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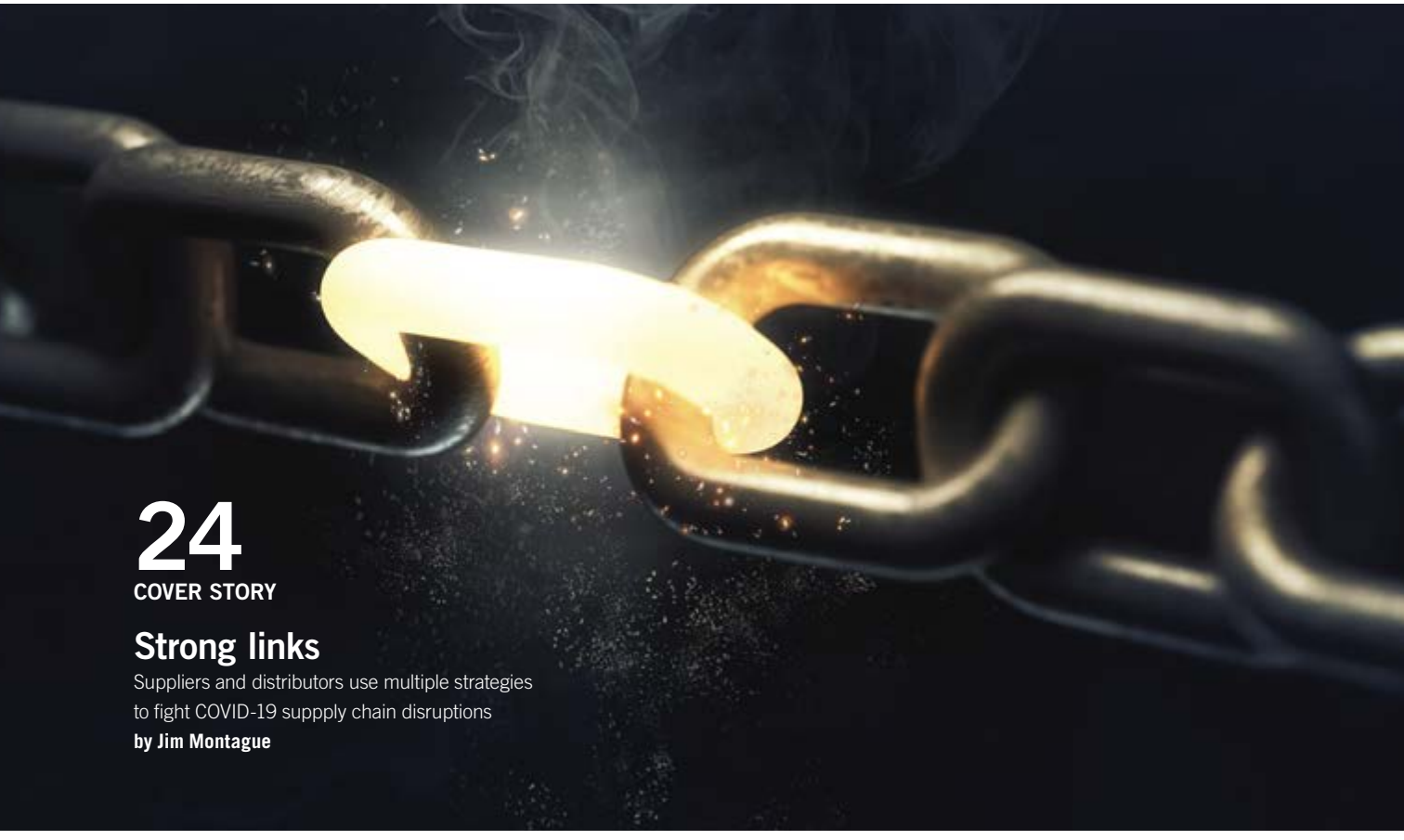

Features

CONTROL (ISSN 1049-5541) is published monthly by Putman Media Inc. (also publishers of Control Design, Chemical Processing, Food Processing, Pharma Manufacturing™, Plant Services and Smart Industry), 1501 E. Woodfield Rd., Ste. 400N, Schaumburg, IL 60173. (Phone 630/467-1300; Fax 630/467-1124.) Address all correspondence to Editorial and Executive Offices, same address. Periodicals Postage Paid at Schaumburg, IL, and at additional mailing offices. Printed in the United States. **Postmaster:** Please send change of address to Putman Media, PO Box 1888, Cedar Rapids IA 52406-1888; 1-800-553-8878 ext. 5020. SUBSCRIPTIONS: Qualified-reader subscriptions are accepted from Operating Management in the control industry at no charge. To apply for a free subscription, email putman@stamats.com. To non-qualified subscribers in the Unites States and its possessions, subscriptions are $96.00 per year. Single copies are $15. International subscriptions are accepted at $200 (Airmail only.) CONTROL assumes no responsibility for validity of claims in items reported. Canada Post International Publications Mail Product Sales Agreement No. 40028661. Canadian Mail Distributor Information: Frontier/BWI,PO Box 1051,Fort Erie,Ontario, Canada, L2A 5N8.

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Role of industry standards undiminshed in digital age

Even as IT and OT converge, industrial applications remain differentiated

IN a process that began to gather steam some 20 years ago, the industrial automation landscape continues to be transformed by an inrush of digital technologies developed for the broader IT market. The information technology (IT) of yesteryear was clearly inadequate for industry's real-time automation needs, so we had no choice but to roll our own operational technology (OT) if we were to take advantage of all that digital technology had to offer.

But that far larger IT market—and research spend—meant faster development cycles and increasingly capable systems. As elements of a dated OT infrastructure are replaced with shiny new IT capabilities, we politely refer to it as "convergence," even if displacement might be a better descriptor.

But as a recent study by the folks at ISA reminds me, it's just fine if the underlying infrastructure is a relative commodity—as automation professionals our real value-add is at the application layer, in the information models and subject-matter expertise that allow us to ensure the safe operation of a cat cracker or to optimize the growth of mammalian cell culture en route to a new virus vaccine.

And what key activity serves to improve the performance of both industrial processes and those automation professionals charged with their upkeep? The creation and maintenance of industry standards, of course, including those developed through the ISA and other standards organizations.

Indeed, among the nearly 300 automation professionals who responded to ISA's June 2020 survey, a majority of respondents said that industry standards (in general) will continue to be "extremely important" over the next two decades. (A full 63% responded "extremely important," while another 33% said "important"—96% all told.)

Other key findings that testify to the ongoing importance of industry standards:

- Most respondents (87%) believe that industry standards make processes and facilities safer.
- Most respondents (81%) believe that industry standards help companies prove compliance to regulations.
- Most respondents (67%) believe that industry standards make it easier to train and cross-train people in technical jobs.
- Most respondents (63%) believe that industry standards make processes and facilities more cyber-secure.

Personal growth and contribution, too

In addition to the role of industry standards in improving overall organizational and process performance, the survey also reflected personal benefits gained by those individuals engaged in the standards-making process.

Among the benefits of standards committee membership related in the study's verbatim comments:

- "Sharing expertise, learning from others' experience across the broader industry, and awareness of trends and changes in industry practice."
- "Ability to contribute to the advancement of industry knowledge, and ensure that standards reflect real-world conditions."
- "Opportunity to share my expertise and give back."

"In creating this survey, ISA wanted to demonstrate the value of standards to the automation community," says Dr. Maurice J. Wilkins, executive advisor at Yokogawa Marketing HQ, ISA Fellow, co-chair of the ISA101 Human-Machine Interfaces Standard Committee, and member of the ISA Executive Board's Industry Reach & Awareness work group. "We're grateful to the many automation engineering professionals who took the time to tell us how standards are helping them, their employees and their organizations."

ISA's committees are eager for help, too. So, if you're interesting in advancing industry practice—and building your own skills in the process—check out the volunteer opportunities at ISA.org. We all thank you in advance for your contribution. ∞

KEITH LARSON
Editor in Chief
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Our real value-add is at the application layer, in the information models and subject-matter expertise that allow us to ensure the safe operation of a cat cracker or to optimize the growth of mammalian cell culture en route to a new virus vaccine.

NEWS & BLOGS

Hawk Measurement Systems launches new website
Hawk Measurement Systems announced the release of its newly redesigned website, hawkmeasurement.com, which includes new features such as a product selection tool, a request-a-quote cart, and much more.
www.controlglobal.com/industrynews/2020/hawk-measurement-systems-launches-new-website

CISA Alert AA20-205A addressed OT networks but didn't address control systems
When the DHS CISA Alert was issued specifically identifying control systems, Joe Weiss had two questions: why now and what happened that was unique to control systems? In his latest blog, Weiss offers his feedback on the alert.
www.controlglobal.com/blogs/unfettered/cisa-alert-aa20-205a-addressed-ot-networks-but-did-not-address-control-systems

Prioritizing employee mental and physical health and safety
In the wake of the COVID-19 pandemic, employee health and safety is more important than ever. Amanda Del Buono interviews Kronos' Kylene Zenk, about digital technologies that help manufacturers monitor safety.
www.controlglobal.com/podcasts/manufacturing-tomorrows-workforce/prioritizing-employee-mental-and-physical-health-and-safety

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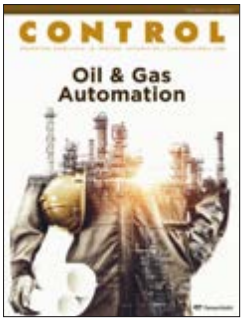

In this new eBook from the editors of *Control* and ControlGlobal.com, you'll find articles about how oil & gas producers are tackling a range of industry challenges. Detailed case studies featured in this report include how standardized automation boosts productivity at Occidental and how Saudi Aramco manages cybersecurity. Other topics covered include natural gas metering, MQTT, the Industrial Internet of Things (IIoT) in oil and gas, and much more. This State of Technology report is now available for download at:
info.controlglobal.com/state-of-technology-2020-oil-gas-automation

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The future of manufacturing & continued importance of automation

What does the COVID-19 mean for manufacturing? In the latest episode of *Control Amplified: The Process Automation Podcast*, Keith Larson, editor-in-chief of *Control* and ControlGlobal.com, and Paul Galeski, founder of Maverick Technologies, discuss the future of manufacturing in light of the coronavirus pandemic. They also speak about the importance of the automation professional going forward after the pandemic. Listen, watch or read the podcast transcript at:
www.controlglobal.com/podcasts/control-amplified/solutions-spotlight-the-future-of-manufacturing-and-continued-importance-of-automation

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Best practices for successful automation and Industrial IoT technology implementation in oil & gas

Automation and Industrial IoT technology solutions provide a way to attain numerous oil & gas industry goals, while also addressing market volatility, safety and regulatory issues. IoT solutions can help optimize resources by improving equipment reliability and uptime, as well as extending workforce effectiveness. Find out how to follow best practices for successful implementation of IoT and automation technologies with this eBook from Advantech. Download it at:
info.controlglobal.com/white-paper-2020-bb-smartworx-best-practices-successful-automation-technology-implementation-oil-gas

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Modern flowmeters verify their measurement performance

Today's smart instrumentation helps plants show documented evidence of flowmeter production through built-in verification techniques traceable to known metrology standards. This whitepaper from Endress+Hauser explains how flowmeters perform self-verification, covering topics includig regulatory requirements, calibration versus verification, verification functions, condition monitoring, and more. The whitepaper is available for download at:
info.controlglobal.com/white-paper-2020-endress-hauser-modern-flowmeters-verify-own-measurement-performance

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Understand your accuracy requirements

Robert Jennings
Calibration & Repair Manager
Endress+Hauser

The essential first step toward measurement success is understanding just how accurate each of your plant's instruments needs to be. That understanding, of course, drives what type of instrument is purchased initially, but also how its performance should be managed in order to continue to deliver that accuracy throughout its lifecycle.

To shed some light on the factors that influence accuracy requirements—and what steps are necessary to maintain desired performance—we caught up with Robert Jennings, calibration and repair manager for Endress+Hauser in the U.S. Now based in La Porte, TX, he'll soon manage the company's calibration and repair services out of a new $38.5 million, 112,000-sq.ft. campus under in Pearland's lower Kirby District near Houston.

Q *Determining how best to ensure that one's instruments are performing as expected is not as straightforward as one might think. More frequent calibrations than necessary can waste resources and introduce downtime and risk, while too few can adversely affect safety, regulatory compliance, product quality and overall profitability. As a first step in an optimal instrumentation management plan, how do I go about determining just how accurate the instruments in our plant need to be?*

A The first step is to perform a plantwide assessment of all your instrumentation. First, identify and make a list of all the equipment parts and all instrument-related systems. This list should include details such as description, location information, operating conditions, working range and history, and any other points that provide a better understanding of the instrument and system function.

Next, evaluate each instrument's criticality along three dimensions: to the end product; to the process operations; and to protecting workers, the environment, and production assets.

The first category—instruments critical to the product—are those that affect product quality, sometimes with regulatory compliance implications such as for aseptic systems. We start here because these instruments have a direct link to company profits, whether it involves providing a consistent mix of ingredients for a food processing application, gauging the completion of a batch chemical reaction or successfully fulfilling the terms of a custody-transfer agreement.

The next category—instruments critical to the process—are those that can upset or shutdown the overall plant or other processes. These instruments can cause inefficiencies and production losses, but do not have a direct effect on product quality or safety.

Instruments deemed critical for their protective role have a direct impact on operator safety, the environment or integrity of production assets. Often, they do not have to be extremely accurate, but they have to function properly and reliably.

Finally, non-critical instruments have no impact on product quality, the overall process or protective measures. These types of instruments are often only used for local or remote monitoring or when manual operations are performed.

After all instruments have been identified and classified into these four categories, a maximum permissible error (MPE) is assigned to each device based on the consequences of its inaccuracy. A critical instrument will usually have a more stringent MPE than a non-critical one. The necessary calibration interval, then, is all about making sure that the instrument continues to perform its critical functions and maintains that performance within the prescribed MPE.

Application-specific factors to be taken into account include the nature of the product being measured, the continuity of the process (continuous use or intermittent use), the need for clean-in-place (CIP) operations, the severity of process impacts and how easy it is to access and remove the instrument for calibration. In some cases, it may only be possible to access the instrument during a complete process shutdown.

If you can show an auditor or other responsible entity that a non-critical instrument has no effect on product quality, safety or the environment, and its MPE is relatively high, then you can claim there is little or no need for periodic calibration. Conversely, critical instruments should be calibrated at intervals appropriate to maintaining critical product quality,

process operations or protective functions. Keep in mind that those instruments deemed critical to safety or the environment often have their calibration frequency dictated by regulatory requirements.

Q *Verification is often cited as a way to ensure the proper operation of instruments without removing them from the process for a full-blown calibration. Can you explain how verification works, and how it is different from calibration?*

A The most important distinction is that while calibration is quantitative, verification is qualitative. Verification should not be confused with calibration since it doesn't compare the accuracy of an instrument against a reference, nor is it used to adjust the calibration factor of the instrument. That being said, verification provides a high degree of confidence that the instrument is operating in accordance with its original specifications based on testing of key internal components.

Verification is done in-line with minimal or no process interruption using the verification functionality embedded within the latest generation of instrumentation or, in the case of older instruments with little diagnostic coverage, using specialized tooling. More recently developed instruments include automatic checks of their own health, providing a continuous source of confidence that the instrument is functioning as intended.

In-line verification improves plant availability because there is no need to dismantle the instrument for calibration. This eliminates the risk of damage of during removal or transportation, and removes the potential for mistakes to be made during reinstallation. And, when performed periodically, verification allows the operator to track the instrument's performance over time. This can provide early notice of an increased risk for measurement drift of the instrument, giving additional confidence in the current performance of the instrument—or early warning of the need for an unscheduled calibration.

For example, Endress+Hauser's latest generation of smart instruments with Heartbeat Technology offer significant reliability and safety advantages, verification

convenience and enhanced opportunities for calibration flexibility. These instruments continuously check their own health with a best-in-class diagnostic coverage typically exceeding 95%. Instrument failures that could cause malfunctioning of safety systems are significantly reduced. Consequently, the risk of an undetected dangerous failure being present in an instrument is extremely low.

Heartbeat Verification enables instruments to be verified locally at the push of a button or remotely via higher-level systems without process interruption or the need for additional tooling. Heartbeat Verification is certified by TüV to be a traceable verification method according to ISO 9001. The automatically generated verification report is in accordance with the IEC 61511 user functional safety standard and consequently meets compliance requirements while reducing documentation effort.

Q Can instrument self-diagnostics and verification help to extend instrument calibration and maintenance intervals? What about proof-testing for safety instrumented systems?

A Confidence from the continuous diagnostic test coverage, together with easily performed periodic verifications, provides many users the flexibility to extend the calibration and proof-testing cycles of their instrumentation, thereby saving time, effort and costs while maintaining safe operations.

The IEC 61508 functional safety standard refers to the probability of failure on demand (PFD) as the basis for instrument reliability. Together with instrument PFDs demonstrated to remain low for extended periods of time, Endress+Hauser's Heartbeat Technology permits many users to extend the instrument proof-testing intervals in their safety instrumented systems.

It bears repeating that dismantling and removing an instrument from a process for testing or calibration introduces additional risk by handling the instrument. Most often, the user already knows that the instrument is probably working properly and safely but is required by internal or external regulations to ensure and document the instrument's functionality at regular intervals. Here, in-line verification can be of significant value, helping to extend more intrusive calibration intervals and saving both time and effort. ∞

Optimize your calibration plan

When there's a need for high accuracy calibration of a large, high flowrate meter, there's simply no substitute for an accredited calibration laboratory such as this Endress+Hauser facility, where meters up to 10 feet in diameter can be traceably calibrated. (Human technician included for scale.)

Establishing ideal calibration intervals based on key regulatory, criticality, safety and quality considerations is only the first step in achieving optimal instrument performance. There are other factors to consider when it comes to developing a plan and executing against it. First, since you're looking to optimize calibration operations and not just keep records, a software application designed specifically to help manage and keep track of your instrumentation is a good first investment.

In a new plant, setting initial calibration frequencies relies on the criticality of the measurement, the maximum permissible error (MPE), the use of self-diagnostics and verification, as well as advice from the instrument manufacturer and qualified calibration team. But in an existing plant, determining calibration intervals based on established work practices and actual historical experience often yields better results.

Indeed, once a calibration plan has been in effect for a few years, the instrument/asset management software takes on an even bigger role. When each calibration is completed, new data is recorded, including the status of the flowmeter before and after calibration. Analysis of these records may very well indicate that the instrument does not require calibration as often as expected, helping to justify longer intervals.

Other advantages of today's instrument/asset management packages include the support of mobile access to an instrument's history and supporting documentation. From the field, a technician can pull up real-time diagnostics, calibration history, troubleshooting instructions and other information needed to properly address issues as they arise. In many cases, modern instruments equipped with advanced diagnostics can determine if a problem exists, and automatically notify the maintenance department.

IN-HOUSE, AT A LAB, OR ONSITE?

Once the need for a calibration is established, a number of other decisions come into play. First, do you have—or can you afford—the necessary equipment to do it in house? And, do you have the properly trained technicians on staff to perform it properly?

Standard maintenance shops are not equipped for some calibrations. Flowmeters, for example, are far more complicated to calibrate than other measurement instruments, such as for temperature or pressure. Professional calibration labs use pipe-clamp measurement sections to accommodate different diameters. The sections tend to be large, making them cost-prohibitive for many asset owner-operators. Calibrating in-house also necessitates the purchase of one or more costly flow-reference devices—these devices require calibration with traceability, adding further costs and complexity to processes. In such cases, the help of an outside services organization is called for—preferably one accredited to the ISO/IEC 17025 Standard for Testing and Calibration Laboratories.

Flowmeters are often removed from systems for the purpose of calibration and sent to a calibration laboratory.

(continued on p10)

Global calibration services on call

Essential process instruments must be tested and calibrated on a regular basis. Endress+Hauser offers accredited calibration services consistent with global standards for nearly all physical, analytical and mechanical parameters—whether performed in a production center, in a service center or on-site at a customer's location. With over one million instruments calibrated each year, the company provides these services for instruments of its own manufacture as well as those of other suppliers.

Endress+Hauser covers all critical aspects of calibration and can perform and advise on all aspects, from in-situ testing to fully accredited factory calibration. And as your calibration services partner, they can help to ensure that calibration activities are cost efficient and align with your process availability requirements.

With optimal usage of resources and advanced calibration methods, they can reduce recalibration time and ensure that your processes continue to run smoothly. They also can help to:

- Manage deviations, identifying the root causes that underlie non-conformities;
- Manage calibration costs with optimized intervals; and,
- Determine the critical KPIs needed to create transparency and drive continuous improvement.

In the U.S., Endress+Hauser provides accredited calibrations with its fleet of portable rigs (photo below) as well as at its laboratories in Greenwood, Indiana (photo top right) and the Texas Gulf Coast. The company's current facility in La Porte, Texas, will be replaced in fall 2020 by a new, state-of-the-art campus in Pearland, Texas (photo, bottom right). All told, Endress+Hauser has facilities in 17 countries that are accredited to ISO 17025 with plans to have facilities in 23 countries accredited by end of 2020.

For more information and video, visit: www.us.endress.com/calibration-usa

Not all instruments are best calibrated by sending them off to a lab. Endress+Hauser is the only instrument provider offering traceable, accredited calibrations at its customer sites using equipment such as this portable rig.

Endress+Hauser's U.S. headquarters campus in Greenwood, Indiana, is home to the first of two A2LA accredited laboratories in the U.S. that provide fully traceable calibration services in accordance with ISO 17025.

Set to open in the fall of 2020, Endress+Hauser's new, state-of-the-art campus in Pearland, Texas, will serve the instrumentation calibration, repair and training needs of customers in the Gulf Coast region. The 112,000-sq.ft. facility represents a $38.5 million investment and replaces the company's La Porte, Texas, operations.

Even with the budget to purchase the most sophisticated calibration and reference equipment available, there is no substitute for a properly trained technician.

(continued from p7)

The commonly held belief is that the necessary calibration accuracy can be guaranteed only under laboratory conditions. However, this is only partially true.

Flowmeters and many other measuring devices can also be calibrated directly on-site by an accredited calibration provider. There are several advantages to this:

- Plant availability improves as the device is calibrated near-line or in-line.
- Sources of error can be detected and eliminated on-site, while the ability to achieve the same result in a calibration lab is limited. Calibration technicians on-site can detect errors during installation and identify blockages or contamination in the pipes directly in the system.
- Cost savings increase due to the speed of completion, reduced downtime and the elimination of an inventory of replacement parts.
- There is no need to disassemble and ship contaminated devices, and costly decontamination measures can be avoided.

Endress+Hauser, for example, has both high-end regional calibration centers across the world as well as fleets of portable rigs—supported by highly trained engineers—that can be brought directly to plant sites. Convenient and cost-effective, this approach removes the need to send instruments offsite. Coordinating an onsite visit with a plant outage also allows multiple instruments to be quickly calibrated and returned to service.

These mobile rigs (see photo) compare a flowmeter's performance against another reference meter with traceability. But for those applications requiring even higher accuracy, or to address especially large meter sizes, one's choices are limited to dedicated calibration facilities such as Endress+Hauser's regional calibration centers in Europe, Asia and North America, where a new Gulf Coast campus will open later this year. These dedicated facilities offer traceable, highest-accuracy calibration of even high flow-rate flowmeters.

Even with the budget to purchase the most sophisticated calibration and reference equipment currently available, there is no substitute for a properly trained technician. Not only do they need to be trained on the mechanics of the calibration process, they also need to be equally qualified in completing and maintaining the documentation. Accuracy, repeatability and reproducibility are key and in the world of calibration, if it isn't properly documented, it didn't happen.

Truly professional calibration needs highly trained experts. While it is perfectly feasible to calibrate some measuring points yourself, other points present a challenge that it is not to be underestimated, even by experts. In cases involving a large number of flowmeters, calibration requires project

This portable flowmeter calibration rig can be brought onsite to compare flowmeter performance against a standards-traceable reference meter, avoiding the delays and potential damage inherent in transporting the meter to a laboratory.

Calibration traceability should follow an unbroken chain of calibrations, so that the highest-level calibration can be traced back to a national calibration standard, or equivalent.

planning. The staff conducting these calibrations needs to consider the minimization of plant downtime, the removal and reinstallation of devices, technical knowledge of calibration, as well as the operation and handling of tools and equipment. Additionally, staff must always know the current applicable regulations to ensure that the correct calibration intervals are being observed and can complete the documentation in compliance with the regulations. After all, calibration provides proof and documentation of compliance with the permitted measurement error and plays an important role in audits and certifications.

Furthermore, taking on internal or in-house calibrations can raise questions from an audit standpoint as to what the company's core competence may be. Is it to produce a product or perform calibrations?

INSIST ON TRACEABILITY, ACCREDITATION

Traceability means that the reference standards used when executing a calibration have also been calibrated using an even higher-level standard. That traceability should follow an unbroken chain of calibrations, so that the highest-level calibration has been traced back to a national calibration standard, or equivalent.

So, for example, you may calibrate your process measurement instrument with a portable process calibrator. The portable process calibrator you used, should have been calibrated using a more accurate reference calibrator. The reference calibrator should be calibrated with an even higher-level standard or sent out to an accredited or national calibration center for calibration. If the traceability chain is broken at any point, any measurement "below" that point cannot be considered the true representation of the measurement. Comparisons between devices under testing, testing equipment and the country's highest national standard are the only way of establishing end-to-end traceability of measured values.

Just as traceability ensures the integrity of calibration standards, accreditation ensures that providers of calibration services have the necessary technical expertise, and that the calibration infrastructure (operating procedures, methods, calculations) and quality management systems meets industry best practices. Endress+Hauser's calibration capabilities, for example, are accredited in the U.S. by the American Association for Laboratory Accreditation (A2LA, www.a2la.org).

Your organization's competitive edge depends on accurate instrumentation. Optimize calibration in line with your needs to enhance productivity, ensure compliance and maintain quality. Schedule calibration of critical instruments, monitor KPIs for process improvement and call on the expertise of accredited calibration service providers when it makes sense to augment your in-house capabilities. ∞

Major brewer redefines calibration process

CHALLENGE:
Reduce the time required for manual calibration of nearly 100 RTD thermometers

SOLUTION:
Endress+Hauser iTHERM TrustSens, self-calibrating thermometers deployed to replace portable micro-baths and other calibrators

BENEFIT:
Calibration time reduced substantially, improved safety and process efficiency

When you're in charge of operations at a large brewery and realize that your team is spending too much time on instrument calibrations, using processes that are potentially hazardous, who do you call?

One major brewing facility in the United States recently faced this challenge. With close to 100 RTD thermometers installed at the plant, the manual calibration process had become time consuming, taking up nearly 80 hours of labor each year.

The brewery had been using a combination of portable micro-baths and other calibrators to perform calibrations on its RTD thermometers. The micro-bath calibrations involve the use of hot oil and an ITS-90 traceable reference thermometer. Each time the micro-bath was moved to a new location, the oil needed to be heated to the appropriate temperature and allowed to stabilize prior to performing the actual single point calibration.

Consequently, this process was taking the tech team around 45 minutes on average to calibrate each thermometer. Performing calibrations using the portable hot oil micro-baths also was creating safety concerns and challenges, as transporting a micro-bath containing hot oil from sensor to sensor had the potential to become a serious safety hazard if not done properly and carefully.

"Calibration is a very intimate process," says Robert Jennings, calibration and repair manager at Endress+Hauser. "Technicians have to stop production, so there's no money being made, and they also have to take instruments offline. There could be a lot of risk involved, not just with the device being calibrated, but then getting production back online successfully."

The brewery's lead instrumentation specialist was challenged to fix the situation. He was assigned to lead a project that would identify a safer and more efficient method of performing calibrations on its fleet of RTD thermometers.

"You can imagine the quantity of instrumentation needing to be calibrated," adds Jennings. "You have to be able to work fast, efficiently and effectively. And then from there, you have to get back online."

The project lead made a quick decision to purchase an Endress+Hauser's iTHERM TrustSens hygienic thermometer, the world's first self-calibrating thermometer, to see if it would save time and reduce risk and cost.

A SELF-CALIBRATING SOLUTION

Endress+Hauser's iTHERM TrustSens thermometer is designed to maximize product safety, plant availabil-

The TrustSens thermometer has a high precision reference built into the temperature sensor which aides in the calibration process.

ity and process efficiency. In particular, the TrustSens thermometer has a high-precision reference built into the temperature sensor which aides in the calibration process. Its automated and fully traceable inline self-calibrations reduce process downtime, helping to minimize risk and costs.

Nathan Hedrick, national product manager at Endress+Hauser, explains why automated calibration capabilities are critical in modern plants: "Assume you've got stable measurements that are unlikely to drift. When the schedule indicates that it is time to manually calibrate the instrument, you may be arbitrarily taking it out of calibration, inducing unnecessary cost and downtime, and increasing the risk of damage to a device that is working perfectly fine. Instruments that are self-calibrating in place enable you to achieve more frequent calibrations that are automatically triggered by pre-set deviations."

Employing the TrustSens temperature transmitter with Heartbeat Technology, calibration results are captured after every successful self-calibration. When technicians need the calibration history, they can connect directly to the transmitter or through a HART connection from the control system. Utilizing TrustSens' DTM the information is visible on the associated software or a printed calibration certificate can also be produced. The TrustSens thermometer eliminates the risk of undetected non-conformance issues without impacting existing validated procedures or GMP.

Typically, TrustSens is employed as a method of in-situ calibration for processes that undergo sterilize-in-place (SIP) on a regular basis. As steam is introduced to the process, the temperature passes through the 118°C threshold that triggers the TrustSens calibration. However, the brewery did not employ SIP, instead using a simple portable ceramic block heater in conjunction with TrustSens unique technology to perform the single point calibration.

In this case, the brewery technicians remove the TrustSens temperature probe from the thermowell and place it in the ceramic block heater. Once the temperature at the RTD exceeds 118°C, TrustSens then begins to cool and automatically initiates the calibration cycle. If the RTD is within the brewery's self-defined accuracy tolerance, a green light appears. The technician then reinstalls the probe into the thermowell and proceeds to the next RTD.

SIGNIFICANT TIME SAVINGS

The self-calibrating thermometer proved up to the task of delivering an efficient means for calibration while also improving worker safety. The brewery tested the TrustSens thermometer side-by-side with one of the facility's original RTDs and was extremely pleased with the results. Using the ceramic block heater, the calibration of the Endress+Hauser iTHERM TrustSens sensor takes no longer than 15 minutes, saving 30 minutes per RTD.

Jennings adds that when performing calibrations, depending on the discipline, the technician may have to rescale the device to get the best resolution out of the outputs. "That's also a risk, because not only are you pulling the device out of the production line, now you're also reconfiguring the device." In cases like this, Endress+Hauser service teams stand ready to support on-site calibrations as needed. "Part of the procedure in our documentation is that we save parameters and forward count. We reconfigure, if needed, to get the best resolution out of the device to see truly how it's performing and then re-stand the device, if necessary."

However, if the brewery replaces the RTDs that are currently in the facility with TrustSens, it will save close to 80 hours in calibration time annually, considering some transmitters are calibrated once a year and others every six months. Using TrustSens as the new calibration solution also greatly reduces the risk to the brewery's technicians by eliminating the hot-oil microbaths that workers were carrying from location to location within the plant.

Jennings adds that the benefits of self-calibrating instruments extend into the realm of optimized inventory. "When the deviation gets to a certain point where it's been adjusted time after time—having that data to know how far you've drifted is critical to planning for replacements." ∞

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Geothermal controls

The type of technology used to capture geothermal energy depends largely on the temperature of the source

THERE are two main types of geothermal resources: convective and hydrothermal. One is where natural hot water or steam is present and can be brought to the surface. The other is where hot rock is present.

The first commercial geothermal electric power plant opened in Italy in 1911. It was the world's only industrial producer of geothermal electricity until New Zealand built a plant in 1958, which is still in operation today. In 1960, Pacific Gas and Electric (PG&E) began operating the first successful geothermal electric power plant in the U.S. at The Geysers in California. The original turbine lasted for more than 30 years and produced 11 MW net power. The technology became popular in Sweden as a result of the 1973 oil crisis, and has been growing worldwide since then. Among other regions, Greenland and Iceland have good geothermal potentials. As of 2017, the global geothermal capacity was about 14.0 GW.

In 2016, the U.S. led the world in geothermal electricity production with 3.5 GW installed capacity from some 80 power plants. While the largest group of geothermal power plants in the world is at The Geysers, the Philippines is the second largest producer with 1.9 GW of capacity online. Geothermal power makes up approximately 27% of the Philippines' electricity generation, but Indonesia's 30 GW of geothermal reserves is probably the world's largest.

The temperature of thermal springs can reach 350 °C (662 °F). At that temperature, "direct heating" is possible. If the groundwater temperature exceeds 150 °C (302 °F), then "flash steam" power plants can be built. And if the water temperature is between 100 °C and 150 °C (212 to 302 °F), then "binary cycle" power plants can be operated.

When the groundwater temperature is less than 100 °C (212 °F), geothermal heat pumps (GHP) can be used to heat buildings in the winter. In the winter, geothermal heat pumps can take the heat from ground water in a well outside the building, and move it to heat air inside the home. In the summer, reverse the flow, and these same heat pumps can cool the building.

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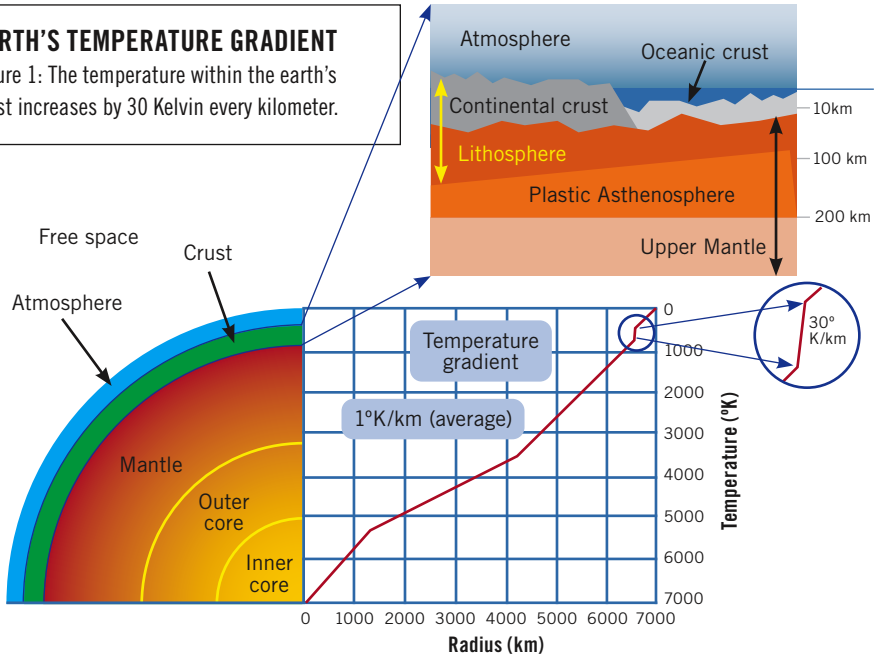
On average, the levelized energy cost of geothermal electric power at the source is about $0.06 per kWh, which is less than fossil or nuclear. Only wind power is less expensive.

EARTH'S TEMPERATURE GRADIENT
Figure 1: The temperature within the earth's crust increases by 30 Kelvin every kilometer.



'Dry' steam plants use steam directly

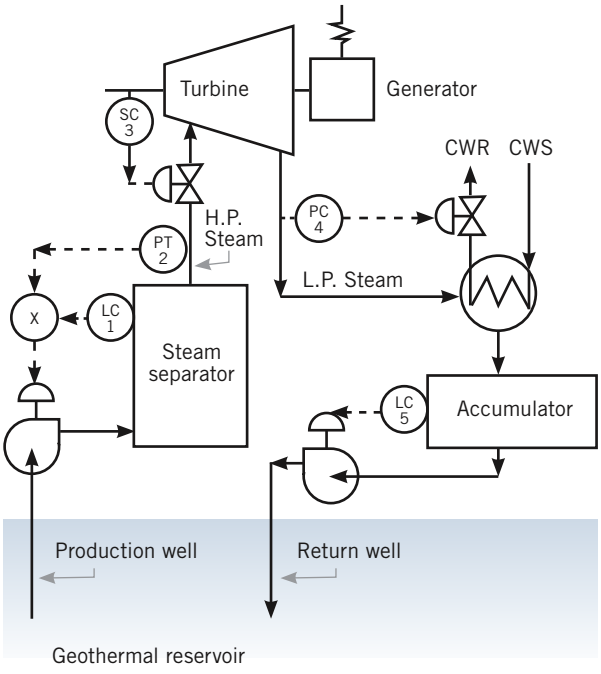
Dry steam plants use the steam directly from geothermal reservoirs. The first geothermal power plant of this type was built in 1904 in Tuscany, Italy, where natural steam erupted from the earth.

The Geysers is a geothermal field located in California's Mayacamas Mountains. It's the world's biggest, single geothermal field. The number of geothermal power plants currently operating in that region is 18, and the present combined generation capacity of these plants is about the same as that of a nuclear reactor, about 900MW. From these plants, essentially the only emission is excess steam.

Flash steam plants fill middle ground

For somewhat lower quality (temperature) energy sources, flash steam plants use low-pressure flash tanks to generate steam from high-pressure hot water at temperatures greater than 300 °F (-150 °C). That vapor is used to drive turbine-generators. If any liquid remains in the tank, it can be flashed again in a second, even lower pressure tank to extract even more energy.

A schematic of the control scheme used to operate a flash steam power plant is shown in Figure 2. Here, a variable speed pump transfers hot water from the production well into the steam separator. The speed of the pump is set by the tank level (LC-1). The level control signal is corrected for steam pressure (PT-2) variations. This control configuration is called a "two-element" feedwater system.



FLASH STEAM POWER PLANT CONTROLS

Figure 2: Optimized controls of a geothermal "flash steam" type power plant.

The high-pressure (HP) steam from the separator is sent to the steam turbine, the speed of which is controlled (SC-3) by throttling the flow of the high-pressure steam. The energy of this high-pressure steam generates the electricity, which is sent to the grid or to other users. The pressure of the steam exhaust from the turbine is controlled by PC-4, which is modulating the cooling water flow (CWF) through the condenser.

The system can be optimized by realizing that the lower this pressure is, the more energy the turbine will generate. So, if there are no other considerations (such as limited availability of cooling water), electricity production can be maximized by fully opening the cooling water return (CWR) valve. If one wants to minimize the cost of operation, that minimum is found where the incremental energy gain obtained by lowering the turbine exhaust pressure exceeds the increase in the pumping cost of cooling water required to achieve that reduction. The condensate is collected in an accumulator tank, and returned under level control (LC-5) into the return well.

Binary-cycle plants leverage low-temperature sources

Binary-cycle power plants transfer heat from geothermal hot water to another liquid, which is turned into the steam that drives the generator turbine. This technology allows the generation of electricity from much lower temperature resources than previously. In 2006, a binary cycle plant in Chena Hot Springs, Alaska, came online, producing electricity from a record low fluid temperature of 57 °C (135 °F). These plants differ from dry steam and flash steam systems in that the water from the geothermal reservoir never comes in contact with the turbine/generator units. Naturally, the secondary fluid has a much lower boiling point than that of the water, and therefore it will flash to vapor, which then drives the turbines and subsequently the generators.

Geothermal energy is just as inexhaustible and renewable as solar energy, and has the added advantage of being continuously available. Its production cost is less than that of fossil energy, but its front-end expenses are often high, if the production wells are deep and the ground is rocky. Still, the cost of generating geothermal power has decreased by 25% over the past two decades. The initial cost for the land and the power plant is approximately $2,500 per installed KW in the U.S., and its power is available all the time.

On average, the levelized energy costs (LCOE) of geothermal electric power at the source is about $0.06 per kWh, which is below the LCOE cost of fossil or nuclear-based electricity. Actually, the only renewable electricity that's less expensive is wind energy at an LCOE cost of $0.04 to $0.06 per kWh.

Geothermal power is inexhaustible, cost-effective, reliable, sustainable and environmentally friendly, but its use has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of geothermal resources, especially for applications such as building heating. ∞

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One bus to rule them all, part 1

Innate security and consistent host interfaces will be key to APL adoption

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If users fail to make their concerns heard, we could end up with another generation of perplexing, kludged-host implementations.

SINCE the commercial availability of systems that could access and aggregate data from intelligent devices, many seem to have become slower. A notable DP transmitter from 1999 would "synchronize"— update all its current data—in a fraction of the time required by its 2020 replacement. As network bandwidth, memory and computing power have increased, frustration with application performance seem about the same—sometimes worse?

A glance at archived websites from 20 years ago demonstrate how our expectations have grown, so you might conclude that content expands to fill the available bandwidth. Routine patching and updates of operating systems, database engines and software mean applications may likewise need to accommodate new security enhancements. And so it's been with digitally-integrated field devices, as manufacturers adapt to changes in hosts, diverse protocols and evolving specifications. Once viewed as fairly speedy, the 31.25 KB baud rate of fieldbus has lost some of its luster when accessing complex devices over busy segments.

If you've been in the discipline for three or four decades, you've seen a few generations of offerings that supported then-contemporary communications, like 1,200 baud HART from the 1980s and 31.25 KB fieldbus from the 1990s.

You most likely also remember that Ethernet was not always fast or ubiquitous. But in 2020, multi-gigabit speeds are common over fiber and twisted-pair copper, and the protocol extends easily to wireless 802.11 infrastructure. Is it safe to assume then, that Ethernet is the *de facto* network standard of today and tomorrow?

As soon as next year, you'll be able to extend it to instruments and other field devices in hazardous areas over single twisted-pair cable. The Advanced Physical Layer (APL) is being created based on IEEE 802.3cg (10BaseT1L), and will be capable of using your fieldbus infrastructure for device power and 10 MB communications over one twisted-pair.

The demonstrations are all plausible, and standards and approvals are in the works. APL may be a tempting choice for your post-2021 grassroots plant or field-device upgrade. All the key developers and standards organizations in the business of process automation have convened to create this new bus to rule them all.

Users must speak up

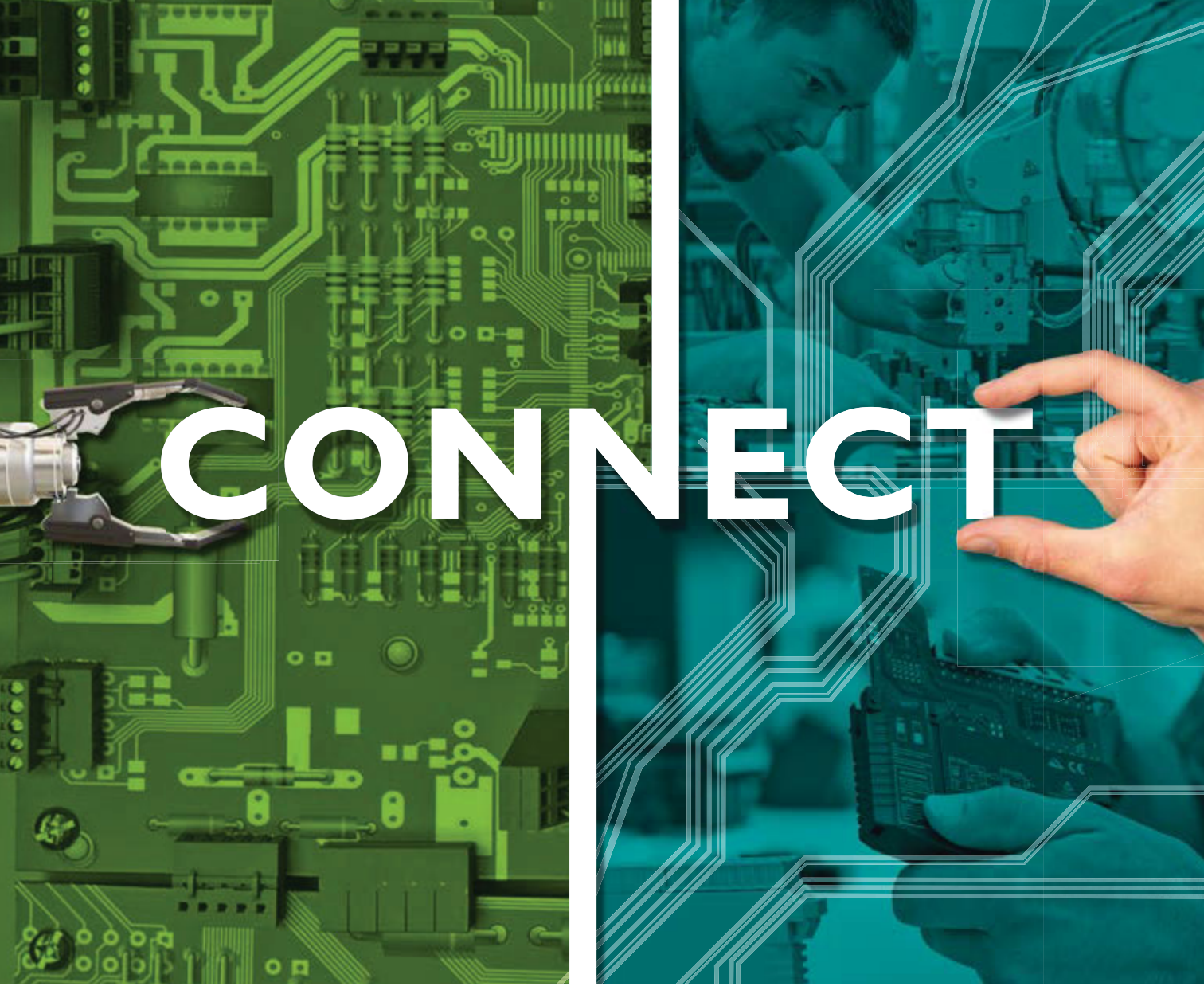
What lessons-learned from the bus wars and troubled HART and fieldbus deployments should be front-and-center in this standards creation consortium? Suppliers will forever be compelled to seek market dominance and POs. So, if users fail to make their concerns heard, we could end up with another generation of perplexing, kludged-host implementations. Now is the time to get developer time and minds focused on solutions that will fulfill end users' needs and expectations.

Security is the most important duty of the controls professional, the most likely malady that will garner visibility at the board and shareholder level, as "company Y was struck by ransomware X" or something akin to that. At the same time, it's the most banal waste of a control professional's time, which you'd hope is focused more on process safety, reliability and efficiency achieved through measurement and control. If the network can ensure that security is innate, it will be one less creature in the thickening morass of patches, upgrades, group policies, etc. that have become routine duties.

Safety: FF-SIF and ProfiSafe both exist as protocols for safety instrumented functions (SIF), but with no logic solvers and few conforming devices. If APL checks the security box, that might be 90% of what's needed for SIF. Maybe we can get out of the business of stocking two devices for every service: one (4-20 mA) for SIF and one for process control.

Pervasive utilization of digital PV: End users don't want to futz with mappings, OPC or middleware to create and display measurement variables, statuses, alarms and diagnostics. Hosts should speak the same language as the bus.

Can APL cure all the ills of modern fieldbus integration? Why not? More to consider next month. ∞



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Pressure points

Rules of thumb for this most ubiquitous of process measurements

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It will only be a matter of time before someone replaces the electronic impulse line with a wireless option.

THOUGH I'm sure the percentage of field measurements based on pressure is decreasing from what I heard at one time was close to 80% of all signals, I'm confident the majority of control inputs continue to be pressure-based, including differential pressure (d/p) for flow and level inference. While many of us take pressure measurement for granted, we must keep in mind several basic rules of thumb, such as placing sensors at the top or side of a line, and using manifolds for isolation and maintenance.

The main reason for placing the sensing line in the correct location is to minimize the chances of something (corrosion, unwanted fluids, etc) in the process affecting the reading. One way in which I have had success in minimizing tap plugging is to use a diaphragm seal instead of a ½- or ¾-in. pipe nipple which, because of its narrow diameter, is more easily "bridged" and hence plugged.

When using a diaphragm, I've learned the hard way to remember the following lessons. First, specify the diaphragm face to be ½-in. to a maximum of 1-in. from the pipe face, especially in slurry or abrasive service. This will prevent the face of the sensing diaphragm from being scoured and damaged by the process fluids. Second, be sure to specify that the inside of the nozzle is ground flush before attempting to insert the diaphragm, which will have a tight tolerance with the pipe wall. You don't want to damage your meter, and then wait until the next outage to complete the project because you "smashed the face" on a piece of slag.

As pressure meter diaphragms are generally quite thin, be very careful when selecting the face materials. In some cases, it may be preferable to select a brittle ceramic rather than one of the metals.

Another source of d/p transmitter problems is the capillary—especially if it extends more than about 10 feet. At this length, response grows sluggish, and accuracy is susceptible to temperature changes if the fill fluid isn't carefully selected. Heat tracing helps, but makes this option quite expensive.

For these reasons and others, several manufacturers now offer "electronic" impulse lines, where two close-coupled (directly connected to the process with a manifold for calibration and maintenance when needed) transmitters are connected electronically rather than via capillary. The electronic-impulse-line approach requires a minimum distance (hence, pressure drop) between the taps to ensure an adequate signal-to-process-noise ratio. Again, depending on the process fluid this distance is coincidentally about 10 feet.

Wireless remote seals?

Electronic impulse lines have been in use for about a decade, and I believe it will only be a matter of time before someone replaces the electronic impulse line with a wireless option. To do so, however, will required continued improvement in wireless power supplies.

Wireless could also be used to connect an at-grade transmitter with local indication to the sensing head in the pipe rack—again, with a potentially proprietary connection to keep down costs, arguably for security, and of course to keep out competitors.

Fortunately, if you have a reasonable relationship with the supplier of your transmitters, they'll consider many of the above items for you, or at least be asking the questions.

Lastly, though it may be intuitive when you look at the way pressure transmitters are made, practically all pressure transmitters are based on differential pressure sensing, with the one leg open to atmosphere and, hence, measuring gauge pressure.

Pressure measurement may be ubiquitous but that doesn't mean that we can take it for granted. In fact, the argument can be made that because it's so widely used, it should be better understood. Hopefully some of the points made this month will spur that conversation. ∞

AVEVA buying OSIsoft for $5 billion

Combination expected to help users optimize operations, drive sustainability, add value

AVEVA (www.aveva.com) reported Aug. 25 that it's agreed to buy OSIsoft (www.osisoft.com) for $5 billion, and combine their complementary platforms, bringing together industrial software and data management to help users accelerate their digital transformations as efficiency, flexibility, sustainability and resilience become increasingly urgent requirements.

The two firms explain that OSIsoft's PI System and other data management software will complement AVEVA's end-to-end engineering, operations and performance software. Integrating PI System with AVEVA's software will create an integrated data foundation that can drive big data, cloud and artificial intelligence (AI)-driven insights to improve business outcomes. Their combination will also allow AVEVA to grow and diversify the industries it serves, and continue to expand its footprint in existing and new markets and geographies.

"Combining AVEVA and OSIsoft is yet another significant milestone in our journey to achieving the ambitious growth goals that we have set. This will not only help us serve existing customers better, but also open the floodgates to new opportunities that will accelerate the delivery of our digitization vision," says Craig Hayman, CEO of AVEVA. "Data has been enabling organizations to more effectively determine the cause of problems by allowing them to visualize what's happening in different locations, departments and systems. This agreement will let our customers improve business processes and eliminate inefficiencies. We're extremely proud to be moving into the next chapter with an even stronger solutions portfolio as well as an ever-increasing and robust customer base which continues to make us leaders in our sector."

PI System already lets users collect, normalize, store and stream real-time, high-fidelity operational data to applications, analytics, and AI and machine learning (ML) platforms. PI System acts as a single system of record for operations data, designed for massive cloud-enabled scale and data sharing across enterprises, and enables insightful operations decision making.

The two product suites are open and interoperable, and many customers already leverage both solutions. As a combined entity, AVEVA and OSIsoft report they'll further deliver on their sustainability goals, and drive further benefits and value for users. Together, their software can further provide full-stack solutions that span edge, plant and enterprise deployment models for many diverse, essential industries, such as consumer packaged goods (CPG), pharmaceuticals, water and wastewater, and utilities.

"Joining forces with AVEVA enhances and extends our ability to deliver on our key commitments to our customers, partners and employees. Together we'll be better able to service the largest digital transformation projects in history, including across industry 4.0+ and IIoT," says Dr. J. Patrick Kennedy, founder and CEO of OSIsoft. "AVEVA's interest in OSIsoft is a testament to our talented team, and the extraordinary value of the PI System as the real-time streaming data infrastructure that powers the industrial world. Today's announcement is the culmination of a thoughtful search for a respected organization that would mesh with our own strong mission- and customer-driven culture. The next chapter in PI's fifth decade will be exciting for our employees and customers, and I look forward to my continued involvement in my new role as the largest individual shareholder in the combined company and as chairman emeritus to ensure we realize the full benefits of this transaction."

Emerson purchasing OSI for $1.6 billion

Emerson (www.emerson.com) announced Aug. 27 it will acquire Open Systems International Inc. (www.osii.com) for $1.6 billion in cash. The transaction is subject to regulatory approvals and customary closing conditions, and is scheduled to close in early fiscal 2021.

OSI provides operations technology (OT) software, and is expected to broaden and complement Emerson's software and ability to help global power industry users and others digitalize operations, modernize their grids, incorporate renewable energy sources, and improve energy efficiency and reliability. The two companies add that combining Emerson's domain expertise and leading technology in power generation with OSI's complementary software and reach in the power transmission and distribution sectors will give users the end-to-end ability to monitor, control and optimize real-time operations across the power enterprise through scalable, software-enabled automation and data management.

"An enormous change is underway as utilities globally are investing to digitize the grid and adapt to rapidly evolving energy sources and new technologies that increase consumer choices," says Lal Karsanbhai, executive president of Emerson's Automation Solutions business. "This acquisition will help the power industry maximize the remarkable opportunity to harness renewable energy sources and to accelerate the transformation to the smart power grid. Emerson now has the opportunity to be a leader in this large, rapidly growing market with a compelling and complete software and technology offering."

OSI's advanced modular technology lets users tailor solutions for their power grid management needs, and is scalable to other industries. Combining it with Emerson's Ovation control system for power generation control will give utilities increased visibility into the status of their power systems, enabling optimized energy efficiency from generation through customer delivery, and enabling the broader industry goal of minimizing carbon footprints.

"Emerson and OSI share a commitment to excellent customer service and offering advanced technologies to help customers manage the reliability and resiliency of the electric grid," adds Bahman Hoveida, president and CEO of OSI Inc. "We're excited to combine our advanced technologies, engineering expertise and unsurpassed customer service, not only to better serve our electric power customers, but to also expand the reach of this critical software into other industries with the Emerson team."

ISA reveals fellows and award winners

The International Society of Automation (www.ISA.org) announced Aug. 21 its four latest ISA Fellows and 14 Celebrating Excellence award recipients. The recognitions honor the outstanding efforts of ISA members in supporting and advancing the society and the automation community. The ISA's Society Admissions committee was chaired by Bridget Fitzpatrick, while the Honors and Awards committee was chaired by Brian Curtis.

2020 ISA Fellows

The esteemed Fellow member grade is one of ISA's highest honors. To earn this distinction, a senior member must possess outstanding and acknowledged engineering or scientific attainments, must receive peer evaluations leading to recommendation for election by the Society Admissions Committee, and must be elected by a majority of the ISA Executive Board. In the 75-year history of the ISA, 495 ISA Fellows have been elected. The 2020 ISA Fellows are:

- Donald Dunn of Waldemar S. Nelson & Co. in Highlands, Texas, for the education and standardization of terminology, requirements and guidance for the process industry-wide safety area of alarm management;
- David Rahn of the U.S. Nuclear Regulatory Commission in Rockville, Md., for developing and implementing of new methodology and acceptance criteria to establish the reliability of critical safety equipment of nuclear power plants;
- John Sorge, retired, of Birmingham, Ala., for his leading, advocating, sponsoring, and technically contributing to activities, projects, and organizations to advance instrumentation and control research on and application of new power-generation technologies; and
- Richard Van Fleet of Andritz Inc. in Cumming, Ga., for providing subject matter expertise and technical support relating to sensor development and implementation of advanced process control and sustained process optimization of pulping and bleaching processes.

Celebrating Excellence winners

Meanwhile, the Celebrating Excellence awards stimulate, enhance, encourage, acknowledge and reward outstanding contributions to ISA and the automation profession by providing an avenue for individuals to compete for recognition within established categories. The Honors and Awards Committee receives award nominations each year, reviews candidate qualifications, and recommends honorees for approval by the ISA Executive Board honorees for approval. This year's winners are:

- Excellence in technical innovation (endowed by Honeywell UOP) to Soliman Almadi of Saudi Aramco in Dhahran, Eastern Saudi Arabia.
- Excellence in technical presentation to Abdulkadar Susnerwala of Air Liquide in Houston.
- Excellence in education to Himanshu Patel of the Institute of Technology at Nirma University in Ahmedabad, Gujarat, India.
- Mentoring excellence to Greg McMillan of Emerson in Austin, Texas.
- Excellence in enduring service to Catherine Andrews of Hile Controls of Alabama in Pelham, Ala.; James Haw of La Porte, Texas; Ian Verhappen of Industrial Automation Networks in Calgary, Alberta, Canada; and Clifford Wuertz of Cypress, Texas.
- Division excellence to ISA's Analysis Division.
- Division leader excellence to Ed Naranjo of Honeywell's process measurement and control division in Eagan, Minn.
- Section excellence to ISA's Bangalore section in India.
- Section leader excellence to Dattatray Sawant of the ISA's Maharashtra section in Mumbai, Maharashtra, India.
- Standards excellence to Donald Dunn of Waldemar S. Nelson & Co. in Highlands, Texas.
- Volunteer leader of the year to Cheri Haarmeyer of Pearland, Texas.

LNS, MESA say analytics critical for transformation

There's a critical correlation between analytics and successful industrial transformation (IX), according to LNS Research (www.lnsresearch.com) and the Manufacturing Enterprise Solutions Association (www.mesa.org), which jointly released Aug. 26 their latest biennial research study, "Analytics that matter in 2020: a new world," as a freely downloadable ebook for a limited time at https://blog.lnsresearch.com/analytics-that-matter-in-2020-a-new-world. It's the latest in the series that LNS and MESA started publishing more than 10 years ago, but the 2020 report also covers the impact of COVID-19 on manufacturers and their transformation initiatives.

The study provides an updated look at where industrial organizations fall in their progress towards using analytics, and finds there's

still more work to do to achieve operational excellence. While the biennial survey by LNS reports a promising 52% increase in industrial companies with a formal analytics program, the report's author, LNS research analyst Andrew Hughes, adds that obstacles remain. "Unfortunately, the industry also still has challenges," says Hughes. "We've only seen a 39% increase in prescriptive capabilities—well behind increases in diagnostic and predictive."

OPC, Spectaris, VDMA launch LADS standard

To help networked laboratory equipment communicate more uniformly, the OPC Foundation (www.opcfoundation.org) announced Aug. 12 that its OPC UA information exchange strategy has been used as the foundation for the new Laboratory Agnostic Device Standard (LADS), and that it's established a joint working group (JWG) with two organizations, the Spectaris (www.spectaris.de) and the Mechanical Engineering Association (www.VDMA.org). The goal of LADS is to create an open, manufacturer-independent standard for analytical and laboratory equipment that reflects different industries and their workflows, can be applied sustainably, and meets future digitalization and automation requirements.

Watlow acquires CRC

Thermal systems manufacturer Watlow (www.watlow.com) reported Aug. 26 that it's acquired semiconductor wafer pedestal manufacturer Component Re-engineering Co. (www.CRCinc.us) for an undisclosed sum. CRC designs, builds and services wafer pedestals used in semiconductor manufacturing. Its high-temperature bonding and refurbishment technologies enable advanced ceramic pedestal and in-chamber solutions that complement thermal technologies developed by Watlow. Integrating CRC into Watlow's business advances the company's wafer pedestal solutions, which are essential for achieving the technological advances in the memory and logic segments of the semiconductor industry. Watlow will have a full suite of wafer pedestal solutions from low to high temperatures, and ranging from a single zone to 80 zones of control and more. ∞

SIGNALS AND INDICATORS

- **EtherCAT Technology Group** (ETG, www.ethercat.org) reported Aug. 27 that it issued its 3,000th EtherCAT vendor ID in July, which is reported to give EtherCAT the broadest base of device manufacturers and adoption in the industrial Ethernet market.
- **Emerson Automation Solutions** (www.emerson.com) announced Aug. 25 that **Jaguar Exploración y Producción**, an independent oil and gas company based in Mexico City, will use its exploration and production (E&P) software and services to maximize the potential of Jaguar's onshore assets and projects.
- **Allied Electronics & Automation** (www.alliedelec.com) reported Aug. 19 that it's added more than 10,000 new product lines, $3.5 million in inventory and 30 new suppliers so far this year. Joining its 450 existing suppliers are bearings manufacturer **Koyo**, conveyor components manufacturer **Pobco**, **Fresh-Aire UV** for HVACR sanitizing accessories, **CW Industries** for switches and connectors, and **Bihl+Wiedemann** for automation solutions for functional safety and data communications.
- **Endress+Hauser** (www.endress.com) reported Aug. 13 that it's broken ground on a new 18,000-m² logistics center in Wörrstadt, Germany, near the Frankfurt airport. The facility will be operated by Hellman Worldwide Logistics (www.hellman.net), and is scheduled to be completed and start operating in mid-2021.
- **Sierra Wireless** (www.sierrawireless.com) announced commercial availability Aug. 19 of its first-to-market EM919x5G NR Sub-6 GHz and mmWave embedded modules. Based on the industry-standard M.2 form factor, these 5G modules will enable OEMs to deploy secure connectivity worldwide at the highest possible speeds with ultra-low latency.
- **Newark** (www.newark.com) reported Aug. 11 that it's published an ebook, "Cable for Factory Automaton," to guide users implementing industrial cables for factory automation. It provides solutions to avoid damage from using commercial cable, and ensure proper transfer of power, data and control signals. It's at www.newark.com/product-assembly-starts-here#GuidetoWire.

Best batch bits and pieces

Control's monthly resources guide includes batch automation case histories and ISA's S88 standard

MANAGE SINGLE-UNIT RECIPES

This blog post, "Process batch control recipe management for single units solved!" by Tag McCormick of Superior Controls, explains how the system integrator used Softing's 56eATM-tManager (TMGR) module to manage interactions with a Microsoft SQL database and enable recipe management for a pharmaceutical process CIP skid. It's at https://superiorcontrols.com/blog/batch-control-recipe-management-for-single-units/

SUPERIOR CONTROLS
www.superiorcontrols.com

COMPACT ISA S88 VIDEO

This three-and-a-half-minute video, "The ISA S88.01 Standard" by OSIsoft Learning, covers the standards basic models, such as the S88 Physical Model and the S88 Procedural Model. It's at www.youtube.com/watch?v=82DtwdJeEeU

OSISOFT
www.osisoft.com

UPGRADING SOLVENT PLANT

This online article, "New batch control system boosts solvent plant" by Nancy Givens of DuPont in *Chemical Processing* magazine, details how its small-batch, semiconductor cleaning solvent plant worked with system integrator Tech-Knowsion and Rockwell Automation to carry out a two-phase upgrade to its controls and batch automaton system. It's at www.chemicalprocessing.com/articles/2019/new-batch-control-system-boosts-solvent-plant/

CHEMICAL PROCESSING
www.chemicalprocessing.com

PAINT PRODUCTION AUTOMATION

This six-page paper, "Automation of batch production in paint industry using PLC" by L. Chitra, Siranjeevi S., Manikandan A. and Saravanan G., all of the Aarupadai Veedu Institute of Technology in Chennai, India, shows how a multi-product plant used an analytical computing model to optimize its volume processing plant and handle all possible decision variables. It's at www.ijitee.org/wp-content/uploads/papers/v9i2S4/B12071292S419.pdf

IJITEE
www.ijitee.org

BETTER PVC PROCESSING

This two-page case study, "Hubei Yihua improves operational efficiency and stability" shows how the China-based PVC manufacturer upgraded its batch monitoring and processing equipment, better coordinated measuring points, simplified interfaces, reduced the need for human intervention, and achieved a 10% improvement in batch control efficiency by adopting Emerson's DeltaV batch and distributed controls and Rosemount temperature transmitters. It's at www.emerson.com/documents/automation/hubei-yihua-improves-operational-efficiency-stability-en-us-190124.pdf

EMERSON
www.emerson.com

ALL THE S88 BASICS

This online article, "ISA-88 (S88) batch control explained" by Peter at PLC Academy introduces the basic aspects of batch processing and programming, including the S88 process model and hierarchy, physical model, three-part procedural model, and relationships between them. It's at www.plcacademy.com/isa-88-s88-batch-control-explained/

PLC ACADEMY
www.plcacademy.com

BREWING AT FULL SAIL

This online case study, "Full Sail brewing taps manufacturing intelligence to enhance process," shows how the Oregon-based brewery installed a new filtration process to use water more efficiently, and adopted batch, historian, control and other software from Rockwell Automation to reduce brew cycle times by 50%, increase brewing capacity by 25%, and gain other benefits. It's located at www.rockwellautomation.com/en-us/company/news/case-studies/full-sail-brewing-taps-manufacturing-intelligence-to-enhance-pro.html

ROCKWELL AUTOMATION
www.rockwellautomation.com

ANALYSIS + TUNING = QUALITY

This 70-minute video, “Batch process control—unique challenges and opportunities” by Greg McMillan, Control Talk columnist, and presented by the ISA, examines how manufacturers use process controls to maintain quality. McMillan explains how to analyze batch data, elevate the operator's role, tune control loops, and establish control strategies to improve batch operations. It’s located at www.youtube.com/watch?v=4k0ne6kF7Kk

INTERNATIONAL SOCIETY OF AUTOMATION
www.isa.org

THE BATCH LAST TIME

The prior version of this resources guide, "Mixing up a batch—maybe eve golden" in Control, Jan '18, included even more useful articles, videos and whitepapers on batch. It's at www.controlglobal.com/articles/2018/resource-guide-mixing-up-a-batchmaybe-even-golden/

CONTROL
www.controlglobal.com

If you know of any tools and resources we didn’t include, send them to ControlMagazine@Putman.net with “Resource” in the subject line, and we’ll add them to the website.

A wake-up call for industry

PAUL GALESKI
Founder, Maverick Technologies, and Vice President and General Manager, Rockwell Automation's Control Products and Solutions Business

"WHAT happens when *everyone* calls in sick? It's just not a question that we ever asked."

That's how Paul Galeski characterizes the stunning wake-up call faced by manufacturers and processors when the coronavirus (COVID-19) pandemic struck earlier this year. We recently had a chance to chat with the founder of Maverick Technologies, a leading provider of automation services and strategic manufacturing solutions, to discuss nothing less than the future of industry and the continued importance of the automation professional. Read on to learn more of his seasoned perspective and "fitness" prescription for moving industry—and the profession—forward.

Q: In some of your recent musings, you've noted how we as an industry, especially those who specialize in automation, were caught unawares by the pandemic. In what ways do you think we didn't have our act together but thought we did? And how did we get it so wrong?

A: Yeah, it's pretty crazy. Talk about a paradigm shift. I won't say we got it wrong; we just didn't get it right. We looked at the world through the same manufacturing automation lens for the past 50 years. But, just like the army's always equipped to fight the last war, we were unprepared for the new enemy that showed up. With the onset of the pandemic, we've needed to attack and manage in a very different way. And it's a more all-encompassing way.

We've done a good job of solving the problem and the challenge as we understood it—the efficiency of global manufacturing, of American manufacturing, has never been better. But our notion at Maverick is that industry needs more than just automation, and that's where we fell short. Industry needs something we're calling flexible, intuitive technology (FIT).

Q: This more all-encompassing view of automation and technology also entails a shift in perspective regarding the collaboration of people and machines. How does our view of that relationship need to change?

A: Well, first of all, we've got to do a better job of defining their respective roles. Think in terms of an org chart: each player should have defined roles, responsibilities and job descriptions. When it comes to a manufacturing environment, I don't know that we've done a good job of defining the role of technology versus that of labor, management or any number of external players. So, before we can go out and become FIT, we must develop that whole mosaic of roles and responsibilities. Once we define those purposes, then we as an industry can start to solve the interactions.

Q: Agility and flexibility have been a priority for industry for many years. What really makes FIT different than the old paradigm of being more flexible and agile?

A: In my experience, our view of agility has been too unidirectional. Sure, we implement changes we think will make our operations more agile, but as we move forward, we need a feedback loop that says, "Okay, we were agile, but we weren't quite agile enough. So, what made us not agile?"

And that's where the intuitive piece comes in. It's not the open-loop environment of the past, but an environment that helps us continually learn as we go and get better with use.

The way I look at the world, there are two kinds of businesses: those that get better with use like Google or Amazon, and those that don't. We really haven't fully explored—and certainly haven't implemented—the full complement of artificial intelligence and other tools that are very common in other industries and environments. We've got a huge opportunity for growth, and those kind of things are what makes FIT different.

Q: Can you give some specific examples of how a manufacturing environment might learn and adapt to changing conditions in real time?

A: Let's just say we've got a pair of pumps that start misbehaving. One is surging and the other is carrying a heavier amperage load than the other, and back and forth they go. They're kind of getting sick, and ultimately a pump or valve fails. Eventually, we wake up, see what the problem is, and fix it. That's open loop, and we keep charging forward again until something else goes wrong.

Well, here the software needs to learn what happened and, when it sees it coming again, make adaptations to the process itself or bring in the human factor. And as we continue to adapt the process, the software will eventually get to the point where it can come up with many solutions to a particular problem.

Q: So leveraging more machine learning, AI-type technologies to do more closed-loop adaptations that are above and beyond what we'd normally do just with a PID loop or even an advanced control algorithm?

A: Yes, exactly. And to provide more contextual information to the human factors that are involved in this organization that we talked about. So, the technology has its role to bring those things bubbling up to the person's attention. And I'm not talking about an alarm that says, "Okay, the valve is closing. It's supposed to be open." That's easy and it's old news. But what were the factors that led up to that? The operator or the maintenance technician needs to get the backstory to help them see what happened, and potentially feedback a better resolution before the failure, before the process interruption, before the potential safety breach.

Q: So what's next? We're six months into this pandemic and apparently still have some ways to go. What do manufacturers and processors really need to start doing now to first make their way forward through this, but also to be prepared for the next unanticipated thing—whatever that is—coming out the other side?

FIT STANDS FOR 'FLEXIBLE INTUITIVE TECHNOLOGY'
Maverick Technologies' FIT paradigm embraces a closed-loop agility that allows the people and systems in a manufacturing environment to continually learn and get better together.

A: Well, let's start with what not to do, and that's go in and make a bunch of changes because you think you know what you need to do. Certainly, if there are necessary safety issues that you've learned of, you go solve those.

But before you make a major initiative to take your systems, process and enterprise forward, take a step back, and recast everything in this new COVID-19 pandemic light. How does that change the landscape? How does it change our priorities? Do a risk-reward analysis, do a SWOT analysis in this new light, and see what you come up with.

Much of what we've done over the past years and decades will still be part and parcel of this exercise. But there's this whole new category, this whole new group of things that we need to be thinking about that we didn't see before.

Also, make sure you've got the right people in the organization that can drive this new paradigm. People who have an open mind, and really don't accept business as usual. People who are willing to say, "Hey, folks, the way we've been doing this ain't gonna work anymore."

How are we going about strategic planning? How are we developing our strategic roadmap? What are the big-picture items that we need to do? Because once we develop a what, we're usually pretty good at getting at the how. But if we don't get the what right, and don't think about it in a big, free-thinking way, then the how is going to miss the target just like before. ∞

For more information on Maverick's FIT paradigm, experience the company's interactive whitepaper at mavtechglobal.com/fit

STRONG LINKS

by Jim Montague

Suppliers and distributors use multiple strategies to fight COVID-19 supply chain disruptions

THERE are hiccups and tweaks, and there's planet-peeling chaos and scrambling madly to maybe survive. Which scenario is the process control and automation supply chain facing? Right, the same one that blindsided everyone else.

"Remote work is the first option, and it's mandatory for some activities and vulnerable people, such as those over 60 years and/or with previous health issues. We had overhauls postponed, and some investment and upgrades were cancelled," says Felipe Gabriel Kuhn Soares, maintenance engineer at Braskem's (www.braskem.com) chemicals and polymers plant in Rio de Janeiro, Brazil. "People on the factory floor are at minimum levels, but onsite workers have constant support from remote personnel. We're also using Microsoft services like Skype and Teams, as well as mobile tools like WhatsApp."

Upheaval and context

While not nearly as decimated as the hundreds of thousands who died and the millions more sickened or left jobless, most process industry users—and the suppliers and distributors who serve them—watched the COVID-19 pandemic turn their plants upside down. Where suppliers and distributors used to wrestle with the shift to online sales, or more recently tried to mimic Amazon's fast delivery methods driven by consumer expectations, they're now hip deep in a health crisis that's disrupting all aspects of their businesses and markets.

"The disruptions occurred early in the pandemic as China and Italy and other hard-hit areas basically shut down and were unable to ship parts. Even if a product, machine or whatever was built in the U.S., more often than not, there are components coming from these places. The good news is most supply points have largely recovered in the last couple of months, and distributors such as ourselves were able to use our inventory to buffer the effect on many customers," says Joseph Schwartz, group executive VP of the Mi Automation Solutions Group at Motion Industries (www.motionindustries.com). "It's clear that, while both manufacturers and distributors have been on a path to increase electronic transactions for at least a couple of decades, COVID-19 accelerated the adoption of e-commerce by customers. Distributors with active and capable e-commerce sites are benefiting, as more customers self-serve rather than meet with salespeople. Will these practices continue, post-pandemic? Most think it will to a large degree."

Pandemic pulse in process

Unfortunately, because COVID-19 emerged and spread so quickly, everyone was forced to cope by using whatever solutions and awareness were handy, at least until better understanding levels and solutions gradually became possible. Some responses were woefully inadequate, but other available tools and existing infrastructures have proven useful and resilient. Of course, most

SPACE TO FLEX

Figure 1: To continue shipping anywhere in the U.S. in 24 hours and anywhere worldwide in 48 to 72 hours, Digi-Key Electronics recently expanded its hub in Thief River Falls, Minn., by building a new, four-story, 2.2-million-sq-ft, $300 million product distribution center next to its existing facilities, linked by a sky bridge, and scheduled to open in 2021. Source: Digi-Key

involve preparation ahead of time, using existing supply lines and relationships, getting networked, and using the Internet and other forms of digitalization.

To collect and confirm specifics about how readers view their supply chains and how they're handling the pandemic, *Control* secured responses from close to 100 end users, distributors and suppliers in its latest 10-question "Distributors vs. Buy Direct" survey in July 2020 (see sidebar, p28). They also reported on the most useful strategies they're using during the pandemic to locate, specify, purchase and implement their components and support services:

- Buying direct from suppliers jumped almost 10 percentage points from 66.4% in 2019 to 75.8% this year, while buying from distributors dropped more than 10 percentage points from 79.6% in 2019 to 68.4% this year.
- Online purchasing from distributor websites also jumped almost 10 percentage points to 72.3% this year from 64.1% last year, but purchases from supplier websites only dropped slightly to 69.9% this year from 72.8% last year.
- Almost three quarters of respondents (74.5%) report they're experiencing supply chain disruptions due to COVID-19, including delayed projects, ordering delays, unavailable products, increased shipping and logistics difficulties and cancelled projects.
- To help fight pandemic-related disruptions, respondents report they're expanding their online presence (38.2%), offering more flexible shipping (31.6%), and adding tech support hours (15.8%), discounts (14.5%) and installation hours (14.5%).

Shorter chains = local reliability

While most links in the process automation supply chain were damaged by COVID-19, and none were unaffected, one type being reexamined is the long, multi-point, global version because it was shown to be increasingly fragile. Because raw materials and basic components from distant suppliers were delayed or unavailable, many users are refocusing on local suppliers that are closer and, in theory, more reliable.

For instance, a key difference in Digi-Key Electronics' (www.digikey.com) strategy is it doesn't have fulfillment centers worldwide, and instead operates one centralized hub in northwestern Minnesota, and relies on fast logistics to get its products where they need to go. "We find it's most efficient to distribute our inventory from one single point, and ship globally from our site in Thief River Falls," says Margaret Cunha, western regional supply chain solutions director at Digi-Key. "We can ship products anywhere in the U.S. in 24 hours and worldwide in as little as 48 to 72 hours." In fact, Digi-Key recently doubled down on its one-hub strategy by building a new, four-story, 2.2-million-sq-ft, $300 million product distribution center, which is located next to its existing facilities, linked by a sky bridge, and scheduled to open in 2021 (Figure 1).

Cunha adds that COVID-19 hasn't impacted its business too badly because most staff and customers quickly transitioned to working at home, while its inventory team continued to work on-site with personal protective equipment (PPE), social distancing and improved safety measures. "About 80-90% of our more than 4,000 employees work at our headquarters. However, four days after the initial shutdown in the third week of March, we were impacted by the shelter-in-place order, and sent most everyone to work from home with laptops, phones and Wi-Fi connections. Our IT department went above and beyond," say Cunha. "It's not optimal, but like many other companies, we've successfully stayed connected through WebEx, Zoom and Microsoft Teams."

Reshore for sure

Of course, one way to shorten a supply chain is for customers to keep more of their suppliers in their own country. "The U.S. Dept. of Health and Human Services (HHS) is contracting with General Motors and Ventec Life Systems, Ford and GE Healthcare, Zoll Medical and Vyaire, and other ventilator manufacturers, but they ran into supply chain issues, especially when relying on overseas networks," says Vikram Kumar, president and CEO of AVG Group (www.avg.net), which includes EZAutomation (www.ezautomation.net). "Ventilators and the chipsets in them depend on printed circuit board assemblies (PCBA), flow sensors and pressure sensors. However, after China shut down at the beginning of the pandemic, problems with their usual supply chains meant many manufacturers had to go to domestic sources including AVG, which does all its R&D and manufacturing in the U.S. We're continuing to help, and even designed a new pressure sensor for these devices."

Kumar reports that COVID-19 and resulting struggles with the usual international supply chain demonstrated that it was less reliable than its users realized. "This has been a real eye-opener for manufacturers and the U.S. economy. It shows they need to onshore production of medical devices and parts, and they can't rely as much on overseas manufacturing," adds Kumar. "These have been tough times for many people, but bringing more manufacturing back to the U.S. will be less disruptive."

On the exporting side, Kumar explains there were delays in AVG and EZ Automation's deliveries because FedEx, DHL and other carriers limited flights, while consolidating by adding commercial containers to regular airline flights were also reduced, though some of this traffic picked up in June and July.

When supply chains are disrupted and economies falter, Kumar adds it's crucial for suppliers and distributors to offer enhanced services and flexible financing to clients facing unprecedented challenges. "Many plants can only allow essential services people onsite, so many scheduled upgrades and projects with capital expenditure approvals were delayed or cancelled. We've been retooling some of our manufacturing because, while automotive production was down, medical, pharmaceuticals, municipal water, consumer goods and groceries are up."

PROTECTION 101

Figure 2: Curtis Seals, outbound supervisor at Allied, tests a conveyor in its new receiving area. As an essential-provider, the company has kept all of its offices and 13-14 warehouses open, where it requires PPE, social distancing and body temperature checks, and has reduced staff and segregated shifts to lessen physical interactions and widen gaps between people. Source: Allied

Longer chains = more low-cost sources

While shorter supply chains and nearer sources are comforting in a crisis, several suppliers and distributors report that worldwide networks have better communications for handling COVID-19's effects, and the low costs, multiple sources and fast transportation that let them dominate in the past will revive soon.

"We're part of a network of partnerships, so we know how the pandemic occurred at different paces globally," says Frank Cantwell, product and suppliers VP at Allied Electronics & Automation (www.alliedelec.com). "We have advanced communications with our sister brand RS Components in the U.K. This gave us detailed pre-warnings, lessons learned and pivot points about dealing with COVID-19 and protecting our staff, so we could mobilize and do pre-work before the pandemic hit North America, and continue to adjust those lessons as it elevated in the U.S."

Just as it's revealed the shortcomings and capabilities of healthcare, governments and other organizations, Cantwell reports that COVID-19 has focused a lens on the supplier and distributors communities. "Many customers have built up their

inventories and safety stocks positions on some items, just as healthcare providers in the U.S. have tried to get ahead on PPE, and are seeking sources closer to home," explains Cantwell. "From a freight perspective, shipping worldwide is obviously costly. However, remote networks can help because we have multiple facilities, and can balance stocking levels between them, and shift products to where they're needed most. It's understandable that users want to source products locally because they feel they're in a better position where they are, but it's important to understand that COVID-19 hotspots can shift quickly, and that's when having worldwide locations can help.

"Ironically, the one positive thing about the recent U.S. tariffs, especially on goods from China, was that suppliers had to seek other sources and facilities, so shipments wouldn't come from a particular part of the world. These efforts to fix and bulletproof their businesses in response to the tariffs prepared many suppliers and distributors to better handle COVID-19 when it arrived. It was surprising, but the problems caused by COVID-19 would have been much worse if we hadn't already been responding to the tariffs."

Dr. Andreas Mayr, COO of Endress+Hauser Group (www.endress.com), adds that, "Our global transportation network, as well as our sales and production centers, found ways to provide optimal support to our customers during this crisis. For instance, to preserve our delivery reliability, we shipped products via express and air freight in many countries. International supply chains were bundled on a regional basis much more than usual. If customers had to shut down operations during the pandemic, we warehoused the shipments in our regional hubs on a temporary basis. This also applied to regions where we were unable to deliver because they were closed off."

Where's the remote?

While many process operations and suppliers have been designated as essential and remain open, they've often been limited to socially distanced skeleton crews, while everyone else has to set up, strengthen or secure home-based Wi-Fi networks and learn to use Zoom, Microsoft Teams other conferencing and remote-work software. Meanwhile, their downstream clients and end users are all experiencing the same upheavals, and range from closed or close to financial ruin to crazy-busy but unable to procure crucial components and ingredients.

Scott Jayes, VP of business operations at Allied, adds its operations in early COVID-19 epicenters like Wuhan, China, and Milan, Italy, enabled it to better mobilize about 95% of its 4,000-5,000 staffers worldwide to work at home, and be confident that they could carry our their roles. "We were already using Zoom and Microsoft Teams, but now we're using them a lot more for day-to-day work, crisis management and business continuity, along with other networking, Wi-Fi and cyber-secure tools," says Jayes. "The pandemic also showed why supply chains need to be based on trusted relationships, and highlights how they can improve resilience."

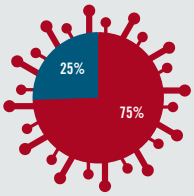
Because it's an essential-provider organization, Allied has also kept all of its regular offices and warehouses open. In these locations, it requires PPE, social distancing and body temperature checks, and reduced staff and segregated shifts to lessen physical interactions and widen gaps between people (Figure 2). "We were an early adopter of enhanced cleaning and social distancing practices, and even explained to staff how to travel to and from work more safely," says Jayes. "We also take a lot of pride in the fact that our products are helping the scientists and developers coming up with a COVID-19 vaccine."

Adds AVG's Kumar, "We have the same phone and online tech support as always, but even though COVID-19 added inquiries and some call volumes, there wasn't a big transition there. What's really increasing is web-based GoToMeet-

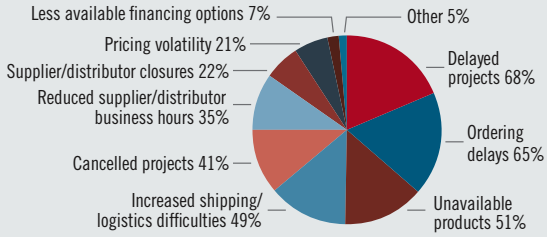
HOW USERS BUY PROCESS CONTROLS DURING THE COVID-19 PANDEMIC

Process control engineers, system integrators, technical professionals and other *Control* readers rely on a combination of supply chains when buying process controls, automation and related devices. These sources include traditional distributors, direct from suppliers, and increasingly via the Internet—which have all been severely impacted by COVID-19. In this latest 10-question survey in July 2020, almost 100 respondents reported on the most useful strategies they're using during the pandemic to locate, specify, purchase and implement their components and support services.

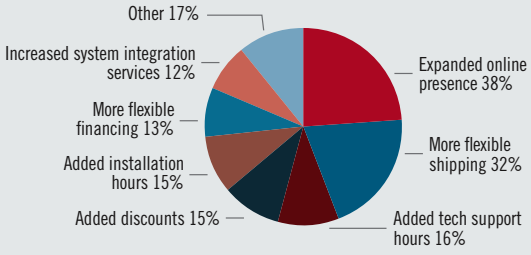
Experiencing supply chain disruptions due to COVID-19



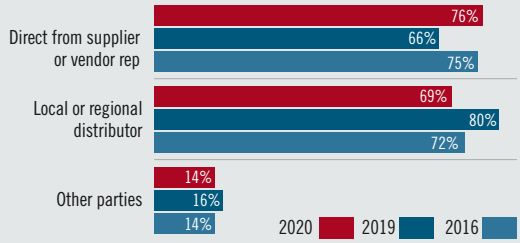
Types of supply chain disruptions due to COVID-19



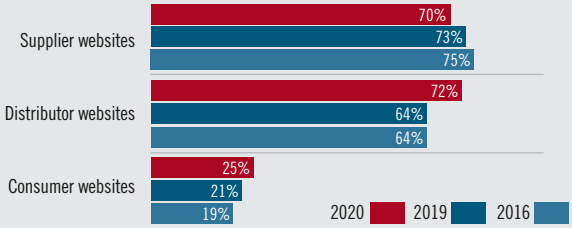
How suppliers, distributors and support organizations are helping users cope with COVID-19



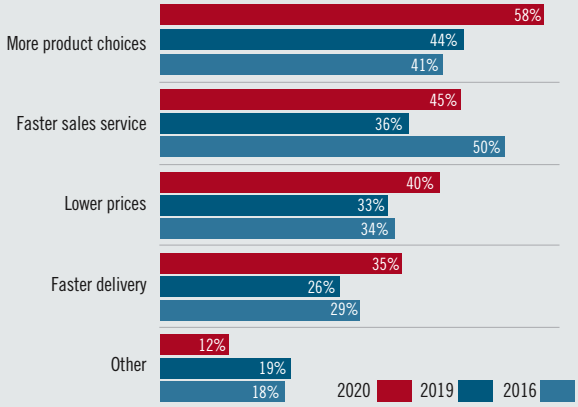
How process control and automation devices are bought



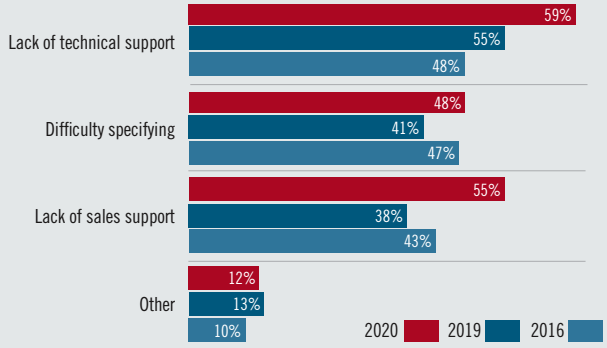
How process components are purchased online



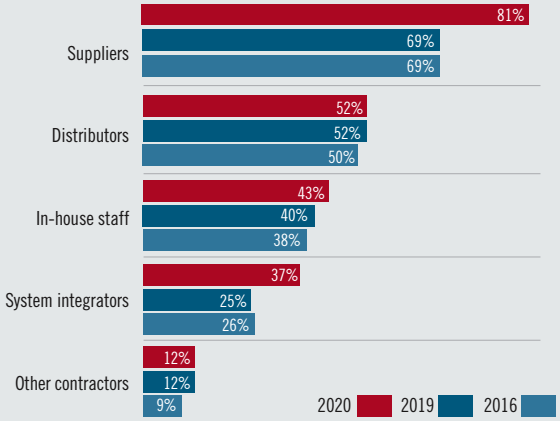
Advantages of purchasing online



Problems with purchasing online



Relied on for technical support and services



For complete results, visit https://www.controlglobal.com/assets/buydirectvsdistributors2020.pdf

ing and Zoom meetings, which I like. They're more efficient because no travel is needed, and we can meet with more accounts per day. We're also adding to our virtual meetings by ramping up our 3D imaging and rotational views of products, so participants can see and experience them better."

However, while online meetings are useful and similar to physical gatherings, Kumar cautions they limit viewers to only seeing what's onscreen. "You can't see facial expressions or hand gestures as well, so we may miss some useful cues," he says. "Likewise, working online from home may limit some work-related distractions, but there are many at home, too. Also, new hires can't get the same training and mentoring they'd get at the office, so we need to be aware of those gaps and fill them. This means more online-ready data access, specifications and data sheets, mobile-friendly pricing, and using collaboration tools like TeamViewer remote desktop software or VNC remote control software."

Culture, community help clients

Just as they shifted to help their staffs and upstream suppliers cope with COVID-19, many manufacturers and distributors are reorganizing to assist their downstream customers.

"If an end user wasn't aligned to respond to COVID-19's effects, they likely saw declining business," says Digi-Key's Cunha. "Some pivoted to aiding responses by others, such as automakers building ventilators, which shows how much flexibility is needed to shift and stay relevant. Many of our customers were able to transition to new projects required to offer support during the COVID-19 pandemic, especially the many smaller contract manufacturers. Digi-Key already has 24/7 tech support, but early in the pandemic, we worked with the University of Minnesota on an open-source ventilator design, and within 30 days released the inventory that a potential first-tier supplier would need to build it."

In fact, Cunha attributes much of Digi-Key's ability to cope with COVID-19 to the sharing practiced by its overall community in Thief River Falls, Minn. "Our people make the difference. We have an amazing company culture where everyone's willing to pitch in and help each other," says Cunha. "It begins with our leadership. The executive staff stays connected to the employees. They care about our well-being and understand that their employees are their largest asset. During the pandemic, the executive team has provided regular updates on its status, where the company is health-wise, safety tracking, health requirements and cleaning procedures. They understand the importance of communication and keeping everyone informed.

"What's interesting about these updates is the connection and communication between staff is as important as the content. Our employees are like a large family and they care about one another. Our community really rallies around when someone needs help, and this type of behavior bleeds into and infuses how we support our customers as well."

For instance, as more personnel work remotely and get familiar with online and digitalized tools, they can interact with clients better, which has a positive effect on their markets, according to Cunha. "Digital communication tools have helped our teams stay connected with our customers, and in some cases our remote staffers have never been busier. Speed is a big result of COVID-19, people have learned to do their jobs differently, transform and pivot to respond faster. Automated supply chain can be enhanced despite the pandemic. We had to do some things differently, but that's not necessarily a bad thing."

Bigger digital jump, better chain maintenance

Beyond anticipating upcoming needs and issues, some suppliers and distributors are working closer with their upstream components manufacturers to project and anticipate customer needs further into the future. This is similar to the close-knit relationships that consumer goods suppliers like Amazon have formed with many manufacturers.

"Because safety and people come first, we follow the World Health Organization's (www.who.int) recommendations," adds Braskem's Soares. "Next, we pay attention to critical processes and operations, maintain a good priorities list for them, communicate properly what's expected, share lessons learned with teams, make risks clear to everyone, empower people, and eliminate waste of time and resources. So, even as safety continues to come first in the future, remote work is also here to stay, and critical process and priorities will keep getting clearer."

Cunha adds, "From the time we get an order from a customer, we can have it picked, packed and shipped in 20 minutes. Our operational proficiency has incredible capacity. Consequently, we just launched our Digi-Key Marketplace (DK+) initiative that enabless customers to order from the upstream manufacturers we work with."

PANDEMIC TO-DO LIST FOR SUPPLIERS, DISTRIBUTORS AND CLIENTS

To better cope with the impacts of the COVID-19 pandemic, experienced suppliers and distributors advise their colleagues and customers to follow some basic recommendations and procedures. These include:

- ❑ Use personal protective equipment (PPE), social distancing, reduced staffing levels, body temperature checks, and enhancing cleaning and disinfecting procedures;
- ❑ Follow the rules and recommendations of local healthcare authorities for safely responding to COVID-19;
- ❑ Investigate, anticipate and manage risks to the supply chain, and establish a plan to gauge impacts, balance cash flow, and determine what's is needed for operations to continue;
- ❑ Build up added inventory or a safety stock of crucial items that are more likely to run low;
- ❑ Seek new backup sources for suppliers and networks that are more likely to be disrupted;
- ❑ Add more lead time to procurement, shipping and logistics processes to offset new delays;
- ❑ Investigate flexible financing and deferred payment options with trusted suppliers;
- ❑ Increase networking bandwidth and cybersecurity capabilities for remote workers;
- ❑ Learn to use online conferencing tools like Zoom, Microsoft Teams, GoToMeeting and others;
- ❑ Maintain an easy-to-use website and add functions for customers and remote staff;
- ❑ Enlist trusted partners to operate an integrated supply chain solution, and source products on your behalf;
- ❑ Research and employ online forecasting, analysis and procurement services like Z2A, Ariba and others to keep track of markets and proactively organize inventories; and
- ❑ Explore application programming interfaces (API) for automating system-to-system price checking, ordering and shipping.

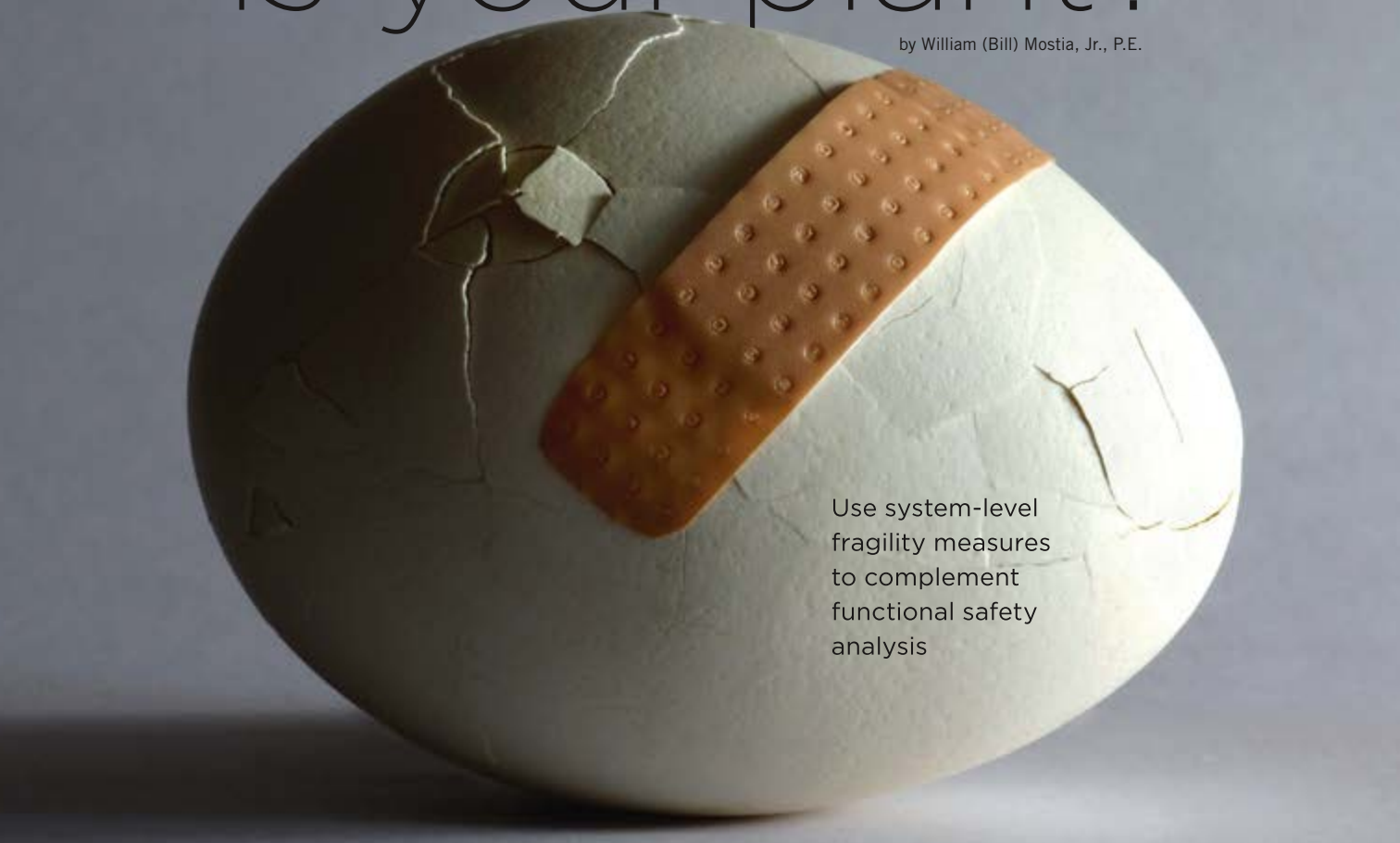
Similarly, Cunha reports that Digi-Key is adopting other more digitalized business practices. "A few years ago, we started using application programming interfaces (API) for system-to-system pricing, availability and ordering for our customers. APIs have been around for awhile, but they're gaining traction with procurement professionals, as they're more flexible than traditional electronic data interchanges (EDI)," adds Cunha.

Cunha adds that optimizing supply chains is made more difficult with the issues and closures caused by the pandemic. "Supply chains mainly require anticipating and managing risks, so it's critical to understand where the weaknesses are in your current supply chain, and put in a contingency plan to gauge impacts, balance cash flow, and determine how to keep manufacturing up and running," says Cunha. "We've been using Z2data's (www.z2data.com) risk-management software for supply chain management because it can highlight areas likely affected by COVID-19 by indicating what components aren't being made, and report on potential ramifications to the supply chain. If impacts are anticipated and financing is maintained, then a manufacturer can survive to play another day, weather the pandemics, and be available for jobs after it's gone."

In the initial days of the pandemic, Digi-Key and Z2Data partnered to offer priority support and component data at no cost to firms building medical devices such as ventilators and testing solutions that fight COVID-19, which helped them quickly source components and ramp up production. Z2Data also offered free-of-charge access to its electronic components database through its Part Risk Manager and Supply Chain Watch software, which let users meet demand by managing their bills-of-materials, make informed part-selection decisions, find cross-references and alternatives, and track inventory availability of parts alongside real-time pricing and lead times. ∞

How fragile is your plant?

by William (Bill) Mostia, Jr., P.E.



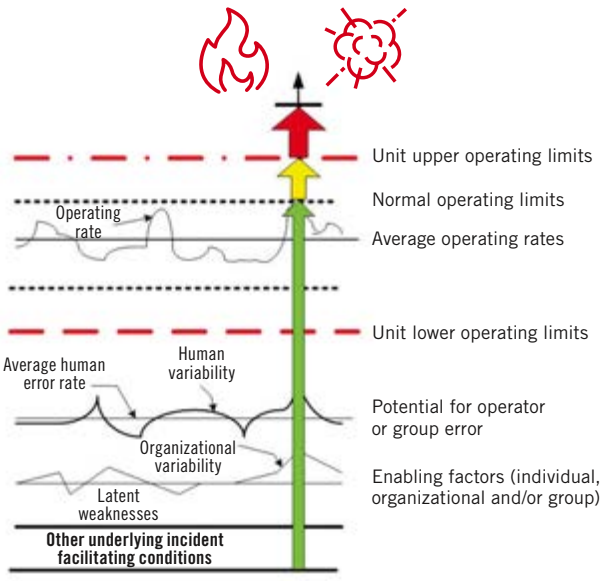
Use system-level fragility measures to complement functional safety analysis

WE as an industry have done an excellent job ensuring that our safety instrumented systems (SIS) provide the risk reduction calculated in our risk assessments. Other improvements in functional safety have further reduced the potential for accidents. Yet we're still having them.[1]

A more holistic approach called the superimposition accident model,[2] together with the concept of plant safety "fragility"[3], has the potential to help improve our overall safety performance.

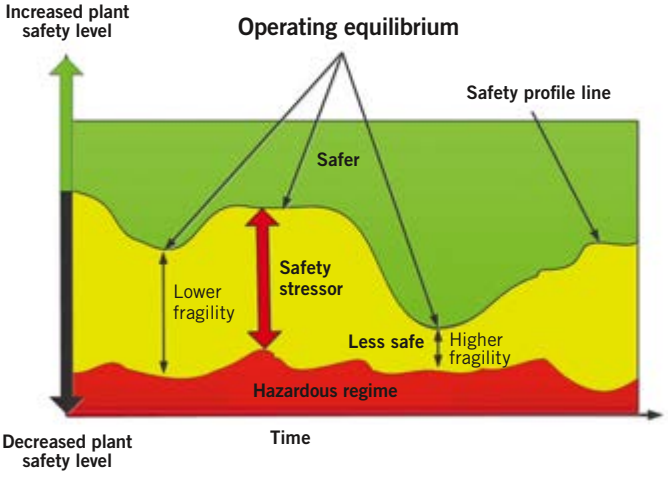
Sometimes incidents happen because many varied things align together in a perfect storm. Certain conditions, states and actions superimposed on one another can increase the likelihood of an incident. Conversely, other conditions, states and actions superimposed on one another can decrease the likelihood of an incident.

This concept is illustrated in Figure 1. What should be noted is that, while the presence of conditions, states and actions may be required for a negative outcome to occur, they're not necessarily sequential or linear in nature. So, while individual human error or actions may lead to an accident, there are quite likely underlying conditions and states that facilitated the occurrence of those errors. The same type of inference applies to positive outcomes: if weaknesses are changed into strengths, the likelihood of an incident can be reduced.



SUPERIMPOSITION ACCIDENT MODEL

Figure 1: Certain conditions, states and actions superimposed on one another can increase the likelihood of an incident. Conversely, other conditions, states and actions superimposed on one another can decrease the likelihood of an incident.



PLANT FRAGILITY PROFILE

Figure 2: The safety profile or operating line indicates the current level of safety under the current operating conditions (green area) and the hazardous regime (red area). The distance between these lines is a measure of a plant's safety fragility.

Plant safety fragility

Safety incidents are seldom simple, nor do they occur in a vacuum. Most incidents have a number of conditions, states and actions that led to or facilitated the incident. When looking at the individual elements probabilistically, e.g. multiplying probabilities together, it's sometimes hard to see how an incident could have occurred based on probability alone. I came to the conclusion some years back that many incidents have a combination of unrecognized background states, conditions or enabling factors that were essentially lying in wait for the right actions or events to occur, which when combined, resulted in an incident. This is essentially an application of the superimposition principle, i.e. actions, states, events, factors and conditions when overlaid, add up to exceed an "accident threshold."

Figure 1 illustrates the superimposition model of an incident where underlying system-level conditions, human error, equipment failure and current operating rates push the system closer to exceeding the plant limits, leading to an incident. The closer the system safety profile is to the hazardous regime, the more fragile a plant's safefy is. When certain conditions or actions (called safety stressors) are combined with current plant safety weaknesses, the plant safety profile moves in the direction of the hazardous regime and the likelihood of an incident increases.

The current process safety methodologies (HAZOP/LOPA) are scenario-based, and provide a "small picture" look at safety by identifying individual hazardous scenarios (small pictures) that can lead to an incident. The methodologies assume that by mitigating a large number of scenarios, plant safety (the big picture) can be improved.

Scenarios are developed by breaking down the process into smaller pieces called nodes, and applying guide words such as too much flow or too little flow to identify initiating causes that could lead to a negative outcome. The frequency of occurrence of the initiating cause and the consequence of each scenario are evaluated. Independent layers of protection (IPLs) are then applied to reduce the frequency of occurrence or to mitigate the consequence to an acceptable level. These methodologies do not typically look at why and how the initiating causes occur, nor do they try to reduce the initiating cause frequency of occurrence, or examine what plant systems or conditions facilitate the occurrence or the subsequent progression of the hazardous scenarios. This is a valid approach as far as it goes, but it's limited to a set of identified potential hazards out of an unknown set of hazardous scenarios.

Big-picture perspective needed

Essentially, this functional safety approach doesn't look at the bigger pictures that may facilitate the littler ones. Instead, these process safety methodologies should be used together with an effort to identify safety weaknesses at the individual, intermediate and system levels, so they can be strengthened, thus reducing the potential occurrence of negative outcomes. To do this, safety weaknesses (fragility) as well as strengths in the plant systems must be evaluated, and the system must be strengthened to eliminate or significantly reduce the level of safety weaknesses.

The safety fragility concept from an operating perspective is illustrated in Figure 2. Here, the safety profile or operating line indicates the current level of safety under the current operating conditions (green area) and the hazardous regime (red area). The distance between these lines is a measure of a plant's safety fragility. Unlike in the figure, however, fragility is multi-dimensional: there can be multiple points in an operational regime or plant where weaknesses under the right conditions can add up to an incident.

The safety profile line in Figure 2 indicatesf a combination of conditions, operating states, system responses, current events and actions, internal and external forces, and variations in the plant hazardous operating regime over time. Time is a necessary consideration as safety can vary over the day, time of the month, or time of the year, as well as with market conditions. For example, the competency to deal with abnormal conditions can vary from shift to shift and things may be more dangerous in the winter or summer or under certain product slates. These variations can significantly affect plant safety fragility.

If, on the other hand, the safety profile line starts to go further up into the green area in Figure 2, the plant safety level will have improved relative to the hazardous regime. And if the safety profile line moves down into the yellow area, safety fragility has increased. If the safety profile line enters the red area, the red area crosses into the green zone, or a stressor occurs to push the profiles together, a safety hazard or incident can potentially occur.

A plant is essentially a large, complex system in a state of safety equilibrium during normal operation, where safety is neither increasing nor decreasing. The system stays in the equilibrium state until some event or condition (a safety stressor) disturbs the equilibrium state. A safety stressor can be defined as a condition or state, event or action that moves the safety profile line and the hazardous regime closer together, increasing the likelihood of an incident. Strength and resilience resist the safety stressor while weakness facilitates the safety stressor.

Table I: Key performance, conditions and state indicator examples
Number of loss-containment events per month/year
Number of near misses per year
Monthly number of abnormal operational events
Number of annual safety demand events
Average plant operator experience level
Average shift experience level
Average plant maintenance technician experience level
Average engineer experience level
How long is your maintenance bad actor list?
Number of monthly operator mistakes due to poor situational awareness
Number of mechanical integrity and reliability events that affected plant operations
Number of outstanding SIS proof tests
Number of control system or instrumentation loops that are in manual or are non-functional
How many mechanical integrity inspections occur monthly/annually?
What are the operator and maintenance technician's impressions of plant reliability and mechanical integrity?

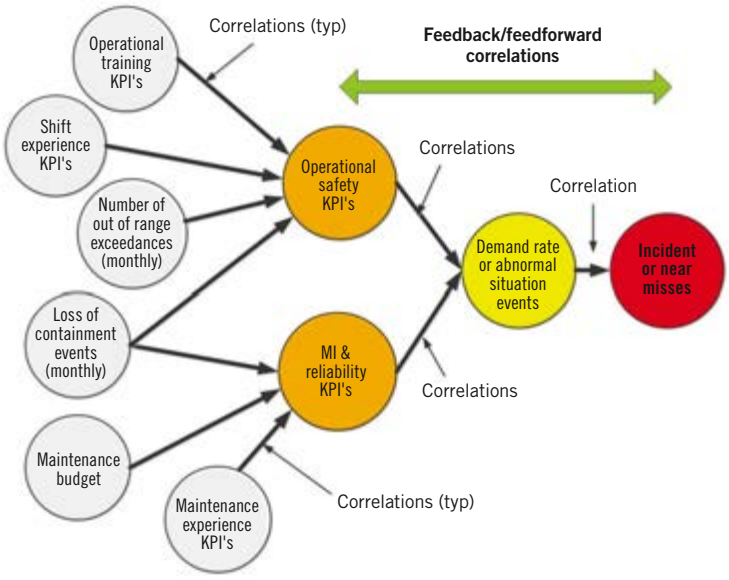
Factors affecting fragility

Functional safety has given us a necessary level of protection while the concept of fragility leads us to a different perspective that also looks more holistically at system-level aspects of safety in a plant. Some of these factors include plant and company safety leadership, safety culture and climate, personnel competency and experience, system strength and resilience, operational and maintenance discipline, inherent safety and plant design, current physical shape of the facility, mechanical integrity and reliability[4,5], as well as data quality (situational awareness)[1]. This is by no means a complete list of system-level properties, states or conditions that affect safety and fragility. Each company and plant will have its own unique system-level properties that affect fragility.

The length limitations for this article prevent a more detailed discussion of these items. My recent Texas A&M Instrument Symposium presentation[3] discusses these items in some detail, including potential key performance indicators (KPIs), conditions and questions to be asked about the current state of the plant.

ANSI/API 754, "Process Safety Performance Indicators for the Refining and Petrochemical Industries" represents KPI for recognized and generally accepted good engineering practices (RAGAGEP) when it comes to process safety, and should be referred to when starting to determine a plant's safety fragility. Many of these KPIs are handled at the local or intrinsic level but not always at the system level or perspective in a typical plant. For example, experience may be examined at the group level but less so at the system level. While KPIs can help provide a measure of existing plant fragility, KPI trends are also important as they can indicate whether plant safety is getting stronger, weaker or steady. Some example KPIs are listed in Table I.

Quantitative calculation of fragility as a single variable is difficult due to lack of a mathematical methodology, as well as a lack of comprehensive metrics or weighting factors. Some aspects of fragility are qualitative in nature, making it more difficult to quantitatively combine disparate metrics to achieve "uber" KPIs indicative of overall safety fragility.



PLANT SAFETY FRAGILITY VECTORS

Figure 3: System-level KPIs may show a plant's underlying weaknesses in one area such as lack of competence or experience, but correlating them to other KPIs that are indicative of the hazardous regime—such as high demand rate, number of abnormal situation events, number of relief valves lifting or number of near misses or incidents—can indicate what things are strong negative influencers. The reverse can also be true, as changes in KPIs can indicate strengthening of plant safety and a reduction in the plant's safety fragility.

Calculating fragility

One obvious approach is to collect data for KPIs that can potentially affect the "strength" or "weakness" of a plant. This methodology will be data- and analytics-intensive, but since a lot of the data is available, it will help provide quantitative results. In addition, data mining may yield additional useful information.

Looking at individual system-level KPIs may show a plant's underlying weaknesses in one area such as lack of competence or experience, but correlating them to other KPIs that are indicative of the hazardous regime—such as high demand rate, number of abnormal situation events, number of relief valves lifting or number of near misses or incidents—can indicate what things are strong negative influencers. The reverse can also be true, as changes in KPIs can indicate strengthening of the plant and a reduction in the plant's safety fragility. For example, increases in operating experience may correlate with a decrease in plant SIS demand rate. It may also be that weakness vectors indicative of increasing fragility prove additive in nature. A simple example of these types of fragility vectors is shown in Figure 3.

How can we combine these complex KPIs in a useful manner? One approach may be weighted averages based on statistical correlations that are fed back as operating time progresses using data analytics to indicate what influences what and to what extent. Another possible approach is the use of a recursive neural network to determine the effects of various KPIs on potential negative and positive outcomes.

Complementary approaches

Current hazard and risk assessment methodologies look at multiple hazardous scenarios (small pictures) to individually reduce the frequency or mitigate the effect of the scenario's consequence. But determining all the possible hazardous scenarios (bigger picture) out of an unknown set of hazardous scenarios limits this methodology.

Fragility, on the other hand, looks at the plant's systems and intermediate-level safety weaknesses and strengths as well as some of the system-level elements common to all scenarios, such as reliability, human error and mechanical integrity. It looks at the bigger picture, and seeks to reduce the plant's safety fragility, improving safety. These methods are complementary—not alternative—approaches.

The purpose of looking at a plant's fragility is to realize that process safety is more than reducing the frequency or consequence of hazardous scenarios by applying functional safety. While functional safety significantly contributes to plant safety, it is not sufficient unto itself. System-level causal factors that facilitate unsafe actions and conditions that lead to an incident must also be considered and the plant's systems strengthened to increase the plant's overall level of safety.

Since a plant's safety fragility is a combination of many things, a holistic approach is necessary to consistently keep the safety profile well away from the hazardous regime. This can be done by building strength and resilience into plant systems, reducing the system facilitation of safety stressors, limiting the events or underlying conditions that can unknowingly drive the operating profile toward the hazardous regime, and shrinking the hazardous regime itself. ∞

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Why you need an OPERATIONS ASSESSMENT

[not an ergonomic study]

User-centric design is the foundation of ISO 11064 — conformance can't be rubber-stamped afterwards

by Brad Walker and Peggy Hewitt, BAW

LATELY we've seen many RFPs cross our desk for "ergonomic studies." Each one is uniquely different but with a disturbing trend. One of the most concerning requests is what we refer to as the "rubber stamp" request. This is when the client, often an engineering company with a project in hand, is looking for a company with human-factors expertise to evaluate a control room design that's already been approved. Why, you might ask, would they ask for an ergonomic study if they already have a control room design? The answer is often simple: the engineering company's client, an operations company, wants to make sure that their new control room will meet ISO 11064 standards for proper, safe control room design.

When designed properly, and applying ISO 11064 standards, a successful control room creates an environment for the operators of situational awareness within the event velocity timeline of the operating company. This equates to a safe, well-thought-out control room environment that should reduce incidents and make it easier to react to and address any incidents that arise.

So with these requests for ergonomic studies, consultants and architects with control room expertise are sought to review the design and provide a report that will ensure the design, once built, will provide all the benefits the operational company is looking for. Those benefits include an efficient and effective environment for control room operators with a high degree of situational awareness to minimize fatigue and operational errors. With a focus on cost savings, procurement managers from engineering companies are asking to have these studies completed remotely, without ever talking to an operator or understanding the operational requirements. Many consultants and console furniture suppliers with limited experience in designing control rooms are taking on these "ergonomic studies," and for a few thousand dollars are providing the rubber stamp that these control room designs will meet ISO 11064.

A process, not an end state

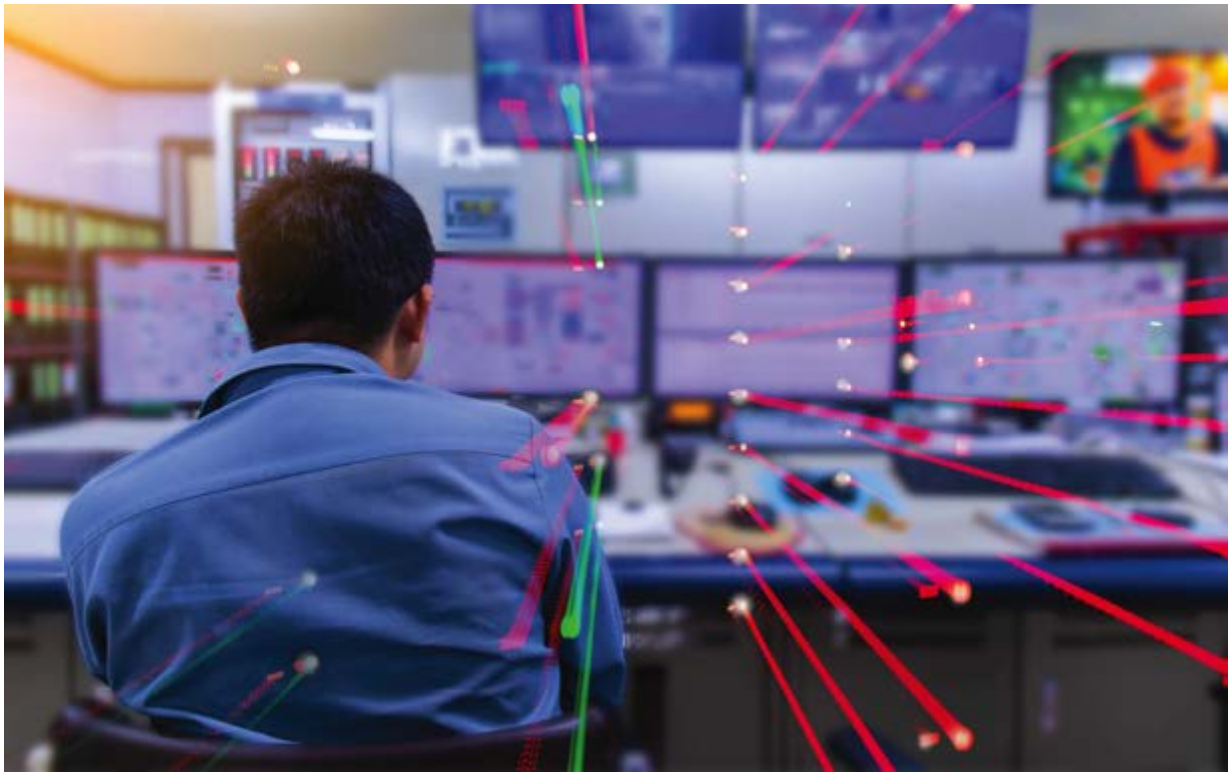
This is a problem on many levels. First, ISO 11064 defines a process, not an end state. If the process—a bottom-up definition of the requirements starting with the operator—was not implemented in the designing of the control room to begin with, a review after the design has been completed will not improve anything. ISO 11064 Part 1 is the most critical and important part of the standard; it explains the user-centered approach as a foundation for the design. It calls out the necessary process, and this is not merely a checklist to achieve its goals. It's a thorough methodology to design a safe, resilient control room where situational awareness is the priority, not the afterthought.

Does the control room design meet ISO 11064, yes or no? This is a *risk* issue. You may want to view it as a standards issue, but it's a risk issue. The standard defines the process: if the process wasn't used the answer can't be yes. The risk is designing and constructing a control room based on a design with no input from the operators and operations team that will be working in this mission-critical environment. The risk of *not* designing the control room according to a defined process results in a variety of issues, such as the following:

- Control rooms with so many reflective surfaces, so much glare and such poor lighting that it's simply turned off at all times.
- Control rooms in a corridor or hallway because the originally designed room was so completely ineffective that the operators had to move out.
- Control rooms so dense that noise continues to be a major impediment to safe operations.
- Control room lighting using the same fixtures found in the rest rooms, and control rooms with lighting specifically known to cause fatigue.
- Control rooms with workflows so poor that operators are constantly disrupted by unnecessary people walking around, and not enough room for effective shift handover activities.

Alone, each of these observations don't mean the operational company will have an incident or failure relating to their control room, but what each of these observations do tell us is that the risk of the operator losing situational awareness within the event velocity required is higher. It's higher because instead of an integrated process that verifies the operator requirements within the context of his or her job, workflow and interactions between people and automation, no human-factors related process was followed, and thus no input from the operator was considered in the design.

We understand the desire to save time and money at every stage of a project. But the actual cost of properly designing a control room at the beginning of the process is often a small



The ISO 11064 standard describes a methodology for creating a control room that will provide operators with situational awareness appropriate to the event velocity timeline of the operating company. Egonomics is only one small piece of the solution that will fit the bill.

fraction, akin to a rounding error in the cost of the entire project. If we then add in the potential higher risk by doing an ergonomic study after the design is done by organizations without the proper credentials, we're making a poor situation worse.

Take for example, the operational HAZOP process, a process every major operation company knows well. Now imagine outsourcing that HAZOP to a hardware vendor or a consultant. This would never happen. Yet, we routinely see ergonomic studies being done by console furniture suppliers and by consultants who may have some human factors experience but have very little experience designing control rooms. The increased risk alone we believe is enough to consider making sure this is done properly.

Start with different terminology

So how do you do a proper ergonomic study? Our first suggestion is to stop calling it an ergonomic study, which literally makes us think we're evaluating fixtures and furniture and viewing angles. We may do this, but what we believe clients need is an operations assessment. This is a comprehensive evaluation of the control room starting with the operations requirements, and includes ergonomics, human factors, workflow, building and room design and layout, lighting, acoustics and finishes.

Changing the name alone won't solve the problems. We also encourage you to employ a control room design firm with a credentialed human factors specialist. This is essentially the beginning of the control room design process, but it can be applied to review an existing design. What is critical is that the work isn't just an approval of a design that was done in a vacuum. To effectively evaluate what's needed in a control room or operations building is nothing short of a comprehensive understanding of the work to be done in that room by the people who will work there.

We think it's worth repeating: designing a control room is a complex undertaking. There are literally thousands of variables that should be considered with each design to ensure an optimum outcome, and there's no such thing as ISO 11064 compliance "rubber stamp." Designing a control room is a series of decisions, trade-offs and constraints—human, fiscal and risk-based. Whether you're designing a new control room or improving one you have, the key takeaway is to follow the process properly. Cutting corners will only increase your risk, and therefore increase costs in the long run. ∞

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When (and how) to apply controller output signal characterization

If process gain changes with controller output, use this approach to linearize loop response and tame troublesome tuning

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Output characterization effectively reduced the change in gain from a ratio of 95:1 to 2:1, making loop tuning much easier.

IF the process gain makes large changes over the operating range, then tuning PID (or other linear) controllers is difficult. If tuned for one region, the controller is undesirably sluggish or aggressive in another.

The change in the process gain may be the result of any of several process or equipment features. One reason could be operation rate or throughput. At high rates, typically, larger control action is needed to effect control of temperature, composition, etc. At high rates, then, the process sensitivity to control action, the process gain, is lower. In this example, the gain is due to or characterized by operating rate.

A second classification reason for gain change might be the operating setpoint. For instance, if a distillation purity setpoint is increased, then changes in purity are less sensitive to control action, which means process gain diminishes. Or, consider pH control; classically, gain is very high when the pH setpoint is near neutrality, but very low in the acidic or caustic region. In these examples the gain change is characterized by the setpoint.

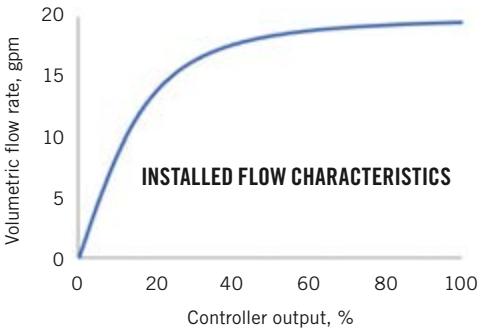

Figure 1: An output characterized example

Third, in some cases, process gain is due to or characterized by controller output. For example, if the inherent characteristic of a flow control valve isn't matched to the flow process conditions, the process gain, the steady state flow rate associated with controller output, isn't linear. Using Equation 3 in my article, "Understanding valve characteristics," *Control,* Aug '20, p 41 (www.controlglobal.com/articles/2020/russ-rhinehart-explains-valve-characteristics), Figure 1 illustrates how steady-state flow rate could respond to controller output (valve position) when a linear valve is installed in a line. In this example, over the intermediate operating range of 5 to 18 gpm, the process gain changes by a ratio of 95:1, which makes controller tuning difficult.

In these three cases, gain scheduling of the controller is a reasonable solution—tune the controller for the several operating conditions (high, medium and low operating rate or setpoint), place the desired tuning values associated with the flow rate or setpoint in a look-up table, and transfer those values to the controller when conditions change.

However, where the static nonlinearity can be characterized by the controller output, and the process dynamic response remains relatively unaffected, output characterization is the recommended solution to linearize the loop response, create a constant loop gain, and solve the tuning problem.

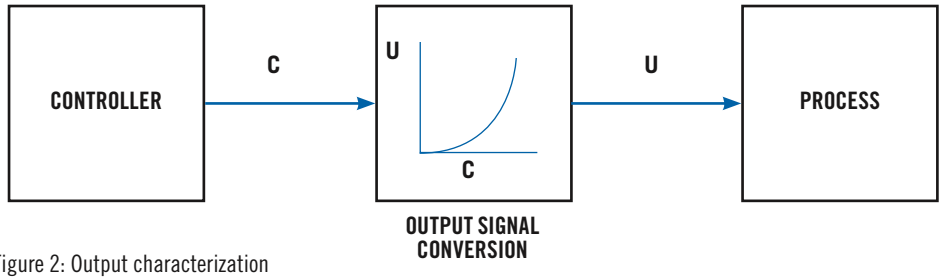

Figure 2: Output characterization

In this technique, the output signal from a controller, *c*, doesn't go directly to the final control element. Instead, *c* is transformed to an alternate signal, *u*, which goes to the final element. The term transform means algebraic signal conversion, a simple function, not a Laplace transform. This is illustrated in Figure 2. As *c* goes from 0% to 100%, *u* also goes from 0% to 100%, but it's not a linear relation. In this illustration, when *c* is at 50% *u* is only at about 20%.

The output characterization signal conversion will have the inverse shape of the process response to the controller output. In Figure 1, the shape is square root-ish. If you were to switch the two axes and plot controller output with respect to flow rate, the graph would appear quadratic-like, which is the shape illustrated in Figure 2. However, the signal conversion has the units of percent to percent, not the process variable units.

This article is about how to get the inverse relation for the output signal transformation. I'll present two methods. One uses an algebraic functional conversion, and the other uses a piecewise linear transformation. Both are grounded in the same compensation concept.

Concept for output characterization

Either do experiments or tap the historian to obtain steady state data for values of the process variable of interest with respect to the signal to the process. Set the output of the controller, the signal to the process, which means that $c = u$, wait for steady state, and record the process variable (PV).

This would represent Figure 1, but rather than a continuum line from a phenomenological model, you'll have discrete data points, which are affected by noise and other sorts of experimental process variability, as well as calibration offset in all of the control system devices (D/A, i/p, valve actuator, measurement, A/D). If possible, include the full range of controller output, *c*. If not, extrapolate to 0% and 100%.

The data may look like that in Figure 3, but you might not have so many data points. Notice the experimental variation. Also, notice the zero offset. In some processes, if *c* is zero, PV should be zero, but calibration errors will make it something else. And, in many processes, minimum PV value isn't zero (consider temperature or pressure).

Second, scale the PV value to a percent of full range, p, using the following relationship:

$$p = 100\ \frac{PV - PV_{min}}{PV_{max} - PV_{min}}$$

Perhaps, plot *p* against the signal to the process, the $c = u$, as in Figure 4. The graph is not necessary, but it may be instructive.

Figure 4 should have the same appearance as Figure 3, except that the vertical axis goes from 0% to 100% and there's no zero offset—when $u = 0$, $p = 0$.

What we'd like is a linear PV response to controller output: when the controller output is 50%, the process is also at 50% of full range, and 23% matches 23%, etc. But in Figure 4, when the process is at 50%, the controller output is a bit less than 20%. We'd like a formula that changes the 50% controller signal, *c*, to a bit less than 20%, *u*, so that when $u = 20\%$ goes to the process, the PV response is 50%. This would be the output characterization formula in the block in the middle of Figure 2.

To get such a formula, third, switch the axes of Figure 4, and recognize that *p* is the desired controller output (Figure 5). Notice that the shape in the relation of Figure 5 is the inverse of the process response. Notice that *u* is the signal to the process from the data generation experiment, and that the horizontal axis is *p*, and is now the desired value of *c*. In the experiments, $u = c$, but what we want is $c = p$.

Now, fourth, use any favorite technique to generate an equation to calculate *u* from *c*. The dashed curve in Figure 5 shows one model.

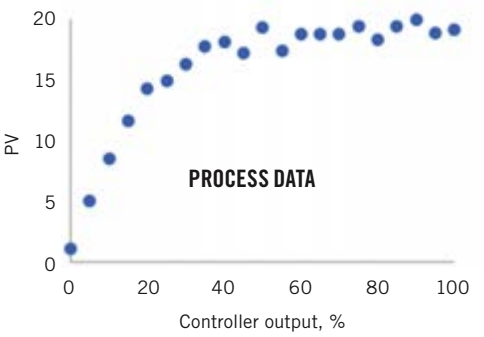

Figure 3: Experimental data reveals nonlinear gain

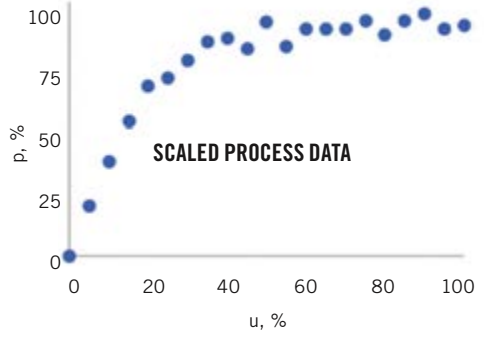

Figure 4: Figure 3 with PV values scaled 0 to 100%

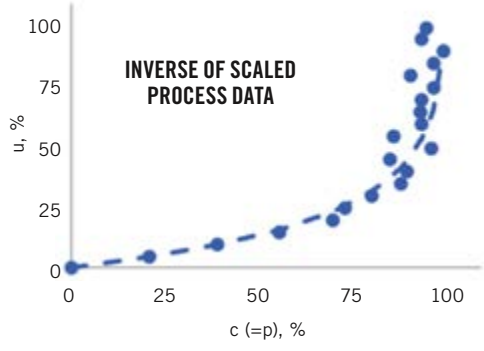

Figure 5: Inverse data with regression model

Mathematical inverse function method

If you're lucky, classic trendline fitting will generate a good relation for the data in Figure 5. However, in this case, quadratic, cubic or other power law or polynomial models don'tot give a good fit. Neither do exponential, logarithmic or many other simple modeling techniques. Consequently, I chose to derive a model structure that seems to fit the data. I looked at the trend in Figure 4, supposed that it could be represented

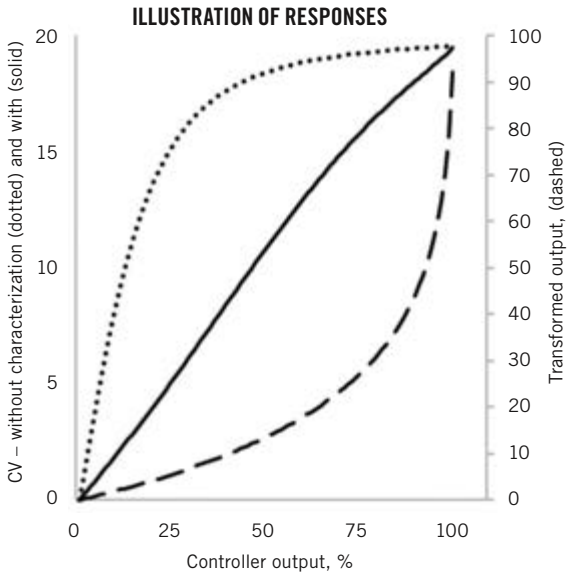

Figure 6: Empirical model impact

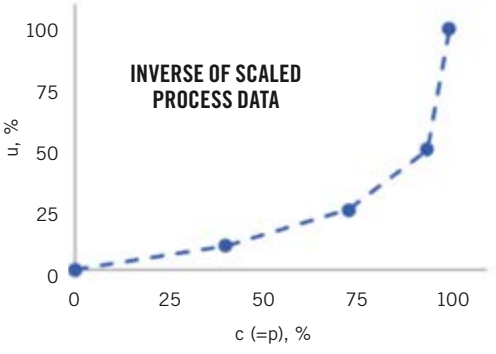

Figure 7: Piecewise linear model

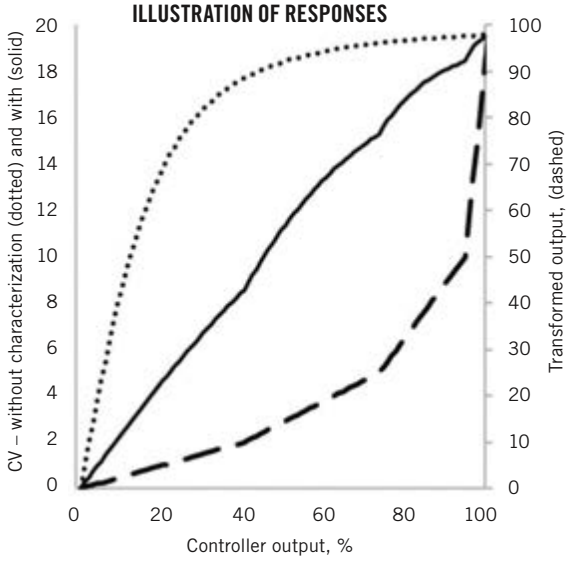

Figure 8: Piecewise linear model impact

by an exponential model (which is not the truth about the relation), then inverted the model to obtain:

$$u = 100\,\frac{1}{\alpha}\;\ln\left(1 - \frac{c}{\beta}\right)$$

and found the α and β values to best fit the data. The dashed line is the model that is used to convert *c* to *u*, which is the output signal conversion block function in Figure 2.

If you have a first-principles model of how the PV should respond to *c*, and can algebraically invert it, then it might be an excellent model for this output transformation. But, since there's no requirement that the process must comply with an ideal first-principles model, you'll likely have to adjust model coefficients to make it best fit the data.

In any case, the empirical model is not a perfect fit to the data. Note in Figure 4 that it's a bit above the data in the mid-output range and a bit to the right of the data in the high-output range. The model isn't the perfect inverse; it's an approximation.

Figure 6 shows the results when the output characterization model is used to convert the controller output, *c*, to the signal to the process, *u*. The dotted curve represents how the process (left-hand vertical axis) responds to the controller output without the signal conversion, basically representing Figure 1. The dashed curve is the inverse model (of Figure 5), which is used to convert the controller output to the signal to the process (use the right-hand vertical axis). The solid curve in the middle is the process response (left-hand vertical axis) to the controller output, with the signal conversion structure illustrated in Figure 2. Without output characterization, the gain changes by a 95:1 ratio (dotted line). With output characterization, the gain changes by a factor of about 2:1.

If the model were to be the exact inverse, the process response would be exactly linear. But an analytical model, fit to noisy process data, can't be exactly the process phenomenological inverse.

Now that the gain is nearly constant, tuning the controller will be easier.

Piecewise linear inverse method

It may be nearly impractical to obtain a single algebraic function to convert *c* to *u*. In many cases modeling the trend in Figure 5 with a piecewise linear (connect-the-dots) relation is simpler and fully adequate. Figure 7 illustrates a piecewise linear model. Select points, so connect-the-dot lines adequately match the data. (Details on constructing the model are included in the extended, online version of this article located at ControlGlobal.com.)

Finally, Figure 8 shows the results using the piecewise linear model as the output characterization. Similar to Figure 6, it shows the non-converted response (dotted) and the transformed response (solid). ∞

Author's acknowledgement: I appreciate the review and commentary from Jacques Smuts, OptiControls Inc. and Gregory K. McMillan, Control Talk columnist, as I prepared this article.

Russ Rhinehart started his career in the process industry. After 13 years and rising to engineering supervision, he transferred to a 31-year academic career. Now "retired," he enjoys coaching professionals through books, articles, short courses, and postings on his web site www.r3eda.com

How best to apply multiple-hole orifice plates?

They can help measure d/p with shorter straight pipe runs, as well as tame cavitation and excessive noise

Q: With **a conditioning orifice plate, how many holes are allowed? Is the maximum limit for the pressure drop through an orifice plate the same as the maximum differential pressure of the transmitter? Are there any other limitations?**

M. ULAGANATHAN
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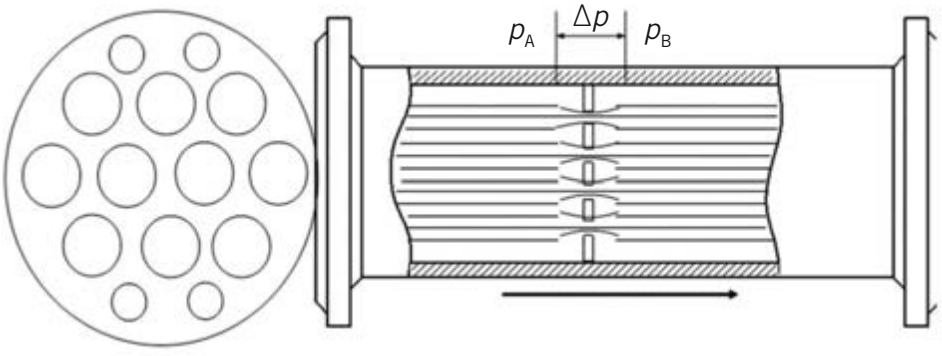
A1: Some multiple-hole orifice plates are used as "restriction orifices" (RO), serving to reduce or eliminate noise and/or cavitation. ROs are also used in front of safety devices (rupture discs, relief valves), which if they suddenly open, can overpressure downstream equipment. Therefore, it's desirable to limit the flow and the rate of pressure reduction through them, so the pressure on the upstream, protected equipment doesn't drop too fast. In a multi-hole plate, the flow is channeled into several streams through multiple holes (Figure 1). This reduces the noise that could be above acceptable limits if a single-hole device is used.

Such a unit can also be used either for pressure differential or flow measurement, depending on which variable is known. I usually estimate the flow through each opening as the total flow divided by the number of holes, ρ, as the density of the fluid, while the pressure drop (ΔP) is measured. Therefore, if ΔP is known, the flow (Q) is:

$$Q = \frac{kA\sqrt{\Delta P}}{\rho}$$

where A is the cross-sectional area of the pipe and k is a constant that includes the effects of the ratio between the total area of the holes and that of the pipe, the engineering units used and such

REDUCE NOISE AND CAVITATION
Figure 2: The flow at the inlet of a restriction orifice is channeled into several streams. Among other characteristics, this reduces the noise and/or cavitation that might occur with a single orifice.



RESTRICTION ORIFICE SECTION
Figure 1: One advantage of a multi-hole orifice section is it requires much less straight pipe run (about 2D on each side) than regular orifices, and can be mounted in horizontal and vertical pipe runs.

This column is moderated by Béla Lipták (http://belaliptakpe.com/), automation and safety consultant and editor of the Instrument and Automation Engineers' Handbook (IAEH). If you have an automation-related question for this column, write to liptakbela@aol.com.

meter characteristics as the thickness of the plate and the quality of the holes (Figure 2). For an area ratio of 0.5, the pressure drop across the multi-hole orifice is about 70–75% of the conventional single-hole orifice.

The orifice thickness is usually twice the hole's diameter, so a large diameter hole could involve an excessively thick plate. Also, while in the case of a single-hole plate there's no "neighbor turbulence" effect that chokes pressure recovery, for a multiple-hole plate the expansions of one jet will impact expansions of the others, limiting pressure recovery. That can be one reason why, for high-pressure drop applications, multiple-hole orifices are chosen.

Some studies suggest the optimum number of holes is seven, but that view is not uniformly shared, and there are other considerations concerning strength and dimension. Accuracy greatly depends on the quality of the holes, and is usually estimated at only 1-2% over a range of 3:1, but the repeatability is usually better than the accuracy. The range of the differential pressure (d/p) transmitter is usually selected to be 1.2 times the maximum ΔP expected.

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A2: There are no codes or standards governing conditioning orifice plates—the formulas are proprietary to the suppliers of these plates. Also, there are practical limitations based on particulates and clogging of the holes. This is best discussed with the vendor.

The limit of the d/p across the orifice plate has nothing to do with the transmitter. The limitations are purely from a process sizing perspective (e.g. Reynolds number). Read ISO 5167 or other good texts such as Lipták or Miller. The transmitter range is then specified to match the orifice sizing requirements

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A3: Generally, orifice plates have either one or two holes: one for the flow and one for the drain or vent. In special applications, where you may have slurries or special fluids, then you may have more, but be aware that calculating the pressure drop is a complicated process and making the orifice plate even more difficult.

The majority of manufacturers have a maximum pressure drop that the sensing element can respond to accurately before you need to change to a sensor with different characteristics. The maximum pressure loss will depend on several factors such as line pressure and maximum line pressure drop. For example, at a line pressure of 1 bar, the pressure drop should be less than 0.1 bar, otherwise the line hydraulics will be affected.

ALEJANDRO VARGA
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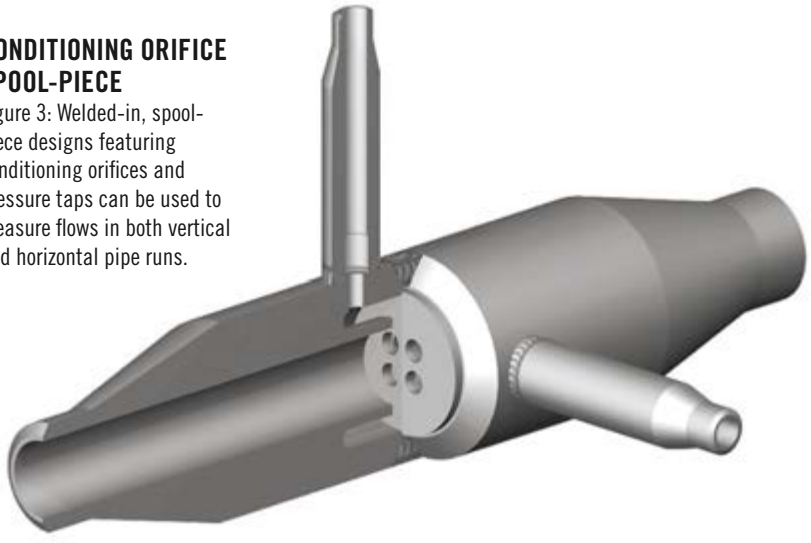
CONDITIONING ORIFICE SPOOL-PIECE

Figure 3: Welded-in, spool-piece designs featuring conditioning orifices and pressure taps can be used to measure flows in both vertical and horizontal pipe runs.



A4: There is no simple answer here, but a range of standards and handbooks show typical designs and applications. In general, the intent of a multiple-hole orifice plate is to serve as a flow conditioner, that is, to make the flow velocity pattern similar to one in a very long straight-pipe run. Again, see the handbooks and the standards.

Usually we don't want to waste energy across a flowmeter, so d/p is normally in the range of 20 to 200-inH_2O (500 - 5000 mmH_2O). This is high enough to realize d/p transmitter accuracy and to be certain of the Reynolds number inside the bore.

In the case of liquids near boiling temperature, excessive d/p may lead to vaporizing of the media. For gases, excessive d/p leads to inaccuracy due to the expansion of the gas not being fully compensated for in the equations. Some standards and handbooks will show at least a plot of the pressure recovery after an orifice plate; this depends mostly on the beta ratio, which is ratio of bore diameter to inside pipe diameter.

An orifice plate will deform or fail if the pressure drop is very high; this is a strength of materials issue. This is very rarely an issue except for flow restriction orifice plates. Flowmeter suppliers can provide further details.

CULLEN LANGFORD
CullenL@aol.com

For an area ratio of 0.5 (hole area to pipe cross-section), the pressure drop across the multi-hole orifice is about 70-75% of the conventional, single-hole orifice plate.

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PULS
www.pulspower.com/us/products/din-rail-power-supplies/ip54-ip65-and-ip67-power-supplies

Seriously stable single-use pH sensor

Maintains less than 0.005 pH drift per day, withstands gamma sterilization .

PLASTIC might not seem more capable than steel, but single-use bioreactor bags beat stainless-steel vessels hands down. This is because plastic containers for fermenting biopharmaceuticals don't require the lengthy, costly cleaning, sanitizing and setup time required by their metallic predecessors. In fact, the single-use renaissance in biopharmaceuticals is revising how basic production equipment and entire facilities are designed in favor of single-use and more modular processes.

There's just one snag. Single-use bioreactors can't tolerate penetrations by tubes, connectors, instruments and sensors because traditional, reusable hardware must be laboriously sanitized to avoid contamination. Unfortunately, though many single-use accessories are integrated into the bags, single-use liquid sensors remain less stable than their traditional counterparts. This is usually because their pH glass electrode membranes dry out in storage, causing their signals to drift and hindering accuracy, and because they can't cope with the gamma radiation sanitizing process used with most single-use bioreactors—until now.

Emerson Automation Solutions has released the Rosemount 550pH Single-Use Sensor that can achieve less than 0.005 pH change per day or 0.035 pH change per week in a worst-case scenario, compared to similar, autoclaved pH sensors that typically only reach 0.071 pH change per day or 0.05 to 0.1 pH change per week. Rosemount 550pH also features up to two years of shelf life from date of manufacture; maximum pressure up to 2 bar; USP Class VI, ISO 10093 and ADI-free compliant wetted materials; and material selection based on lowest achievable extraction profiles, which are performed in accordance with Biophorum Operations Group (BPOG) guidelines that are available when ordering. The sensor easily installs into 1-in. barb fittings on single-use bioreactors and can begin measuring immediately with no time needed to wet its glass for a stable measurement. It also ensures functionality before filling the bioreactor with a true, one-point standardization against a fully traceable storage solution.

"We cover a lot of industries such as oil and gas, chemical and life sciences, so we already had stainless-steel, steam-sterilized pH sensors," says Brandon Haschke, senior product engineer in the Rosemount division of Emerson Automation Solutions. "However, as single-use batch applications increased, we wanted to create a sensor that could bring the accuracy and reliability of traditional pH sensors to those single-use processes, integrate with their bags, and handle gamma radiation sterilization.

"550pH achieves greater stability because of its wet-storage capacity that keeps its pH glass membrane in just 2 mL of a pharmaceutical-grade, close-to-pH-neutral phosphate buffer solution during its entire storage life, which ensures healthier measurements and reduces setup time. Our buffer has been tested in small-scale batches and didn't affect viable cell count or titer of the end product. Other single-use sensors use dry storage, which means their pH glass membranes need to be in solution for 30-120 minutes before they can measure and makes them less stable and accurate."

BETTER FOR BIOREACTORS

Rosemount 550pH uses wet-storage buffer solution to protect its pH glass membrane and achieve stability and an accurate, healthy signal, and is made from polymers than can handle gamma-spectrum sterilization.

Because users can be sure the pH of the buffer solution won't change over time, Haschke reports they can be confident when punching in their millivolts-per-pH sensor performance slope numbers during setup that the measurements they'll send to the analyzer will be within the right accuracy window. "This is the source of 550pH's accuracy," says Haschke. "If its accuracy is ±0.1 pH and stays constant, then the sensor will only drift by 0.005 per day or 0.035 per week."

The other primary talent of 550pH is that its components can successfully withstand the gamma-spectrum radiation that will blast the whole single-use assembly to kill any bio-burden. "Many substances can't stand gamma radiation and will get damaged and break like plastics left out in the sun for too long," adds Haschke. "So we picked stable materials for 550pH that can handle acid and base conditions from 2 pH to 12 pH, maintain their same polymer structure before and after sterilization, and go through the gamma radiation without any extractable substances getting into the bioreactor process." ∞

For more information, visit Emerson.com/Rosemount550pH

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EQUIPMENT & MATERIALS

AD INDEX

Productive productivity, part 1

Greg talks quick-wins and KPIs with Eastman Chemical's Héctor Henry Torres

GREG MCMILLAN

Gregory K. McMillan captures the wisdom of talented leaders in process control, and adds his perspective based on more than 50 years of experience, cartoons by Ted Williams, and (web-only) Top 10 lists. Find more of Greg's conceptual and principle-based knowledge in his Control Talk blog. Greg welcomes comments and column suggestions at ControlTalk@putman.net

GREG: In this *Control Talk*, we're fortunate to have Héctor Henry Torres, principal control systems engineer for Eastman Chemical Co., discuss methods for improving process performance and to assess productivity to identify improvement opportunities using statistical tools. Additionally, control techniques are suggested for improving process performance. This is the first part of a two-part series. This material and much more originated from the chapter on "Improving Process Performance" in *Process/Industrial Instruments and Controls Handbook,* Sixth Edition (McGraw-Hill, 2019).

Héctor, what are be some of the methods for measuring productivity?

HÉCTOR: There are different methods used to measure productivity. The most common are: % gross yield (%GY), % utilized capacity (%UC) and % right first time (%RFT).

%GY indicates how efficiently raw materials are being transformed into salable goods. An increase in %GY leads to a decrease in the manufacturing or unit costs, and represents an immediate increase in capacity solely due to improved process efficiency.

%UC indicates the proportion of available equipment on-stream time used to create on-spec product. Together with the nominal production rate, %UC helps describe the manufacturing capability. The available equipment time in a month or in a year multiplied by the nominal rate helps determine available plant capacity.

The %RFT produces overly optimistic numbers as it only measures the proportion of on-spec product of the total units produced.

GREG: What is the first step one should take to improve productivity?

HÉCTOR: First, focus on getting early benefits by identifying and implementing quick-win ideas. A quick-win is a noticeable improvement that can be delivered shortly after the improvement project begins, and has an immediate and tangible benefit. The best quick-wins are inexpensive, easy to implement, and provide the team momentum by driving early hits.

Conduct brainstorming sessions with operators, supervisors and engineering staff to come up with a list of quick-win ideas to implement. Explain first what a quick-win is and, before starting the process, emphasize that not all the ideas might qualify as true quick-wins; however, all the ideas exposed will be part of the list. A committee is then formed to evaluate all the ideas.

When screening the ideas, use questions such as: would the implementation of this idea lead to a noticeable improvement in gross yield? And, could this idea be implemented within a relatively short time? If it could lead to a noticeable improvement in yields but it can't be implemented in a short time, then the idea qualifies as a long-term project. While quick-wins lead to immediate results, strategic projects offer sustained and long-term solutions. Make sure you inform all the participants of the results of the assessment and the implementation plan forward. Measure and document the benefits driven by the quick-wins.

Manufacturing practices rank as one of the main categories leading to productivity losses. Most quick-win ideas lead to improvements in such practices. Quick-wins require either procedural changes or the provision of additional tools for monitoring. Some procedural changes can be leveraged by means of the control system, where programming of process conditions and associated process actions ensure a procedure is executed during certain circumstances. Additional tools for monitoring could be as basic as designing conditional alarms or improved control system graphics that provide the operators with better situational awareness.

Standardize new practices by updating your standard operating procedures (SOP) and standard operating conditions (SOC), failure mode and effects analysis (FMEA), control plan, as

well as control system basic process actions. In addition, don't forget to provide proper training.

GREG: How can we quantitatively assess process performance?

HÉCTOR: Identify the process conditions that cause the quality characteristics to deviate from specifications. Load upsets are present in all processes. They're disturbances in the process that could originate from upstream processes, rate changes, changes in feed or ambient conditions and raw materials. In turn, the process is subject to its own nature when processing inputs that could be both measured and unmeasured. The process has an embedded dynamic response that's subject to delays (dead times) and lags (time constants). The process also responds with a certain magnitude reaction to a given change in the input (process gain). The observed responses of the process—controlled and critical variables—are also subject to the measurement system in place.

Process output variability consists of inherent and disturbance variations. The inherent variations follow a consistent and stable pattern of variability over time. This variability is associated with "common causes" and is considered short-term. The disturbance variations are characterized by changes in variability led by sudden and momentary changes in the process output or by a shift in the level of operation that are identified as "special causes" and are encountered in long-term data.

Determining the opportunity for improvement is normally done by comparing short-term and long-term process variability. Short-term variability is observed when process inputs are kept constant. That is, short-term variability doesn't include changes in the manipulated variables, different operators, formulation changes, etc. The variability observed in the controlled output variable is merely an indication of the inherent process variability. In some cases, this variability is induced by poor sensor selection and location.

The long-term variation can come from different sources: equipment, day-to-day process changes, operators, varied raw material lots, seasonal variations, etc. The objective is to determine the causes of variability and reduce their impact.

Both short- and long-term variations are normalized to allow comparison of different processes and establish the process capability. The short-term variation represents the best the process can perform and is considered the process entitlement. The long-term variation represents what the customer is observing. It's a picture of the actual performance of the process. The normalized versions of the variability in a process are known as capability indexes:

1. Potential process capability (Cp) is the best achievable capability if the process were centered in the specification range. It considers the tolerance range divided by the short-term process spread.
2. Short-term process performance (Cpk) is the current index based on the actual location of the process.
3. Long-term process capability (Pp) is the actual long-term capability if the process were centered in the specification range. It considers the tolerance range divided by the process spread in the long-term.
4. Long-term process performance (Ppk) is the current index based on the long-term location of the process.

All are calculated in the same way; the difference is the standard deviation used. The Cp and the Pp assume the mean of the controlled variable is on target or, in other words, centered in the range. The Cpk and the Ppk are the actual performance based on the current location of the process.

GREG: For supporting figures and referenced equations, see the extended version of this column at ControlGlobal.com. Also, stay tuned for Part 2 on how to improve process performance, special causes of variability and best practices. ∞

For the Top 10 ways to reduce long-term variability in marriages, plus enlightening productivity figures and equations, see the online version of this column at ControlGlobal.com.

Speak up

Don't hang back during onscreen gatherings

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All the high-definition screens, high-bandwidth networking, fanciest augmented-reality tools and best interactive software aren't worth anything if we won't talk to others and be forthright in sharing what we know.

IF you're already up to your eyeballs in Zoom meetings, home schooling and/or getting the kids back to school, and countless other pandemic-related responsibilities, then I'm sorry if you're already doing what I'm about to suggest and for getting on your last nerve.

Anyway, many of the stories I've covered for *Control* in recent months have obviously had large COVID-19 components, notably this issue's "Strong links" cover article (p24) on supplier and distributor responses to the pandemic and last month's "Must-have mobility" cover article (p28) about how mobile technologies can help users cope with it.

The print and much larger online versions of these stories include many examples of the perseverance and creativity that pretty much everyone is exhibiting to alleviate COVID-19's impacts. The main message seems to be: thank goodness for Zoom and Microsoft Teams and the interfaces, software, and Wi-Fi and Ethernet links that make them possible.

However, it's never all good news, especially these days. So, even though virtual, face-to-face gatherings restore some of our personal interactions—and spur some of us to shave and put on nicer shirts—they still fall short of real, in-person meetings. Several sources report that, while they value online interactions and realize they're now essential, they're also aware it's not as easy to pick up on the physical cues and gestures that are a large part of how humans communicate. This may not be a terrible problem with one or two onscreen presences, but it quickly becomes one as participants multiply on displays that remain the same size.

Those sources add it's no longer simple to see the doubts on a coworker's face in a particular situation, and encourage them to share their concerns. Online meetings let more people fall through the cracks and shadows at the back of the class—and suddenly an old and ugly problem raises its head again.

I've come to call it "destructive reticence," but it's been expressed to me in dozens of forms. The joke that the extroverted engineer looks at your shoes while talking. Or the several long-ago interview subjects, who actually said, "I didn't get into engineering to talk to people." Or even the occasional process industry manager, who wanted a black box or other component to optimize their application, so they could avoid the necessary mess of interacting with and training their pesky staff members.

Everyone wants a magic bullet, but this level of holding back goes way deeper than simple convenience or laziness. It describes itself politely as not wanting to tell others what to do, but below the surface, it's more about not wanting to stick our necks out, frankly not caring enough about others, or just being plain scared.

In one of my earliest jobs in the mid-1980s, I was assigned to do simple man-on-the-street, question-of-the-day interviews and take photos outside a small-town supermarket, but instead I sat petrified in my car for 45 minutes agonizing about who was I to be asking anyone questions. I really needed my little $210 per week paycheck, so I got over my fears for the moment. More than 10,000 interviews later, I still hesitate for the same reason. No kidding.

I guess personal interaction just doesn't come naturally or easily to many of us, even if we're known for being chatterboxes. However, due to COVID-19 and social distancing, we need to overcome underlying fears again, be more willing to communicate, and make our virtual interactions succeed despite their onscreen and technical limits. All the high-definition screens, high-bandwidth networking, fanciest augmented-reality tools and best interactive software aren't worth anything if we won't talk to others and be forthright in sharing what we know.

As you can tell, I'm no expert, so I can only advise taking some deep breaths, and jumping off that diving board. Some visualization and mental preparation is always useful, but don't wait too long either. Good luck. ∞

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