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COMPRESSED AIR INNOVATION

TEN YEARS OF PROGRESS IN THE 4TH UTILITY POINT TOWARD A MORE RELIABLE, ENERGY-EFFICIENT FUTURE

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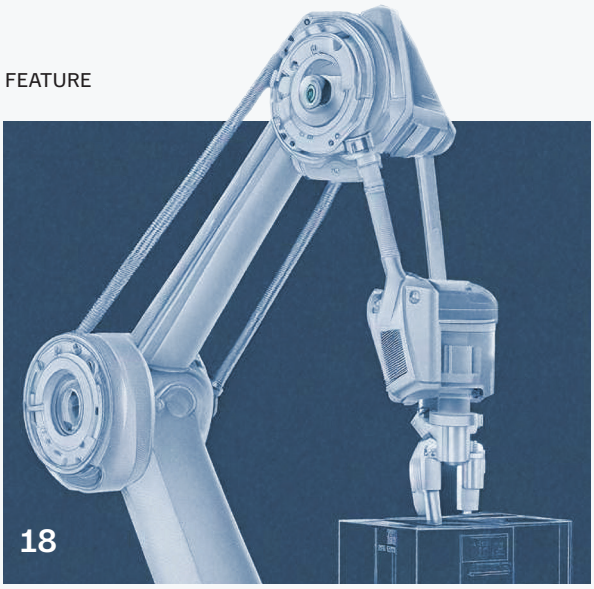
FEATURE



Key Considerations For Cobots: Plan, Install, Operate, And Maintain

Cobots are an extension of your production systems, and these steps can help you integrate them fully into your operation

COLUMNS

DEPARTMENTS

COVER STORY

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Compressed Air Innovation

Ten years of progress in the 4th utility point toward a more reliable, energy-efficient future

ENDEAVOR BUSINESS MEDIA

Endeavor Business Media, LLC
30 Burton Hills Blvd, Ste. 185
Nashville, TN 37215
800-547-7377

Chris Ferrell
CEO

June Griffin
President

Patrick Rains
COO

Paul Andrews
CRO

Jacquie Niemiec
Chief Digital Officer

Tracy Kane
Chief Administrative & Legal Officer

John DiPaola
VP & Market Leader
jdipaola@endeavorb2b.com

Jeff Mylin
Business Development Manager
jmylin@endeavorb2b.com

Brennan Lafferty
Business Development Manager
blafferty@endeavorb2b.com

EDITORIAL STAFF

Thomas Wilk
Editor in Chief
twilk@endeavorb2b.com

Anna Townshend
Managing Editor
atownshend@endeavorb2b.com

Alexis Gajewski
Senior Content Strategist
agajewski@endeavorb2b.com

Michael Annino
Art Director
mannino@endeavorb2b.com

CONTRIBUTING EDITORS

Joe Anderson, CMRP, CRL, CARO
David Berger, P.ENG.
Sheila Kennedy, CMRP
Joe Kuhn, CMRP
Doc Palmer, P.E., MBA, CMRP
Jeff Shiver, CMRP, ARP, CPMM, CRL

PUBLICATION SERVICES

Robin Darus
Sales Support Specialist
rdarus@endeavorb2b.com

Edward Bartlett
Production Manager
ebartlett@endeavorb2b.com

Melissa Meng
Ad Services Manager
mmeng@endeavorb2b.com

Subscription Requests
Local: 847-559-7598
Toll free: 877-382-9187
PlantServices@omeda.com

THOMAS WILK
From the Editor

CONCENTRATION

This issue of Plant Services features a terrific cover story from Ron Marshall, our resident expert on compressed air systems. His story continues our occasional look back this year at the past 10 years of maintenance and reliability, and he charts the evolution of compressed air technology across three key areas: technology design, asset management, and industry-wide performance metrics and training opportunities.

Part of what struck me about Ron's article was the breadth and depth of his memory when thinking back on significant changes in industry. True change often happens when an innovation is so compelling that change doesn't feel like a disruption. In cases like that, it can take a good memory and strong attention to detail to remember how things used to be done, and why they were done that way.

In general, people who work in our industry have an unusually strong sense of concentration and institutional memory. With physical assets that can last 20 years or more, it's practically a job requirement for maintenance technicians to have a deep knowledge of those assets' operating histories and failure modes. I was reminded of this during a podcast interview with Cintel's Dave Aebischer, who I met at this year's Leading Reliability conference. He gave a presentation on how he used vibration analysis and motion amplification technology to troubleshoot a structural resonance issue on power generators that were failing regularly the field.

Thing is, to help solve the more recent problem, Dave remembered back 25 years to when he had seen a similar resonance issue crop up on previous generators used in the same footprint. His ability to recall and apply that previous solution was key in getting ahead of the more current set of failures, something that he discusses in depth in a new episode of our Great Question! podcast.

Our leadership columnist Joe Kuhn calls this a "Go and See" mindset, where intense observation and frequent floor walks are used to reinforce a problem-solving mentality. Joe writes in this issue that "observation is required to fully understand current state and reveals simple and rapidly implemented solutions—most often at zero cost."

Condition monitoring tools and data historians have given technicians the ability to scale their knowledge and expertise, but the human mind is still critical in knowing what to observe and how to make key problem-solving connections across time and across assets. Δ

Thomas Wilk, Editor in Chief
twilk@endeavorb2b.com, (630) 454-7012

JOE KUHN
Leadership in Action

6 SIGNS OF A RELIABILITY CULTURE

Best-in-class reliability tools are secondary to a culture that focuses on eliminating waste

Engineers, maintenance managers, and plant managers are all looking for transformative best practices, tools, or equipment design improvements that will elevate their equipment reliability and cost performance to world class. The reality we all eventually face is that there is nothing we can buy off the shelf to shortcut the journey toward reliability excellence. If there was, everyone would have it.

Equipment reliability only comes from a change in how we think and act; in a word – culture. A misguided path taken by many practitioners is to simply implement every tool employed by others deemed best in class. Example: Plant A has a CMMS, a full-time reliability engineer, OEE teams, a Tuesday planning meeting, separate planned and unplanned work crews, oil sampling and vibration analysis on all critical assets, 20 KPIs that are tracked, one planner for every 20 craftsmen and one supervisor for every 10 craftsmen.

All we need to do is mirror what Plant A is doing and we will get Plant A results. What can go wrong?

IT IS ALL ABOUT WASTE

If you only remember one thing from this article, let it be this: Reliability is a relentless pursuit of waste elimination. Every reliability best practice targets inefficiency.

Why do we plan work? Answer: to ensure prioritized work is executed safely, downtime is minimized, precision work is performed, work performed is efficient, and the equipment returns to service on time making quality product.

What do all these have in common? You got it, waste. The challenge of the change agent is to know the specific wastes in your plant and then to apply the right tool to reduce or eliminate it. Eventually you may deploy each tool, but sequence matters a lot. Establishing organizational momentum (quick wins), positive business results and maintaining long-term sponsorship are critical to every change effort. Countless reliability change efforts have died because a lack of tangible business results produce a lack of confidence by management. In my plants, results needed to be seen in 90 days or less.

Imagine you are the coach of a basketball team. From game film and statistics review, you determine you are losing games in the fourth quarter due to player exhaustion and poor free-throw percentages. Now a consultant compels you to implement best practices of great basketball teams beginning with passing, turnovers, and shooting 3-pointers. Your team will garner more wins faster by focusing on conditioning and foul line performance.

WHAT CHARACTERIZES A RELIABLE PLANT?

I have worked in 41 different locations across the globe – some as a practitioner, three as a plant manager, and many as a consultant. Every plant is on a reliability journey. Those that are accelerating forward with sustainable results I have found have a few things in common. Here are six:

- **A culture of "Go and See":** KPIs point you where to look for wastes, but they are not a substitute for using intense observation to know reality. Observation is required to fully understand current state and reveals simple and rapidly implemented solutions—most often at zero cost.
- **A problem-solving culture:** Everyone at the plant knows how to surface problems and how changes get implemented. It is a formal, trained, and documented process. Examples: Overall

Joe Kuhn, CMRP, former plant manager, engineer, and global reliability consultant, is now president of Lean Driven Reliability LLC. His YouTube Channel offers content on creating a reliability culture as well as financial independence to help you retire early. Contact Joe Kuhn at *joekuhn1964@gmail.com*.

equipment effectiveness (OEE) teams assigned to critical assets; a dedicated reliability engineer.

- **A culture of accountability:** All employees know their jobs, and there are consequences to doing it well and poorly. Examples: performance expectations with numerical targets and by-when dates; a morning meeting where the results of yesterday are detailed along with help needed for today and tomorrow to meet expectations. Management spends a significant amount of time connecting the dots of daily actions to long term results. Sustained poor performance is addressed by management.
- **A culture of learning:** Failure is accepted as an accelerated learning tool. A training system exists to ensure precision maintenance is known and is being executed. Risk aversion is discouraged because it is the major obstacle for culture change. New technologies are tested and implemented.
- **A culture of execution:** A process exists for getting work identified, approved, and executed. Obstacles are anticipated and counter measured by supervisors and planners. Despite obstacles, we get the job done.
- **A partnership culture exists between maintenance, engineering, and production:** While I vehemently advocate that reliability is owned by operations, everyone has a critical role to play in producing a winning team. Blaming of others is rare.

WHAT IS MISSING?

In my experience, all tools are secondary. It's a trap; tools and processes are what you see when you go to a plant but not what makes the plant reliable. Decisions and behaviors are below the waterline of the reliability culture glacier.

If you have seen the movie Moneyball, you witnessed the team manager (Billy Beane) transform the Oakland A's from mediocrity to a contender by shifting focus from what has been traditionally valued by owners and scouts to what really mattered to winning (getting on base). The A's competed with the New York Yankees on one-third of their budget. This philosophy was quickly adopted by all major league teams.

What really matters with reliability and maintenance? Eliminating waste. Δ

SHEILA KENNEDY
Technology Toolbox

SIMPLIFY LUBE MANAGEMENT

New software and technology help you upgrade your plant's lubrication program

LUBRICATION PROCESS IMPROVEMENT

Mobile apps and oil monitoring systems streamline routine tasks. The new eLube app from **SKF Lincoln** spawned a new family of products, including its CLP Smart Series compact lubrication pumps that can be wirelessly set, monitored, and controlled using the app on a smartphone.

From the SKF eLube app, users "can check the status of their system or even initiate a lube sequence remotely. This feature streamlines the workflow for lube technicians, virtually eliminating the need to physically visit their individual systems," observes James Verseman, automated lubrication systems (ALS) product manager at SKF Lincoln. "Time saved means more efficient operations and enhanced productivity."

The LubePM mobile app from **Noria Corporation** extends its lubrication program management platform to include lubrication route management and execution. The cloud-based app elevates lube route efficiency, reduces lubricant waste, increases accountability, and provides real-time reporting and analytics.

Noria Corporation President Bennett Fitch says LubePM "enables technicians with a mobile tool to tackle daily lubrication tasks and help them learn best practices on the go. Behind the scenes, it doesn't just store data; it contains algorithms to dynamically build lubrication job plans, optimize lubrication intervals and volumes, prioritize cost-avoidance initiatives, and report key metrics from everyday lube routes."

The new LUBExpert ON-GUARD online monitoring system from **SDT Ultrasound Solutions** supports smart ultrasound-assisted relubrication. For Dylan Heit, a reliability manager in the pulp and paper industry, transitioning to ON-GUARD enabled continuous frontline asset health monitoring and alarming, precise autonomous condition-based lubrication functionality, and real-time temperature indication.

"We put SDT's ON-GUARD to the test on a highly lubrication-sensitive asset, considering both temperature and response variabilities. The system's condition-based lubrication data revealed a nearly 50% reduction in grease requirement at the non-drive end bearing location compared to the drive-end bearing on the same rotor, offering valuable insights for future program strategies," Heit explains.

LUBRICATION MEETS IIoT

Real-time, continuous condition monitoring with the WearDetect IoT platform from **Gill Sensors & Controls** provides early warning of mechanical damage to ferrous components. It can detect and differentiate between normal wear (fine particles) and damaged component scenarios (coarse particles), trend fine particle wear rates, and send alerts to key personnel to avoid critical component failure.

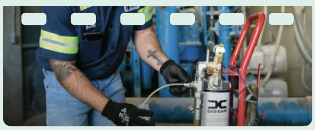
According to John Warhurst, technical product specialist at Gill Sensors & Controls, no special training is required to interpret the data produced, making it a highly effective but simple addition to a condition monitoring strategy. "The maintenance team receives the earliest awareness of equipment wear and greater control over their preventative maintenance and production schedules," he adds.

The OPTIME Ecosystem from **Schaeffler** merges smart condition monitoring with lubrication management, forming a comprehensive IoT predictive maintenance solution. Operated from a mobile app, it supports day-to-day maintenance operations and helps in creating data-based maintenance plans.

"By combining the plug-and-play functionality of our OPTIME CM sensors with the convenience of our intelligent OPTIME C1 automatic lubricator, the OPTIME Ecosystem allows customers to simplify two very important maintenance tasks, while at the same time benefiting from

Sheila Kennedy, CMRP, is a professional freelance writer specializing in industrial and technical topics. She established Additive Communications in 2003 to serve software, technology, and service providers in industry. She can be reached at *sheila@addcomm.com* or *www.linkedin.com/in/kennedysheila.*

VIDEO REFERENCES



LubePM
↗ https://www.youtube.com/watch?v=p1ZSrPUbSvY

STD Ultrasound Solutions
↗ https://www.youtube.com/watch?v=mp_jDhpqKQU

significant cost savings and contributing to sustainability by reducing unplanned downtimes and waste," says Felix Tenner, VP of Schaeffler Lifetime Solutions Americas.

Collecting real-time data from a network of online oil quality sensors from **Poseidon Systems** and combining it with traditional lab samples and SCADA data enables robust oil analysis. Oil condition monitoring software in Poseidon Live, the company's IIoT solution, enables this holistic view and understanding of oil health.

"There is a lot of buzz about generic failure prediction algorithms using ML or AI," observes Jeff Lubkowski, director of product development at Poseidon Systems. "Our predictive algorithms integrate high quality, asset-specific data collected by our next-generation, real-time oil condition sensors, ensuring that we identify and prevent the 'unexpected' failures as well as those that are statistically likely."

Machine Vitals sensor technology from **Trico Corporation**, a new addition to its Sensei IIoT Network, integrates into the headspace of oil reservoirs for real-time condition monitoring data collection to help bridge the gap between oil analysis intervals.

The integration of Machine Vitals' health data with historical maintenance logs offers a robust framework for comparative analysis when reviewing oil analysis results, notes Dan Freeland, application engineer at Trico Corporation. "And, if opting for oil analysis through Trico, it ensures that these results are woven into the Machine Vitals platform, providing a detailed and comprehensive insight into your machinery's condition." Δ

DOC PALMER
Palmer's Planning Corner

HOW MANY PLANNERS DO I NEED?

Whether you aim for 1:30, 1:15, or 1:10 depends on factors like crafts, geography, and personalities

"How many planners do I need?" is a great question! A ratio of having one planner for every 20-30 craftspersons is a great benefit to a company, but better ratios of having one planner for even fewer craftspersons makes sense as well. We should consider exactly what we are doing with these planners and think about new work, jobs-in-progress, project teams, dual roles, geography, and even planner personalities.

PLANNING AND SCHEDULING, PROPERLY DONE

Planning properly done is making the best job plan possible subject to the constraint that we must plan nearly all the work. We all want fantastic plans as a guide for new craftspersons and a reference for senior craftspersons, but we simply cannot start there. Instead, we set the planners up to run a Deming Cycle of continuous improvement over the years, especially incorporating craft feedback.

A good question is, "why don't we want the planner to make a fantastic plan to begin with?" Well, for one reason, planners simply do not have the time to make a perfect plan for each and every job from scratch. We also need to admit that no plan is ever perfect anyway. Instead, we set our planners up from the start to get all the jobs through a cycle of continuous improvement, forever looking for opportunities for plan improvement. This approach leads to better job execution over the years as we utilize learned knowledge.

Another good question is, "why do we need to increase our work order completion rate if we are a good, profitable company?" Simply put, good companies still have a fair amount of reactive work whereas great (more profitable) companies have hardly any reactive work. Good companies cannot get to the extra proactive work to keep things from breaking in the first place. Fortunately, the addition of a planner makes 30 persons as effective as 45 (the 50% increase), with the extra 15 persons doing purely proactive work.

SO, HOW MANY PLANNERS DO I NEED?

A single planner can keep up with 20-30 craftspersons, considering that the planners do not have to make perfect job plans and they make weekly schedules simply as a full list of work to challenge supervisors. This 1:20-30 ratio assumes that about 30% of the work being pre-planned is PM work that does not need much planner attention.

Some persons advocate having a planner for every 15 craftspersons. Certainly, this 1:15 ratio allows making better job plans. However, do not lose sight of the ultimate value of planning as a system of improving plans over time. And do not waste extra planner capacity making overly complicated schedules. (I wonder if some value of advocating for a 1:15 ratio is to make sure that management gives us at least 1:25 ratio.)

A planner-to-craftsperson ratio of 1:10-20 is certainly a benefit. With the extra planner capacity, the planners can also help craftspersons with jobs-in-progress find information on the fly as problems pop up. Generally, planners cannot spend the extra time to help jobs-in-progress when trying to stay ahead of 20-30 persons. Fully loaded planners must count on skilled craftspersons owning the job once jobs go into progress. But the planner is a great resource to help resolve unexpected field conditions and could help some jobs if planning for fewer than 20 persons. Helping jobs-in-progress, of course, should not preclude planning

Doc Palmer, PE, MBA, CMRP is the author of McGraw-Hill's Maintenance Planning and Scheduling Handbook and is managing partner of Richard Palmer and Associates. For more information including currently scheduled workshops, visit *www.palmerplanning.com* or email Doc at *docpalmer@palmerplanning.com*. Also visit and subscribe to ww.YouTube.com/@docpalmerplanning

all the new work coming in. The exception would be that on-the-fly help for a true emergency job always trumps everything else.

Going further, a planner to craftsperson ratio of 1:5-15 is still a benefit. For the 50% productivity bump alone, 1:2 is a break-even point: one planner plus two craftspersons are as productive as three craftspersons. But the advantage goes further. The planner can stay ahead of planning the new work, can help jobs in progress, and can be on some teams such as for projects, safety, and root cause analysis.

Ratios of 1:5-10 also allow planners to have dual roles. Perhaps the planner can also run a small storeroom or do predictive maintenance analysis. Nonetheless, the dual role should be a staff role. Try not to combine a planner role with a supervisor or craftsperson role. Supervisors and craftspersons perform line roles that cannot be put on hold. Combining such staff and line roles frequently result in the staff role of planner being neglected.

THE HUMAN ASPECT OF PLANNING

Other considerations for optimizing your planner ratio include geography, multiple crafts, and planner personalities. The planner ratios generally depend simply on numbers of craftspersons regardless of asset quantity or value: "For so many craftspersons we need so many planners." But a single planner might be planning for several geographically close facilities, each with only a few craftspersons. Planner travel might justify planning for fewer than 20 persons. Also, a single facility might have only 10 craftspersons, but several crafts being mechanics, electricians, and instrument techs that would keep a single planner busy. We also cannot forget the human aspect – some planners are simply faster than others. One planner may be able easily to stay ahead of 30 craftspersons while another planner might be better planning for only 10 persons.

Finally, adding an additional person is a major (painful) step at almost any company. But we are not doing that! If you have 20 craftspersons, promote a craftsperson to a supervisor equivalent role as a planner. Voila! With planning, you get 10 persons for free out of your remaining 19 craftspersons. You have 29 persons for the same cost as 20.

The more planners the merrier. Planners help us save and apply knowledge for better job execution. Planners help us complete more proactive work to eradicate failures. Our plants become more available, more reliable, more environmentally responsible, and safer.

We better accomplish our mission. We grow beyond good to great! Don't settle! Δ

JEFF SHIVER
From the Plant Floor

6 CAN'T-MISS RELIABILITY CHECKPOINTS

Use these to take your program to the next level

With many individuals, the question is often, "Where do I start or continue?" To that end, this article presents a foundational roadmap with six checkpoints for individuals and their organizations to better their journey in maintenance and reliability practices.

#1: MAINTENANCE PLANNING AND SCHEDULING

Establish a formal planning role and staff it with a skilled craftsperson. Clearly define the planner's responsibilities and authority. Train them and maintenance supervision as a minimum on the function. To start, prioritize the work using a simple ranking with a 1-4 scale (emergency, urgent, planned, outage). Begin with basic job planning by creating simple job plans for corrective work, including required parts, tools, and estimated time. Provide a feedback form so technicians can help improve the job plans over time.

#2: COMMUNICATION AND COLLABORATION

Establish a cadence leveraging work process systems to build the partnership between maintenance and operations. Hold a cross-functional meeting weekly to develop work priorities and a weekly maintenance schedule. Ideally, operations will appoint an operations gatekeeper(s) to interface with the maintenance planner(s) and supervisor(s).

#3: IMPROVE EQUIPMENT MAINTENANCE STRATEGIES

I strongly encourage you to take a reliability-centered maintenance (RCM) introductory course to understand the framework. In doing so, you will approach PM optimization very differently. With optimization, the failure modes are identified, and tasks are developed to address them in a way that is both technically feasible and worth doing. For condition monitoring tasks, provide specifications that find the potential for failure early enough to plan and schedule the corrective actions to reduce the amount of reactive work. Focus on precision maintenance approaches.

#4: CMMS

Use your CMMS to ensure that the equipment hierarchy is correctly identified using parent-child relationships down to the lowest appropriate level. When possible, write work orders to the child asset (i.e., the motor as opposed to the cartoner) to build good equipment history. Leverage failure codes as well to assist in understanding opportunities for improvement. Adhere to the concept of "no work order, no work or parts" to help understand where asset issues exist and reduce MRO storeroom stockouts.

#5: MAINTENANCE PLAYBOOK

Begin with basic standard work procedures such as planned work execution. Document the process workflows and RACIs, training personnel in the processes. Audit three work orders each week to ensure that the processes are working. Use the audits to look for continuous improvement opportunities.

#6: PERFORMANCE MEASURES

In addition to operations measures like overall equipment effectiveness (OEE), establish maintenance execution metrics such as labor utilization, PM compliance, schedule compliance, schedule breakers, and planned vs. unplanned work to capture and show improving trends over time. Δ

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

Written by
Ron Marshall
Marshall Compressed Air Consulting

COMPRESSED AIR INNOVATION

TEN YEARS OF PROGRESS IN THE 4TH UTILITY POINT TOWARD A MORE RELIABLE, ENERGY-EFFICIENT FUTURE

Compressed air systems are part of most industrial facilities and could be described as the "heart of the plant." Should the system fail to deliver a reliable, clean, cool, and dry supply of compressed air at a constant pressure, in a cost-effective manner, some big troubles may occur.

Michael Annino / Shutterstock-AI

In years past, ensuring this constant delivery required continuous manual intervention that consumed valuable time resources from your stretched maintenance personnel. But things are different these days. In the last 10 years or so, both large innovations and incremental changes in the compressed air world have improved things for compressed air users.

This article reviews key improvements that have happened in the compressed air industry over the last 10 years in the areas of technology design, asset management, and industry-wide performance metrics and training opportunities.

1. TECHNOLOGY DESIGN

Variable speed drive (VSD) compressors

Industrial air compressors that are controlled by variable frequency drives and DC drives have been around since the late 1990s; however, the past 10 years have seen significant improvements implemented.

VSD compressors adjust their motor speed to match the exact air demand of a system while providing a constant pressure. This type of control is one of the most efficient methods of part-loading compressors and results in significant energy savings by reducing the power consumed during low demand periods in an almost 1:1 turndown ratio. The technology also extends the lifespan of mechanical components by reducing mechanical stress and wear, leading to lower maintenance costs and increased reliability.

In the early days of VSD technology the control enhancement was nothing more than bolting on a variable drive on a standard compressor. This resulted in less than optimum performance and limited speed turndown, causing motor failures, control problems, and reduced efficiency, especially at the low end of the speed range. In recent times the manufacturers have learned how to match the characteristics of the air ends with the required speed range performances, providing a flatter efficiency curve, increased turndown, and better efficiency.

In earlier days, compressed air monitoring systems consisted of various analog gauges installed on the compressor and various other locations. Modern control and monitoring systems feature intuitive, user-friendly interfaces that make it easier for operators to understand and manage system performance.

Manufacturers have started providing better quality drives with the compressors as well as specially designed motors that are more compatible with VSD technology, thereby extending the lifespan of the units. We all have learned that a “control gap” exists in systems where the VSD is not correctly sized. In the old days a customer might purchase three equal sized 100 horsepower compressors for their system, one being VSD, but through experience this turned out to be a problem. To prevent control gap we have learned the VSD must be larger than the base compressors with which they must work. This often requires that the VSD be at least one size larger than the fixed speed compressors.

Finally, in recent years the specific power numbers of all compressors have been coming down (low is good), including VSD versions, and currently VSD controls are starting to creep into the market for centrifugal compressors.

Noise abatement

Several innovations have been implemented in recent years to make industrial air compressors quieter. Some compressor designs are so quiet it could be argued that there is no longer a need for a separate compressor room in clean locations.

One of the primary methods for reducing noise in industrial air compressors is the use of sound insulation and specialized enclosures. These enclosures are now designed with better sound-absorbing materials that significantly dampen the noise generated by the compressor’s motor and internal components. They often feature advanced designs that not only contain noise but also allow for improved ventilation to prevent overheating.

Innovations in vibration dampening have been implemented through the use of rubber mounts, pads, and other isolators that absorb vibrations and prevent them from being transmitted to the surrounding structure. Also, manufacturers have developed smoother-operating motors and fans with improved aerodynamic designs and quieter bearings, and these advancements are helping to reduce noise associated with air cooling systems.

Lastly, the use of advanced materials and construction techniques has further helped reduce noise levels. Components made from composite materials can absorb sound more effectively than traditional metal parts. These materials are used in various parts of the compressor, including housings and guards, to reduce noise emission.

Heat recovery

Industrial air compressor heat recovery systems have become more plentiful and are now easily integrated, resulting in significantly enhanced energy efficiency and sustainability in various industrial processes or plant heating requirements that can use the heat-of-compression generated by air compressors.

Traditionally, waste compressor heat is expelled to the atmosphere, resulting in energy losses. However, advanced heat recovery technologies now allow this heat to be effectively harnessed and utilized for other purposes within the facility, such as space heating, water heating, or preheating air for other industrial processes. By integrating heat exchangers and efficient heat transfer mechanisms, these systems can reclaim up to 90% of the waste heat, turning a potential energy loss into a valuable resource.

Also by capturing waste heat, companies can lower their dependence on additional heating sources, thereby reducing fuel consumption and greenhouse gas emissions. Overall, these advancements in heat recovery technology are playing an important role in promoting energy conservation and sustainability in the industrial sector.

2. ASSET MANAGEMENT

System monitoring

In earlier days, compressed air monitoring systems consisted of various analog gauges installed on the compressor and various other locations. It was rare to see any type of flow measurement and even rarer to see power consumption monitoring installed. Personnel maintaining these systems needed to rely on paper-based methods to trend and troubleshoot their systems in order to detect inefficiency and impending equipment failures.

Modern control and monitoring systems now feature intuitive, user-friendly interfaces that make it easier for operators to understand and manage system performance. These interfaces often include visual dashboards, customizable reports, and simple navigation. Many manufacturers now choose to transmit data through onboard cellular connections, storing the data for analysis. This data can be used in tending and troubleshooting the system and generating warnings or alarms.

Many modern compressed air systems now use advanced smart controllers that optimize compressor performance by adjusting operations based on real-time demand. These controllers help reduce energy consumption and extend the lifespan of the compressor. In particular, the integration of Internet of Things (IoT) technology allows for real-time monitoring and remote control of compressed air systems. IoT-enabled devices can be used to collect and analyze data continuously, providing insights into system performance and potential issues. These systems can monitor and manage the energy usage of compressed air systems, identifying inefficiencies and suggesting improvements.

There also has been a move to cloud-based platforms for storing and analyzing the data used to monitor compressed air systems, providing centralized access to these data from multiple locations. Users can access performance data, generate reports, and receive alerts from anywhere, enhancing overall system management. Some of these systems have integrated digital twin technology, a way to create a virtual replica of the compressed air system, allowing for detailed

simulation and what-if analysis to be used in improving the system operation. This helps in diagnosing problems, optimizing performance, and planning upgrades without interrupting the actual system.

One nagging problem challenging good compressor control is the lack of a universal agreed-upon air compressor communication protocol, unlike the HVAC industry (which does rely on a common protocol). The root of this challenge centers on the fact that compressors of different makes and vintages persist in the field, and they continue to leverage a variety of available electronic communication languages. Control designers have now started to design their systems with the ability to strip any operating data and even to control the equipment through digital connections.

Air quality monitoring

As the market for higher quality compressed air has grown so has the availability of new, more accurate, and more affordable instruments to detect the dryness and cleanliness of produced compressed air. Many facilities in the food and electronics industries must ensure that compressed air is free from contamination that could cause product rejection. Some must actually report and validate their air quality to inspection agencies.

Instrumentation has greatly improved for the measurement of dew point, temperature, flow, and oil content. Recently some companies have developed sophisticated measurement boxes that can even count and categorize entrained particles within the compressed air that could harm sensitive processes. Use of these instruments protects the compressed air production process against hidden failures that may result in future product quality problems.

Isentropic Efficiency is a performance metric recently added to CAGI data sheets. It eliminates confusion about published specific power numbers, and provides a more comprehensive assessment of a compressor's energy efficiency.

Ultrasonic leak detection

There have been some big changes in the ultrasonic leak detection world. Recently developed acoustical imaging leak detectors represent a significant advancement in the detection and quantification of air leaks. These devices employ arrays of sensitive microphones and advanced software to detect the ultrasonic sound waves generated by air leaks.

The collected data is then processed to create a visual representation, or acoustic image, of the sound environment on a display screen. This visual image highlights the precise location of leaks, making it easier for maintenance personnel to identify and address them quickly and accurately, and in many cases will provide an estimate of the cost. The technology's ability to provide real-time, high-resolution images enables more time efficient and accurate inspections compared to traditional methods, such as using standard ultrasonic guns.

3. INDUSTRY INITIATIVES

CAGI Data Sheets and third-party verification

The Compressed Air and Gas Institute (CAGI) 3rd Party Performance Verification Program is undoubtedly an important industry development from the past 10 years. The program has been running for several years now, and was started to ensure the accuracy and reliability of performance claims made by manufacturers of compressed air equipment. In this program, participating manufacturers voluntarily submit their products for testing by independent, accredited laboratories. These labs measure key performance metrics such as airflow, power consumption, and efficiency, and then compare the results against the manufacturer's claims. Verified data is published in standardized CAGI Data Sheets, providing a transparent and consistent format for consumers. Standardized data sheets are required to be published on company's websites, allowing easy comparison of different products and ensuring that consumers can select the most efficient and suitable equipment for their needs.

Recently added to CAGI data sheets is a performance indicator called Isentropic Efficiency. This metric eliminates the confusion about published Specific Power (kilowatts per 100 cfm) numbers, which change with compressor output pressure, and provides a more accurate and comprehensive assessment of a compressor's energy efficiency as compared to traditional metrics. By including Isentropic Efficiency,

CAGI Data Sheets now offer a clearer picture of how well a compressor performs under real-world conditions, through all desired operating pressures, enabling consumers to make more informed decisions based on true energy performance.

CAGI data sheets have been developed for fixed speed, variable displacement, and variable speed screw compressors in both lubricated and non-lubricated varieties. There are also CAGI sheets for refrigerated air dryers, designed to aid compressed air users in comparing the difference between inefficient standard dryers using hot gas bypass control and efficient cycling dryers that might use thermal mass control, or some other method to save energy during part loads.

Training and certification

There also have been some key changes to training and certification programs within the compressed air industry over the past 10 years. Comprehensive training programs have been offered by the Compressed Air Challenge since the late 1990s, focusing on best practices for compressed air system design, operation, and maintenance. These programs have educated tens of thousands of industry professionals on how to optimize system efficiency, reduce energy consumption, and improve reliability.

Within the last ten years the most popular delivery method for these sessions has become virtual rather than in-person, a trend accelerated during the COVID crisis and one that has greatly decreased the cost for both participants and training hosts. The CAC's Fundamentals and Advanced training continue to be updated to meet with modern day standards. A new training has been developed called Compressed Air Assessment and Project Development to teach industrial compressed air professionals about best practices in assessment methods. This training is part of the body of knowledge used in two newly developed CAGI personnel certification programs.

The CAGI CCASS (Certified Compressed Air System Specialist) program recognizes individuals who have demonstrated a high level of expertise in compressed air systems. This certification ensures that professionals have the knowledge and skills to design, operate, and maintain efficient and reliable compressed air systems, promoting industry standards and best practices.

Lastly, an upcoming CCASA (Certified Compressed Air System Auditor) program certifies auditors who specialize in assessing compressed air systems and identifying opportunities for improvement. Certified auditors conduct thorough evaluations, provide actionable recommendations, and help facilities implement energy-saving measures. This certification enhances the credibility and effectiveness of compressed air system audits. Both certifications are available to anyone worldwide and are achieved by writing examinations at certified testing centers. More information on both certifications can be found at cagi.org.

FUTURE INNOVATIONS

The compressed air world continues to change and will continue to improve in the future. There are exciting developments coming to help you, the user, better operate your systems through advanced instrumentation and easy to use interfaces. Air compressors, dryers, filters, piping and other components will improve as time goes on, making air systems run more reliably and efficiently. What innovations are in store for us in the next 10 years? Let's just wait and see. Δ

Ron Marshall first developed his skills as an industrial compressed air systems expert at Manitoba Hydro, where he worked for 38 years, supporting more than 600 energy efficiency projects. He now operates his own compressed air energy efficiency consulting firm where he provides technical advice, system auditing, and training. Ron is a level 2 instructor with Compressed Air Challenge and conducts training internationally. Contact Ron at *ronm@marshallcac.com*.

SPONSORED CONTENT

Industry Perspective

Mike Aughenbaugh is the associate target market manager for Swagelok Company where he is focused in the oil, gas, chemical, and refining markets. Prior to joining Swagelok Company in early 2023, he worked for three Swagelok sales and service centers dating back to 2006 in many different roles.

ENGAGE EARLY WITH YOUR SUPPLIERS

This and other best practices will help keep you on track for successful maintenance turnarounds

With plant turnarounds requiring significant resources to plan and execute, there are many factors to take into consideration. The pandemic magnified some of the issues in this space and challenges still exist today, making it important to implement best practices that will enable success. In this interview, Swagelok's Mike Aughenbaugh explains the evolution of turnarounds as a result of the pandemic and best practices that can enable improved processes.

PS What hurdles has the industry overcome in regard to turnarounds since the pandemic, and what challenges still exist?

MA As we all know, supply chain was impacted by the global pandemic. In the manufacturing world, there were many surprises when it came to materials—getting access to exotic alloys and even basic carbon steel was a challenge at times. Because many people were remote, it became more difficult to collaborate on large undertakings like a plant turnaround.

Through that process, though, there were a lot of lessons learned that are driving the changes we see now in the industry. One of the big ones is more detailed procurement strategies where it is no longer just about the big equipment coming in—facilities are focused on smaller products too.

The on-site accumulation of materials now happens earlier. Rather than a few weeks in advance, you may find a pallet of equipment or materials on-site six-to-seven months in advance of when they are needed—and that's been a big change.

Also, full product project usages are now essential instead of spot purchases, so plants are looking at the totality of those items that they need as opposed to splitting that up into smaller purchase orders. Overall, the trend is for a more detailed look at everything.

One of the remaining challenges is labor shortages. To adapt to that, there are times now when third parties are not only on-site to fulfill orders, but also to conduct services that were previously conducted by direct employees.

PS What are some best practices that plant teams should implement to conduct successful turnarounds?

MA The number one best practice in my mind is to *engage early with your suppliers*. This has always been critical, but the pandemic put that into hyperdrive. What I mean by "very early on" is when a plant is in the actual planning stages of that project, that's when to reach out to vendors.

Another one, which is elevated by labor shortages, is to *go after prefabricated assemblies*. A lot of times facilities will want to update things, such as grab sampling systems or seal flush assemblies or gas distribution systems. These are all customized systems that generally you would hand over to an engineering house to design, and then they would hand it off to a contractor or someone else to fix. Engaging those vendors early, making that its own part number, is just going to eliminate or reduce the number of hours that you need to install that component. Now, instead of spending all your time on the details of individual fittings, for example, you can order that one panel and install it and it could speed up the process or even reduce cost in some cases.

The final thing is the quality of labor that you have on site. One of the trends with refining and chemical plants, for example, is that more of their labor is coming from outside of the facility, which can lead to variation in the quality of the systems. The International Association of Oil & Gas Producers (IOGP) is

Go after prefabricated assemblies, such as grab sampling systems or seal flush assemblies or gas distribution. These are all customized systems, and engaging those vendors early will eliminate or reduce the number of hours that you need to install that component.

Consulting with your most reliable suppliers prior to engaging in a plant turnaround can make the process run more smoothly and efficiently.

putting together some best practices, and they talk a lot about having good tube fitting training for on-site people to include contractors and others that may not be direct employees. It's critical to focus on the consistency of the systems that are being installed in your facility, the consistency of the startup commissioning procedures, and the inspections.

PS Can you share any case studies that show how those recommendations can help facilities improve their performance?

MA A great example to share relates to tank blanketing at an oil and gas storage facility. The tops of those familiar large-diameter, multi-million-gallon tanks containing gasoline products are blanketed with nitrogen to ensure optimal operation. A customer was experiencing poor nitrogen flow to the vapor space of its tanks. It was assumed that a clogged component must be lurking within the convoluted fluid system created during the initial nitrogen system setup. Swagelok's field engineering team visited the site to perform a root cause analysis. The team quickly realized the issue wasn't a bad component, but rather an inefficient system layout. The field engineers then proposed an optimal system that offered much better results.

In the past, a vendor like Swagelok would not have been involved with that system analysis, nor the solution. The company would have simply provided the parts ordered, and the customer would have continued to spin its wheels troubleshooting the issue. Instead, the field engineers' recommended system design changes can now be used during the next turnaround to optimize the customer's additional tank blanketing systems.

PS What are some final takeaways that plant teams should consider as they move into their next turnarounds?

MA I would suggest enlisting the help of your suppliers. Suppliers are sometimes viewed as salespeople, but a lot of times they have resources on their end that can assist with things that you may not know about, so reach out to them—it can be an important part of turnaround and project work. For the suppliers that I've been involved in the past, having more people in the picture who can provide solid recommendations is critical. Since these people are experts of the products you're installing, they really can fulfill those details to make the project run smoothly — and you can have each of your project teams reach out to them directly.

Some of the areas that they may be able to help with include material takeoffs, upgrades that align with ESG initiatives, local inventory, and help in adhering to IOGP standards. Working closely with a supplier on these issues can provide reductions of excess components, support in lowering emissions, and earlier identification of issues. Δ

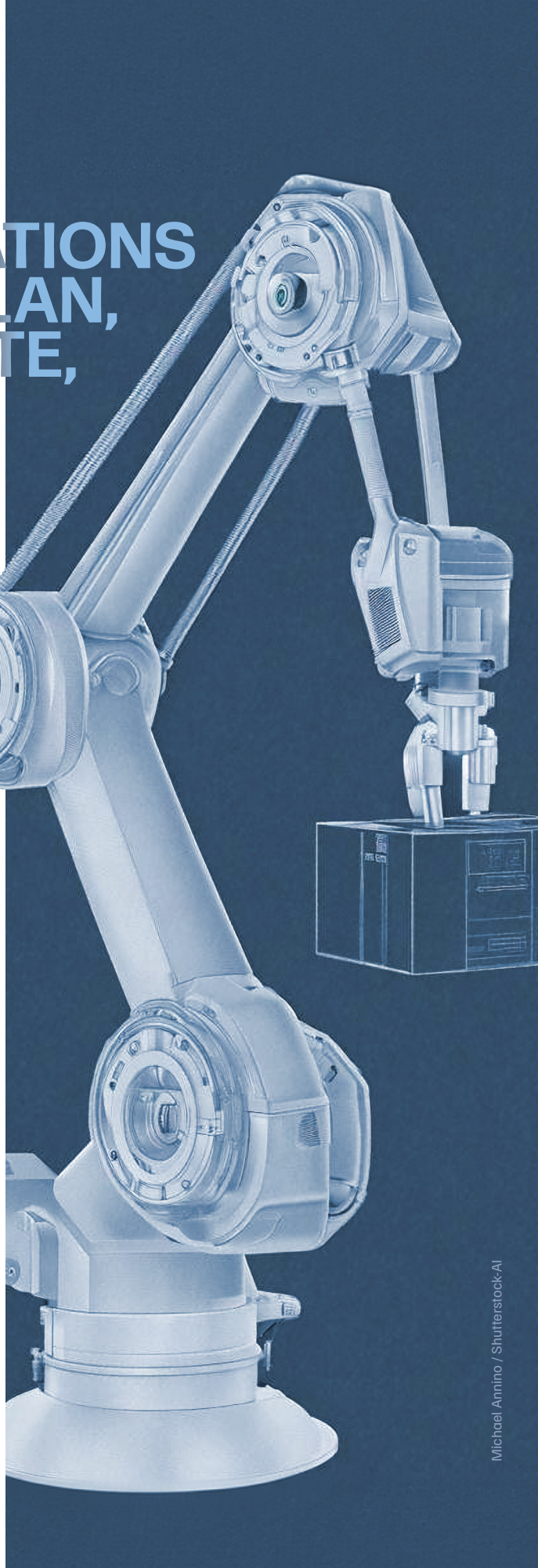
KEY CONSIDERATIONS FOR COBOTS: PLAN, INSTALL, OPERATE, AND MAINTAIN

Cobots are an extension of your production systems, and these steps can help you integrate them fully into your operation

Written by

Parth Sagpariya

Motion AI



Michael Annino / Shutterstock.AI

Successfully integrating collaborative robots (cobots) into the plant environment requires carefully considering several factors to ensure efficiency and safety. This article explores the key considerations when installing, operating and maintaining cobots in industrial settings.

EVALUATE AND IDENTIFY YOUR NEEDS

Before diving into robotics or automation in general, you must know your current system. This typically means collecting data using lean tools like value-stream mapping (VSM). Once you have your data, identify areas for improvement; they are often your bottlenecks or quality concerns. Then conduct a return-on-investment study to identify the task that benefits the most from automation.

Analyze all data collected during the VSM and determine the KPIs required to complete that task, such as payload, throughput, precision, and repeatability. The right technology choices and integration plan design will be based on this assessment.

DESIGN AND PLAN YOUR SYSTEM

This phase involves selecting the right components and the best robot design solution that align with your project requirements.

Considering the compatibility of new equipment with your current production equipment is crucial. New automation technologies require upgrading other hardware or software that will interact with the latest equipment. Projects often require redesigning the current processes, layouts or procedures.

A detailed plan should outline every system aspect, including components, integration, timelines, budget, training needs and potential risks.

- **Workspace design and layout:** Workspace layout is pivotal in facilitating seamless collaboration between a cobot and its human coworkers. Designing workstations with clear delineation between human and cobot-operated areas minimizes the risk of collisions (see **Figure 1**). Incorporating ergonomic principles enhances the comfort and efficiency of human workers interacting with cobots, improving productivity and employee satisfaction.
- **Risk assessment, safety regulatory compliance and documentation:** One of the most important steps is conducting a comprehensive risk assessment of cobot deployment. Ensuring compliance with safety standards such as ISO 10218 and ISO 15066 is essential to guarantee safe operation around humans. Implementing built-in safety features such as force limiting, speed control and presence sensing can prevent accidents and injuries. Maintaining detailed documentation of cobot installations, operations, maintenance procedures and safety protocols is required for regulatory purposes and auditing. Keeping informed about updates and changes to regulations and standards enables prompt adaptation of cobot systems and practices.

FIGURE 1. This cobot system was designed for a palletizing application.

- **Selecting the right equipment:** Ensure you have the right cobot and peripherals for optimizing the overall system. Start by finding the requirements for your cobot; this includes but is not limited to payload capacity, reach, speed and repeatability, plus the programming environment associated with the cobot. Once these details are identified, research the technical specifications of different cobots on the market that match your requirements. Lastly, confirm the cobot can adequately communicate with your existing systems or that you have a feasible plan to make it compatible with peripheral equipment. Most importantly, choose something easy to use without retraining the entire workforce or redefining your whole process.
- **End-of-arm tooling (EOAT) and grippers:** Selecting the appropriate EOAT and grippers based on specific tasks and applications is critical for cobot performance (see **Figure 2**). Compatibility and ease of integration between cobots and EOAT minimize downtime and optimize efficiency. Many off-the-shelf adaptive grippers have connection software with the robot developed, like a driver for your PC. The manufacturer produces the driver to control the EOAT or the gripper more easily. Adaptive grippers can be effectively used for multiple parts or actions, leading to time savings (from tool changeovers, design and construction) and long-term costs. Lastly, consider adding quick tool changers to all EOAT to reduce your future maintenance or changeover times.
- **Safety components:** Not all cobots are the same. Confirm that the cobot specifications meet regulatory and industry standards to truly make them collaborative robots. Consider using power- and force-limiting cobots to maximize your collaborative environment. Decide what external safety components your system needs. The robot may be collaborative, but the robot task or part being handled may not be and can still lead to worker injuries. Common safety components often used with cobots include multi-level safety laser scanners and light curtains for hard system stops or partial caging.
- **Programming and integration:** User-friendly programming interfaces are essential for cobot programming by operators with varying levels of technical expertise. Integrating cobots with existing production systems, machinery and software streamlines operations and maximizes productivity while minimizing costs.

DEVELOP A MAINTENANCE AND TROUBLESHOOTING SCHEDULE

Refer to the cobot's manual to develop a routine preventive maintenance (PM)

Images are courtesy of Motion Ai.

plan. Create your own inspection plan to check for damage or abnormal motion/sounds. Most importantly, note if the owner's manual calls for specific tasks such as lubrication and calibration of cobots and associated equipment. Attending to these ongoing tasks will keep your cobot running as intended for as long as possible.

Create troubleshooting guides and access to technical support for maintenance and line workers to enable timely resolution of issues, minimizing disruptions to production and maximizing uptime. Lastly, remember to regularly inspect and maintain EOAT to prevent wear and tear, ensuring consistent performance and reliability along with the cobot.

Common tips for maintaining your cobot should include:

- Grease all joints and gears if called out in the owner's manual.
- Check and clean the robot, including the arm, wiring, tooling and pedestal/base.
- Replace filters on cooling fans and vents (if needed).
- Check for leakage caused by worn seals.
- Clean the EOAT, sensors and other safety components.
- Replace the battery on encoders if required.
- Watch and listen to the robot in motion. Mechanical problems in the joints can often be heard as abnormal sounds.

EXECUTE AND FINE-TUNE COBOT IMPLEMENTATION

In addition to your system, you must plan cobot implementation in your facility. Prepare for the initial investment and potential disruption to production.

Aim to modify your production schedule or implement the new system during planned downtime. Start by installing the cobot and related hardware and integrate them into your control systems. Phased rollouts or adjustments might be required as the system is being set up. Monitor the feedback from your systems during installation. Fine-tune any parameters to meet the performance goal. Most importantly, document everything related to the installation, from what worked as expected to all the changes or adjustments made.

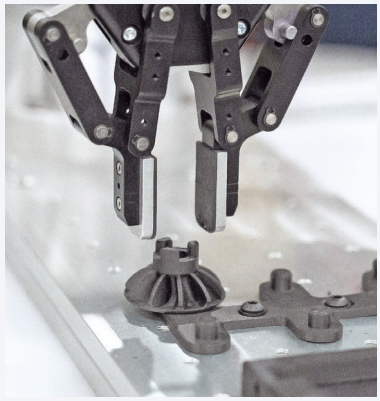


FIGURE 2. Selecting the appropriate end-of-arm tooling and grippers based on specific tasks and applications is critical for cobot performance.

Seek an outside company or an integrator to work with early on if you feel uncomfortable or lack the knowledge on certain aspects of implementing the new system (e.g., programming, design or communication setup).

TRAIN AND SUPPORT YOUR WORKERS

The most crucial step is employee training, which is vital to fostering a culture of collaboration and trust between human workers and any new automation systems. Training programs are necessary for educating employees on safe interaction with cobots, including proper handovers, operating procedures, handling emergencies, maintenance and troubleshooting techniques.

Besides training programs, providing continuous support and resources to employees is also beneficial as they adapt to their new cobot coworkers. Regular feedback sessions ("town hall meetings"), cyclical refresher courses, and access to updated training material can further enhance their knowledge and skills. By nurturing a culture of learning and development, you can create a more proficient, confident workforce that can maximize the benefits of your facility's current and future automation advances.

OBSERVE AND SUPERVISE THE SYSTEM

After implementing new robotics and automation systems in your facility, you must monitor the progress closely in the initial stages. Evaluating how the new systems affect productivity, quality and safety is essential. Measuring success with KPIs can help identify where to further optimize or reorganize.

Continuous monitoring allows you to collect data to make informed decisions about system changes or future upgrades. In addition to monitoring progress, it is also important to schedule reviews of the performance data to ensure that the systems are operating efficiently. Consider adding remote monitoring methods and data-gathering systems to access performance whenever and wherever required. Δ

Parth Sagpariya is a Robotics Application Engineer for Motion Automation Intelligence (Motion Ai). He applies his automation passion and expertise to design, develop and deploy cutting-edge solutions for industrial and commercial companies. Through projects involving robotic arms, sensors, vision systems, and software integration, Sagpariya helps improve customer efficiency, quality and safety.

PLANT SERVICES

Endeavor Business Media, LLC
1501 E. Woodfield Rd. Suite 400N
Schaumburg, IL 60173
(630) 467-1300

John DiPaola
VP & Market Leader
jdipaola@endeavorb2b.com

Jeff Mylin
Business Development Manager
AZ, CA, CO, IA, IL, IN, KY, MI, MN, MT, ND, NE, NM, NV, OH, OR, SD, UT, WA, WI, WV, WY, Western Canada
(847) 533-9789
Fax: (630) 467-1120
jmylin@endeavorb2b.com

Brennan Lafferty
Business Development Manager
AL, AR, CT, DE, FL, GA, KS, LA, MA, MD, ME, MO, MS, NC, NH, NJ, NY, OK, PA, RI, SC, TN, TX, VA, VT , Eastern Canada
(330) 357-1379
blafferty@endeavorb2b.com

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AD INDEX

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THE CAPTAIN
Captain Unreliability

IT'S HIGH TIME TO REDEFINE MTTR AND MTBF

Who can extend the mean time to retraining and between flushes the most?

Classically, MTTR and MTBF have been utilized to demonstrate the efficiency and effectiveness, respectively, of a maintenance organization. These lofty measurements are, let's face it, fodder. They are relatively useless in our efforts as we continue to struggle with simple things like getting a work order written, let alone knowing precise timestamps, which would provide usable data for either of these measurements. For most of us, these two are simply a pipe dream.

To make them more useful, let's revisit these two critical acronyms and redefine them to more accurately reflect the realities of reliability initiatives.

MTTR – MEAN TIME TO RETRAINING / MEAN TIME TO REPLACEMENT

This is the average time to a leadership change, which requires a reliability professional to take three steps backwards, justify their existence all over again, and retrain a new leader on why leadership should focus on and support reliability efforts. Sometimes, this plumbing nightmare includes a complete rewrite of the reliability strategy, in order to better align things with the leader's understanding of reliability from the one article they read 10 years ago. Who doesn't love snaking a toilet? Thank goodness for the opportunity to start over, am I right?

Other activities that clog up the drain system and reduce reliability flow include a shift to a new framework, CMMS, or asset hierarchy because it just happens to be what the new leader was used to at their last location. Things were so good there, they left. In today's climate, it's likely they left something steaming there as well, so why not replicate that for you?

But fear not, for you are the master plumber of leadership transitions. You know how to navigate the twists and turns of corporate political piping and keep the plumbing of your organization flowing smoothly. So, strap on your tool belt and get ready to train another unsuspecting soul on the intricacies of reliability – it's just another day in the circus of leadership.

> A reliability flushing is something we can all relate to.

MTBF – MEAN TIME BETWEEN FLUSHES

This is the average time between reliability programs. A reliability flushing is something we can all relate to – this is when your site is so reliable that leadership, change or no change, decides they no longer need a reliability program. They clean house like a 3.8 liter flush. People, standards, initiatives, technology: all go right down the drain.

Reliability programs stand in the bowl of an old water closet. Their goal of reliability is the handle way above the bowl. Year after year they stretch to reach the bowl and make progress. But once they reach the handle, guess what happens? Reliability is flushed down the drain. Until such time that the organization operates unreliably, you are no longer needed.

But fear not, for you are the master plumber of program maintenance. You know that just because everything is running smoothly now doesn't mean it will stay that way forever. So, keep your plunger at the ready and your nose at the ready for any signs of trouble. After all, a reliable program is like a well-maintained toilet – you may not notice it when it's working, but the place sure stinks when it's not! Δ

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.

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