless Communication	✓ Wi-Fi (802.11b,g,n), Bluetooth (used with Mobile app to provision network settings)		X
Programming Software	FREE CO-PGMSW		FREE Connected Components Workbench

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The career road not taken

This science fiction fan considers his own alternate engineering future

One of the most rewarding aspects of working as chief editor for Plant Services is also the one that carries a great deal of responsibility: the ability to identify the stories that matter most in our industry, and then share them with you.

Working in this field represents one of the two career options that most appealed to me in my late teens and early 20s. I spent a lot of time in high school reading science fiction, which has been described as the literature of change. Most of my interest leaned toward "hard sci-fi," which bases its storytelling around the possible future implications of real scientific advances. Some writers in this group include Charles Sheffield, Joan Slonczewski, and Gregory Benford, each of whom have the ability to not only explain complex scientific concepts but also to make them relevant to our everyday lives and choices.

Since that time, my career has followed the path of the technical communicator. This was not always a deliberate choice. In college, I started out studying chemistry, having been inspired in high school by an excellent science teacher (and by a lot of hard sci-fi) to focus on how to solve pressing real-life engineering problems.

However, after spending two years trying to master the art of lab work and not doing so well (and running into the brick wall known as physical chemistry), I switched to my other passion, literature, and earned a degree in English with a math and chemistry minor. During those years I also worked for the college newspaper, The Daily Illini. It wasn't the science beat, but it was a good position to be in when breaking science news would happen, such as when an uncontrolled thermite reaction demo in the university chemlab almost killed some onlookers.

My next career stop was Ohio State University where I taught writing courses geared towards engineering undergrads. The stop after that was with Battelle Memorial Institute, working with environmental scientists to turn field data into reports for the DoD and EPA. Finally, I spent 8 years as lead content developer for Panduit, working with the B2B press and helping that company tell its own environmental story.

It's frustrating that climate change has only increased in urgency over several decades.

And the other career option, the path in my case which was not taken? That would be environmental scientist. And it's amazing and frustrating to consider that one of the biggest stories of the '80s, climate change, has only increased in urgency over the past several decades.

That was the story that drew me toward environmental science in the first place, and since that time, instead of being part of a direct engineering solution, I've quietly worked with students, scientists, and now plant practitioners to fight the good fight for the sake of our planet. Our Big Picture Interview this month with Peter Garforth is one of those opportunities.

You can hear our full conversation as part of Plant Services' Tool Belt podcast. And here's to a future where the challenges of climate change are resolved.

Thomas Wilk, Editor in Chief
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Leaders keep their cool under pressure

Most mistakes by new team members are learning opportunities for all: what's the teaching moment?

Earlier this year, I reconnected with an old shipmate, who is now in a very senior position in an important division of a large corporation. I was assigned with this fellow aboard the Coast Guard Cutter Spencer way back in 1988. At the time, I was the leading petty officer (supervisor) for the Auxiliary Division. This fellow had reported aboard as his first assignment out of recruit training.

When I was giving a workshop on productive leadership to his organization, my old shipmate related a story, something that stuck with him for more than 34 years.

Leaders take responsibility for their team members. When my team member/shipmate made a mistake, it's because I didn't put him in a position to do better.

The story goes like this. The newly minted Coast Guardsman reported aboard his first ship and was assigned to my team. Coming from boot camp, a person learns to be part of a team and to be focused on carrying out your mission. It does not prepare you for the finer points of maintaining and operating shipboard equipment. Learning shipboard systems happens over time as fellow shipmates show you the ropes. You are given responsibility as you get familiar with your duties.

This process of learning the ropes happens in every work environment. In the Coast Guard, new arrivals generally get more mentorship and support than in industry, but the idea is the same. The new person is coached through the activity by experienced people. If judged within their ability, they are given the responsibility to carry out the tasking on their own.

Well, in this particular case, my shipmate was asked to perform a preventive maintenance task. The task was to "clean the sea strainer." On a ship, duplex sea strainers are used to strain sea water that is pumped through heat exchangers to cool equipment. Duplex sea strainers are used because one strainer can be on-line, while the other strainer can be accessed and cleaned without disrupting the system the strainer supports.

On that day, my shipmate was judged to be capable of cleaning the sea strainer since he had been aboard for a couple of months and was presumed to have been taught the proper procedure. The procedure is pretty simple. Whichever sea strainer is on-line, the technician must shift the plug valve from the on-line strainer to the other strainer. Once the valve has been shifted, the strainer that had been straining water can be accessed by loosening toggle bolts that hold the strainer cover down against a seal on the top of the strainer housing. The technician then removes the cover, cleans the strainer, inspects the cover seal, replaces the strainer and reinstalls the cover and toggle bolts.

The procedure works well, as long as the first step of the process is done first. You see, if you loosen the toggle bolts without shifting the plug valve, the head pressure on the sea strainer sprays water all over the place.

One of the first rules of seamanship is to keep sea water outside of the ship. If you don't, and too much water comes in, the buoyancy effects are overcome by gravity (the ship sinks). Imagine being a new person, alone in an isolated part of the ship, and water is now flowing into the ship because you forgot the first step. You shift the plug valve to stop the water flow, but there is now water sloshing around in the bilges.

Here's the important part. When my shipmate came to me and told me what happened, he was expecting me to chew his butt. I didn't. What he said I did was to ask him, "Did you learn anything?" He said yes, relieved and empowered.

Years before, I did something dumb (a story for another article). When my supervisor didn't get angry with me, I asked why he wasn't angry. His response was that it was his responsibility to put me in a position to have done better. Leaders take responsibility for their team members.

When my team member/shipmate made a mistake, it's because I didn't put him in a position to do better. People try to do the best they can, often without the knowledge, time, tools, parts, or whatever they need to do a good job.

Go forth and do great things.

Tom Moriarty, P.E., CMRP is president of Alidade MER, Inc. (www.alidade-mer.com), and is author of the book The Productive Leadership System; Maximizing Organizational Reliability. To get an autographed copy of his book, visit https://alidade-mer.com/productive-leadership/book/. Contact him at tjmpe@alidade-mer.com, 321-773-3356 (office), or 321-961-4306 (cell), and find him at www.linkedin.com/in/alidade-mer.

Maximize motor reliability and efficiency

Features like self-monitoring and onboard predictive analytics help to reduce unplanned downtime

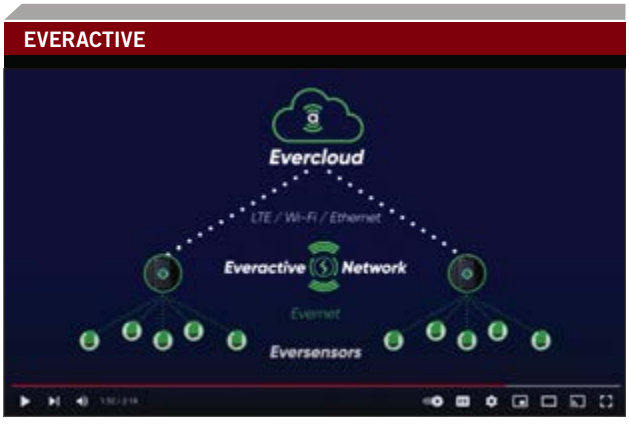
Choosing the right motor and drive for an application is central to achieving the desired performance and service life. Strategic monitoring and testing help to keep the devices and systems in top form. The following are some offerings that further these crucial goals.

MOTOR AND DRIVE DEVELOPMENTS

Increasing motor safety and reliability and providing a higher degree of flexibility were the challenges tackled when the SIMOTICS SD200 severe-duty motor line from Siemens was designed. A small detail like swivel hooks for lifting the motor, supporting up to four terminal box locations, and off-the-chart starting torque characteristics with low inrush current, are just some of the SD200's differentiators, says Oscar Palafox, technical product manager for low-voltage motors at Siemens Motion Control Business.

"We also looked closely at the energy cost savings and designed a motor that's not only suitable for the highest nominal efficiency regulation today, but we also made sure that our design exceeds these values. We made an IE4-equivalent efficient motor available to the market, as well," adds Palafox.

Baldor-Reliance Critical Cooling motors from ABB are targeted to clean rooms, data centers, hospitals, and other applications requiring stable temperature control and continuous operation. The inverter-duty motors, best suited for HVAC applications that use variable frequency drives, include remote monitoring for increased safety and predictive maintenance.



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The motors are designed with hybrid ceramic ball bearings on both motor ends to eliminate bearing currents, says Bevan Christiansen, HVAC segment manager for Baldor-Reliance motors. "The innovative use of ceramic ball bearings in Critical Cooling motors makes the motors so reliable that they come with a lifetime warranty against bearing failure due to shaft currents," he observes.

Motor condition monitoring driven by sensors that use batteries face interruptions from planned or reactive battery replacements.

The new PowerFlex 755TS drive from Rockwell Automation, the first six-pulse variable frequency drive with TotalFORCE technology, is designed to support a multitude of industrial applications. Continuous self-monitoring and onboard predictive analytics help to reduce unplanned downtime. Adaptive control features enable faster startups and increase energy efficiency, productivity, and throughput.

The patented TotalFORCE technology "brings a simplified and consistent user experience to virtually any motor control application in three key ways: flexible, high-performance control; operational intelligence; and eased commissioning and optimization," explains Andy Gagnon, senior manager of mechanical development at Rockwell Automation.

MONITORING AND OPTIMIZATION SOLUTIONS

Motor condition monitoring driven by sensors that use batteries face interruptions from planned or reactive battery replacements. The batteryless Eversensors that power Everactive's Machine Health Monitoring (MHM) solution enable always-on condition monitoring for all rotating equipment. Eversensors, built for rugged industrial environments, harvest energy from sources such as indoor solar light, thermal gradients, RF, and vibration to continuously sense, process, and wirelessly transmit machine health data.

Rather than risking sensor downtime and replacing expensive batteries, time can be focused on the data that the system collects to predict more failures on more equipment, says Chad Dyson, Everactive's MHM application specialist. "We are able to collect and transmit data once a minute wirelessly. You get more data, more time to analyze failures, and no battery maintenance," he explains.

The new ATPOL III energized motor and power analysis instrument from All-Test Pro facilitates the detection phase of condition monitoring programs for assets that contain any electrical equipment, such as motors, generators, or transformers.

"ATPOL III uses the electrical equipment's voltage and current as the transducer to quickly determine the condition of the entire machinery system, including the quality of the incoming or outgoing electrical power, machinery loading, and efficiencies," comments William Kruger, training manager at All-Test Pro. The test results can be uploaded into the latest ATPOL 8.0 software for analysis and a report displaying the results of the automatic analysis. When connected to a pre-installed ALL-SAFE connector, the entire process can be completed in less than five minutes per machine, Kruger adds.

The Snell Group offers comprehensive motor testing instruction. Its Electric Motor Testing Training Series (EMTTS) is a 32-hour, seven-section course offered live or online on demand. It moves progressively from electrical theory basics and electric motor fundamentals to topics including de-energized motor testing, energized power quality analysis, spectral analysis, and safety considerations. Optionally, the topics can be purchased individually.

Trainees learn why and how to maximize motor performance and reliability through processes such as measuring inrush current. Don Donofrio, an instructor and consultant at The Snell Group, explains: "Sometimes it is what you don't see that can cause motor failures. Monitoring inrush can identify many failure mechanisms."

REFERENCE WEBSITES:

www.siemens.com	www.everactive.com
www.abb.com	www.alltestpro.com
www.rockwellautomation.com	www.thesnellgroup.com

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How the Internet is improving asset data

By easing the burden of data analysis, Internet-based services can improve equipment management

Management has developed a love/hate relationship with the Internet, albeit mostly love. The greatest fear of senior management is cyberattacks that can bring companies to their knees in terms of ransom, unscheduled shutdowns, wanton destruction, industrial espionage, false readings, loss of control of equipment, malware attacks, and nuisance hacks. But all that has been clearly eclipsed by the myriad of benefits that have contributed to our growing dependence on the Internet. Below are some of the more significant ways asset management continues to benefit by the Internet.

OUTSOURCING CMMS SERVICES VIA THE INTERNET

One of the easiest ways for CMMS vendors to jump into the world of e-commerce and the Internet is to offer subscription-based software available remotely via the cloud or a vendor-based host site. Today, companies are looking to focus on their core competencies for maximum competitive advantage and minimal cost. It is expensive to run your own information technology department and what benefit does it provide? It may be more cost-effective to outsource the data processing function to a company for whom this is their core competency, namely the CMMS vendor or their third-party partner. They have the know-how and the economies of scale to provide the service efficiently and effectively.

Companies that go this route access their data from any location via a private intranet or the Internet. The vendor assumes responsibility for some portion of hardware and software maintenance, upgrades, customization, redundancy, back-ups, business recovery planning, security, and so on.

Despite the obvious benefits, the reasons why more companies have not opted for this approach are deeply rooted in misconception. First of all, management pride and a feeling of loss of control translates into that "we can do it better in-house" feeling. Secondly, there is a strong sense that outsourcing is more expensive, but that is usually because total cost of ownership or lifecycle costs are ignored. Thirdly, security of data is always in question. There is a perception that vendors may misuse their data, for example, selling it as benchmarking data, deliberately or unwittingly using the data to help a competitor, and leaving the data open to industrial espionage. This is exacerbated by a constant stream of news headlines featuring big companies that have fallen victim to some sort of cyberattack, despite previous public assurances that everything will be done to prevent such an occurrence.

INTERNET-BASED PROCUREMENT

Internet-based CMMS inventory, requisitions, approvals, and purchasing modules have automated the time-consuming and error-prone manual and semi-automated systems of the past. The process starts with an electronic purchase requisition approved online for content and dollar amount. Then, for stock items, it automatically becomes a purchase order that is sent via the Internet to the vendor. For non-stock items, buyers can get quotations electronically. Upon notification of goods received, the system creates an electronic invoice for certain key vendors, and payment is initiated. This automates the costly process of matching invoice to receiving documents, to purchase order, to quotation, to purchase requisition.

One way industry has found to cope with the disappearance of experts is to forever enshrine their knowledge in software.

REMOTE DIAGNOSTICS AND MONITORING

All too often companies take for granted the wealth of information and experience provided by more senior employees. When a top resident mechanic in a given area leaves after 25 or even 5 years, he/she takes with a body of knowledge about the equipment that is difficult to replace. Many companies learn the hard way, the importance of simple human resources management through cross-training, succession planning, redundancy, duplication, mentoring programs, and so on.

One way industry has found to cope with the disappearance of experts is to forever enshrine their knowledge in software. Early experimentation with expert systems, machine learning, and artificial intelligence included attempts by the medical profession to computerize the diagnostic skills of the best and brightest physicians of the world. It was during this and subsequent experimentation that we learned just how remarkable the human brain is when analyzing complex diagnostic problems, such as knowing when and how to cross a busy highway without getting killed.

In the field of maintenance, two sources of knowledge-based diagnostics have emerged, each of which can be available through the Intranet or purchased from a vendor via the Internet. These are described briefly below. Bear in mind that these systems, like a CMMS, are one of several tools

available to management. They are not intended to replace the need for proper human resources management.

CMMS-based troubleshooting. Long-time coming for CMMS vendors is the development of a troubleshooting database. This is, in its simplest form, the computerized regurgitation of the troubleshooting documentation buried at the back of the owner's manual for each piece of equipment. The benefit of computerization is that you can do searches, sorts, and filtering of the data to ease finding a solution to a problem. You can also print the portion of the troubleshooting guide that is relevant to a given job and attach it to the work order.

A more sophisticated approach used by some CMMS vendors is to link diagnostic information with problem, cause or failure codes. Suppose the problem code "flickering light" is selected for a given piece of equipment by the originator of a work request. Stored in a troubleshooting database will be a series of possible approaches depending on the cause of the problem. The flickering may be caused by a faulty ballast, loose wire, spent bulb, or electrical problem at source. The CMMS will draw on the troubleshooting database, keyed on the problem code and associated piece of equipment, to supply a prioritized list of possible causes. As well, procedures to determine the cause are provided

If the database is regularly updated by the maintainers themselves, then much of the knowledge gained on the job is retained long after experienced employees are gone.

Once the cause is identified, action required to solve the problem and eliminate the cause efficiently and effectively is provided by the software. Thus, for a flickering light caused by a faulty ballast, the database may suggest either the repair or replacement of the ballast depending on various criteria. Analysis of historical problem, cause, and action codes can assist in identifying recurring problems for key equipment.

Just as simply as you can add PM tasks to a CMMS, you can also add troubleshooting data, based on field experience. If the database is regularly updated by the maintainers themselves, their supervisors, and maintenance planners, then much of the knowledge gained on the job is retained long after experienced employees are gone.

When the troubleshooting service is purchased from a vendor, you have a larger pool of information about the equipment from which to draw. For example, an OEM can create a comprehensive troubleshooting database using data from companies with the same equipment across the industry and even across industries. Some software vendors have made this kind of data available for purchase for years (e.g., facilities, vehicles).

PdM-based diagnostics. Predictive maintenance software has two components: data collection and data analysis. There are scores of vendors of the software and hardware used in the collection of data such as vibration, viscosity, and infrared readings. Data is collected automatically using permanent, online metering devices, or using handheld or mobile equipment operated by inhouse or external technicians. Data can also be collected and transmitted to a vendor via the internet.

Data is then dumped into diagnostic software for analysis. There are only a handful of vendors of these expert systems. Trends are plotted by the software showing the extent and type of deterioration. Analysis algorithms and sometimes artificial intelligence can assist in making sense out of the complexity and shear volume of data collected, by determining the possible causes of deterioration and suggesting a strategy for dealing with the problem.

Some CMMS vendors have experimented with integrating their software with the data collection and diagnostic components of predictive maintenance packages, in order to generate preventive maintenance work orders. Because the analysis software is so specialized and data so voluminous, very few CMMS vendors have built a successful interface let alone written their own predictive maintenance module. Examples of specialized PdM software include pipeline integrity software for the oil and gas industry, and infrastructure management software such as for pavement, bridges, and buildings.

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Why to implement a 5-level priority system

Accurate work order prioritization will show defects in maintenance and help measure planning time

Recently we discussed using a simple, but not too simple, priority system to coordinate between operations and maintenance. This month let's go past the workings of the system and more into the philosophy. The priority system is a key player in facilitating our profitability. But who should care? Who sets the work priority? Should it ever change? And how well are we using the priorities?

Quick recap: The Palmer preferred priority levels are something along the lines of 0-Emergency, 1-Urgent, 2-Next Week, 3-This Month, and 4-Longer. Five levels allow two levels for breaking the weekly schedule (perhaps 20% of our work) and three levels for can wait a week, can wait a bit longer, and don't want to forget (altogether about 80% of our work).

PRIORITY SYSTEM SUPPORT AND UNDERSTANDING

The priority system is a huge deal! Our spread of work per the priorities actually defines the profitability of our plant! We make profits with assets that run to produce a product we sell. The more priority 0's and 1's (emergency and urgent) work orders we generate, the less our assets are running. Not every breakdown threatens production. For example, a primary pump fails, the backup pump starts, and the operator writes a priority 2 or 3 (non-urgent) work order. But no plant has perfect designs that cover all contingencies and people write priority 0 and 1 work orders when situations threaten production. Having higher profitability is absolutely related to having fewer priority 0 and 1 work orders.

Management and first line maintenance supervisors must care. Priority 0 and 1 work orders are defects! Maintenance is about preventing emergencies and urgent situations that threaten production. Having 0's and 1's mean we have "failed to maintain." Now we are in the "fix it" mode recovering production assurance. Management must not be comfortable simply that we fix 0's and 1's as soon as possible. If we average, say, 600 new 0's and 1's each month, management must care about reducing that rate of defects. First line maintenance supervisors must also care. These supervisors must push back against operators that call wanting this or that done. It's no problem that operators call, but supervisors must insist operators use the appropriate priority code, 0 for break the schedule today, and 1 for break the schedule this week. We must be able to quantify our defects.

Generally, the original requester of the work sets the priority of the request. This operator is on the spot seeing the exact asset condition and understands the importance of the asset in its operating context: "Hey, if we don't fix this valve today, we'll lose too much product" or "This motor can wait a week or so."

We also need to help everyone understand the priority system. Consider bulletin boards and putting little business cards on everyone's keyboard showing the levels with a few words of description. Have the CMMS computer default new requests to priority 3 or 4. Some plants have a gatekeeper that is usually a senior, experienced operator helping judge the new priorities before maintenance has to scramble: "That broken pump can really wait until next week" or "The overall water supply is low and the demineralizer must be fixed tomorrow." Some plants have a brief morning meeting to review all new work requests with the same function as a gatekeeper.

Supervisors must insist operators use the appropriate priority code, 0 for break the schedule today, and 1 for break the schedule this week. We must be able to quantify our defects.

PRIORITY SYSTEM ACCURACY

Consider also the accuracy of the priority selection. It is often difficult for a requester to decide "Is this really a 1 or 2?" "Is this really a 3 or 4?" People with unproductive maintenance forces are very concerned with picking the correct priority "because 4's will never get done." But people with productive maintenance forces are not overly concerned with the priorities because everyone's work gets done.

Generally, we should not change the priority after a work order has arrived in maintenance. Don't change a priority 0 or 1 to a priority 3 because we won't have the right parts on-site for a few weeks. Instead, keep the priority and be able to measure how well the storeroom supports emergency and urgent work. We also should not "age" work orders across priorities: Some people say that a priority 4 should become a priority 3 after so long, then a priority 2 after so long, etc. But a priority 4 squeaky wheel will never be as important as a priority 1 boiler feed pump banging loudly right now. Instead, we need to be more productive to complete the

priority 4 work. Nonetheless, a gatekeeper properly should raise the wheel from a 4 to a 1 if the squeak has gotten worse and may soon impact production.

We should not change the priority after a work order has arrived in maintenance. Don't change a priority 0 or 1 to a priority 3 because we won't have the right parts on-site for a few weeks.

MEASURING PLANNING AND MAINTENANCE

Evaluate how we are doing, overall for maintenance and in the planning phase. Measure if we usually finish priority 1's within a week of being requested, priority 2's within a couple of weeks, priority 3's within a month, and at least know how we do on priority 4's. Use a "median" score rather than a "mean" average. (A straight mean average would cause one or two work orders that took forever to skew the meaning, no pun intended.) For planning, we should generally plan the work in half the priority allotted completion time. In other words, try to plan the priority 2 work (2 weeks to complete) within a week; plan the priority 3 work (a month to complete) within two weeks; and plan the priority 4 work within a month. We can also measure medians for planning times.

The priority system is a super big deal: Managers, supervisors, operators, and planners must actively involve themselves in leveraging the priority system to create and maintain a profitable plant. "That's what it's all about."

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 online help and currently scheduled public workshops, visit www.palmerplanning.com or email Doc at docpalmer@palmerplanning.com.

Personnel changes put focus on the basics

The keys: clearly defined responsibilities and a system to track performance and knowledge sharing

After doing several reliability assessments in recent months across different companies and industry verticals, I wanted to share some of the common issues and thoughts on how to overcome these problems to drive better performance.

People are swapping roles more frequently than ever it seems. Organizations are struggling with many personnel movements, in or out of the business, and internal moves. It's common to find individuals floundering due to the lack of clearly defined roles and responsibilities. The graphical business processes and RACI charts might be right under people's noses, but the information is not shared. I've talked with several site managers who have transitioned into new roles only to find themselves defining personnel responsibilities to get things moving forward. Have an onboarding process that shares the roles and responsibilities. Set the expectations and then hold people accountable to meet them.

Nearly every group claims to do Root Cause (Failure) Analysis, but in reality, few get the desired results from a return perspective. Every group has some triggering event criteria that drive the start of a 5 Whys or deeper root cause investigation. Usually, there is an electronic form that the operator fills out stating what happened along with the date and time. The investigation consists of a few individuals, often managers and supervisors, sitting around a table. The people who witnessed it or might have something legitimate to say about how the equipment is operated or maintained are missing. Speaking of process, there is no framework followed, and the opinions in the room have bias. The document is updated with a few assumptions, maybe with some perceived root causes, and sent up the management chain if required to meet regulatory documentation requirements. There is no communication back to the plant floor on the findings. Maybe a work order is written, but more than likely, an email is sent asking someone to take some action. At that point, the analysis outcome dies a slow death. Nothing changes. Simply put, there is no follow-up.

There are software tools that centralize the incident reporting, quantify the risks and losses, document the analysis, and track the intended actions to fix the issues. While that's a better solution, simply using a spreadsheet as a tracking tool is an improvement over random email. Record the event, the date and time it occurred, quantify the loss in dollars or product volumes; use failure codes to categorize the event, the recommended actions, who is assigned the action, and the expected completion date. Once per week, bring up the tracking spreadsheet in the production meeting and get updates in the group setting. From a reporting perspective, show how many events by category have occurred, the total losses, and improvements implemented in trend format. Determine if you are trending better or worse and adjust as needed.

People are swapping roles more frequently than ever it seems. Organizations are struggling with many personnel movements, in or out of the business, and internal moves.

The list is long for maintenance planning and scheduling. Individuals with little to no craft skills are placed into the planning and scheduling role. Then, no training is provided. If training is provided, there is no mentoring on applying the skills learned. So, these individuals are set up to fail out of the box. The MRO storeroom is a mess. Bills of materials (BOMs) don't exist. Maintenance planning consists of trying to find parts for all work, not just planned. Forget the development of corrective job plans. Logged work order hours match the estimated PM hours without exception. The crafts rarely provide detailed feedback, and at times, that feedback is ignored by the planner. And lastly, there are no performance indicators to drive the desired behaviors.

To address planner development, develop formal qualifications, and assess competency; use planner scheduler certifications that include training and coaching. The competency assessment should continue until the planner reaches the desired level of performance. Address the issues with the maintenance systems. Establish job planning criteria to include corrective and PM job packages. Teach the value of the feedback loop to ensure that PMs and job plans are updated. Audit by taking groups and walking down completed work to ensure all are meeting the expectations. Fix the processes where required.

In each section, the items don't require significant change. It's just forward to the basics with the foundation and following through. What is keeping you from getting there? Please do share.

The future of work is changing fast

System integrators are poised to help you navigate the changing *who*, *what*, and *where* of your job

José Rivera is the CEO of the Control System Integrator Association (www.controlsys.org). He recently recorded an episode of Plant Services' The Tool Belt podcast with Editor in Chief Thomas Wilk to preview the upcoming CSIA Executive Conference being held in Denver, Colorado from June 27-30.

PS *Why was theme of "The Future Of Work" chosen?*

JR Selecting "The Future Of Work" as a theme came very natural because we have been going through a dramatic global transformation over a relatively short period of time. It goes well beyond system integrators and the automation communities, and we're not done yet.

We have supported this theme with three tracks. The first one is people or the ***who***, and in our case, it is about the talent that works for the system integrators and the one that they want to attract. This has always been a challenge for system integrators and the Great Resignation combined with a search in demand for system integrator services has made this worse. System integrators are being very creative in the way they're addressing this, and I'm sure that we will end up with new forms of working engagements.

At the start of the pandemic, when people were making remote work viable, some gained a better appreciation of the workplace, but in a redefined way.

Then the second track is about the ***where***, or where work takes place. And it's not just about the office versus home. It is about the redefinition of what the workplace—thus the office—is supposed to provide. At the start of the pandemic, when people were making remote work viable, some gained a better appreciation of the workplace, but in a redefined way. So everybody's now trying to come up with, what does hybrid work mean? And everybody's coming with their unique solutions, which is perfect.

We at CSIA conducted a survey a year ago, and we asked about where you see yourself working. It was very interesting to see how the younger generations were the ones who wanted to go back to the office. To me, that was counter-intuitive, because these are the generations that are very comfortable working remotely, but they need the social element. They need the mentoring. And the best way of doing that is by being in the office, maybe not every single day, but a certain number of days.

The other thing that I would say about the work taking place is that system integrators had to figure out how to deliver some of the work remotely. Some system integrators had SATs, which stands for site acceptance testing, to deliver their projects and complete them. But several manufacturers or many manufacturers were not allowing non-employees to their sites. So how do you complete your project? They had to find and workaround, but also develop tools that allowed them to deploy their solutions without having to put their feet on the manufacturer's site.

And the last track is about the deliverables by the system integrators, so the ***what***. It's the scope of work that system integrators have been providing. It has been growing over the years, right? So, 20 years ago, all system integrators were doing was PLC programming and control panel assembly. And today, the diversity is so big that there are some system integrators that don't touch the hardware. They're just working at the software level, MES, etc., and it's fascinating to see that diversity. I think that now with this pandemic and digital transformation also, the role of the system integrator as a consultant coming in earlier in the projects is going to be a growing trend.

PS *There's a definite trend towards maintenance and reliability teams—the primary audience for Plant Services. They're having trouble back-filling old positions, positions where they've had retirements, and so, at the moment at least, they're partnering out a lot more often either with OEMs or OEMs and their partners, which would include the integrator community. And to get what these teams need to get done at work, it is going to take a lot more collaboration earlier in the project. You simply can't bolt on the integration aspect. It's got to be thought through at the point of defining project goals.*

JR Yes, and some of these manufacturing sites are in remote locations. If you're trying to attract talent, young talent, normally younger people want to live in the more urban areas, right? And so, how can you attract these resources? So, if we talk, let's say, remote work, and now you allow this individual to work a certain number of days

remotely, that I think increases the probability of you being able to attract these resources.

But one thing that I would say about the maintenance, the reliability, and the operation workers: when they went through the pandemic, a lot of them didn't have the option of working remotely, right? These were positions that demanded that you be there and they required a lot of sacrifice from these workers.

They had to deal not just with the Great Resignation, but they also had to deal with coworkers who got sick and now suddenly had to quarantine, so reduced staff. Then there were all these concerns about spread of the virus, particularly at the very beginning of the pandemic. What I have heard is that from the manufacturer site, in the past, a lot of the projects were justified just from a financial perspective. Now resiliency is one of the elements of the equation, and because we have the Great Resignation too, what you are then having are many more projects that are driving a lot of the system integrator business that try to reduce the worker concentration on the manufacturing flow and help deal with this Great Resignation problem.

In the past things were a little more predictable. Now that has been turned around, and maybe now having a little bit of extra inventory, as long as it's the right one, it's an advantage.

I think that this is creating opportunities within your audience because they can become the experts in these new tools. They can become the go-to resources for them, such that the work of the reduced set of people that are in the factory becomes much more efficient. If, for example, you're deploying this predictive maintenance type of tools, right? When you are scheduling your maintenance, your shutdowns, it's not unscheduled. It is one that you have programmed.

And in these days where worker availability, etc., is limited, you don't want to mess it up. You don't want to be the one that suddenly has workers sitting because this machine broke down. You want that to be a scheduled shutdown, right? So, more than ever, these tools that are predictive and not reactive. These tools have existed, and I think the pandemic is now providing impetus for them to be deployed more widely.

In the past things were a little more predictable, right? We were able to deploy things like just-in-time inventories or elimination of inventories were just in time and lean initiatives. All of that was great because it reduced cost. Now that version has been turned around, and maybe now having a little bit of extra inventory, as long as it's the right one, it's an advantage. So it has had a lot of impact, what we are going through right now in our world.

Break down silos, both data and people

Asset stakeholders across the organization shouldn't be going about their work in isolation

Oswaldo "Oz" Rodriguez
Head of Product GTM Strategy, Lloyd's Register

Operators may use a variety of tools and techniques – hardware solutions, software packages, sensor technologies – to monitor for and manage different aspects related to the performance of their plant. But are they compromising their pursuit of net-zero goals or asset performance if they're not integrating that effort into their overall management of individual assets?

Oswaldo "Oz" Rodriguez is a technologist with a background in software engineering, and is currently the head of product Go-To-Market strategy with Lloyd's Register Digital Products (www.lr.org). He recently spoke with Plant Services editor in chief Thomas Wilk about why it's time for industry to come together to promote sustainability and protect the planet (www.plantservices.com/podcast-series/the-tool-belt/setting-and-achieving-your-plants-sustainability-goals).

In this special Industry Perspective, Rodriguez explores the potential gains of a layered approach to asset management.

Q: When it comes to asset management, there seem to be as many approaches available as there are assets in the field. What would you say is one challenge that all asset management professionals have in common?

A: Everyone has an angle when it comes to managing critical pieces of infrastructure within a plant. The integrity professional is managing the asset from one distinctive perspective, while it's likely that others will have a specialist focus on areas such as safety, reliability, productivity and environmental impact.

But if they're managing their remit within a siloed structure – with no common platform where they can quickly share data to expedite decision making – then is each discipline operating under a degree of avoidable constraint? And does that in turn mean the asset itself is not being run at optimum efficiency?

Operators of course manage their plants in the round; every element of a system is part of an interconnected process, and implementation of discrete maintenance and repair regimes for each of those in isolation would never prove successful. It makes perfect sense. If you go to the doctor with an ailment, they'll check the bigger picture – medical history, other health issues, allergies – before prescribing a remedy that not only targets the problem but also factors in your overall wellbeing.

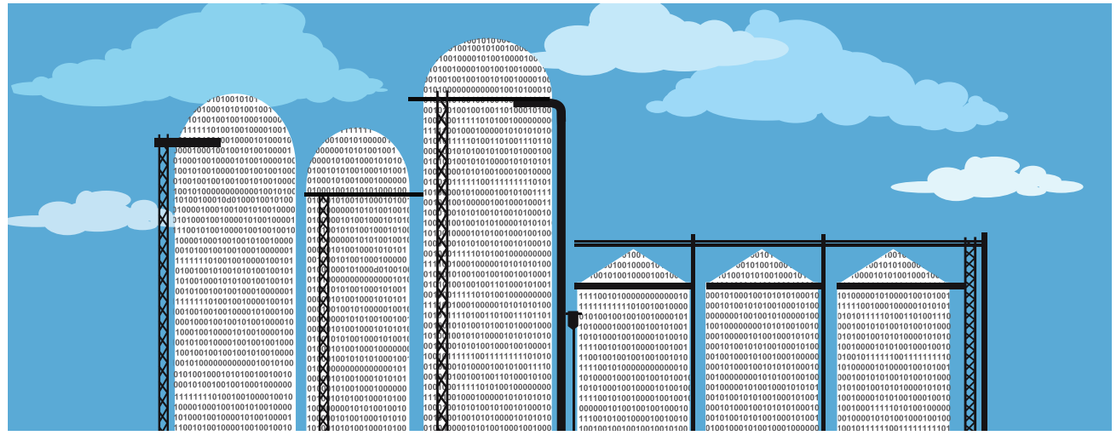
Those same principles should apply if you narrow the focus down to an individual piece of equipment. Each discipline with a stake in its performance and wellbeing shouldn't be going about their work in isolation either. With access to all asset data, they'd be equipped to make fully informed decisions not only in the context of their specialist layer but also in the best interests of the asset, and the business as a whole.

This is a topic that's interesting to us at Lloyd's Register, not least because of how it has the potential to help deliver on global sustainability goals in the wake of the COP26 Climate Change Conference: an asset's optimum working performance will embrace its energy consumption and emissions levels, amongst other factors that affect the overall asset health and support your key initiatives.

Q: You bring up the very real challenge of data silos preventing teams from obtaining actionable information from their machine health data. What are your thoughts on the organizational silos that also exist, that keep people across teams from working together effectively?

> Each discipline shouldn't be going about their work in isolation. With access to all asset data, they'd be equipped to make fully informed decisions not only in the context of their specialist layer but also in the best interests of the asset, and the business as a whole.

A: I stated at the outset that the integrity expert has a particular focus, but any integrity failure has potential consequences in a much wider context – across areas ranging from safety and productivity to environmental. Their counterparts in those disciplines, meanwhile, have their own specific responsibilities and indicators which constitute good performance. They all use specialist technologies and practices to deliver on their remit, but not necessarily as part of a complete plant strategy. They're deploying the right tools and making the right decisions within their own scope of duty, but could they too be impacting the other areas of asset performance?



It's a scenario that presents the possibility of wider challenges arising; of someone, at some point, missing something of operational or commercial significance.

It's also why we're now exploring technology-led concepts with our partners which could serve to underpin a new approach, allowing businesses to focus inspection and maintenance where it counts and address risk beyond that of just what its known. You might call it a layered model, fully aligning the various disciplines and offering a shared, centralized view of all areas of asset activity.

Q: And this layered model would facilitate improved communication and collaboration across stakeholder teams?

A: Creating a centralized view not tied to certain technologies or vendors that anyone in an organization can access at anytime, anywhere would eliminate the shortcomings associated with this form of tunnel vision, offering every stakeholder full and live visibility not only of their own data but also the changes and decisions others are making. An instant oversight of the impact – positive or negative – that production variations have on energy use or emissions management, for example, can only support optimum performance. Having full oversight enables people to make smart use of data, to speak the same language as their assets and unlock their knowledge.

More broadly, it would better inform strategic business decisions on asset maintenance or replacement. Managers could better understand where their best long-term options lie. Do the prospects of much enhanced energy consumption and emissions performance, for example, outweigh the cost of investing to replace aging assets? Or is the current repair and maintenance program still the best route to take in efficiency terms?

Through adopting a higher level of understanding of their assets as a whole, operators can identify and quantify opportunities for business performance improvements, as well as better, safer operations.

The concept of interconnected layers would also facilitate the introduction of new elements if necessary, and that's perhaps significant given that many operators are looking to introduce new emissions and energy consumption-specific tools in pursuit of net-zero objectives, allowing them to drive better business value in both digital and energy transitions.

Q: What are the obstacles that would need to be overcome with this kind of asset management approach?

A: Bringing new technology onboard without integrating it into the full asset performance structure may undermine its power: just another data point, not contributing to the complete asset strategy to its full extent because not every factor is being considered. Certainly, the new application might help in monitoring and controlling emissions, as an example, but the production regime, energy use, integrity programs – all of these are part of the bigger net-zero picture.

Lloyd's Register is working with partners and customers to assess the layer concept for asset performance. The digital transformation journey has delivered numerous industry gains, but it is our experience that people are still to a large extent working in isolation – albeit with more advanced solutions at their disposal. We believe there's an opportunity to harness the power of digital to fully connect asset layers with its corresponding actors.

Compressed air system drain efficiency

For the best energy and cost savings, don't overlook this simple and fairly inexpensive part of your system

by Brian Mann, ME, PE, Sullair

Your manufacturing operation is a complex ecosystem, and keeping that system not only running but efficient as well is a never-ending, always changing task. Each process, machine, and throughput calculation requires trained and experienced engineers and other specialists to design, run, and maintain. Millions of dollars are often injected into the facility and machinery, and process efficiency is tirelessly studied, measured, and re-designed—all in the name of profitability and efficiency.

Focus and investment in the rigors of design, maintenance, and high tech and trending machinery, and process improvements, however, can sometimes cause the process engineer to overlook a simple, but significant detail: the compressed air system drain. This seemingly small detail can provide some noteworthy energy savings—and in a world of tightening sustainability targets, every little bit helps.

Will the installation of the correct drain solve all your compressed air (and other) efficiency woes? Likely not, but it is one of the easiest and least expensive updates you can make that will have a measurable and consequential impact on your efficiency goals.

COMPRESSED AIR—WHERE DOES THE WATER COME FROM?

To understand how and why your compressed air system drain is so important, we need to first look at what is draining and from where and why. Air compressors ingest ambient air, which is mostly nitrogen, with oxygen and trace other gases along with particulate contaminants and water vapor. Compressed air cannot hold the same amount of water vapor as ambient air, so the moisture eventually condenses and must be removed.

Installing the proper drains within a compressed air system is vital to avoid the needless discharge of compressed air and the associated demand increase.

Because of inefficiencies in the compression process, the temperature of the air being compressed increases during the compression process, causing the ingested water to remain in its vapor state. The temperature of compressed air at the exit of the compression chamber is typically too high for use in an industrial setting, so it is cooled before being discharged to the downstream air treatment components. As the compressed air is cooled, water vapor condenses into liquid and is removed by the moisture separator downstream of the compressor aftercooler. Once the liquid water, or condensate, is collected, it must be removed from the system.

Retained liquid, or bulk water, can result in the development of rust, scale, and corrosion in the compressed air piping system. The water can also be very damaging to pneumatic tools, often washing the lubricant from the internal moving parts. Because of these considerations, removal of water from the compressed air system is an important design, operation, and maintenance consideration.

However, removing the water from the system needs to be done in a manner that minimizes the discharge of compressed air from the system. Air unintentionally escaping the compressed air system—along with the water—constitutes an unproductive or inappropriate use of compressed air that costs money in the form of wasted electricity.

DRAIN TYPES

Condensate management is likely the most overlooked aspect of compressed air system

design. Installing the proper drains within a compressed air system is vital to avoid the needless discharge of compressed air and the associated demand increase. A properly designed compressed air system will have multiple drains. Locations requiring drains include the moisture separators, filters, receivers, piping dead legs, and any other place that condensate may collect.

It is important to recognize that the volume of condensate discharged from the different locations will vary significantly. A well-designed condensate management system not only includes drains at the appropriate locations, but also sizes the drains correctly. Condensate drains are not a "one-size-fits-all" proposition.

In practice, a variety of condensate drains are used throughout the system. Some users employ a cracked open valve or a V-notch valve. Others have adopted a manual drain that needs to be operated by maintenance personnel. These options likely either result in a waste of compressed air and/or ineffective removal of condensate from the compressed air system.

Still other systems use a timer drain to remove condensate—a seemingly more efficient option. An issue with timer drains is that they usually have a strainer upstream of the reduced port valve so that particulates do not clog the valve. The strainer will foul and plug instead, rendering the timer drain just as ineffective as if the valve itself were clogged. Despite the strainer being easy to clean, it is still another component to be maintained. Timer drains are typically set to discharge the largest anticipated condensate volume, with a factor of safety. The drain opens regardless of the presence of condensate. If condensate is absent, the drain discharges compressed air—adding to the compressed air demand in the facility.

THE SIMPLE SOLUTION

The best drain for both function and process efficiency, including eliminating wasted compressed air, is a no-loss drain. There are many styles, sizes, and designs for every application. They are called no-loss for a reason; no compressed air is exhausted when the drain opens to discharge condensate. Typically, a small amount of condensate is retained in the drain; much like the water that remains in the trap on your home sink drain piping, ensuring that no compressed air is discharged.

Many no-loss drains use capacitance to sense the presence of moisture. As an additional benefit, they often include self-clearing functions. If the drain senses that the reservoir remained full after a discharge cycle, the drain will repeat the discharge cycle. After multiple discharge cycles, a fault is indicated, usually with a visible fault indicator bringing the problem to the attention of plant maintenance personnel. If you have a limited maintenance staff, the dry contacts usually provided can be wired to a control panel to remotely indicate a drain failure.

STOP DRAINING YOUR PROFITS

The drain is likely the least expensive component in the entire compressed air system—or even the entire manufacturing operation. Many capacitance-style no-loss drains can be purchased for less than $500. The high-tech Variable Speed Drive (VSD) controlled refrigerant dryer purchased for $50,000+ will not provide dry air if the $500 drain isn't working correctly, which makes this inexpensive component suddenly very important.

And, in terms of energy and cost savings, the no-loss drain can have a significant impact on a company's bottom line. Air leaks can be notoriously expensive and when the facility is losing air through a partially opened valve for "continuous draining operation," literally throwing away money. Consider the opened valve as a 1/8" opening and the compressed air system is operating at 100 psig. If the blended power cost is $0.10/kWh, the operating cost of this drain exceeds $4,000 per year. The ROI on that $500 no-loss drain is therefore significant and worth more than a passing glance.

Now that a drain has removed the moisture, reduced the demand for compressed air and saved a few bucks, don't forget that the expelled condensate must be managed.

DISPOSAL

Now that a drain has removed the moisture, reduced the demand for compressed air and saved a few bucks, don't forget that the expelled condensate must be managed. Be sure that the discharge of any drain goes to an approved location. Approved locations exclude the ground, the roof, the floor, and a stream. Be sure to consult your EH&S department, environmental permits and/or municipal sewer provider before discharging condensate anywhere.

Put the right drain in the right place for an inexpensive, often overlooked, but impactful upgrade to your plant's ecosystem efficiency.

Brian Mann, ME, PE, is the air systems manager for Sullair (www.sullair.com). Since joining Sullair in 2019, Brian has collaborated with Sullair channel partners and customers to maximize compressed air system energy efficiency. He holds a Master of Engineering in mechanical engineering degree from the University of Louisville and is a CAGI Certified Compressed Air System Specialist.

Safety auditing to prevent slips and falls

With a plan to increase traction in hazardous and high risk areas, everyone goes home from work safe

by William Davidson, SLIPNOT

Approximately 10% of walking surfaces in manufacturing and industrial workplaces, including platforms, catwalks, mezzanines, stairs, and ladders, are considered high-risk for slips and falls. These risks are compounded when water, oil, or grease enter the environment, as they often do in "wet" manufacturing plants that process chemicals, foods and beverages, and other products.

Flooring safety audits assess walking surfaces throughout the workplace to prevent slips, trips, and falls. The resulting solutions from a safety audit can prevent more than 90% of these accidents.

SURFACE SAFETY ASSESSMENTS – WHY DO THEM?

Auditing walking surfaces is an important part of safety improvement, employee retention, and ensuring peak performance.

During challenging labor markets, no one wants to lose an employee to injury. The U.S. Bureau of Labor Statistics (BLS) reported 211,640 injury cases involving falls, slips, and trips in 2020. Many more go unreported. Sadly, 805 of them ended in fatality, according to 2020 Census data on fatal occupation injuries from the U.S. Bureau of Labor Statistics. The BLS also reports 22% of reported slip and fall incidents cause three days or more away from work.

Unsafe walking surfaces can also be a drag on productivity. Consider the difference between walking on a dry sidewalk and an icy one. People become tentative, slow their strides, and alter their gaits. The same dynamics apply to a slippery floor. When employees have to walk slowly and cautiously to avoid slipping, that slows productivity and weakens morale.

SURFACE SAFETY AUDITS: HOW TO DO THEM

Traffic, environment, and walking surface are the three most important surface safety factors an auditor or safety team should consider, and each has several components. It's also important to listen to employees and revisit any injury events to determine causes.

> To conduct a surface safety assessment, get out on the floor. Walk the production or manufacturing line with your head on a swivel.

To conduct a surface safety assessment, get out on the floor. Walk the production or manufacturing line with your head on a swivel. Visit the following areas, and analyze and document what you see.

Elevated surfaces. Slipping or falling from an elevated surface is inherently more dangerous. Platforms, catwalks, mezzanines, crossovers, stairs, and ladders are common fixtures in wet manufacturing. Visit each one in your facility.

- Observe which materials are being used. Diamond plate is easy to fabricate and relatively durable. Unfortunately, it is commonly mistaken for a slip-resistant product and loses any non-slip properties when wet or exposed to dust particles, increasing the odds of a slip and fall injury.
- Are there trip hazards on elevated areas, such as neoprene mats that can roll up or change the walking surface? Installing high-traction walking surfaces eliminates the need for mats.
- Do stairs have high-friction treatments on the nosing and the hand railings? Both should be anti-slip to ensure safety (see Figure 1).

Figure 1. Stairs can be retrofit to increase their anti-slip properties. To maximize safety on stairs, apply high-friction treatment on the nosing and the handrails.

Figure 2. Elevated surfaces such as platforms and ladders are used extensively in food manufacturing facilities so employees can access and maneuver around mixing tanks, feeders, baggers, and other equipment. The platform and ladders pictured here have been bonded with high-friction surface material to eliminate slips, trips, and falls and make the work environment safer for employees.

Wet areas—Look for flooring or surfaces that are commonly wet. This can include any area used to process food or liquids. Spaces unrelated to production, such as loading bays exposed to the outdoors, can also be slippery.

- Watch for trench and round drains and surfaces that collect liquids. Do people have to walk across drains? If so, they should be fabricated with high-traction, anti-slip surface technologies.
- What contaminants accumulate on floors, such as water, oil, or animal fats, and how are they being cleaned? Some cleaning solutions break down a surface's anti-slip properties. Select a detergent that upholds food processing sanitation requirements without degrading the flooring.

Slippery surfaces. Talk to employees during the safety assessment. More importantly, listen and observe.

- Are there surfaces people continually slip on? Employees know where the problems are and often share that information with each other. You might hear someone say: "Watch out for those stairs when they get wet."
- "Slippery When Wet" signs often highlight a deeper safety issue that can be mitigated with a better solution.
- Caution tape flags a dangerous area, drawing attention to a problem management hasn't resolved. Temporary grip tape that begins to peel can become a trip hazard.

Traffic. Look at traffic and consider the volume and type.

- Are people moving in one direction or both? Are there intersections?
- What is moving around: employees, carts, trucks, forklifts?
- When moving equipment enters the mix, hazards increase. People have to constantly look around, because employees may have to stop them suddenly. Carts are heavy and a challenge to control on slick surfaces.

CREATE A PLAN TO MITIGATE HAZARDS

Once the tour is complete, sit with the safety team to establish a plan to increase traction in hazardous areas. If you aren't sure where to invest resources, bring in experts to test walking surface safety.

The standard metric for surface safety is coefficient of friction (COF), which measures the resistance between two surfaces— in this case, the flooring and an employee's shoe. Bonded surface technologies that have thousands of tiny, random surface peaks have a high COF. These peaks retain their anti-slip properties over time even when wet and after years of wear, providing effective slip and fall prevention and long-term durability (see Figure 2).

Companies sometimes balk at investing in fall safety because budgets are a concern. Still, if somebody hurts themselves in an accident, that will add significant costs in medical care, lost production time, and potential litigation. Creating a proactive roadmap and working steadily to eliminate slip, trip, and fall hazards can demonstrate definitive progress to achieve regulatory and legal requirements.

Companies with the best safety records make it a company value and invest accordingly. Protecting employees reduces the risk of injury and drives an overall safety culture that keeps people on the job and maximizes productivity.

William Davidson is CEO of SLIPNOT, a manufacturer of specialized safety flooring and surface technologies (www.slipnot.com). He is focused on driving growth for investors and employees and providing value to customers, including facility and safety managers, specifiers, and installers. Davidson has a Bachelor of Science in Mechanical Engineering from South Dakota School of Mines and Technology.

How to build the new industrial workforce

Industry is struggling to skilled find workers; it requires better education and information support systems

by Anna Townshend, managing editor

William B. Bonvillian and Sanjay E. Sarma's book *Workforce Education: A New Roadmap* gives a vast background of manufacturing job growth and loss through the centuries, and the forces behind the changes. It examines current workforce education programs and what makes them successful. And it envisions the future of industry as it relates to the recruiting new and retaining incumbent talent.

The following are some of my major takeaways for manufacturing and its new workforce education, but you'll likely find much more on your own in this encyclopedia of workforce history and recommendations for developing the needed future technical skills.

MANUFACTURING DRIVES THE U.S. ECONOMY

Between 2000 and 2010, manufacturing lost one-third of its jobs, driven largely by international competition. By 2017, 17% of those jobs had returned, but the following year, manufacturing output remained 4.7% below 2007 pre-recession levels. "The low productivity level signals an underlying innovation system problem," Bonvillian and Sarma say.

Tracking manufacturing jobs and productivity matters because historically manufacturing drives the U.S. economy. Similarly, manufacturing is the largest job multiplier, so those job losses (or potential gains) also reverberate through other sectors.

"Manufacturing has long been understood as the economy's largest job multiplier: manufacturing processes raise demand for raw materials, energy, construction, and services from a wide range of supplier industries," Bonvillian and Sarma say. "Manufacturing's effects on the economy are even greater when the entire manufacturing value chain plus manufacturing for other industries' supply chains are taken into account; manufacturing could account for one-third of GDP and employment."

WORKFORCE EDUCATION IS LACKING A SYSTEM

In many cases, workforce education is thriving in local pockets at community college, at federal institutions, and at individual employers. Those that have pushed hard for a locally trained workforce often reap the benefits, but the overall system cannot grow at that rate, the authors argue. They suggest that there is a growing disconnect between work and school. In general, industry is not informing what should be taught, and education is not preparing workers with the right technical skills. In addition to feeding new entrants into the workforce, incumbent workers also need access to continuing education to keep up with technological advances.

"Our education system is not ready to prepare our workforce for the rapid rate of technology advancement led by information technologies," the authors say. Between 1996 and 2008, the percentage of workers that received employer training dropped from 20 to 11 percent, and individual employers that plan education opportunities rarely pool resources.

"There are few incentives to collaborate, and this gap in collective activity amounts to a market failure. What is lacking is a system," Bonvillian and Sarma argue. "If the United States is to move into advanced manufacturing, there is no effective system at present for educating the workforce in the advanced skills it requires."

U.S. INDUSTRY NEEDS MANUFACTURING-LED INNOVATION

Disconnection also exists between innovation and production. "While the United States relies on entrepreneurial start-ups with venture capital financing to bring innovation into the economy, venture capital is focused increasingly on returns from software, service, and biotech. 'Hardtech' firms that planned to manufacture received only 5 percent of venture funding investments in 2015 and thus are effectively being blocked from scaling their innovations," Bonvillian and Sarma say.

In the U.S., R&D is the source of innovation, not manufacturing. "But innovation is a system, from R&D through production stages, and the failure to understand production as a key part of that system is a fragmented view," Bonvillian and Sarma explain. "If the United States wants to keep pioneering new technologies, we will also need manufacturing strength. A strong innovation system is crucial to the U.S. advanced economy; a technology strategy disconnected from manufacturing advances leads to a broken innovation system."

Countries like Germany, Japan, Korea, Taiwan, and China have manufacturing-led innovation. New advanced manufacturing paradigms (digital production, advanced materials, nanomanufacturing, mass customization and energy efficiency) demand it.

"The core idea behind advanced manufacturing, then, is to bring the still strong U.S. innovation system more directly into manufacturing. This, in turn, will require new advanced workforce skills and corresponding training," the authors

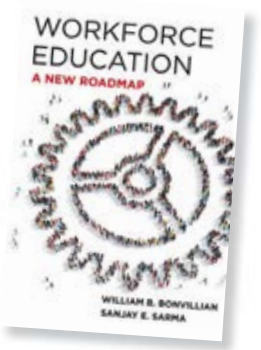
explain. "A system is needed in which a connected network of firms, universities, labor, governments, and national and corporate labs together nurture the next generation of production technologies, processes, and education infrastructure."

THE LABOR MARKET SYSTEM IS BROKEN

This network of connected systems for workforce development is also broken. "Workers and employers alike are largely flying blind," Bonvillian and Sarma say. Many different agencies collect relevant workforce data, but they serve the public independently. Bringing those resources together may serve as a starting point.

Workforce and labor data is primarily managed by several federal agencies: the Bureau of Labor Statistics and the Employment and Training Administration in the Department of Labor; the Census Bureau in the Commerce Department, and the National Center for Education Statistics in the Department of Education. Another larger group of agencies also collect relevant data.

"The core idea behind advanced manufacturing is to bring the still strong U.S. innovation system more directly into manufacturing. This, in turn, will require new advanced workforce skills and corresponding training."



"It's a mess; but suppose we had a navigation system. There could be online-delivered interventions to help workers facing job dead ends find work opportunities requiring skills adjacent to their own that they could master," Bonvillian and Sarma say.

Some work has been done to bring all this data into one usable system. "This rich lode of government data could provide a base for an operating information system that potentially could be complemented by employer and educator data," the authors say. "Overall, to be an efficient system—the invisible hand to work—this system must operate at a large scale."

ONLINE, ON-DEMAND TECHNOLOGIES CAN SCALE

In many cases, the pandemic sped up the adoption of remote or online work, school and more. For many younger students, it highlighted the importance of face-to-face interaction, but for industry it accelerated an already trending investment in remote capability and digitally-connected facilities.

The groundwork for this has been laid for quite some time. In the 2010s, Massive Open Online Courses (MOOCs) became widespread and have greatly influenced training. This type of education technology, or *edtech*, combines a short video format with computer grading, and online forums for students to interact with teachers. Humans are wired to learn in 10-minute chunks; after that, we're essentially prone to zoning out, according to the authors. "YouTube is probably the most important edtech platform out there," the authors say.

There are many emerging forms of edtech—automatic lecture capture, AI grading and testing, intelligent tutoring systems (ITS), which teach by modeling to the student, simulations and more. Industry is already using many of these tools – artificial intelligence, machine learning, AR/VR and simulations, which are making strides as edtech too. It's a natural partnership for industry education. In addition, these types of learning formats, the authors argue, are geared toward learning by doing or hands-on learning, which is suited to industry technical training needs.

"These online, on-demand technologies hold great promise for education and for workforce education in particular. Unlike, a classroom, they can operate at a great scale," the authors say. With AI, the potential is that systems can guide and personally adapt training for individual students, at scale. "With a workforce of more than 150 million people requiring systematic upskilling and lifelong learning, and a problematic existing delivery system, it is difficult to envision how to provide this access without extensive use of the scaling possibilities of online education," Bonvillian and Sarma say.

SOFT SKILLS ARE IMPORTANT

Even for industrial environments, researchers suggest that social skills, among other soft skills, are important for today's workforce. Bonvillian and Sarma outline many definitions of this elusive skill. The National Network of Business and Industry describe personal skills (integrity, initiative, dependability and reliability, adaptability, and professionalism); and people skills (teamwork, communication, and respect). The Center for Third Space Thinking at the University of Southern California have identified five core soft skills—adaptability, cultural competency, empathy, intellectual curiosity and 360-degree thinking. "The labor market increasingly rewards social skills; with more and more jobs requiring high levels of social interaction as team production expands, workers rely on each other, and employers need workers that can adapt flexibly to workplace changes, including the ability to trade jobs and tasks," the authors say.

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Automation, succession, and heroism

What does Rick Astley have to do with effective leadership? Read on to find out!

by The Captain

This month we bring you a selection of The Captain's best advice from the several recent columns.

ON AUTOMATION

Automation is sexy, fun to talk about, and cool to have in a facility. The great thing is that the country is sold on having automation and thinks that there are these huge benefits to having it.

The fact that you can have a robot replace people is great. No more drama of having to deal with people. No need to worry about the lack of skills, people calling in sick, and no ideologies to deal with.

The greatest benefit of all is the cost. Think about it: replace 20 headcount by automating the back end of your facility, which will save you $1 million a year in labor. The cost of automating the back end of your facility is $10 million, and that's a 10-year return on investment—a great project by any stretch of the imagination.

Then, you can raise the cost of your product because you overspent to look cool, leading to less volumes, and ultimately either shutting your doors or shipping the jobs overseas to produce it at a lower cost. What is not to like about that?

> Constantly bring up how your succession plan is coming to fruition, and how you are looking forward to the day you depart from the company.

ON SUCCESSION PLANNING

Always hire someone more incompetent than you to develop for your replacement. I know that this will be hard given your own incompetence, but the great news is that there is always someone out there more incompetent than you.

Also, you could just hire a college kid. Synchronized swimming as a major is the perfect fit for the organization. Or, forget the qualifications, hire based on identity. Seems to be the most popular trend at this time, so why not take advantage of it?

There are several advantages for both employers and employees to having a formalized succession plan in place: Employees know that there is a "chance for advancement" which can lead to more empowerment and higher job satisfaction. Knowing that most companies hardly promote from within, this is a great way to take the next imbecile, give them hope, and severely disappoint him or her when the promotion does not come his or her way.

Okay, really there are not any benefits to the organization, but there are benefits for you. It will make you look good in your own eyes! Also, it will make you look smart, because you are using big words like "succession planning" and can constantly bring up how your succession plan is coming to fruition and are looking forward to the day you depart from the company.

ON WAYS TO BE A HERO

- The grass is always greener. Remember that.
- Be a high-profile, flashy leader. It's way more fun.
- Self-promotion is always key.
- Guard information. They are coming for you.
- Leadership is all about position. You can't influence without it.
- Define a win in terms of getting you a promotion.
- Personal success above team, always.
- If it's not your vision, critique it until it is yours.
- People follow leaders because of authority, not competence. There is hope for you.
- Things Rick Astley will never do: Give you up, let you down, run around, desert you, make you cry, say goodbye, tell a lie, hurt you. Don't be Rick Astley.

Captain Unreliability is a satire of the state of manufacturing in 'Merica, USA, by an industry professional known for using humor to get the point across. Email him at Captain.Unreliability@ReliabilityX.com, or follow him on Twitter: @CUnreliability. Also, consider becoming Unreliable today by getting your Captain t-shirt at https://reliabilityx.com/product-category/gear.

THE HEART OF MOTORS RELIABILITY

by Matthew Conville, MBA, P.E., EASA

These four factors have the greatest impact on the health of your motor systems

Balancing plant maintenance costs and activities with the need to achieve production goals is a daily challenge for most maintenance professionals. Since the motor-driven system is often a critical component in this dynamic, let's look at some best practices to help it achieve those goals and meet customer demands.

To plant maintenance pros in most industries, these are familiar questions:

- "How do we improve reliability within our plant?"
- "How can we reduce unplanned downtime, so our production stays more consistent?"
- "How can we decrease our total cost of ownership of our equipment?"

They phrase it differently, but ultimately each of these questions is about improving the efficiency and reliability of the motor-driven system. Although that encompasses a wide range of components including fans, pumps, and drives, here we'll focus on the electric motors.

As a class, motors are among the most efficient and reliable machines in most plants. But when one fails, especially if it fails unexpectedly, plant reliability obviously suffers. The resulting downtime can slow or halt production, sometimes ruining raw materials and components or even damaging finished product. If you're seeking answers to the questions about plant reliability and unplanned downtime, solutions that make motors last longer and prevent premature failures are good places to start. Such solutions will likely decrease your total cost of equipment ownership as well.

FAILURE ANALYSIS

Since motor failures often are a call to action, let's start there. The mean time between failures can vary widely, so determining the root cause is the first step toward improving the motor-driven system's reliability. Was there a maintenance issue or a previous failure? Was the motor well suited for the application load, torque, start-stop, and environmental requirements? Was it installed and aligned properly, or did the process change after installation?

Some maintenance pros have the experience to analyze motor failures, but usually it's a task for a qualified service center. A qualified service center can also help you determine what to do next, weighing such factors as the type of repair/rewind, the cost and availability of new equipment, the application requirements, and the efficiency of the repaired motor versus that of a new one.

Once identified, many causes of failure are easily remedied. For example, studies have shown that the most common motor failure involves the bearings, which can be a simple, cost-effective repair. Other solutions may include improved maintenance, condition monitoring, a motor rewind, or a replacement motor. Unless you determine the cause of failure, though, neither efficiency nor reliability will improve—even with a new motor.

THE "BIG FOUR" FACTORS IMPACTING MOTOR HEALTH

Earlier we looked at the importance of failure analysis. What we do with that information can have a major impact on equipment efficiency, reliability, and cost of ownership. Often the motor isn't the root cause of the problem; it's external factors from the application that I call the "big four":

- routine maintenance
- environment surrounding the motor-driven system
- alignment during installation
- power supply for the motor-driven system.

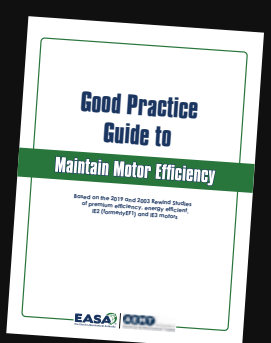
Failure to address the "big four" will likely result in the same failure of a new or newly repaired motor.

Maintenance. To prevent winding and bearing failures, keep the motor clean and follow the manufacturer's recommended lubrication intervals. As a best practice, do not mix lubricants, many of which are incompatible and cause premature bearing failure. Over- or under-greasing a bearing can have the same result.

Environment. Key things to monitor in the motor-drive system's immediate environment are ambient temperature and vibration, relative humidity, airborne contaminants, and potentially corrosive elements. Individually or collectively, these could hasten bearing and winding failures.

Also, make sure there's sufficient airflow to cool the motor. If the motor has air filters, change them regularly.

THE EFFECTS OF REPAIR / REWINDING



Even the most energy-efficient motors can be repaired with no loss of efficiency, if the repairs are in accordance with the best practices in ANSI/EASA Std. AR100. This was proven in a recent study by EASA and the UK-based Association of Electrical & Mechanical Trades (AEMT Ltd.): The Effect ofRepair/Rewinding on Premium Efficiency/IE3 Motors. This study validated through third-party testing that ANSI/EASA Std. AR100 repair best practices will maintain the efficiency of the repaired motor, whether it's a mechanical repair or a full rewind.

Based on that study, EASA and AEMT also published the Good Practice Guide to Maintain Motor Efficiency, a supplemental document which explains why these best practices are important and how they should be implemented. It's useful not only to service centers but also to practitioners who want to educate themselves about repair/rewind processes they receive. Download a free PDF of this guide at: **https://plnt.sv/2206-GPG**

Dirty filters restrict airflow into the machine, causing it to run hotter and increasing the risk of bearing and winding failures.

Alignment. Something commonly overlooked during the installation process is proper alignment. Make sure the alignment of the motor-drive system is within tolerance, not just an individual component. For example, flexible couplings often function adequately with a fair amount of misalignment. However, a motor-driven system will generate less heat and lower vibration levels if it meets or exceeds the most stringent alignment specification for that system. This will lead to longer bearing life and a more efficient motor-driven system that can save money on utility and repair costs.

Power supply. The quality of the power supply is important for winding longevity. Common concerns include variation in supply voltage that is more than +/-10% of the nameplate voltage, voltage unbalance at the motor terminals that exceeds 1% of the average voltage, and transient peak voltages at the motor terminals. Voltage variation and unbalance can increase winding temperatures and cause premature failures. Transient peak voltages at the motor terminals can damage winding insulation, creating turn-to-turn or ground faults.

CONDITION MONITORING

Once the motor-driven system is set up properly and you've handled the "big four" factors impacting motor health, condition-based monitoring can help prevent unplanned downtime. This could be as simple as having the service center check vibration, temperature, and insulation resistance on a prescribed timetable.

Remote condition monitoring with Industrial Internet of Things (IIoT) devices is the next step. These devices detect and record step changes in certain inputs and then prompt you to investigate. Some of them even use machine learning to reduce false positives, by getting "smarter" as they see more anomalies and receive feedback from users.

The key to success with either method is to evaluate and act accordingly when there is a step change in a monitored trend. This may prompt you to send a motor out for reconditioning before it fails, keeping your productivity up and your repair costs down. If you need help during the evaluation and action phase, rely on a service center that adheres to ANSI/EASA Std. AR100.

REPAIR STANDARDS

If repair turns out to be the best option, it's logical to ask how you can be sure the work will be done correctly. Fortunately, the motor repair standard approved by the American National Standards Institute (ANSI), ANSI/EASA Standard AR100-2020: Recommended Practice for the Repair of Rotating Electrical Apparatus defines the performance criteria for a quality repair. It also cites best practices from widely accepted industry standards organizations, such as ANSI, ABMA, CSA, IEC, IEEE, ISO, NEMA and NFPA. To be assured of the highest quality repairs, specify that they be made in accordance with ANSI/EASA Std. AR100-2020.

To learn more about ANSI/EASA Std. AR100-2020 and the "big four" or find a service center that participates in the EASA's Accreditation Program, visit EASA's Electromechanical Resource Center at www.easa.com/erc.

WHY CONSIDER AN EASA-ACCREDITED SERVICE CENTER?

EASA has long encouraged motor users to require that service centers adhere to ANSI/EASA Std. AR100. Many users also require that each step in the supply chain comply with some quality assurance program. The EASA Accreditation Program fulfills this need and beyond that, it has several components that are key to the efficiency and reliability of your motor fleet, including:

- use of calibrated equipment with traceability (where required for precision measurements)
- 23 audited categories covering everything from initial inspection to completion of the repair
- more than 70 motor repair/rewind criteria are audited to ANSI/EASA Std. AR100—from terminal connections to core testing, from shafts and rotors to frames, housings, and bearings and balancing
- continual, documented employee training
- internal and external auditing.

EASA's Accreditation Program requires annual internal audits and independent, third-party on-site audits initially and every three years to ensure compliance with ANSI/EASA Std. AR100-2020. Motor users can provide this accreditation to their customers to show that a critical part of their supply chain or process has a quality assurance program that meets the industry standard–ensuring efficiency and reliability.

Matthew Conville, MBA, P.E. is a technical support specialist at EASA, Inc., St. Louis, MO; 314-993-2220; (fax) 314-993-1269; www.easa.com. EASA is an international trade association of more than 1,700 firms in nearly 70 countries that sell and service electromechanical apparatus.

ENERGY MONITORING MEASUREMENT TO REDUCE COST

Six power quality measurements to uncover hidden issues in electrical systems

by Jason Axelson, Fluke Corporation

Hundreds of power quality measurements monitor electrical systems on your motors and drives. But these six, specific measurements can help uncover hidden issues in a plant's energy use which often lead to additional costs, equipment damage, and even unscheduled downtime.

1. VOLTAGE UNBALANCE

In a balanced, three-phase system, the phase voltages should be equal or very close. An unbalance in these measurements can cause poor performance or premature failure. These large problems can be caused by smaller issues that are much easier to fix if caught during regular, preventive maintenance measurements, such as:

- mechanical stresses in motors, often due to lower torque
- high current in motors and three-phase rectifiers
- unbalance current flowing through neutral conductors in three-phase wye systems.

The major costs are associated with motor replacement and lost income due to circuit protection trips. Replacing equipment combined with the cost of labor for the work and the unplanned downtime can add up quickly.

To catch voltage unbalance issues, look at the inputs to motors, VFDs, and UPSs. It's important to know how much of an unbalance should raise a red flag. According to the EN50160 power quality standard for required voltage unbalance, as a ratio of negative to positive sequence components, it should be less than 2% at the point of common coupling. NEMA specs call for less than 1% for motor loads. Consult your user manuals for other equipment. NEMA MG 1 states the motor must be derated for unbalance greater than 1%.

2. TOTAL HARMONIC DISTORTION

Total Harmonic Distortion (THD) is all harmonics on an asset combined. Some current distortion is normal, it's a part of a power system supplying electronic loads such as computers, business machines, electronic lighting ballasts, and control systems. But anything more than 5% on any phase should be investigated further. At this level, or for longer periods of time, it can cause problems like:

- high current to flow in neutral conductors
- motors/transformers running hot, shortening their lives
- increased susceptibility to voltage sags, potentially causing resets
- reduced efficiency of transformers, or a larger transformer is required to accommodate harmonics
- audible noise.

The major costs of THD are associated with the life of motors and transformers shortening. If the equipment is part of production systems, income can be affected as well.

To find these kinds of issues, take measurements and track baseline normal for your motors, transformers, and neutral conductors serving electronic loads. Monitor current levels and temperature at transformers to be sure that they are not overstressed. Neutral current should not exceed the capacity of the neutral conductor.

3. INCREASING PHASE CURRENT

As insulation deteriorates, it begins to leak. Loads will draw slightly higher current as they age, and they may send some of this leakage current into the grounding system. Faults within the equipment may also cause high ground current. These issues can lead to further damage, shortened asset life, unscheduled downtime, and unplanned cost if left for too long. Excessive phase currents can further damage insulation and overheat the load; over-current can cause protection devices to trip; and excessive ground current can create unsafe voltages on metal chassis, cabinets, and conduit.

With increasing phase current, the highest costs often come from premature motor failure and the lost income from

Figure 1. Taking preventive maintenance measurements with a power quality analyzer, like the Fluke 1777 Power Quality Analyzer can help you catch energy issues before they become too large.

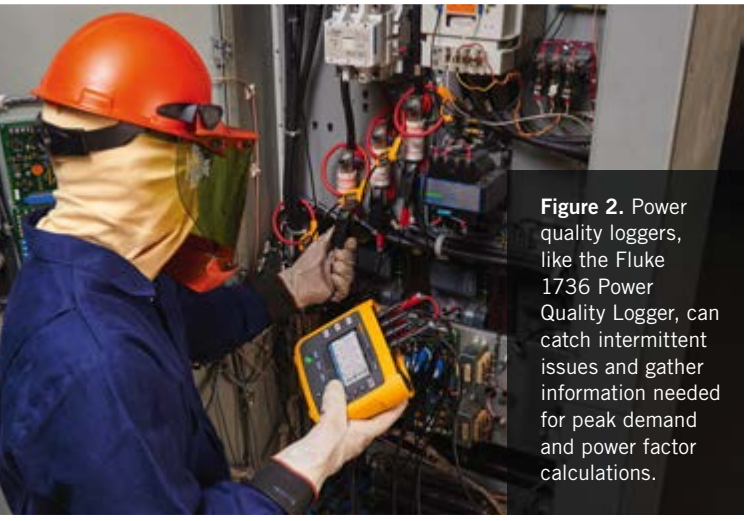


Figure 2. Power quality loggers, like the Fluke 1736 Power Quality Logger, can catch intermittent issues and gather information needed for peak demand and power factor calculations.

over-current protection devices tripping. In order to catch these issues before they become too large, regularly check and monitor any critical load, but especially motors, VFDs, and transformers. The best way to check insulation is by periodically checking equipment with an insulation tester. You can also check equipment while it's in service by measuring and tracking all the currents (phase, neutral, and ground) to make sure none of these are increasing significantly over time.

Measuring against the nameplate rating of the load should give you a baseline to raise red flags. The nameplate rating should never be exceeded. Track the phase current being drawn by a load over the months or years so you can get a sense whether the current is changing and take mitigating action before the issues are too big.

4. VOLTAGE SAGS

Voltage sags are momentary reductions in RMS voltage. Loads may be added without notifying plant management, and these loads may draw down system voltage, especially if they draw high inrush currents. Also, as electrical systems age, the impedance of the system may increase, making the system more prone to voltage sags. Most loads will operate at 90% of nominal voltage, but if voltage sags further or for extended periods of time, it can cause resets on electronic equipment or overcurrent protection trips. Sags on one or two phases of three-phase loads can cause the other phase(s) to draw higher current to compensate.

Voltage sags can lead to lost income when a computer randomly resets, control system resets, VFD trips, and shortened life of backup power system's UPS due to frequent cycling. As part of your preventive maintenance program, tracking measurements on motors, VFDs, UPSs, or panels serving power to computer equipment or industrial controls should help catch issues as they arise. Taking the steps to mitigate the problems before they get too large can save you unplanned downtime and cost.

5. PEAK DEMAND

Utilities monitor the amount of power a facility consumes. Several times an hour, utilities will calculate the average demand for that interval. Peak demand is the highest average demand during all the intervals in a billing cycle, and is what the company will charge based on. Commercial and industrial customers can manage the high cost of peak demand rates by staggering load cycles to reduce total draw at any one time.

The potential savings here depends on the rate schedule of the utility. But, checking a few things can help you adjust assets and schedules to cut peak demand rate costs, such as:

- Find out what demand interval the utility uses.
- Measure demand over time at the service entrance using a power quality logger.
- Look for significant loads operating concurrently, and use demand measurements to verify readings for the individual loads.

6. POWER FACTOR

Power factor is an equation to show energy efficiency in a facility. It's the ratio of working power (measured in kW) to apparent power (measured in kVA). Apparent power, or demand, is how much power is used to run equipment and machinery. Apparent power is found through the total amount of working power (kW) and reactive power, or wasted power (kVAR), combined. Power factor is usually expressed as a percentage—and the lower the percentage, the less efficient power usage is.

Utilities may charge higher rates or penalties for low power factor, penalizing facilities requiring higher reactive power. To avoid paying higher utility fees, power factor should be higher than .97. System capacity restrictions cause voltage drops and overheating, so capacitors may be applied on individual loads, at a confluence of several loads, or at the service entrance to improve power factor.

Looking into a few areas can help you reduce these costs. Understand if your utility rate plan charges for reactive demand or low power factor. Find out how the utility measures power factor. Are they looking at peak intervals or averages?

Finally, while running preventive maintenance routes through a facility, identify loads that are causing lagging reactive power. Once you know where the issues may be coming from, you can develop a strategy for power factor correction and eliminate as many utilities penalties as possible.

Jason Axelson is a product application specialist for Fluke (https://www.fluke.com/en-us), which manufactures electrical test and measurement tools, including multimeters, clamp meters and insulation, earth ground and installation testers. For more than 15 years Axelson has been helping customers and partners find solutions for Power Quality, Scope Meters and Battery Testers. He also conducts application training to help diagnose and resolve both technical and product inquiries.

Ask the Experts: Compressed Air Challenge

Start with understanding your current compressed air system, before building anew

In this Ask the Experts feature, which will run quarterly in Plant Services, expert instructors from the Compressed Air Challenge (CAC) will 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 facilities enjoy the benefits of improved performance of your compressed air system.

The first question in this series: "My compressors are failing, and I need to buy replacements. What should I do to renew my compressed air system?"

Chris Beals (Denver CO, L1 Trainer): The first thing that should be done is to have a compressed air system review performed, in a product neutral way, by a qualified compressed air system auditor. Why product neutral? This is recommended to put the client's best interests first, rather than promoting the interests of the service provider sales staff. Customers should have a discussion about this prior to contracting with a provider to perform the compressor air system review. The review should provide the end user with the proper size and types of compressors and dryers, and the information required to maximize the system efficiency and reliability. Armed with the information from the review, the end user can then request bids from their local compressed air equipment distributors. While price is often a major factor in whose compressors are selected, the end user should consider the vendor with the best service reputation, even if the compressed air equipment costs a little more.

For more information about selecting a service provider see "Guidelines for Selecting a Compressed Air System Provider" in the Compressed Air Challenge website library (www.compressedairchallenge.org/library).

Greg Ashe (Kaeser Compressors, Denver, CO, L1&2 Trainer): Understanding why the existing equipment is failing should be the first step before new equipment is evaluated. Are they old and have run their course, due for maintenance, or installed in a harsh environment? Correcting the environment in which the compressors operate can make new equipment last longer while requiring less maintenance and maybe most importantly less downtime. Once the reason for failure is understood, we should look at how much air is needed and at what pressure.

A common practice is to replace existing equipment with identically sized new equipment, which assumes the original equipment was sized correctly and there haven't been any changes to the compressed air demand. This is often a false assumption given that compressed air leaks are always growing and plant production is ever changing.

There are various levels of compressed air audits that can help size a new system, and arguably the larger the system the easier it is to cost justify a thorough study. The most complete studies include both the supply and demand side of the system, but smaller systems can also benefit from a simpler audit so long as it's accurate.

Whatever the data, it's important to have it properly interpreted and explained by an experienced professional because things are not always what they seem, and compressed air systems are no exception. Armed with a report on how much air is currently needed and, perhaps, an estimate of future air needs, if available, it's finally time to look at new equipment options.

Bill Scales, P.E. (New Hyde Park, NY, L1&2 Trainer): Excellent question, which may address or raise other problems and additional questions. It is important to review maintenance records for each of the multiple (two, three, or four) compressors.

ABOUT COMPRESSED AIR CHALLENGE

The mission of Compressed Air Challenge (www.compressedairchallenge.org) is to promote energy and operational efficiency in compressed air systems for industry through information and training, leading end users to adopt efficient practices and technologies while leveraging collaborative cooperation among key stakeholders. To carry out its mission, CAC maintains a group of 20 highly qualified and experienced instructors who are available to deliver its various product-neutral training offerings through in person or online training delivery. To learn more about upcoming training opportunities visit the CAC calendar at https://www.compressedairchallenge.org/calendar.

- Are they from the same manufacturer and about the same age?
- What are some of the reasons for individual compressor shutdowns?
- Is it a specific component that is common to each?
- Does the plant do its own maintenance or have a service agreement?
- Are manufacturing processes affected if one compressor shuts down?
- What are the design operating pressures of the compressors, and present compressor discharge pressures?

If you have taken the CAC's Fundamentals of Compressed Air Systems training, you may have a copy of our Best Practices for Compressed Air Systems Manual. Refer to Section 2 titled "The Supply Side – Compressor Room Equipment," which guides the reader through selecting compressors, treatment equipment, cooling methods, condensate removal methods, compressor controls and primary receivers, pressure/flow controllers, and methods of interconnecting components for optimum performance. To obtain a copy check out the CAC's bookstore (https://www.compressedairchallenge.org/bookstore).

Do you have a compressed air related question you would like to ask our experts? Email training@compressedairchallenge.org to request an answer.

One other thing, be sure to repair all compressed air leaks, and set pressures for compressors and the system at the lowest pressure that maintains production requirements.

Paul Shaw (Berlin, CT, L1&2 Trainer): I would start by understanding the existing system, both the pros & cons. What does it do well, what doesn't it do well and why is there a need to replace it. I would then do a walk-through and data log the system to determine the demand side requirements for flow and pressure, check for leaks and inappropriate uses, and finalize how much compressed air is needed both for the present and possible future expansion.

I would also like to understand the current power costs and voltage, the existing piping network to see if it is adequate or needs improvement, and the budget for the project. Once we have that information, we can determine the type and size of the compressor, whether it needs to be oil-free or lubricated, the control type, and the storage, drying, and filter requirements. Energy efficiency, heat recovery, space requirements, and reliability should also be part of the final analysis.

Ron Marshall (Winnipeg, MB, L1&2 Trainer): One often overlooked item when considering replacing compressed air components is awareness. It is difficult to persuade the people buying the new equipment of the benefits of purchasing more efficient premium compressors and related components, because they don't know what is possible. And often the users of the compressed air in the industrial plants do not know about the high cost of wasting compressed air through leakage and inappropriate use.

Since the electrical cost of producing compressed air is by far the largest part of the life cycle cost of an air compressor, often consuming more than the purchase cost in a single year, it pays to be educated about what options are available when purchasing compressed air equipment. Awareness of end use and waste reductions can also help; sometimes enough savings can be found on the demand side of a system to eliminate the purchase of one or more compressors and the associated components.

I would suggest sending key staff at least to our Fundamentals of Compressed Air Systems seminars to help them learn what is possible. Participation in our Advanced Management of Compressed Air Systems, and Compressed Air System Assessment & Project Development seminars can also lead to additional important knowledge of how to address complex compressed air problems and how to calculate possible savings. Also available is a User Awareness option.

ACHIEVE ROBUST PROTECTION FOR MODERN GEARBOXES

Consider the benefits of synthetic industrial gear oils to extend drain intervals and protect your gearboxes

by David Hobson and Daniel O'Meara, Lubrizol

The cost of machine downtime can be astronomical in industrial plants, and facility managers are tasked with doing everything in their power to maximize uptime and reliability.

Industrial gearboxes are common assemblies found inside a wide variety of industrial environments, such as wind turbine drives, conveyer belt drives, robotics, or crusher drives. A single part failure inside a gearbox can result in complete production shutdown, lost throughput, lost revenue, and high maintenance costs. Typically, the minimum production downtime from a gearbox failure is around two to three hours. For somewhere like a steel mill, this may mean losses in production totaling in excess of $200,000 per hour. This doesn't include labor costs, which can be excessive if outside contractors are required to make repairs. For large mills, these costs can balloon exponentially.

This scenario serves to highlight the importance of high-performance industrial gear oils (IGOs) and their ability to provide robust protection for these critical pieces of machinery. In recent years, IGOs have become even more important, with industrial markets demanding higher productivity and 24/7 operation, elevated levels of protection to ensure durability and extended gearbox life, and increased power to operate at a range of extreme temperatures.

How have IGOs managed to keep pace with these growing demands? In this article, we'll explore the evolution of IGOs, some inherent challenges involved in modern formulation techniques, and how the right chemistries can help provide complete protection to help plants get the most from their most critical gearbox applications.

MODERN MACHINE DEMANDS

Modern industrial activity has sought efficiency gains in every aspect of regular operation—and IGOs are no different. Today, it is expected that IGOs provide longer drain intervals so that the maintenance of replacing the oils must be performed less frequently. Simultaneously, modern gearboxes have become smaller and operate hotter in order to minimize design footprint and maximize efficiency, respectively.

These needs are driving formulations toward the use of synthetic base stocks rather than traditional mineral oil base stocks. Particularly within environments that regularly experience harsh conditions (mining, marine, wind, and steel), synthetic IGO formulations can deliver extended drain intervals while providing robust protection for all elements of the gearbox, helping to lower total cost of ownership for critical equipment.

FORMULATING HIGH-PERFORMANCE IGOS

So, how have IGOs evolved to accommodate these demands? First, it's important to understand the fundamental performance characteristics synthetic IGO formulations must provide in today's gearboxes:

- wear protection, helping to prevent failure modes like micropitting, cracking, and scuffing
- foam control and air release
- compatibility with non-metal components within the gearbox, including paint and seals.

These performance characteristics (and others) are codified within various stringent standards from OEMs or governmental agencies and national standards. In some cases, IGO products may need to meet more than 20 specifications, including those from major gearbox OEMs like Flender, SEW, Sumitomo, and ZF Industrial.

Performance meeting these standards is realized through the addition of chemical additives to the synthetic base stock. These additives ensure wear protection, corrosion protection, water shedding, and foam control. Large advancements in antiwear chemistries have been made in recent years to ensure gearboxes are protected robustly against a multitude of possible failure mechanisms. In order to have a stable blend of polar chemical additives in a nonpolar synthetic base oil, a compatabilizing chemistry is also incorporated. The compatabilizer must not compromise the benefits of using a high-quality base oil, high-quality additives or compromise the kind of performance that plant teams depend on.

COMPATIBILIZER COMPLEXITIES

However, modern gearbox operating conditions have created some challenges to this simple-sounding recipe for high-performance IGOs. Traditional compatibilizers have been ester-based, a chemistry that has long been cost-effective and readily available while providing the right characteristics for formulating. But esters' chemical makeup can change when in contact with water ingress (a condition faced by marine gearbox applications), which can alter the IGO's performance. Excessive heat—a condition inherent to smaller, more efficient gearboxes—can also cause esters to change, compromising performance. Finally, esters are not always fully compatible with modern paint formulations and seal compounds.

Seal compatibility is in fact one of the biggest challenges to the use of some compatibilizers in new IGO formulations. Particularly in dynamic applications, where a shaft exits the gearbox and operates at different speeds at various intervals. At the point where the shaft exits the gearbox, a radial seal helps prevent lubricant leakage as well as ingress of contaminants from the exterior of the gearbox. The IGO must be benign to the seal, not causing any chemical breakdowns that may cause for example embrittlement, shrinkage, softening, or hardening.

Traditional ester-based compatabilizers can interact with seals in high temperature environments and cause excessive seal swell—a swollen seal, over time, will eventually act as a grinding mechanism against the shaft. This scenario will inevitably cause the sealing contact to fail, leading to costly maintenance and downtime.

MEETING THE NEEDS OF MODERN FORMULATION

Delivering complete IGO solutions that do not compromise on performance at any level requires new compatibilizer chemistries that enable a broad range of performance characteristics without inadvertently causing material compatibility issues in modern gearboxes. The ideal IGO formulation enables robust tribological protection of critical gearbox bearings while not interfering with the chemical composition of the seal.

For plant operators, it's also important that compatibilizer chemistries interact with older gearbox technology—backward compatibility is important for operational efficiency. The ideal IGO formulation for modern gearbox applications enables high performance in a brand-new gearbox as well as older models, allowing plant operators to stock a single IGO for every gearbox. Importantly, this ideal IGO should further meet a broad range of OEM and national standards for the most widespread applicability and robust protection of critical gearbox components.

Armed with greater knowledge of what makes for an ideal IGO, it can behoove plant operators to work closely with their lubricants suppliers to make the most informed choice for your operations. The right formulation can help eliminate unnecessary maintenance and downtime, enhance operational efficiency, and bolster the bottom line.

David Hobson is technology manager for industrial additives, and Daniel O'Meara is industrial OEM manager for The Lubrizol Corporation (www.lubrizol.com), based in Wickliffe, OH.

AD LITS

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It's not hard to rethink your energy plan

Nervous about how current events will impact your energy costs? Take the time to build in few flexibility

Peter Garforth heads a specialist consultancy based in Toledo, Ohio and Brussels, Belgium. He advises major companies, cities, communities, property developers, and policy makers on developing competitive approaches that reduce the economic and environmental impact of energy use. Garforth also is a Plant Services contributing editor, writing our bimonthly Energy Expert column. He recently spoke with Editor in Chief Thomas Wilk on how a current confluence of crises is underscoring the security and cost risks of fossil fuel dependency, and why it has the potential to reshape the energy landscape.

PS *What is your sense of how strategic the thinking is right now around energy in industry? Are organizations asking the right questions?*

PG Let's start with the good news. If you look at the three big energy-consuming sectors of the world, over the last 20-30 years on almost any tracking index, industry worldwide has outperformed transportation and the built environment (homes, buildings, and some non-industrial processes) in improving energy efficiency.

Just as a quick reminder, energy causes 70% of the anthropomorphic, or human-induced, climate change effect; so energy is the heavy hitter, along with land use and some specific manufacturing processes.

So that's the good news, and that also says there's a lot of DNA already in the industrial sector too that can be harnessed and pulled together to create that next big step, which is to go from where we are to where we are self-declaring where we want to be, which is something in the range of net-zero emissions, which essentially says eliminate all fossil fuel use one way or the other. There's a lot of good practice built up over the years to help us get there.

The less good news is going from where we are today to that net-zero in something well under a single generation is going to require deep rethinking of the energy infrastructure of corporations. That's going to require game plans, which are not the usual operational ones with "we'll do it if we can manage it but manufacturing always has the first priority" or similar pressures. We're going to have to bake our net-zero goal into the decision-making at all levels, be it as simple as retooling a production line up to deciding on the location of a new factory or whether to close an existing factory.

In other words, we now need a very robust roadmap, which must have a horizon at least as long as your target. So if your target says 2035 net zero, then that's the minimum for your horizon. If it says 2050 net zero, same thing. So, at a minimum, align your goals and your plans, and that's not a new thought, it's just a rational normal process.

Then the next thing; you cannot write a 30-year operational plan. You don't know all the variances that will come up. You don't know the policy changes. You don't know the market shocks. You don't know the outcomes of current situations like Ukraine. You don't know technology cost. So there's lots and lots of variables.

The roadmap not only has to be very disciplined in terms of what goals it's trying to achieve, but it also has to be very flexible in its governance, its decision-making process, its capital allocation process to make sure it can absorb technical policy cost market shifts, which are completely unpredictable if you're looking at more than, let's be honest, a few weeks. That is the paradox, that we need a game plan that's robust, bounded, and goal driven, but it's also flexible, not only in its content but in its governance, to allow changes to be absorbed without losing track of the goal.

PS *Operations teams have the access to the kind of data that would be involved to build these plans, right? And it's not that onerous to build a plan.*

PG It's not. If you take the average corporation, the biggest variables of course are always, what's going to be the market volume, and the production volumes of any given plant. We've got other obvious variances that you see as the drivers of the energy performance of a corporation. The analytical planning aspect of it is not as onerous as you would think, especially given that industry has usually pretty good tracking data.

But if you look at it in terms of creating a successful roadmap, the governance discipline, key will be the allocation of authority to allow business managers, utility managers inside plants, facility managers, production line managers, real estate managers within the corporation to make coherent decisions that all contribute to that big game roadmap.

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