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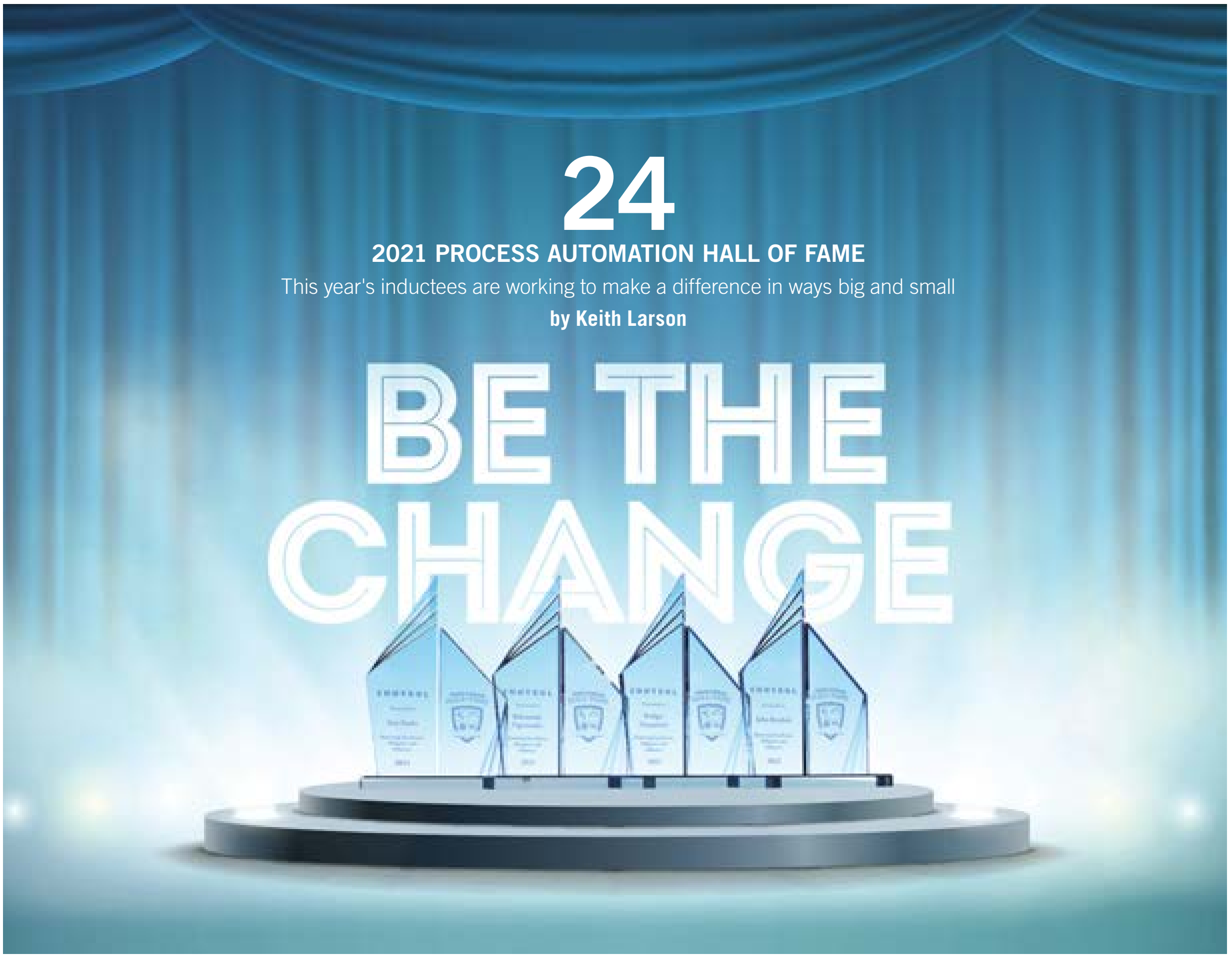

Features

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Departments

CIRCULATION

Food & Kindred Products	13,230	Paper & Allied Products	2,784
Chemicals & Allied Products	6,582	Pharmaceuticals	4,533
Systems Integrators & Engineering Design Firms	9,702	Rubber & Miscellaneous Plastic Products	3,297
Primary Metal Industries	6,541	Stone, Clay, Glass & Concrete Products	1,690
Electric, Gas & Sanitary Services	5,071	Textile Mill Products	1,221
Petroleum Refining & Related Industries	1,992	Tobacco Products	155
Miscellaneous Manufacturers	3,222	Total Circulation	60,020

There's room for an 'A' in STEM

Our Hall of Fame inductees are refreshed and sustained by artistic pursuits

IF you look at the cover of *Control* magazine, you'll see the tagline "Promoting Excellence in Process Automation." You, our readers, design, build and maintain the instrumentation and automation infrastructure of the critical industries that support the needs of global society—from energy to clean water, nourishing food and life-saving pharmaceuticals. And if we can help spread the word of the new advances and promulgate the best practices that can make your processes safer, more productive and sustainable—then I, for one, will sleep better tonight.

The work we do in this industry is important, and that's partly why one of my very favorite projects every year is the induction of new members into the Process Automation Hall of Fame. The 60+ current members named since its inception 21 years ago nominate then vote on other outstanding contributors to the practice of process automation to join their ranks.

And it's my honor, privilege and pleasure to interview, profile and present to you our 2021 inductees in our cover story, starting on p 24: Tom Burke, currently global director of industry standards for Mitsubishi Electric but longtime of the OPC Foundation; Bridget Fitzpatrick, process automation authority for engineering consultancy Wood; John Rezabek, process control specialist for Ashland; and Dr. Babatunde Ogunnaike, William L. Friend Chaired Professor of Chemical Engineering at the University of Delaware.

One of the things that struck me in particular when talking to the Class of 2021 is a dedication to making a difference in the world, in ways large and small—from advancing the industry standards that help raise the performance of our industry, to mentoring the next generation of engineers who will solve the challenges of the day, to making sure that the needs of front-line workers are met by those designing the solutions they'll live with day and day out.

But another thing that I've noticed in years past and found driven home among this year's inductees is a perspective and humility shaped not only by the STEM pursuits of science, technology, engineering and math—but by the arts as well. When asked what sustains them outside of their work, I quickly discovered passions for art and nature, music and poetry.

Bridget Fitzpatrick collects National Park admission tickets like they're merit badges. Tom Burke has a taste for Louisiana artist George Rodrigue's Blue Dogs—although the price of his works has climbed substantially since his death in 2013. Our own John Rezabek was on course to be a professional musician before a wage-related epiphany landed him in engineering school. (He still plays trombone on the side.) And Babatunde Ogunnaike plays guitar in his church's worship band—that is, when he's not writing poetry, such as the piece he was commissioned to write and read at the inauguration of Nigeria's current president, Muhammadu Buhari.

Ogunnaike stumbled into poetry when in 1977 as a college student in Lagos he read in the newspaper of a competition to contribute lyrics for a new Nigerian national anthem. He wasn't impressed with some of the examples in the paper, so submitted some himself. He left for graduate school at the University of Madison soon after, but subsequently learned from his father that some of his words had made it into the final lyrics. (And perhaps just to prove Rezabek's instincts correct, his share of the prize totalled 50 naira, or about 31 cents.)

I'm frankly not sure if a talent for STEM pursuits tends to come bundled with a passion for the beauty of art, nature, music and language—or if it's these latter pursuits that refresh and sustain those who would excel at engineering pursuits. Either way, it makes our 2021 inductees a fascinating Zoom interview—that I hope to follow up with a properly fascinating dinner conversation just as soon as we're all able. ∞

KEITH LARSON
Editor in Chief
klarson@putman.net

"When I asked our Hall of Fame inductees what sustains them outside of their work, I quickly discovered passions for art and nature, music and poetry."

NEWS & BLOGS

Engineering, operations and maintenance often don't view cybersecurity as their problem
This is the first of two blogs on control system cybersecurity representing the opposing views of engineering and network security. This blog represents those in engineering operations, maintenance and safety, where cybersecurity is viewed as incidental.
www.controlglobal.com/blogs/unfettered/engineering-operations-and-maintenance-often-do-not-view-cyber-security-as-their-problem

Solutions Spotlight podcast: Innovations in ultrasonics
Keith Larson and Dawn Massa Stancavish, COO and CIO, Massa Products, discuss applications for ultrasonics and how Massa is providing custom innovations for unique applications.
www.controlglobal.com/podcasts/control-amplified/solutions-spotlight-innovations-in-ultrasonics

Don't overlook cyber-vulnerable building control systems
Buildings and data centers have been using insecure building control system devices and network protocols. Yet, the focus has been on software, data in the data center and controller connections to the Internet, not the cyber-vulnerable control devices.
www.controlglobal.com/blogs/unfettered/data-center-cybersecurity-dont-overlook-the-cyber-vulnerable-building-control-systems

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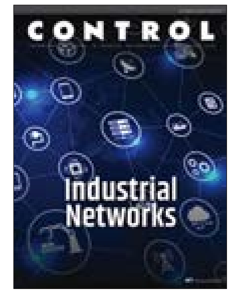
Latest on industrial networks



As the number of connected, Industrial Internet of Things (IIoT-enabled) applications increases, industrial networking becomes ever more important. In this latest State of Technology Report, the editors of control compile the most recent and valuable *Control* and ControlGlobal.com content on the topic of industrial networks. Get your copy to read latest headlines, including: APL standard to make field-level Ethernet a reality; plantwide I/O approach streamlines plant start-up; is redundany still redundant?; and more. The new report is available for download at:
info.controlglobal.com/state-of-technology-2021-industrial-networks_ios

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Process Control Basics: Level Measurement

Measuring the level of material in a tank, reactor or other vessel is more complicated than it seems. Every container and material comes with its own set of special level measurement challenges. This insightful video from the editors of *Control* and ControlGlobal.com dives into the various applications and factors you should consider when selecting the right level instrumentation for your particular application. Topics covered include the necessary evils, application issues, questions to consider and much more.
info.controlglobal.com/video-ebook-2021-process-control-basics-level-measurement_proc

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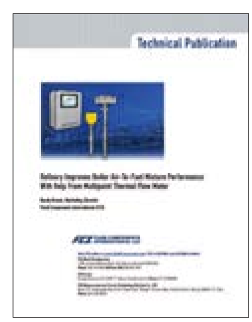
How to slash boiler fuel costs



Learn how plant engineers optimized their boiler's air-to-fuel mixture and significantly reduced natural gas costs in this Plant Boiler Case Study from Fluid Components International. In this case study, you'll discover why the company's MT100 Series Multipoint Thermal Air/Gas Flowmeter can be the perfect answer to burner combustion issues. This paper also explains how optimizing boiler performance also helped reduce the plant's carbon footprint.
info.controlglobal.com/case-study-2021-fci-hot-tip-slash-boiler-fuel-costs_proc

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Using power sensing to monitor and protect pumps

Measuring the power of your pump motors can protect pumps against unexpected events such as running dry, cavitation and jams. Power sensors can also enhance existing sensor environments including vibration, flow and temperature, and unlock insights into energy management and predictive maintenance. Learn how they work and how to get started in this whitepaper from Load Controls Inc.
info.controlglobal.com/white-paper-2021-load-controls-using-power-sensing-monitor-protect-pumps_proc_saf


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*All prices are U.S. published prices, subject to change without notice. AutomationDirect prices as of 11/5/2020. Hoffman prices are taken from www.alliedelec.com 11/5/2020. Allen-Bradley prices are taken from www.wernerelectric.com 11/5/2020. Prices may vary by dealer. Many other part numbers are available from vendors.

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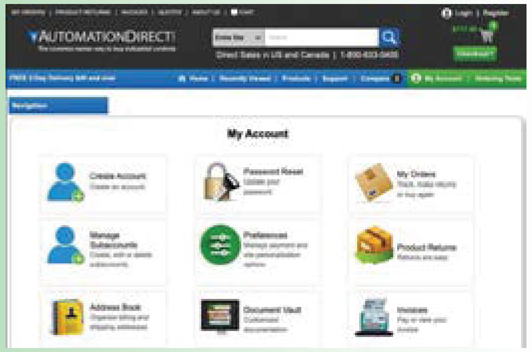

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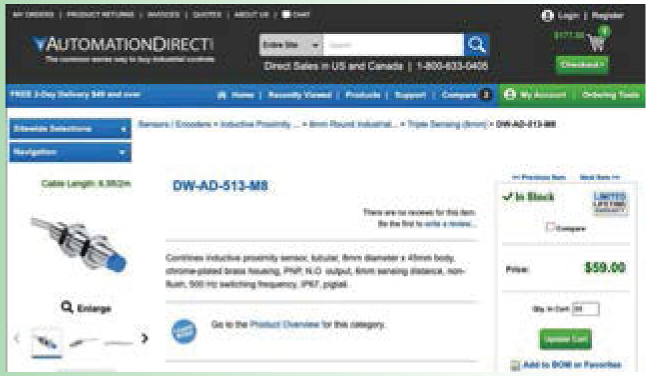

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Please Recycle This Magazine

Opportunities ahead for Ethernet-APL

Ian Verhappen raises quite a few good points in his recent opinion piece on Ethernet-APL *["Ethernet-APL: Potential vs. possible," Feb '21, p. 16]*. I'd like to comment on a couple of these.

First and foremost is the idea of the killer app. Perhaps as instrument architecture evolves to take advantage of the much greater bandwidth of Ethernet-APL, a killer app that hasn't been identified before now will emerge. But in the meantime there are plenty of applications for plant data that are presently underutilized because of the "friction" associated with getting at the instrument data. Predictive maintenance, enterprise-wide analytics, and process optimization come to mind immediately.

Remember that Ethernet-APL is simply a physical layer. A high-speed, IP-based, two-wire physical layer that has the advantage of supporting intrinsic safety. In the last paragraph, I spoke of friction. One of the major advantages of Ethernet-APL is the potential to remove a significant part of the friction associated with moving data all the way from the instrument to the enterprise without multiplexers, gateways, protocol translators and the like. For engineers, particularly new engineers familiar with IP networking, Ethernet-APL will be much simpler to install and configure than current plant architectures.

On top of Ethernet-APL lies an application protocol, like HART-IP, which essentially is old reliable HART encapsulated in an IP packet. HART-IP is used in many HART multiplexers. Now, two-wire Ethernet-APL with power enables HART-IP to be directly deployed on instruments. And since most plant engineers are familiar with HART and every major asset manager or DCS supports the HART protocol, support for HART-IP enabled Ethernet-APL devices is already available.

On the plant software side of the brownfield application, EtherNet-APL instruments can easily be absorbed. But what about the enterprise software and analytics? How are they handled? Until a single application protocol can extend from in-

strument to enterprise there will still be a gateway in the chain to supply information to the enterprise. Fortunately, the software specification to bridge the gap between OT protocols like HART-IP and IT protocols like OPC UA already exists in the form of a standard for a Process Automation Device Information Model (PA-DIM). Commercial products supporting PA-DIM will be available in 2021.

Lastly, let's address the greenfield vs. brownfield topic from the physical side. Yes, a goal of Ethernet-APL is to reuse existing cabling, and no doubt some companies will do just that. Bt by and large, users are not ripping out instruments and are frankly pretty satisfied with their existing HART 4-20mA installations. So, like WirelessHART before, a large opportunity for Ethernet-APL lies in expansion of existing facilities to incorporate additional sensing points. For a good primer on these opportunities, review the NAMUR Monitoring + Optimization (M+O) concept, which itself is part of the NAMUR Open Architecture (NOA) model (www.namur.net).

Finally, as the technology gets some mileage underneath it, users will better understand the advantages, become more trusting, and begin expansion of their installations beyond M+O and into supervisory and even regulatory control.

PAUL SEREIKO
Director – Marketing and Product Strategy
FieldComm Group

Need more from your process? Invest in your people!

Why technology investments aimed at reducing headcount often miss the mark

STEPHEN MADDOX
Business Development Manager
User Centered Design Services

"Knowing that the majority of operating expenses are absorbed by staff poses an obvious question: isn't it logical to optimize this asset to get as much out of it as you can?"

AS we move into 2021, we're happy to report that over the past 20 years, we at User Centered Design Services (UCDS) have worked with representatives of more than 100 organizations to help convince their management to invest in human factors. This isn't an easy undertaking. More than one engineer has removed their hardhat to pull their hair out in frustration. To an engineer, witnessing near misses, exceeded operating limits, and automated processes running in manual tells a story. That story is very clear: we can do better! We have to do better!

But where do we center our efforts to achieve “better”?

It's been studied and reported that companies’ operating costs are increasing. Many would believe that the majority of operating costs come from maintenance, utilities and equipment management. But 82% of the money goes to payroll: the workers. Yep, you heard that right. The people are the highest operating cost. Of course they're a critical component, but—are they really that important?

Meanwhile, upper management is under pressure to reduce costs. Is it any surprise they look to achieve their objectives with fewer people? Often these decision-makers are steered to a technology solution to reduce headcount. Humans seem to pose a higher risk, are hard to predict, and can make decisions that are hard to measure. They're also very expensive!

More automation isn't always better

Many engineers believe that we need to focus on automation to optimize processes and increase the number of loops an operator can handle. They want to develop solutions like "safe park"—an easy button for returning the operation to a more conservative state when something abnormal happens (almost always when running flat out). Some plants have been able to implement such solutions, but the cost is extremely high and it takes a long time to see results. Engineering complexity requires more, higher-salaried professionals to maintain the new technology-based system; they also require outside expertise and new technology. This type of project can get very expensive and risky. As evidenced by past experience, investing in technology can come back to bite you in the end. A Frankenstein creation of smart logic becomes a maintenance nightmare and a high-risk proposition because it requires human input and an exhausting analysis of potential failures.

Current projections based on the past 20 years' experience indicate the near future of industrial operations isn't going to be a technological feat that reduces or replaces the human worker. The reality is that we absolutely need humans even as we must reduce operations costs.

A focus on human performance

Many operational planners are starting to focus on human performance. Acknowledging human limitations and asking questions like: can we improve human performance—do better, achieve more, reduce risks, and accomplish the long goal? Can I lower costs by investing in the human element, the workers, and how well they perform? Can I increase human performance from an average 88% output to 95% and even 100%? How can I improve human performance and reduce the risks that human reliability poses to operations?

Knowing the majority of operating expenses is absorbed by staff poses an obvious question: isn't it logical to optimize this asset to get as much out of it as you can? Our findings answer this question with a “yes.” With the right approach and outside help you can increase and improve human performance. This requires an integrated human factors methodology that examines operational culture, worker behavior and user interfaces. To improve human performance, you have to assess, address and manage human behavior, and identify why they do what they do. The human element, your people, are the most expensive and valuable asset you have. You spend time and money maintaining your car, why not in the people who make operations possible?

For entertainment purposes, imagine your car is your business and gas is your cost. You want to drive twice the distance with the gas you have in the tank. The obvious solution would be to eliminate the need for gas. Perhaps an electric replacement or engine conversion is too expensive, and you have no choice but to use the gas you have for the next 10 years. Since you're already paying for it, why not invest in improving your gas to increase your traveling distance? A car requires gas just like your operation requires people. What if you could travel twice as far for less than you're paying now by adding a little boost juice to your gas?

Your competition may be doing just that—adding a boost to human performance. We're seeing this across the globe, with companies reducing waste, maintenance, energy, turnover time and asset costs. The most visible return we see after a project is the reduction in time the process is running outside the ideal operating envelope and the increased time running at optimal levels. The second thing that's obvious is operator morale and gratitude. Morale is a critical human factor that's directly related to safety and profit. Don't under estimate the impact it has on day-to-day decisions.

Our customers are looking at human-performance and error-free task management as alternatives to a technology-centric solution. They're assessing situational awareness, abnormal situations, job-task performance, operator workloads, worker competence, supervisory requirements and user interfaces, such as alarms and operator displays, and video- and audio-integrated workstations with large-screen overviews of critical processes.

All of these are related components that must be interconnected into the design of a control room to form what we call an integrated human-factors solution. For error-free task management, we see our customers developing programs focused on how to do the job right every time, which we classify as conduct of operations and operational discipline. These programs have a director, and start with leadership alignment, documentation and training. It's a practice that UCDS president Ian Nimmo has been developing for more than 30 years.

The most visible return that UCDS sees after executing a human-factors project are fewer excursions outside the ideal operating envelope along with increased time running at optimal conditions.

Internal leadership needed

The companies that are getting the most out of human performance are the ones that appoint an internal operations performance improvement leader to work closely with outside industrial experts in human factors and operator-workload management. These leaders are successful when they integrate a human factors/human behavior program with the following guidelines:

- Newly developed, documented standards for operational tasks based on clearly defined roles, responsibilities and objectives;
- Classroom training with visual aids to ensure responsible decision-making during abnormal operations;
- Operator management systems software to aid routine tasks and decision-making to reduce variances in human performance between workers and shift teams;
- Software tools to reduce complacency and enforce compliance with a documented standard; and,
- Task assessment to identify risks of human error and get help from industrial experts to mitigate those risks (also referred to as operator task and workload assessment).

Companies are putting real performance systems in place that use technology not as a replacement but as an aid to reduce human error. Technology that's user-centered is also error-resistant. A performance boost for the human to perform at a higher and safer level requires discipline, tools, support and a great understanding of human limitations. It also needs an expert who knows all the best practices being used successfully in the control room and the field. When a human performance-based program is implemented successfully, management is happy to see its supporters were right. ∞

Behind the byline

Steve Maddox is business development manager at User Centered Design Services Inc., a U.S.-based consultancy focused on operational excellence, with a vision of implementing best practice solutions. He can be reached at smaddox@mycontrolroom.com.

Collaboration lost

Don't let pandemic constraints interfere with seeking feedback from the front line

JOHN REZABEK
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Once a unique strength and path to innovation at which we excelled, how much has our year of a pandemic-hogtied culture robbed from us?

THE plant had started up on graphics that closely resembled the then-current generation of Honeywell's Universal Station, even though the DCS was not Honeywell. A few years later, grayscale graphics were being advocated, where color unrelated to alarms or abnormal conditions was muted. Instead of yellow numbers for process variables, graphical representations were favored. I recall explaining to the plant manager how DoD studies had shown how fighter pilots could comprehend and react to bar graphs and pictograms much faster than numbers, giving them an edge in combat. His response, and I paraphrase, "Why would I want my operators to have to react like fighter pilots?"

Clarence "Kelly" Johnson of the famed Lockheed Skunk Works, creators of the first stealth aircraft as well as the fastest and highest-flying spy planes yet created, insisted his engineers were never more than a few dozen yards from the production floor. His successor, Ben Rich, relates how Kelly had one of his test pilots take him along on a flight as least once a year, which was terrifying but cemented his own dedication to serving the ultimate end user. For our plant, there was a deeper point for engineers to internalize: disruptive graphics changes were going to foment an obstacle to operators understanding and forming mental models of the novel process.

Operators are tasked with spending eight to 12 hours or more at a time staring at graphics created by engineers. And they're expected to navigate the plant with optimal safety, productivity and efficiency without breaking anything. I remember a talk given by a brewer who discovered he could change the graphics on his European-made brewing kit's control system. While a complete novice in the realm of process control, he hilariously observed the graphics were "designed by engineers who had no idea what we needed to look at."

Advocates for high-performance graphics and abnormal situation management may view this with some dismay, but their efforts and insights are not in vain. After hearing the complaints and admonitions of operators, the site's graphic designers began a more phased and gradual approach, beginning by limiting colors and making some of the bright yellows and oranges of the originals more muted or grayscale. An offline pump was gray instead of red, for example. With the advent of new 16:9 widescreen, flat-panel monitors, designers began rolling out more consolidated and task-focused graphics, which also employed a color scheme closer to grayscale (but not vastly different from the originals). Operators, given the option to utilize either set of graphics, began using the newer ones more often. With successive updates, additional distracting color choices were replaced as well.

Listen and respond

That we're better when we work with the "victims" upon whom we inflict our hopefully useful designs is not exactly a novel concept, but it's surprisingly rare in some cultures. Collaboration with end users—constructors, operators, maintainers—functioning in the "real world" and incorporating their feedback—adjusting our designs to better suit their needs—not only begets a project more likely to succeed, it helps with utilization and end-user buy-in. Once a unique strength and path to innovation at which we excelled, how much has our year of a pandemic-hogtied culture robbed from us? A command-and-control hierarchy, where the smart guy at the top disseminates direction and knowledge down the pyramid to the front lines, functions as well with Zoom or Team meetings as it does in person. But seeing one's solution gathering dust in a deserted corner can be a better catalyst for improvement than sad phone calls from the engineer who installed it. Joining your customer in struggling to use it in the real world is even better.

Zoom and Teams may mean we save on travel and commutes, and we're getting involvement from contributors whose travel is more constrained. More end users can engage with standards committees, for example. But let's not neglect the increasingly atrophied muscle of in-person collaboration that's been taken from us. Our ability to hear and incorporate ideas and feedback from the front line: it may be the path to distinctive innovation. ∞

The big bang of explosion proof

Scratch-free flanges and properly tightened bolts are critical to enclosure integrity

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I've seen instances where only a few bolts are properly tightened, and others are only finger tight and, in some cases, not even threaded flush—in part because there are so many of them. This enclosure is no longer explosion-proof.

FIRST let me say that I'm likely showing my bias this month, as most of my career I've worked with intrinsically safe approaches to electrical circuit safety in hazardous areas. There have been, however, instances—particularly in the analyzer world where we had mixed voltages (i.e., 120 VAC analyzers with 4-20 mA outputs)—where explosion-proof was the only viable option.

If you'll recall, explosion protection is based on the fire triangle, with the three sides necessary to support fire or explosion being oxygen (air), fuel and energy. Intrinsic safety works by keeping the energy level below the ignition threshold, while explosion-proof measures work on containment. That is, by keeping the energy of an explosion inside an enclosure from escaping to the outside. Because of the principles on which explosion-proof measures are based, design and especially maintenance are key factors to their success.

I always specify backplanes in any enclosure I design. Not only does this help with being able to mount equipment without worrying about enclosure integrity, it has the added benefit of providing a roughly 1-in. gap between anything being mounted in the enclosure and the side wall. Though a tight fit, it leaves room for most people to get a finger in if they need to access something along the edge. I also prefer a hinged enclosure, more so for larger units and especially so for explosion-proof ones; the doors are quite heavy and the hinges help keep things aligned.

This leads to the next important consideration: space, not only for the equipment and connections but also for maintenance. Space considerations include not just room for components and cables themselves, but for fingers and tools as well as heat dissipation. Heat rises, so the top of the enclosure will normally be warmer than the bottom—keep that in mind when placing components. Also, will the enclosure be in the sun or shade? Remember that solar heating can quickly add several degrees to the inside temperature and, unlike with one's car, we can't open a window to let the heat out.

Components inside will inevitably fail at some point, and that means they'll need to be replaced. Further, other elements in the enclosure will require maintenance or calibration at regular intervals (fingers and tools again).

Maintenance can introduce risk

Maintenance activities also mean opening the enclosure, and in the case of an explosion-proof one, such actions introduce risk. This is not only because the area may need to be declassifed while it's opened, but there are also many ways in which the integrity on which the containment principle depends can be compromised.

The flanges on an explosion-proof enclosure not only act as radiators to disperse heat, but also as a sort of restriction orifice to dissipate energy. Their integrity is absolutely critical. The flanged surface needs to be kept clean and free of scratches, especially ones that extend across the full surface. The tight seal of the flange contains the energy.

Keeping the seal tight also requires that all the enclosure bolts are properly tightened. I've seen instances where only a few bolts are properly tightened, while others are only finger tight and, in some cases, not even threaded flush—in part because there are so many of them. Such enclosures are no longer explosion-proof.

One suggestion I've seen for putting on enclosure covers of any type, but especially explosion-proof ones, is to use the same concept as you would when bolting on a car tire: tighten and re-tighten bolts in sequence, going back and forth across the enclosure diagonally. After putting the bolts on finger tight, start tightening in one corner then criss-cross the enclosure at least twice to be sure you have them all completely and evenly tightened. Spending a little extra time getting it right now could prevent a catastrophe later.

For my part, I say give me my "plain" NEMA 4X box with intrinsically safe components, where I only have to verify the design, keep out the bugs, prevent condensation, and...

Hey, wait a minute! I guess working with enclosures of any kind is not so simple after all. ∞

AVEVA, OSIsoft put heads together

'Performance Intelligence' program expected to unlock data potential and accelerate digital transformation

AFTER buying OSIsoft (www.osisoft.com) for $5 billion last August, AVEVA (www.aveva.com) showed March 22 how they're joining forces to meet the expanding information management needs of industrial users and companies, and accelerate their digital transformation. Their combined portfolio is bringing OSIsoft's data management capabilities together with AVEVA's industrial software to enable its Performance Intelligence program.

To provide greater operational agility and resilience, AVEVA reports that Performance Intelligence connects information and artificial intelligence (AI) with human insight to enable faster and more accurate decision-making to help users and industries boost sustainability. The partners report this will "give the people behind essential processes the rich, reliable data they need to better measure and understand the entire industrial lifecycle. Areas where Performance Intelligence is likely to have the most impact will include organizational productivity, operational agility, and sustainability."

Craig Hayman, CEO at AVEVA, reports it and OSIsoft's combined software portfolio is driving digital transformation for more than 20,000 users worldwide, as well as operational efficiency to empower people, industries, and communities. "Together we're redefining the capabilities of industrial software. Through Performance Intelligence, we can see worlds of data from bold new angles, and inspire better understanding of complex value chains to boost performance and drive sustainability," explains Hayman. "The combined impact of AVEVA and OSIsoft will enable our customers to manage complex industries more efficiently. Our expanded capabilities elevate AVEVA's commitment to deliver operational agility that turns opportunity into business value for our customers."

Jean-Pascal Tricoire, CEO and chairman of Schneider Electric, adds that, "AVEVA and OSIsoft joining forces creates an industrial software and data leader. Through its extended ecosystem and broader, deeper portfolio, AVEVA delivers an enhanced level of efficiency to support the digital transformation of industries. We support AVEVA's agnostic approach, working in collaboration with customers and partners to offer integrated solutions that elevate performance and operational agility."

Schneider Electric is a major supporting shareholder and alliance partner of AVEVA. They also combined their software businesses about three years ago.

"We stand in awe of the innovation of our customers—the people who operate our society's essential industries—who use our technology every day to improve performance, protect health and safety, keep the lights on, and make the world run more smoothly," adds Dr. J. Patrick Kennedy, OSIsoft founder. "They inspired us to join forces with AVEVA, so we can broaden our scope and increase the value we can bring to their important work."

Hayman adds, "This acquisition is a major milestone for AVEVA, enabling our team to draw on Dr. Kennedy's vast leadership experience and domain expertise. We're honored to continue the journey together with Pat in his new role as chairman emeritus. With Performance Intelligence, we can confidently say that AVEVA is paving the way to become the industrial software and data leader, heralding the start of an exciting new chapter for the industrial software market."

Water analyzer relies on robotics and the cloud

KETOS INC. (www.ketos.co) has developed a water quality sampling and testing system, Ketos Shield, which employs multi-axial robotics and embedded processors to measure 26 parameters, provide real-time insights, and use Internet links to relay results to a cloud-based analytics service—so users don't have to visit their hardware and facilities so often. Its robotics deliver samples to stacked, vertically integrated sensing and processing components inside its enclosure. The company adds that modular, bench-top, microwave oven-sized and autonomous Ketos Shield also eliminates the need for static water testing, constant cleaning or manual calibration.

"Handheld probes and analyzers measuring pH, conductivity, chlorine and other parameters have gained online capabilities in recent years, but they still use up consumable resources and require users to visit their physical equipment and operations every few days and deal with data proliferating from multiple sources," says Meena Sankaran, founder and CEO at Ketos. "We've come up with a way to shift the water quality operations mindset to a

ROBOTIC WATER ANALYZER
Ketos Shield water sampling and testing system uses multi-axis robotics to measure 26 parameters

way to collect and analyze more data. We asked users to list all the parameters they wanted, including heavy metals, took their EPA target limits, and developed a system to measure all of them with 95% confidence."

Ketos Shield is reportedly ideal for high-frequency water sampling applications, such as ground and surface source-water monitoring, industrial process water, reservoirs, processed fracking water, and drinking-water quality. It's available on a subscription basis; sends raw data from its applications via Ethernet and wireless networking protocols to its cloud-based analytics platform; and can store and integrate year of static data to provide a unified view of operations.

Because it was designed and built in-house, Ketos Shield's microcontroller employs its own application program interface (API) to interact with all types of external data processing systems and services. It can give users real-time alerts, EPA or customized threshold-based diagnostics, custom reports, historical trends and actionable insights by continuously analyzing water data with machine learning (ML) principles. This not only provides early warnings about water quality, but also lets predictive modeling optimize process controls of chemical feeds, groundwater contamination and water reuse.

"If a user is running numerous pumps and regulators on Siemens Mindsphere or another platform, we can integrate with all of them," explains Sankaran. "Ketos API can pass data to whoever needs it. We also partner with OSIsoft, so PI System users can access Ketos Shield through the API, or send data points to it to help develop predictive models."

NovaTech appoints new CEO

NOVATECH LLC (www.novatechautomation.com) announced March 31 that Conrad Oakey has been appointed CEO. He succeeds Volker Oakey, who has owned and led NovaTech since 1979, and will continue as board chairman to ensure an effective leadership transition and focus on long-term strategies.

NovaTech provides automation solutions for electric utilities and process manufacturers worldwide. It acquired acquired GSE Systems in 2003 and Bitronics in 2008, and more recently integrated its power and process divisions to sell across traditional markets. These modifications streamline NovaTech's internal operations, encourage innovation, and offer more complete solutions for users.

"With these changes, the time to introduce a new CEO felt right," says the elder Oakley. "We have a strong and energetic

group of leaders. Conrad has been preparing for this for most of his life. I could not be more proud to make this handoff. I'm confident and excited about the future of the company."

Conrad has held a variety of positions at NovaTech for 23 years, and these personal and professional connections make him uniquely qualified for the role of CEO. He has served as NovaTech's VP of strategy and communications since 2018. Most recently, he was the primary architect of NovaTech's corporate strategy, which he'll use to prioritize economic, environmental and technological initiatives. Conrad earned a dual B.A. in chemistry and studio art from Williams College in 1998, and in 2013, he earned an MBA from Duke University's Fuqua School of Business.

"I'm honored to lead the business that my father and his colleagues have built. I want to credit my father for his accomplishments, and for mentoring me in preparation for this role," says Conrad. "I commit to carry forward his legacy and accomplishments, while ensuring that we're flexible and responsive to the present, dynamic realities of our business. We're going to lean heavily into innovation for growth. I'll work with leaders at every level to generate innovative products, streamline processes, grow into adjacent market segments and geographies, and recruit and develop world-class talent into our NovaTech family. What stays the same is our commitment to NovaTech's core values, employees and customers."

Yokogawa picks new North America leader

YOKOGAWA (www.yokogawa.com) reported March 21 that it's promoted Kevin McMillen as president and CEO of its 60-year-old North American business. He'll align efforts to drive a stronger sustainability focus, and work with industries toward Yokogaw's goals of achieving net-zero emissions, ensuring the well-being of people, and transitioning to a circular economy (www.yokogawa.com/us/about/sustainability).

McMillen has experience in industrial automation, control and digital transformation. Since 2016, he served as VP of system sales for North America. He received his B.A in management and accounting from Marshall University. McMillen's experience is expected to help Yokogawa North America carry out its "innovate forward" philosophy of anticipating and solving tomorrow's challenges with its industrial automation and digitalization portfolio of measurement, control and optimization products and services.

"The energy transition is challenging the relevance of many industries, and driving many businesses to reevaluate their strategies in alignment with society and emerging technologies," says McMillen. "Yokogawa is committed to supporting a much-needed transition across all forms of energy production to a more sustainable landscape, and enabling a higher quality of life for our present and future societies." ∞

SIGNALS AND INDICATORS

- **Emerson** (www.emerson.com) launched a complete corrosion and erosion monitoring portfolio on March 8 with digital capabilities and full integration with its Plantweb digital ecosystem through its new Rosemount 4390 corrosion and erosion wireless transmitters and Plantweb Insight non-intrusive corrosion application. The monitoring portfolio turns existing offline corrosion probes into online tools to monitor for the risk of corrosion or erosion in oil and gas processing.
- **Valmet Oyj** (www.valmet.com) reported March 29 that it will supply its Valmet IQ Moisturizer system at **DS Smith Contoire-Hamel**'s paper mill in northern France to improve the moisture profile of the client's board for better corrugated performance. Valmet will also implement its Advantage DCT 200 tissue line including stock preparation, automation system and a Focus rewinder at **Aktül Kagit Üretim Pazarlama A.S.**'s mill in Pamukova, Sakarya province, Turkey.
- **ABB** (www.abb.com) announced April 1 that it's launching HoverGuard, which it reports is the world's fastest, most sensitive drone-based leak detection and greenhouse gas measuring system. HoverGuard will help operators increase their safety and environmental capabilities in line with the Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act that became law in December 2020.
- **Hottinger Brüel & Kjær** (www.hbkworld.com), a subsidiary of **Spectris plc** (www.spectris.com), reported April 1 that it's acquired **Concurrent Real-Time Inc.** (www.concurrent-rt.com) for $166.7 million in cash. Concurrent provides real-time computational hardware and software solutions, and the transaction is in line with HBK's strategy to provide an end-to-end virtual test capability to complement its traditional strength in physical test and measurement. Concurrent will be added to Hottinger Brüel & Kjær's VI-grade Virtual Test business unit.
- **Digi International** (www.digi.com) reported Mar. 29 that it's acquired **Haxiot** (www.haxiot.com), which manufactures low-power, wide-area (LPWA) wireless technology, and has a LoRaWAN product portfolio that includes client modules, intelligent industrial devices, gateways and its scalable X-ON cloud IoT platform.

Is HMI downtime ever acceptable?

PETE DIFFLEY
Senior Manager,
Global Partnerships,
Trihedral Engineering

AS an end user and system integrator, Pete Diffley long endured the downtime headaches that come with managing a fleet of plant-floor, human-machine interfaces (HMIs)—and keeping the operators who use them up to speed as well. He points to how HMIs have traditionally been architected and deployed as a primary source of past frustrations, and now, as senior manager of global partnerships for Trihedral Engineering, developer of VTScada HMI and SCADA software, he proposes an alternate path forward. *Control* recently caught up with Diffley to discuss where traditional approaches to HMI have fallen short, and how a different way of thinking can substantially improve system resilience and alleviate production downtime.

Q: It seems common sense to say that downtime is bad. Yet downtime due to issues with HMIs seems to be tolerated in some manufacturing settings. Can you explain why that is?

A: For decades now, the high-speed, high-volume production lines typical of the food and beverage, pharmaceuticals and other consumer-packaged-goods industries have relied on programmable logic controllers (PLCs) paired with HMIs to provide deterministic automation on the one hand and plant-floor operator visibility and interaction on the other.

The PLCs are purpose-built for industry, and designed for years of relatively uninterrupted operation. But the HMIs, often based on relatively short-lived information technologies, typically are less robust. There's a cultural acceptance—a tolerance, really—that HMI workstations fail, but every time they do, the "money machine" stops and there's a mad scramble to get things running again. Such failures paired with the need to patch, update and swap out obsolete hardware, software and operating systems accrue to a downtime tax that includes scheduled and unscheduled components.

Additionally, at the machine level you may have another layer of operator interface. Operator interface terminals (OITs) have their own local displays for machine configuration and operation. Further complicating things, there may be yet a third layer of production dashboards on the wall displaying aggregate KPIs such as overall equipment effectiveness (OEE)—a whole hierarchical universe of operational display systems, each created and maintained separately. When anything needs to be changed at an application level, you may need to take the line down. It all adds up.

Q: Some sort of redundancy would certainly help address this issue. But at the same time, having a hot standby workstation paired with every HMI seems a cumbersome and impractical solution. Are there lessons that the discrete and hybrid industries can learn from how the continuous process industries, such as power or chemicals, implement redundancy?

A: The solution lies in how the HMI software itself is designed.

An online configuration methodology that allows changes to be made to the application without requiring a restart or stoppage of the production process is always the goal. It's surprising that not all platforms support some form of this.

Consider a distributed control system that has multiple operator consoles networked to the same process controllers, rather than focusing on redundant pairs of primary and backup HMIs. This allows supervision to be transferred from one console to another while the other is updated. Also, each workstation can be a hot backup to every other workstation or to central plant SCADA server(s).

As a result, any of those nodes can take charge in the case of an outage, or if a change needs to be made on the local HMI instance. Further, the node enlisted to take temporary control can be just about anywhere—elsewhere on the production floor, in an on-prem data center or in the cloud.

And if the HMI software is designed to allow remote access via HTML 5, the operator can continue to run the machine from a tablet or smartphone, even as the local HMI is repaired, replaced or updated.

So, with this approach to redundancy, no one line is dependent on any one HMI.

Q: Can this same approach be used to manage those multiple layers of HMIs used for local interface, machine coordination and higher level KPIs?

A: Yes, and that very question strikes at another important aspect of how HMI/SCADA software should be designed—to allow essentially unlimited scalability from the perspectives of functionality and scope. For example, the core functionality of Trihedral's VTScada software is essentially the same whether you're implementing a simple, standalone 50-tag HMI solution, or one that spans multiple production lines, multiple locations and millions of tags.

A small, standalone system can be grown into a large, networked one without having to replace the software itself—the functionality is all there from the start. This also means that the same software used to gather data from and interact with a standalone machine can also help operators visualize the machine coordination tasks and production KPIs mentioned earlier. The software may run on different physical platforms at each level, with different functionality "turned on" at each, but all the HMIs operate together across a networked environment in a seamless and fully scalable fashion. A second advantage of basing all of these various HMIs on a software package like VTScada is that now all the displays are updated in real time; you're no longer looking at an OEE metric that could be an hour old.

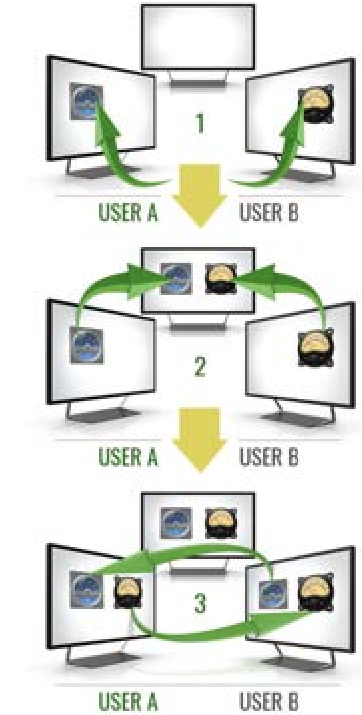
Q: I'd also offer that the ability to deploy and test proposed changes to an HMI—for example, on an updated operating system with a different look and feel—offers a significant opportunity to better prepare operators for how to interact with that new interface.

A: Absolutely. Many organizations use training systems that stand alone from the production units. These training environments represent an enormous investment of time and money spent in a vain attempt to keep them current and up-to-date with those on the plant floor.

You can show the operators what the new screens might look like—but what if you could show it to them with live production data from their production line, rather than with "simulated" data that may or may not resemble the machines they're responsible for? In short, when an operator or technician has less than a full understanding of how to interact with their new screens, it creates downtime. This approach helps solve that training problem—and with a lot less effort and expense.

Q: A common mindset among those responsible for the care and feeding of traditional HMIs is that once they're operating reliably, don't upset the apple cart by making any changes. Meanwhile, the underlying hardware is aging, the operating system isn't kept up to date, and security patches are neglected—all of which increase the risk of serious downtime.

A distributed HMI/SCADA architecture certainly make change easier. What other aspects of the Trihedral approach make it easier for HMI users to stay continuously current?



EXAMPLE ONLINE CONFIGURATION
A distributed HMI architecture allows multiple instantiations to be synchronized in real time.

A: One of our core value propositions is that any project developed for the VTScada platform will remain forward-compatible for life. That means you can replace your current HMI platform with Microsoft's latest Windows 10 OS, spin up our latest version of VTScada—and the HMI project you developed three or more versions ago will migrate easily to the newest. Moving project code to a new and unknown platform is at best a scary proposition. But our promise is that our software will always run your project on the latest and greatest platform. Always. ∞

BE THE CHANGE

This year's inductees to the Control Process Automation Hall of Fame are working to make a difference in ways big and small

Whether volunteering their time to advance critical industry standards, mentoring engineering students as they take on society's Grand Challenges, or simply making sure that operators' voices are heard, this year's inductees into the *Control* Process Automation Hall of Fame are a potent force for positive change. For the people and organizations with which they work, for the practice of process automation—and for the world.

On the pages that follow you'll find the stories of the four humble yet passionate individuals who were voted into the *Control* Process Automation Hall of Fame by those 61 members who have been inducted since the institution was first convened in 2001 (see table).

Please join me in congratulating and welcoming to the Hall of Fame **Bridget Fitzpatrick**, process automation authority for engineering and consulting firm Wood; **Dr. Babatunde Ogunnaike**, William L. Friend Chaired Professor of Chemical Engineering at the University of Delaware; **John Rezabek**, process control specialist for specialty chemicals maker Ashland Inc. (and longtime columnist for *Control*); and, last but certainly not least, **Tom Burke**, global director of industry standards for Mitsubishi Electric, as well as director of strategic marketing for Mitsubishi's Iconics software brand and global strategic advisor for the closely allied CC-Link Partner Association.

If they've not touched you in the course of your professional or educational journeys, I hope that you enjoy getting to know—and being inspired by—Bridget, Tunde, John and Bob on the pages that follow. It was an honor, a pleasure and a privilege to interview each of them.

— Keith Larson

THE CONTROL PROCESS AUTOMATION HALL OF FAME

2001
Béla Lipták
Greg McMillan
Greg Shinskey

2002
Marion"Bud" Keyes
Terry Tolliver
Harold Wade

2003
Karl Aström
Lynn Craig
Charles Cutler

2004
Terry Blevins
Thomas M. Stout
Ted Williams

2005
Richard Caro
William "Bill" Luyben
Russell Rhinehart

2006
Edgar H. Bristol II
Richard E. Morley
Wyman "Cy" Rutledge
Kathleen Waters

2007
James H. Christensen
Thomas F. Edgar
Angela Summers

2008
Vernon Trevathan
William M. Hawkins
Dale E. Seborg

2009
Hans Baumann
Renzo Dallimanti
Pat Kennedy
Carroll Ryskamp
Cecil Smith

2010
Joseph S. Alford
John Gerry
Willy Wojsznis
Yutaka Wakasa

2011
John Berra
Sigurd Skogestad
Maurice Wilkins

2012
Mark Nixon
Tom Phinney
Vern Heath

2013
Dennis Brandl
John MacGregor
Peter G. Martin
Ian Verhappen

2014
Dave Emerson
Paul Murrill

2015
Don Bartusiak
Armando Corripio
James Downs

2016
Charlotta Johnsson
James Rawlings

2017
Eric Cosman
Charles Moore

2018
Thomas McAvoy
Herman Storey

2019
Nicholas Sands
Carlos Smith

2020
Penny Chen
Duncan Mellichamp
Ian Nimmo
Martin Zielinski

2021
Thomas Burke
Bridget Fitzpatrick
Babatunde Ogunnaike
John Rezabek

NEW MEANINGS FOR MODELS

As an industrial practitioner, researcher and educator, **Dr. Babatunde Ogunnaike** has built career out of redefining models. The model-predictive control (MPC) polymer reactor strategies he helped pioneer at DuPont in the 1980s went on to become standard practice across industry. Today, the William L. Friend Chaired Professor of Chemical Engineering at the University of Delaware is working to model and control the incredible complexities of biological processes with an eye to streamlining the production of biopharmaceuticals, and enabling the practice of personalized medicine at scale. But the models he's perhaps most proud of are those he developed to encourage the cross-pollination of academic and industry points of view—to the ultimate betterment of both.

This last model innovation dates back to when Ogunnaike was finishing his doctorate in chemical engineering at the University of Wisconsin. He was about to return to his native Nigeria to teach at his undergrad alma mater Lagos University, when he realized he was ill-equipped to give his students the industrial perspective that most of them would need. So he improvised, signing on for what he now calls an "industrial post-doc," a year of real-world experience with Shell, split mostly between the company's Houston engineering center and its Norco petrochemical complex in nearby Louisiana.

"It really rounded out my training, but was unheard of at the time," Ogunnaike says. Most PhD candidates headed for academia opted for an academic post-doc, and those headed for industry just went. The experience stuck with Ogunnaike when he returned to the U.S. to take a position in DuPont's central engineering organization, where he was soon heading the group doing pioneering work in process systems engineering, including optimization, modeling, control, data analysis and process analytical technique development.

But he was also fully engaged at the University of Delaware, teaching and writing textbooks on process control and statistical analysis. "I stayed on at DuPont because at that time we had arguably the best collection of process systems engineering people in the world—all under one roof. When I came to interview, I'd never seen a group like that in my life, and I thought 'Academia is going to have to wait.' Groups don't come up like that but once in a while."

While at DuPont, Ogunnaike approached his boss, the late Dave Smith, and proposed formalizing the industrial post-doc experience that had served him so well. "I sold the concept and we finagled the funds to finance a number of people who had already accepted an academic position to come work in the group for a year." And while the program hasn't withstood the trials of time, it "graduated" a number of highly respected leaders in the field, including Frank Doyle, Richard Braatz, Michael Doherty and Jay Lee. Other leading academics also joined the group for

"Let's go change the world together." Ogunnaike's latest appointment is to lead the University of Delaware's Grand Challenges Scholars Program, where he'll mentor the students in their efforts to engage with society's most pressing issues—from climate change to personalized medicines. (Shown here in pre-COVID times.) Source: Kathy F. Atkinson/University of Delaware.)

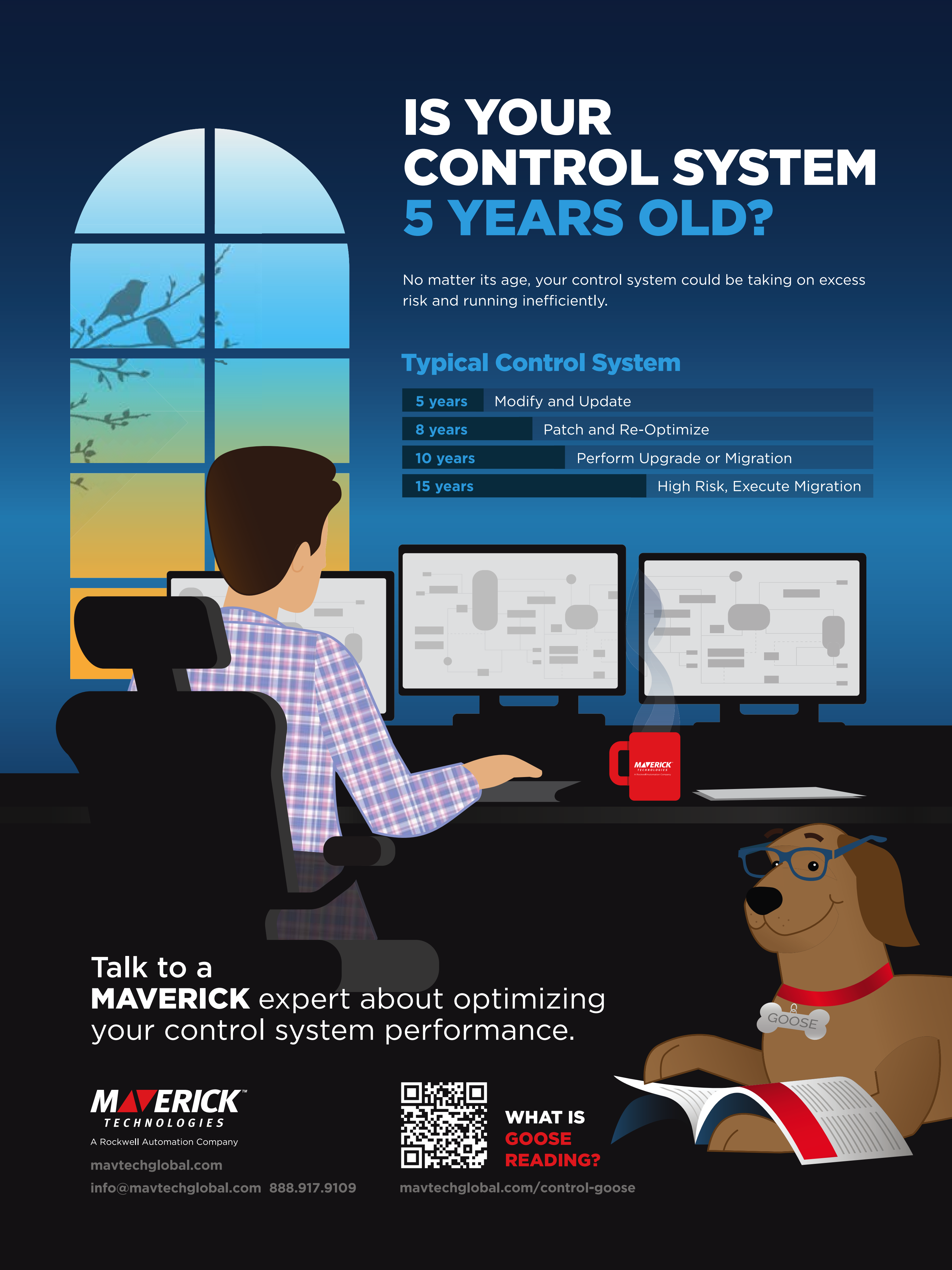
a time, including fellow Process Automation Hall of Fame members Thomas McAvoy and James Rollins.

"The fresh PhD grads left us with a portfolio of problems that now had a 'so what' attached to them," Ogunnaike says. That understanding continues to shape the questions they ask and the type of meaningful research they pursue, he says.

It was during his time at DuPont that Ogunnaike's dormant desire to better understand the behavior of biological systems was sparked by a group of neuroscientists, who were studying neurons in order to understand the science of how actual neural networks do what they do.

"Our ability to control biopharmaceuticals manufacturing is some 50 years behind what we can do it the mainstream chemicals industry," Ogunnaike says. This is due in part to regulatory requirements but more so because of how tremendously complicated biological systems are. This complexity arises from how difficult it is to influence what goes on inside cells purely by manipulating the nutrients or conditions in the bioreactor. "We're recreating the concept of controllability, but it's taking all the tricks in the book—all we know about modeling, about multivariable control, about state estimation, plus new nuances specific to biological systems." Ultimately, his work has implications for personalized medicine as well, which cries out for the leadership of process systems engineering professionals to manage the tremendous amounts of data that such efforts will entail.

"It's fun to look at biological systems from the perspective of a control engineer," Ogunnaike says. "And I'm having a ball doing it."


IS YOUR
CONTROL SYSTEM
5 YEARS OLD?
No matter its age, your control system could be taking on excess risk and running inefficiently.
Typical Control System
5 years Modify and Update
8 years Patch and Re-Optimize
10 years Perform Upgrade or Migration
15 years High Risk, Execute Migration
MAVERICK
GOOSE
Talk to a MAVERICK expert about optimizing your control system performance.
MAVERICK TECHNOLOGIES
A Rockwell Automation Company
mavtechglobal.com
info@mavtechglobal.com 888.917.9109
WHAT IS GOOSE READING?
mavtechglobal.com/control-goose

A PASSION FOR PROBLEM-SOLVING

After finishing her bachelor's degree in chemical engineering at MIT, **Bridget Fitzpatrick** didn't enter industry with a specific career path in mind. Rather, she tended to seek out and follow the most interesting and difficult problems she could find.

It was at times a circuitous path, but she solved a lot of thorny problems along the way as she followed her interests through a series of specializations—from process engineering to controls engineering and middle management at Celanese. She jumped to Mustang Engineering (an embedded contractor, now Wood) where she's gone through stints of technical practice leadership, systems optimization and consulting. Today, Fitzpatrick serves as Process Automation Authority for the global consultancy and engineering firm, Wood, where she also leads the Process Automation Systems domain of the Global Technical Expert Network.

"I will admit to being an engineer at heart, looking to solve problems," she says. "Or, as Peter Martin would say, 'Save the World!' "

Along the way, Fitzpatrick also picked up an MBA in Technology Management from the University of Phoenix, which came in handy setting technology strategy at Celanese and in more recent efforts to help Wood's clients chart survival and leadership paths. Through workshops and other in-depth operational analyses, she focuses on unlocking solutions across the entire value chain.

Of late, she's had a hand in the work of the Open Process Automation Forum, and has helped spread the word of the benefits of the IEC 61499 standard in enabling a new generation of open and interoperable distributed control systems. But her standards work with the Abnormal Situation Management Consortium was perhaps most formative.

"One of the other things I found over time was that the science was relatively easy to solve, but that getting humans to do the right thing was a different mat-

Bridget Fitzpatrick is a big fan of National Parks and visits them whenever she can, including this side trip from Calgary's tar sands to visit Lake Louise in Alberta, Canada's Banff National Park and to Maine's Saint Croix Island (facing page) where she "strolled" with this statue of a Passamaquoddy woman.

ter entirely," she says. "So, much of my career has focused on getting the right information to the right people at the right time—a fair bit of focus on HMI, alarm management and human factors."

Fitzpatrick has derived considerable satisfaction in helping to make steady progress at improving operator response by providing better controls, better interfaces and better alarms. Indeed, it was her contributions to the "innovative improvement of alarm management and HMI design practices" for which she was named an ISA Fellow.

"And really, the relationships are what I remember most strongly," she adds. "When I think back, I think of the co-workers and clients that I value and had fun working with first—and when I look closer, we were generally doing innovative things to solve challenging problems."

When she's not solving industry's problems, Fitzpatrick clearly enjoys nature, and confesses to a bit of an obsession with National Parks. "I've travelled extensively for work over the years, and anywhere I go, be prepared for 'Wait, wait—there's a brown sign with white letters!'" She also enjoys "playing with investments" and has led investment clubs designed to inspire younger generations to get started early.

"My advice is that you should pursue things that you enjoy," she says, of her advice to those just getting started in industry. "Work hours are too much of your waking hours to not enjoy it. Find things you like and see what develops into a passion."

And don't let accepted norms constrain innovation, she adds. "You must break the current mold to create anything truly new. Incremental, slow improvement is a good thing. But also look for the breakthrough concept, then figure out how to engineer the pace of change to be safe."

BUILDER OF BRIDGES

For **Tom Burke**, most recognizable as the longtime president and executive director of the OPC Foundation, open standards and personal relationships are what make the world go round.

Today, he serves as global director of industry standards for Mitsubishi Electric as well as director of strategic marketing for Mitsubishi's Iconics software brand and global strategic advisor for the closely allied CC-Link Partner Association. This follows nearly two decades as the public face of the OPC standards and the organization that supported them since the original specification was first conceived in the mid-1990s until he stepped away in 2018.

Released in 1996, the original OPC specification was first conceived by a group of four competitors in the human-machine interface (HMI) software space as a means to take on Wonderware's relative dominance in the arena of software connectivity with third-party devices. Then a developer at Rockwell Automation, Burke was among the specification's chief authors, then taking the helm full-time to evolve the standards and keep them relevant despite the onrush of alternative technologies. Burke, who measures a standard's success by the unflinching benchmark of marketplace adoption, also drove the open-source release of the OPC UA specification—which paradoxically saw paying company memberships more than double over the past five years to now include 1,000+ organizations.

Looking back over the past two decades, Burke is most proud of the organization's ability to recognize and address a fundamental industry need, then bring together a range of competitive interests to develop specifications and technology to help solve real-world problems. "It was all about people, and how we assembled a cohesive team of individuals across competitive companies—all of us with the same vision of working together to develop the best specifications, technology, certification and process," Burke says. "It's about competitors collaborating to deliver value on behalf of end users."

Burke says that as the years passed, collaboration became his favorite word. He began to realize the value of working cooperatively with the other industrial communication organizations, and especially other standards organizations worldwide. "OPC UA was focused on interoperability and providing data and useful information between IT and

While Tom Burke's professional focus is on broadly accepted standards, his personal tastes are decidedly more niche—including an assortment of '70s-era, gull-winged Bricklins in various states of repair and Louisiana painter George Rodrigue's Blue Dog artwork.

OT before we could even spell IT and OT," he says. "I wanted the MES players and the enterprise players to be able to connect up to our control systems and get useful data and information from all of the devices and applications."

"More fundamentally, what I've learned over the course of my career is the value of and the importance of relationships," Burke says. "It's not the technology that matters, it's the people. It's so important that you form the right partnerships and alliances.

"One of my greatest accomplishments was recruiting volunteers from all of the automation players in our industry," Burke adds. "They devoted 100% of their time to a shared goal and vision of interoperability. We constantly had to look at all the technology and stay ahead of it."

Most recently, he championed formation of the organization's Field Level Communications (FLC) initiative, which is now working to implement OPC UA at the lowest levels of device networks over standard Ethernet made deterministic through the use of Time Sensitive Networking (TSN) extensions. "I knew that we needed to leverage TSN technology; getting a critical mass number of suppliers behind me to support OPC UA over TSN was key."

DIGITAL INTEGRATION'S SERVANT LEADER

When **John Rezabek** graduated high school in the 1970s, the long and fruitful career in process controls and instrumentation that was to come wasn't yet on the radar. Rather, he enrolled in the Cleveland Institute of Music with ambitions of playing trombone for a symphony orchestra. "Being the young, idealistic person I was," Rezabek says with a wink, "I thought I could play my trombone and inspire the nations to live in peace."

But a funny thing happened on the way to the philharmonic. He had a side gig doing arrangements and playing in the brass section of a lounge band that headlined at exotic venues like the local Holiday Inn on weekends. "I had an awakening," Rezabek says. "Somewhere along the line I came to the realization that to thrive in this society, you have to do something that people truly value. But I did learn that it was good to be part of a team, and to be contributing in a meaningful way."

Rezabek carried that life lesson forward, as he completed his B.S. in systems engineering at Case Institute of Technology, and then joined Standard Oil of Ohio's corporate engineering group in 1981. As occurred at many of the oil and gas majors during the 1980s, personnel cuts at corporate led Rezabek to take a position as an analyzer supervisor at the company's Lima Refinery. So began a series of process control assignments that had Rezabek working for four different legal entities—BP Amoco, BP, International Specialty Products, and finally Ashland—without technically changing organizations.

Through the years, his work with analyzers in particular "opened the thought of digital integration—it's a term I've used

John Rezabek still blows his horn (literally) on a regular basis, including as an alumni member of the Madison Scouts Drum & Bugle Corps., which has performed at the Macy's Thanksgiving Day parade and recent Mardi Gras celebrations in New Orleans. Here he enjoys a beer with wife Barb and his baritone.

forever," he says. "If you have a microprocessor-based device, and a microprocessor-based host, they should be able to talk together." Back then, analyzers were more prone to go off in the weeds—due to sample system issues or other causes—and you just didn't know it, Rezabek says. This hampered the ability of operations folks to trust the analytical measurement, especially for closed-loop control applications. "It was 'I think I'm going to shut that off and run it in manual because I don't know if the analyzer is working correctly or not.'

"But with digital integration—using Modbus at the time—you had data validation, plus diagnostics," Rezabek adds. "You could get a clue from afar if something wasn't right, whether the measurement was okay or if something needed to happen."

Rezabek's second encounter with the power of digital integration came when, during a major modernization, the plant had the opportunity to use Honeywell smart transmitters that spoke digitally to the Honeywell DCS. "It was a great advantage. The DCS could bring in case temperature from all the instruments, and the operator could tell if an instrument was freezing up or getting too hot. "One of the operations team leaders attributed that insight to keeping the refinery running through the winter. That really stuck with me, and I thought we should have it all the time."

Then the opportunity came to be at the vanguard of digital integration: a new BP chemical plant was on the drawing board just as FOUNDATION fieldbus was being readied for market. "It was a compelling pitch, and served the vision of digital integration," he says. From there, Rezabek admits he became "a bit of an advocate" for fieldbus, including a stint as chair of the Fieldbus Foundation's end user advisory group. In that same period, he became a regular columnist with *Control*, and has now shared his perspectives on digital integration—and other related topics—for 15 years and counting.

When asked what words of wisdom he would impart to those just starting out in a process automation career, Rezabek counsels to not forget who the real end user is. "It's often missed that we in engineering are service providers to the operations organization. They're making the product that pays the bills. Seek their input and aim to make them more effective. It helped me be a better engineer—and get the systems I designed used and maintained."

Some things haven't changed since Rezabek's days as a contributor to the success of that lounge band all those years ago. "The feeling of being accepted as a trusted member of the team is tremendously satisfying," he adds. "When I walk into the control room, I get, "Oh good, John's here. That's what keeps me working."

In short, "Hope that they welcome you when you come, and hate to see you go." ∞

Safety gets a digital lifeline

Driven by COVID-19, process safety streamlines with new software, digitalized tools and improving standards

by Jim Montague

PROCESS safety has never been easy, but it can get easier. Because it requires awareness and motivation beyond immediate operations and production goals, process safety was traditionally seen as a drain on labor and resources. Periodic attempts are made to reframe it as a good investment, but they run into the fact that safety initiatives remain time-consuming. They typically require many manual steps, while support software for performing process hazards analyses (PHA) and layers of protections analyses (LOPA), are often isolated from their data sources, can't communicate with each other, and can't reach higher-level analytics functions. Fortunately, better software and other forms of digital transformation are beginning to show that they can streamline many of these former hurdles.

"Process safety is usually upgraded after users migrate to new process monitoring and control technologies, but I don't think safety is going to slow down digital transformation. Digital transformation and its available data, visualization and simulation tools are going to pull process safety along with it," says Angela Summers, president at engineering consultant SIS-TECH (sis-tech.com). "This is because software tools like hooking up models to digitalized clones of control systems allow users to simulate events, and see how their production and safety instrumented system (SIS) responds. This lets users optimize operations and safety, improve their interfaces, enable controls recovery from events, and produce data trends that can be compared to earlier estimates. These simulations also make future estimates more accurate, and reduce much of the usual guesswork in maintaining production and safety."

Summers reports the key to effectively simulating operations and safety systems is the data that's fed to the model, and how closely the simulation matches the actual process to tighten estimates. She adds that SIS-TECH has been working with Indiss Plus dynamic simulation software from Corys (www.corys.com/en) that uses chemistry first principles to model routine operations and infrequent events.

"We also understand that we can't chase every shiny penny software package out there. Process safety practitioners are trained to be cautious and conscious of safety loops that don't run as often as processes that are running all the time," explains Summers. "We preach that SISs should adopt proven technologies, so operations needs to check them first, see how they impact production, find and address any gotchas, and gain sufficient experience before using them for process safety. This is good practice that still applies in the new, increasingly digitalized, and hopefully post-pandemic world. The need for severity and frequency evaluations in PHAs and LOPAs aren't changed by technology."

Pandemic pushes virtual PHAs

Just as it's altered other work processes, COVID-19 has driven users and system integrators to perform PHAs, LOPAs and similar tasks online, using tools like Zoom, Microsoft Teams and others, according to Chet Barton, P.E., F.S.Eng., controls and automation process safety industry lead at Hargrove Controls + Automation (www.hargrove-epc.com) in Baton Rouge, La., and a certified member of the Control System Integrators Association (CSIA, www, controlsys.org).

"It used to be rare to conduct a virtual PHA, but priorities shifted during the pandemic. While it once seemed critical to have everyone in the same room, some clients began prioritizing project schedules over the in-person experience. We've performed multiple virtual PHAs because of restrictions to site access, and this will likely continue even as site access restrictions relax," says Barton. "So we set up Teams meetings, share our screens, look at the P&ID and other PHA documents, and pretend we're there in person. Everyone was worried initially because we always met in-person before, but we learned that we could do the PHA remotely because its essence is just a discussion about what hazards could be there and what do to about them. Since we're mainly talking about hazards, consequences and mitigations, it's possible to do a remote PHA by practicing some of the basic work-at-home skills. Many users and companies are realizing that remote work is OK, and the same is true for doing PHAs. Once you try it and get used to it, it works."

Stress drives digital acclimation

Faisal Khan, incoming director of the Mary Kay O'Connor Process Safety Center (MKOPSC, https://psc.tamu.edu) at Texas A&M University's Engineering Experiment Station (TEES), reports that different regions and industries are adapting their COVID-19 responses as the pandemic evolves.

"Most of the chemical facilities in developed regions were able to continue operating in safe modes," says Khan. "However, reduced staffing in control rooms due to COVID-19 reportedly contributed to two major chemical incidents in India." The first incident was a styrene gas leak early on May 7 at the LG Polymers plant in Visakhapatnam, Andra Pradesh, which reportedly killed at least 11 people and sickened hundreds. The leak from two 5,000-tonne tanks reportedly happened as staff were preparing to restart the plant after COVID-19 restrictions were eased. The second incident was an explosion on June 11 in a vessel at the Hemani Industries agricultural chemicals plant in Ankleshwar, Gujarat, which killed at least eight people and injured 50.

Dr. Steve Gandy, global business development VP at exida (www.exida.com), agrees that the mid-February freeze and power outages shuttered many plants in Texas, and also forced many of the state's refineries to close because they don't have the heat-trace equipment used in colder regions to keep oil and gas production thawed and running.

"We visited and talked with end users who were shut down for weeks, either because they had no power or their pipes and valves froze," says Gandy. "Many plants have backup power, and could shut down safety if they had to, but others couldn't get into their facilities or couldn't deploy more than a skeleton staff because of continuing COVID-19 restrictions. One client's power came back, but they still couldn't get back in. The freeze and the pandemic were a real double whammy."

Organize data, save labor

Probably the most important way to streamline process safety is making the data it relies on easy to access and analyze, which saves time and effort, and makes safety procedures more likely to be developed, implemented and followed.

"I think remote work and digitalization will have big impacts on process safety. This is similar to what happened with predictive maintenance and advanced process control (APC), which have been available for a long time and got more sophisticated, but can generate so much data that users don't know what to do with it," says Hargrove's Barton. "We work with many users that don't have the time to input and keep up with safety data because they're mostly worried about keeping their processes up and running."

For instance, one of Hargrove's chemical plant clients wanted to adopt aeShield's (www.aeshield.com) database-oriented, safety-management software, so it requested one of Hargrove's teammates to learn it, help implement it, and serve as an ongoing consultant. "The problem is that many clients who want to improve process safety have a hodgepodge of systems and safety documentation, which is often outdated or lost, and this stops their safety programs from getting started," says Barton. "That's why some hire us to perform audits, fill in gaps in their safety programs, and update existing documents or generate new ones. These documents include PHAs and LOPAs that are supposed to be revalidated every five years. They also include safety interlocks based on the PHAs and LOPAs that address specific operations, safety scenarios and mitigations that should also be tested periodically.

"Unfortunately, there are many times when this hasn't been done for awhile, so users and whoever is helping them must make lists and check the accuracy of the ones they can find, produce new interlocks for each one that can't be found, and develop safety requirement specifications that define what each interlock should do. Each facility typically has hundreds of interlocks. Usually, we can find documents for half of them, and half of those are usually correct. Luckily, software is getting better at organizing all this data, and this can help process safety, too."

Even though safety management software is separate from process safety controls, aeShield and Mangan Software Solutions' (https://mangansoftware.com) Safety Lifecycle Manager (SLM) software let users input safety interlocks and track testing and trips. This lets Hargrove's clients monitor and validate their assumptions, and make sure they realistically represent what's happening. This is especially important for PHAs that need to be revalidated every five years, which has been required since the early 1990s by the U.S. Occupational Safety and Health Administration's 1910.119 standard, "Process safety management (PSM) of highly hazardous chemicals (ww.osha.gov/laws-regs/regulations/standardnumber/1910/1910.119)."

"These tools consolidate all our safety data in one centralized place, which allows better access and documentation," explains Barton. "In the past, if we tried to assess a potential incident that could only happen every 10 years, such as loss of utilities during a startup or shutdown, we might only have anecdotal evidence or tribal knowledge to rely on. However, safety lifecycle software enables long-term documentation and access, and lets users develop an interlock that will be triggered if this infrequent incident occurs. It also documents new trips or other events, pulls and

SAFETY SOFTWARE TOOLBOX

Recent effort to improve process safety documentation and modeling have resulted in a variety of software solutions. Some of the most notable include:

- aeShield (www.aeshield.com) safety lifecycle management software makes it easier for non-safety staff to interpret risk from reports; simplifies safety integrity level (SIL) calculations; ensures compliance with IEC 61511/ISA 84 standards; and enables compliance documents to support routine operations.
- AssetCare software from mCloud (www.mcloudcorp.com) simplifies operations and maintenance of process assets by using artificial intelligence, analytics, 3D digital twins and advanced sensing to help users simplify and make sense of asset data. This lets them predict asset failures before they happen, plan and manage facility changes, and manage fugitive emissions.
- Indiss Plus dynamic simulation software from Corys (www.corys.com/en) is based on chemical engineering first principles, and matches process behavior at normal operations or during transient periods, whether the models are part of a dynamic study or incorporated into an operator training simulator (OTS).
- Safety Lifecycle Management (SLM) software from Mangan Software (https://mangansoftware.com) consists of interconnected application modules that cover process and functional safety lifecycles. It has tools for risk assessments, HAZOP and LOPA management, instrumented, non-instrumented and relief systems for independent protection layers (IPL), safety instrumented system (SIS) design, operations and maintenance, and SIL verification.
- PHA-Pro software from Sphera Solutions (https://sphera.com) reports that it makes risk assessments (RA) proactive instead of reactive by providing a framework, configurable methodologies and RA workflows that let users standardize and record risk assessment data and make sure they have sufficient controls. Sphera recently acquired Petrotechnics to enhance its end-to-end, operational risk management software.
- RiskPoynt (www.riskpoynt.com) software integrates real-time telemetry from assets to help users manage operational risks. It translates complex RAs for each safety barrier into visual displays that are easy to interpret and act on at all organizational levels.

stores their data, and puts it in context, so users can fill in gaps in their procedures, enable key performance indicators (KPI), and make personnel safer by allowing better testing of systems including safety interlocks."

Safety standards play catch up

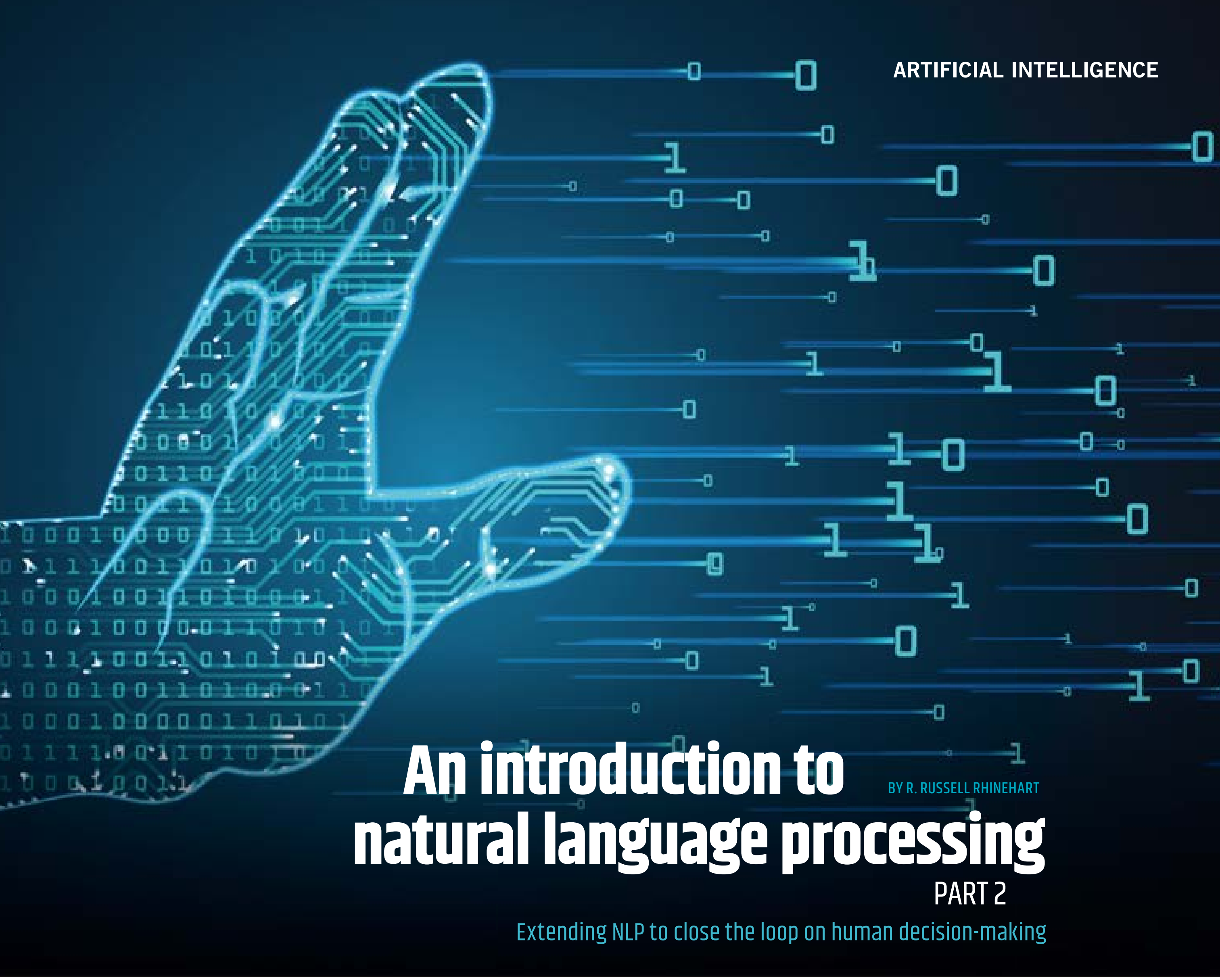
Even though COVID-19 and the Texas freeze's power outages are the latest, most visible forces impacting many process manufacturers' safety efforts, digitalization has been steadily increasing for years, and safety standards are ramping up to help.

"Previously, transmitters installed in the 1980s could run for 30 years or more. However, as transmitters got smarter and added diagnostics, their lifecycles got shorter due to their on-board software," says SIS-TECH's Summers. "We don't know how much shorter, but it could be 30-50%, depending on when and to what extent suppliers upgrade their products." Of course, shorter lifecycles can be a problem for users responsible for thousands of devices, so Summers adds there have been ongoing meetings by the subcommittees developing the IEC 61511/ ISA 84 standard for SISs. These efforts include the launch of the new ISA 84 Working Group 3 guidance on obsolescence strategy, which plans to release a review draft in May 2021.

"Because so much process equipment only gets replaced after running until it breaks, many users don't want to hear about replacing components simply because they're obsolete, rather than patching them and trying to keep them running," says Summers, who is also an ISA 84 member. "Managing all the devices in a process facility—and then planning to address those that are obsolete—isn't something many process engineers have been dealing with. However, after 50 years of their process applications remaining basically the same, many engineers are learning they need to integrate digitalized systems and cybersecurity, so they can successfully migrate to a new operational world, while keeping the old one running."

Summers reports ISA 84 WG 3 will cover several topics, but will focus on how to assess obsolescence, and how to justify replacing obsolete devices to managers. "Digitalization also ties into obsolescence. Old systems only provide a limited view of what can happen in a process because they only work with a few architectures and communication protocols, so users can't access to the data beyond the plant floor and can't leverage outside resources to solve problems," she explains. "However, new systems can work with cloud-computing services, so you can see what hosts are running or what the trends look like, resolving problems faster."

Summers adds that managing obsolescence doesn't always involve a clear-cut migration from old hardware to new software, and that transitioning can get murky when hybrid systems of older hardware and next-generation hardware need to coexist. "Some devices are available for Ethernet networking and Internet of Things (IoT), and some are not, so the question is how does a user take advantage of the next generation when older devices don't support it? Or, if a user is trying to simulate part of a production line, how can they do it if the data can't be delivered at the speed the simulation needs?" asks Summers. "This is a big challenge because most process plants have patchworks of applications and devices that were updated at different times, but IoT and the cloud is the way things are going to be." ∞



An introduction to natural language processing

PART 2

BY R. RUSSELL RHINEHART

Extending NLP to close the loop on human decision-making

CONTROL is the procedure of deciding and implementing action, it doesn't have to mean regulatory feedback algorithms. Here are some rules we might use as control actions, which are relevant to making a decision about what to wear:

- If it's cold and breezy, then wear long pants, sweater and jacket.
- If it's nice and calm, then wear short-sleeved shirt and lightweight pants.
- If it's cold and windy, then wear long pants, sweater, coat, hat and gloves.

Very generally, the rule structure is:

IF (antecedent situation)
THEN (control action)

And more specifically:

IF (temperature is category
AND wind is category)
THEN (wear N items)

Since there are three linguistic categories for each of two process variables as shown in Tables I and II, there would be $3^2 = 9$ rules. Note that the rules are stated for the perfect or ultimate linguistic categories, but that most actual conditions will result in some validity to two adjacent temperature and two adjacent wind categories, making four of the nine rules simultaneously and partially valid.

Table I summarizes the nine rules. Here, one rule is of the form:

IF (outdoor temperature is in "Cold" category and wind speed is in "Breezy" category) THEN (appropriate action is: wear seven items of clothes.)

This sort of logic can be translated into natural language processing control (NLPC). For a heat exchanger this might be specifically:

IF (temperature actuating error is positive-low, and rate of change is negative-large) THEN (incrementally adjust the controller output by +0.5%)

The IF part of such rules is termed the antecedent, and the THEN part is the consequent.

Returning the discussion to the weather and clothing decision from Part 1 of this article (March '21, p. 32), starting with a temperature of 32 °C (89 °F) and a wind speed of 7 km/hr, the associated figures and equations yield temperature membership values of 0.0, 0.6 and 0.4 in the categories of Cold, Nice and Hot, respectively. These values also indicate membership in the three columns of Tables I and II.

Similarly, figures and associated equations from Part 1 of this article show that

Wind Speed

Windy	9 Items	6 Items	4 Items
Breezy	7 Items	5 Items	3 Items
Calm	6 Items	5 Items	3 Items
Temperature	Cold	Nice	Hot

MATRIX OF WHAT TO WEAR

Table I: The decision of how many articles of clothing to wear depends on how hot or cold the air temperature is and how calm or windy the air movement is.

Windy μ_W(7 km/h)=0.1	9 Items Truth = 0.1*0 = 0	6 Items Truth = 0.1*0.6 = 0.06	4 Items Truth = 0.1*0.4 = 0.04
Breezy μ_B(7 km/h)=0.9	7 Items Truth = 0.9*0 = 0	5 Items Truth = 0.9*0.6 = 0.54	3 Items Truth = 0.9*0.4 = 0.36
Calm μ_C(7 km/h)=0	6 Items Truth = 0*0 = 0	5 Items Truth = 0*0.6 = 0	3 Items Truth = 0*0.4 = 0
	Cold μ_C(32ºC)=0	Nice μ_N(32ºC)=0.6	Hot μ_W(32ºC)=0.4

MATRIX OF DRESS RULES SHOWING RULE TRUTH

Table II: The calculated control action, in this case wearing four pieces of clothing (rounded down from 4.3), is determined from the truth-weighted sum of all rules in the matrix.

the wind speed of 7 km/hr has a 0.0 belongingness to the Calm category (and the lower row of Table II). It also has a 0.9 belongingness to the Breezy category and the middle row, and a 0.1 belongingness to the Windy category and its upper row.

There are two common methods to choose the belongingness to each cell in the Table II matrix. For the first, consider belongingness as a probability or likelihood, then the probability that the condition is in one particular cell is the probability that it's in the row of the cell *and* in the column of the cell. (Although, useful, the likelihood analogy is weak.) But with the likelihood viewpoint, products of row-column belongingness values represent the *truth* that a process variable set is in a particular cell. These cell values are also indicated in Table II.

Conveniently, the sum of all of the truth values is unity because: 1) the membership functions are linear, 2) adjacent membership functions share break points, and 3) the row-column membership product is used for the rule truth. (There are alternate approaches. I prefer this simple one.)

The truth of a rule is the weight or importance given to that rule, and the blended control action is the truth-weighted sum of all rules, as described in the general equation, and for this particular example:

$$Action = \sum_{AllRules} T_k A_k$$

$$Action = 0 \bullet 9 + 0.06 \bullet 6 + 0.04 \bullet 4 + 0 \bullet 7 + 0.54 \bullet 5 + 0.36 \bullet 3 + 0 \bullet 6 + 0 \bullet 5 + 0 \bullet 3 = 4.3\ Items$$

Here, T_k represents the truth of the kth rule, and A_k represents the action to be taken if the kth rule was perfectly true.

The calculated action “Wear 4.3 items” is the control action. If this was a controller output command to a valve, “Open 4.3 % more,” then the decimal part is acceptable. However, because the answer in this clothing example can only be an integer, one might round the result as is done in digital processing with a finite bit length for variables. The equation converts the qualitative rules and qualitative characterization of the process variables into a definitive, implementable value.

Another common convention to assess the truth of a rule is to use the minimum of the row-column membership values as the truth for the cell. In general then, the truths don't sum to unity, so an additional weighting uses the individual truths normalized by the sum of all truths. In my experience the several approaches are equivalent.

The extension to analysis and control of higher dimension situations is straightforward. For example, relative humidity could be included as a third consideration in making the choice of what to wear. This would place three process variables in the antecedent making it of dimension three. For a 3D antecedent, the rule matrix would be a rectangular volume. If sun intensity and time duration are also considered in the decision process the antecedent would have five dimensions. The extension to higher-order antecedents is easily performed in programming, but it's not amenable to visualization.

NLPC uses human rules for automating decisions, without advanced mathematics (such as calculus or Laplace transforms), and it permits nonlinear action. If you have applications in which IF-THEN conditionals automate routine engineering or operator decisions or actions, then you're almost implementing NLPC. Better than the normal use of IF-THEN conditionals, NLPC permits smooth transitions between categories.

NLP provides a framework for standardization of how heuristic rules are implemented. Operators and managers can understand the linguistic logic, and they can state the rules in natural language. The recorded body of rules provides additional benefits in training and developing process understanding.

Simple to implement, document

Normally, process experience among operators and engineers is sufficient to develop an NLPC application without performing either experimental process-response testing or controller-tuning explorations. NLPC can integrate user-defined action for feedforward and constraint avoidance.

However, NLPC needs break points defined, perhaps averaging three for the first linguistic category, then one more for each additional category for each process variable, and one control action for each rule. If NLPC is replacing proportional-integral (PI) control, then commonly there are two process variables, actuating error and rate of change of error. If each has five linguistic categories (zero and two “plus” and two “minus“ categories), then there are 25 rules and about 14 break points, summing to about 40 user-required values. Gain-scheduled PI control over four regions needs eight tuning values and three break points for a total of 11 values.

The simplicity of gain-scheduled PI control and the widespread familiarity with PI algorithms might override the benefits of using NLPC to replace PI for feedback control. Most NLPC vendors offer PI substitutes and software features that make it simple to set up improved control. But in my opinion, replacing PI in feedback control isn't where NLPC has its largest advantages.

Identify where your people are routinely observing something and taking corrective action, then consider automating that action with natural language programming control.

NLPC should be considered as an automaton solution wherever engineers or operators observe, perceive, and take routine supervisory corrective action. Consider NLPC for automating process management action, rather than replacing feedback control. If you're either personally implementing or automating the implementation of heuristic rules, you have a potential application for NLPC.

Identify where your people are routinely observing something and taking corrective action, then consider automating that action with NLPC. For example, do they observe time-to-breakthrough on a carbon-bed absorber to adjust the absorb-to-steaming cycle period? Do they observe outlet composition on parallel reactors to adjust feed rate between reactors? Do they observe zero-crossing behavior of a controller to increase or decrease gain? Using the NLPC structure will standardize the multiple applications of heuristic supervisory activities throughout your enterprise.

As with any automation approach, the control rules and the categorization of process variables in NLPC reflect the knowledge of the creator, not necessarily the best logic, and they may even integrate folklore. That it works, does not mean it represents either a valid or best underlying understanding. Use an application to see if results affirm your intuitive understanding. Be willing to improve.

Further, like any control strategy or controller tuning, NLPC reflects the process understanding at one time, which may need to be revised when the process equipment is changed or used under significantly different conditions.

Finally, don’t call it fuzzy logic! Dr. Zadeh’s insight on logic and its mathematical formulation was transformational, simple and effective. He gets much respect! But his choice of that term does not evoke confidence or security in the minds of process managers. If you want to implement it within industry, call it natural language processing or whatever makes it acceptable in your community. ∞

Part 1 of this article, which explained the mathematics behind natural language processing, appeared in the March 2021 issue of Control.

Behind the byline

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 website www.r3eda.com.

Orifice flowmeter inaccuracies

Given the multitude of contributors, don't place too much stock on absolute accuracy

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.

Q: **On the first page of section 2.15, "Orifices," of your *Instrument Engineer's Handbook, Fourth Edition - Process Measurement and Analysis, Volume I*, it's written that "if the bore diameter is correctly calculated, prepared and installed, the orifice can be accurate to ±0.25 to ±0.5% of actual flow."**

My question is as follows: according to formula 3 of ISO 5167-1 and ignoring all other uncertainties except the discharge coefficient, C, the minimum uncertainty for mass flow rate is the same as the uncertainty of C. The latter, as per clause 5.3.3.1 of ISO 5167-1 is at minimum 0.5%.

SAEED BEHESHTI MAAL
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A1: A very useful question, because it shows that sometimes loop performance and component performance are confused. In the front of each chapter of my handbook, the key data for only the discussed component (in this case the orifice plate) is given, but not for the flow loop. Such key data includes uncertainity, which can also be called error or inaccuracy (but certainly not accuracy). The data for the orifice plate, as discussed in Chapter 2.15, is only for that component and assumes a calibrated plate.

This is probably also the case with the ISO statement because it assumes that ß, D, Re etc are accurately known constants and contribute zero error. With loop components, this is quite common. For example, when ABB reports its Flow-X calculator uncertainty is 0.006%, it doesn't mean the flow measurement error will only be 0.006%. In short, my advice is to read not only the front summary, but the whole chapter in my handbook because the front page summary is only for the components discussed and can be misunderstood. Actually, in future editions, I might just leave out these summaries to avoid such misunderstandings.

Now, let me elaborate about the other potential error contributions to the total uncertainity of an orifice-type flow measurement. The volumetric flow, Q, through an orifice is:

$$Q = CA\sqrt{h/\rho}$$

The mass flow, W, is:

$$W = CA\sqrt{h\rho}$$

Where Q is volumetric flow, C is the discharge coefficient, A is the pipe cross-sectional area, h is the pressure drop across the orifice, and ρ is the density. Now, let me mention potential error sources, which will add to the total uncertainty of the orifice-type flow measurement.

Density (ρ): The uncertainty in density (or composition) measurement is usually high (particularly in natural gas measurement), and the resulting error is additional to that of the orifice error itself. The fact that density is under the square root when measuring the mass flow is advantageous because that reduces the increase in the flow measurement error. Errors will also occur if the pressure drop exceeds 0.25 of the inlet pressure because that creates excessive density changes as the flow passes through the orifice.

Discharge coefficient (C): The variation in C is the main contributor to the total flow measurement error because C changes are caused not only by ß ratio variations (ß ratio must stay within 0.2 and 0.65), but for many other reasons. For example, C changes as velocity profile changes due to Reynolds number variations. Figure 1 shows the relationships between discharge coefficient C and the Reynolds number for a number of head-type flow sensors, including concentric square edged, beveled, eccentric, integral and quadrant radius orifices.

C also changes if the location of the vena contracta varies, because it moves with the velocity of flow, and also because the downstream pressure tap is usually not at the vena contracta. Usually flange or corner taps are used in pipe sizes under 2-in., vena contracta taps are used for 6-in. or larger pipes, and pipe taps are used for sizes in between. In addition, as material builds up on the inner surface of the pipes or as corrosion or erosion reduces the sharpness of the orifice edges, the value of C also changes.

Recalibration, rangeability: Dual chamber orifice fittings allow orifice plate removal, replacement or insertion without interrupting the flow by changing orifice plates under pressure, so they eliminate unscheduled downtime. These dual-chamber devices can be operated oth manually or be motorized, and can reduce measurement uncera-tinty. They can change the flow rating (increase the rangeability) of the measurement by sliding a new plate into the flowing stream with a different ß ratio. Such fittings can also be used to replace orifices that have likewise lost the sharpness of their edges or can replace them with calibrated plates.

Transmitters: In addition to the above error sources, the measurement error of the developed pressure drop contributes further uncertainty to the flow measurement. Even newer smart transmitters with automatic span switching usually contribute about 0.1% full scale (FS) error, which being a fixed quantity, has to be multiplied by the rangebility to determine the % actual reading (AR) error at minimum flow.

The bottom line is that even newly calibrated plates with state-of-the-art transmitters will have 1% or so uncertainty; the error of an uncalibrated orifce with an analog transmitters will be no better than 2% and will grow worse over time.

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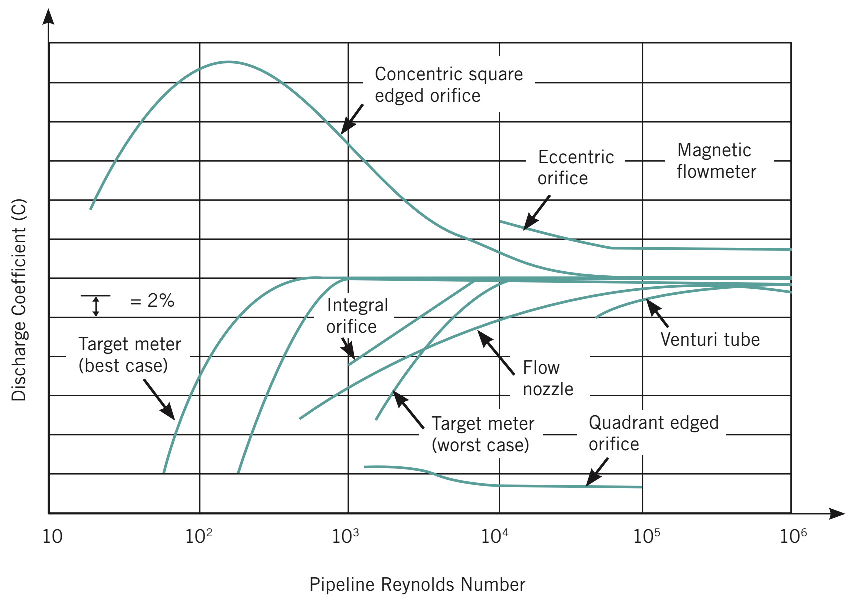

FLOW COEFFICIENT VS. REYNOLDS NUMBER

Figure 1: For differential-pressure-generating flow elements, flow coefficents vary with the Reynolds number of the flow being measured.

A2: Regarding the question of orifice plate accuracy (I hate that word), it simply can't be better than the overall uncertainties of the individual components. As a starting point, the uncertainty of the discharge coefficient has to be added to the uncertainty of the measuring system, i.e. the differential pressure cell used to turn the indicated differential pressure into a flowrate. This takes the minimum uncertainty well above that stated in the *Instrument Engineers' Handbook*. I have to say the statement it's made is misleading in the extreme. The methodology outlined in ISO 5167-1 should be followed, and all the influential effects have to be considered.

In my experience over 40 years, I haven't found an installed orifice plate to be better than 1% even when new. The edge sharpness and pipe internal roughness change with time, and I've done independent audits on older orifice plates and found in some instances the overall uncertainty to be greater than 5%. I hope this helps answer your concern.

DR. RICHARD FURNESS
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A3: Perhaps you've discovered a misstatement in the *Instrument Engineers' Handbook*. Also, an orifice flowmeter doesn't measure mass flow, only volumetric flow. Perhaps the statement in the ISO 5167 standard relating to mass flow is inaccurate.

Second, who cares? Using an orifice flowmeter for accurate flow measurement is foolhardy. An orifice flowmeter will never be accurate, and will become less accurate over time as the sharp edge of the orifice wears. Using flange-taps is common, but the downstream flange tap is never at the location of the vena contracta, even though an orifice measurement depends on the downstream tap being located precisely at the vena contracta.

If accuracy is needed, use a positive displacement, turbine or Coriolis flowmeter. Orifice flowmeters are most often applied in flow control where accuracy isn't required, but repeatability is important.

DICK CARO
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A4: Possibly the ± 0.25% refers to a calibrated orifice.

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Flow innovations come in waves

Improvements in Coriolis, ultrasonics—and increased accuracy—allow flow measurement in diverse settings

CORIOLIS FOR HYDROGEN FUELING

TMU-W high-pressure Coriolis mass flowmeter is designed for hydrogen fuel dispensing units. Its design is reported to be unique, providing the highest possible stability and accuracy. TMU-W is certified to the OIML R 139 2018 international standard for hydrogen fueling stations, and has a 1.5 accuracy class. It's also suitable for other high-pressure applications for liquids or gases, such as injection skids, fracking or extrusion. TMU-W is pressure resistant to 1,000 bar and provides two 4-20 mA current output signals.

KOBOLD INSTRUMENTS INC.
412-788-2830; www.koboldusa.com

USING SURFACE ACOUSTIC WAVES

Flowave 8098 flowmeter uses a patented surface acoustic wave (SAW) process to perform measurements, so there are no installed fittings or constrictions, and no empty spaces in the measurement tube. Measurements are also performed without contact between the sensor elements and the medium. Because the measuring tube is identical in fluidic terms to other straight tube sections where it's implemented, Flowave 8098 also avoids pressure drops. Installation is straightforward due to its compact size and light weight.

BURKERT FLUID CONTROL SYSTEMS
800-325-1405; www.burkert-usa.com/en/type/8098

GAS MEASUREMENT FOR BREWING

Versatile, green-friendly ST75 thermal air/gas mass flowmeter measures natural gas, CO_2 and mixed waste gases in small line sizes to optimize brewing fermentation processes, product quality and overall plant efficiency. It features accuracy to ±2% of reading with ±0.5% repeatability over variable temperatures in line sizes from 0.25 to 2 in. (6 to 51 mm). ST75 is factory preset to a wide turndown range at 10:1 to 100:1. It operates over a 0.01 to 559 SCFM (0.01 to 950 NCMH) flow range, depending on line size.

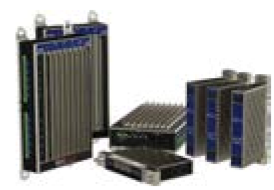
FLUID COMPONENTS INTERNATIONAL (FCI)
800-854-1993; www.fluidcomponents.com

ULTRASONIC METER ADDS PRESSURE, TEMPERATURE

Proline Prosonic Flow G 300/500 ultrasonic flowmeter integrates pressure and temperature sensors. It can be supplied with two transmitters, either Proline 300 compact version or Proline 500 remote version with up to four inputs and outputs, which lets it output not only flow, but also pressure, temperature and other process variables. Prosonic Flow G can measure dry and wet gases with ±0.5% precision, repeatability and reliability, and operates at up to 150 °C (302 °F) and at pressures up to 100 bar (1,450 psi).

ENDRESS+HAUSER
https://eh.digital/Prosonic_G_us

CONTROLLERS ADD FLOW CALCULATIONS



Open Secure Automation (OSA) platform and its OSA Flow and OSA Remote^{+}Flow controllers have embedded Flow-Cal software and algorithms for flow measurement. Their combination lets users manage measurement and custody transfers, program field I/O and control strategies, and deploy protocols such as HART, EtherNet/IP and Modbus, along with OPC UA and MQTT. OSA^{+}Flow also features a temperature envelope of -40 °C to 80 °C (176 °F), extreme galvanic isolation for EFT and EMP, and 64 cGB secure flash memory.

BEDROCK AUTOMATION
781-821-0280; www.bedrockautomation.com

PRESSURE GAUGES FOR CORROSIVE GAS FLOWS

PG-35, PG-35H, and PG-35L pressure gauges from Nidec Copal Electronics measure the pressure of corrosive gases and liquids in industrial automation equipment and medical equipment. The gauges withstand these extreme environments because the internal silicon-chip sensor is encased in a stainless-steel diaphragm. The sensor's output functionality can be programmed using buttons located near the display. Users can program how the switch outputs engage, adjust pressure settings, and set units of measurement.

DIGI-KEY ELECTRONICS
www.digikey.com

FOUR METERS IN LESS THAN HALF THE SPACE

Rosemount 8800 Quad Vortex flowmeter meets stringent safety standards, where SIS are required, and is reported to be the first with quadruple sensors and transmitters to meet SIL requirements. Housed in an all-welded meter body, the meter provides a compact flow solution with built-in redundancies for added safety without introducing additional leak points. It reduces piping needs threefold by eliminating added flanges and pipe runs required for installing multiple flowmeters in a redundant flow measurement solution.

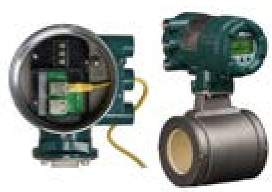
EMERSON AUTOMATION SOLUTIONS
www.Emerson.com/RosemountQuadVortex

SENSOR FOR VALVE POSITION FEEDBACK

F31K2 dual-valve position sensors have a beacon that's visible from long distances to give onsite operators instant, reliable valve position data. The sensor’s double-housing design provides twice the mechanical protection and a high ingress-protection rating. LEDs indicating power supply, sensor and valve conditions are integrated into the F31K2's encapsulated sensor module. Its housing materials ensure high resistance to UV, temperature and corrosion. NAMUR Ex i (Zone 0/20) and Ex nA (Zone 2/22) versions are available.

PEPPERL+FUCHS
www.pepperl-fuchs.com/usa/en/20180.htm

ETHERNET AIDS FLOW CONTROL



Admag TI AXG magnetic flowmeter has high-speed, bidirectional EtherNet/IP communications that enable improved control, configuration and data collection between field instruments and control. It has plug-and-play integration with PLCs, high-volume data transmission, and enhanced settings. Admag TI AXG also features built-in verification, 0.1 in. to 20 in. (2.5 mm to 500 mm) diameters with PFA or ceramic liners; up to ±0.15% of flow rate accuracy; and explosion-proof, submersible and hygienic versions.

YOKOGAWA
https://bit.ly/3bdxXry

MEASURE CONDUCTIVE FLUID FLOWS

Inductive electromagnetic flowmeters offer high accuracy and are suited for flow measurements of fluids with electrical conductivity from 5 µS/cm (20 µS/cm for demineralized water). Measurements are independent of density, temperature and pressure. Their operating principle is based on Faraday’s magnetic induction law. They can measure the flow rate of a conductive liquid in any process, including chemical, pharmaceutical, paper, food processing or water/wastewater treatment.

FUJI ELECTRIC
https://americas.fujielectric.com/em-flow-meters

LOW-COST, ACCURATE CORIOLIS

CorFlo Coriolis mass flowmeters allow real-time measurement of density and flow in liquids, slurries and gases. Thermal meters combine the convenience and accuracy of conventional mass flowmeters with lower costs, but CorFlo is also reported to provide the most accurate measurements (±0.1~0.5%) for process fluids, while achieving low pressure drops. It also has more measurement sensitivity and stability, performance over a wide flow range, and minimal process, mounting and environmental effects.

HAWK MEASUREMENT
www.hawkmeasurement.com/product/CMFM

BALL VALVE FOR PRECISION FLOW

Type-21a Seat Support Technology (SST) true-union, flow-control ball valves are available in ½ in. through 2 in. sizes. They have a precision-machined PVC ball with center provisions to support PTFE seats from 0% to 100% of capable flow. Type-21a produces equal percentage flow characteristics for fine throttling, requires directional installation, and has a flow-direction label. SSTs are manually operated, include a 0°-100° indicator plate, and have an indicator line that doubles as a carrier-adjustment tool.

ASAHI/AMERICA
800-343-3618; www.asahi-america.com

COMPACT METER FOR GAS CUSTODY TRANSFERS

Flowsic500 compact, ultrasonic gas meter is designed for precise custody transfers of natural gas. It's reported to enable extremely accurate measurements in distribution applications. Because it lacks moving, mechanical parts, Flowsic500 is also durable, reliable and maintenance-free. It's also overload-proof and monitored by an intelligent diagnostics system. When used in transfer and measuring stations, Flowsic500 provides the security of continuous and blockage-free gas supplies.

SICK USA
800-325-7425; www.sick.com

SAFE, STABLE LIQUID FLOW SENSING

Sensirion SLF3S liquid flow sensor provides safety, stability and long-term reliability, monitors system operations, and detects common failure modes for a range of applications. The liquid flow sensors in the SLF3x series are based on Sensirion's proven CMOSens technology, which optimize costs by simplifying design without sacrificing easy fluidic, electrical and mechanical connections. Their straight and unobstructed flow channel has no moving parts.

NEWARK
www.newark.com/sensirion/slf3s-0600f/liquid-flow-sensor-0-002lpm-12bar/dp/83AH9489

ULTRASONIC METER EXTENDS VISCOSITY RANGE

Optisonic 6300 V2 ultrasonic flowmeter has a clamp-on design, and measures flow anywhere without interrupting processes. New features include a viscosity range up to 200 cSt, no need for re-greasing due to solid coupling material, next-generation signal converter for enhanced application range, Namur NE107 diagnostics and integrated thermal energy calculation. Optisonic 6300 V2 is suitable for diameters from ½ in. to 160 in. It has a process temperature range of -40 °F to 392 °F (-40 °C to 200 °C).

KROHNE
800-FLOWING (978-535-6060); www.us.krohne.com

CLAMP-ON, ULTRASONIC METER UPDATES AT 100 Hz

Sitrans FS230 clamp-on, ultrasonic flowmeter offers cost savings with high accuracy, ease of use and reliability in flow processes. Its 100 Hz data update rate provides diagnostics and error-handling efficiency. In addition, Sitrans FS230 features an external Digital Sensor Link (DSL), which is an external module that processes analog signals from transducers, and digitizes them to enable robust communication over long distances to the transmitter without electromagnetic interference.

SIEMENS
www.usa.siemens.com/clamp

VISUAL INDICATION OVER VARIABLE AREAS

ProSense FG1 mechanical, variable-area flowmeters have visual indication of flow rates. They provide ±5% full scale accuracy and ±1% repeatability. Two adjustable flow limit pointers indicate high/low/normal flows. ProSense FG1 is made of high-impact polysulfone plastic with brass fittings (½ and ¾ NPT models). FG1 is available with ½ in., ¾ in. or 1 in. NPT process connections and easy-to-read flow scales in gpm and lpm. Measurement ranges are 0.25-2.5 GPM (1-10 LPM) to 4-28 GPM (20-100 LPM).

AUTOMATIONDIRECT
www.automationdirect.com/variable-area-flow-meter

C1D2 / ZONE 2 FLOW COMPUTER

To increase precision in custody transfers, Flow-X flow computer has obtained Class 1 Division 2 (C1D2) and ATEX/IECEx Zone 2 certification for accurate measurements in mid- and downstream oil and gas processes, even in the harshest conditions. C1D2 / Zone 2 extends its operating temperature range from -40 °C to 75 °C (-40°F to +167°F) with 5% to 95% humidity. Flow-X also has analog inputs that provide what's reported to be unmatched 0.008% accuracy.

ABB
www.abb.com

Ethernet testing for everyone

Cable and network tester simplifies identification, fault finding, wire maps and performance

IN times of rapid technical change, even users that don't test cables and networks regularly may still install many devices and need to test cables and networks. To give them a much-needed assist, Fluke Networks is introducing the LinkIQ industrial Ethernet (IE) cable and network tester.

"Many networks are moving from point-to-point hardwiring or fieldbuses to Ethernet, and users jiggle or swap out cables when they experience problems. However, they often don't have the right tools and use specialized devices like protocol analyzers, which isn't a great approach," says Mark Mullins, product marketing manager at Fluke Networks. "We've got a long history in cable testing, so we know it's OK for an email to resend a data packet, but it's not OK on an industrial network. Our idea was to make it easier for users to test cables and networks, and illuminate problems because just over half of Ethernet failures are related to cabling."

Mullins reports that LinkIQ lets users:

- Validate cable performance to support using Ethernet protocols, such as EtherNet/IP, Profinet, EtherCAT and others;
- Identify miswired and split pairs on cables terminated with RJ45, M12X, M12D and M8D connectors;
- Identify connected switch information, such as switch name, port number and virtual local area network (VLAN);
- Install and troubleshoot Power over Ethernet (PoE) devices via switch negotiation and PoE load test methods; and
- Document work steps done with LinkWare PC software.

Mullins adds that LinkIQ can typically determine if a cable is bad in six seconds. It also finds the distance to the fault, and provides a wire map of the cable under test. This new tester also performs nearest-switch diagnostics to identify network issues and validate switch configuration, eliminating the need to use another device. Other features include analog and digital toning, port blink, 802.1x authentication, remote office locators, and the ability to manage results via LinkWare PC software.

WHAT'S ON YOUR WIRE?
LinkIQ industrial Ethernet cable and network tester from Fluke Networks tells users what happening on their cable, connectors and networks.

LinkIQ also determines switch port speed up to 10 Gbps, evaluates PoE performance under load, and saves time by combining and automating formerly separate tests. "The three things LinkIQ can connect to are cables, cables with remote identifiers and cables plugged into networks, which can tell users about the far ends of their networks," explains Mullins. "LinkIQ shows cable lengths up to 1,000 feet, complete wire maps, and cable and switch configuration. Previously, users needed multiple devices to get these results. And, even though an equivalent, high-end device like a network certifier might deliver more data, it would cost five or six times as much."

Mullins adds LinkIQ's biggest breakthrough is it simplifies cable, connector and network testing, which also makes it easier for users to ensure performance in their devices and applications. "Users often don't know if a given cable can handle the communication speed they'll need, so it helps that LinkIQ can shows its bandwidth like a speedometer. It provides the simple pass/fail indication they want, so they don't have to waste time interpreting results, " adds Mullins. "They also want to know where their cables go, and LinkIQ provides a tone generator that works with a probe, lets users blink on a port like a light switch, and displays the connected switch's name, port and VLAN number."

Because many devices rely on Ethernet power, LinkIQ tells users how much is available. Finally, LinkIQ also lets users quickly document their work, save up to 1,000 test results, and store and report them in one LinkWare PC database. And, once these results are in a database, users can compare current results with those from years ago to enable higher-end testing and commissioning projects. "One of our beta testers told us, 'I can do all the cable and network testing I need by pushing one button on LinkIQ. It makes me feel like I can give it to interns, and they can install and troubleshoot devices on my network for me.' " ∞

For more information, visit www.flukenetworks.com/edocs/linkiqtm-industrial-ethernet-cable-network-tester

HIGH-PERFORMANCE COMPUTER FOR IoT EDGE

UNO-238 compact IoT edge computer is powered by the latest eighth-generation Intel Core i processor, and provides a competitively priced, high-performance computing solution in an optimized compact form factor. UNO-238 features swappable RAM for increased flexibility and easy maintenance, while the built-in, onboard 32GB eMMC storage with dual M.2 expansion enables rapid deployment for diverse IoT applications.

ADVANTECH
www.advantech.com

RAMAN SPECTROMETERS FEATURE 24/7 CONNECTIVITY

Kaiser Raman Rxn2 and Rxn4 analyzer models integrate analyzer and control software in a fixed purpose device with built-in intelligence. The *in situ* spectrometers also communicate with external systems over networks using standard automation protocols, providing users with reliable chemical composition measurement with secure 24/7 connectivity, enabling Industry 4.0 strategies via increased data security and automated communication.

ENDRESS+HAUSER
https://eh.digital/3qrMbuu

GIGABIT MANAGED SWITCH BRIDGES IT, OT NETWORKS

Allen-Bradley Stratix 5800 managed industrial Ethernet switches support Layer 2 access switching and Layer 3 routing for use in multiple layers of a plant's network architecture. Robust security capabilities and ISA/IEC 62443-4-2 certification help enhance network security. The switch also has fixed and modular designs, giving users flexibility to configure it based on application needs. It offers combinations of copper, fiber and Power over Ethernet (PoE) ports to support a wide range of architectures.

ROCKWELL AUTOMATION
www.rockwellautomation.com

EQUIPMENT & MATERIALS

AD INDEX

Responsible control valve response

Efforts are underway to include responsiveness measures in valve specifications

GREG: I became sensitized to the need for control valves to respond to small signal changes during my many decades of doing pH applications, as described in my ISA book, *Advanced pH Measurement and Control, Third Edition*. A resolution limit of 0.1% for even the best control valves could translate to a 2 to 12 pH oscillation in a strong acid and strong base neutralization. Since resolution limits are in percent of valve capacity, this translated to an increasing need for multiple stages of neutralization, with the first stage setpoint on the flattest part of the titration curve, and the largest control valve and last stage on the steepest part with the smallest control valve.

Threatening this capability was the realization that the actuator size stocked was marginal, increasing the resolution limit to 0.4%. Further, the response time of the positioners would increase by more than an order of magnitude for changes of less than 0.4%, and the resolution near the seat more than doubled the resolution limit for even the best throttling valves, causing a corresponding loss of rangeability.

My work over many decades on compressor surge control made me keenly aware of the need for control valves to quickly respond to large signal changes and the first-hand-experienced dangers of replacing a positioner with a volume booster, instead of putting the booster on the positioner output, as documented in my Momentum Press book, *Centrifugal and Axial Compressor Control*. Large valves with consequentially large actuators need an 86% response time of less than 2 seconds for a 50% change in signal for surge control.

Also, I have repeatedly seen on-off valves posing as throttling valves, where the backlash and resolution exceed 8% as revealed in the *Control* article, "Is your control valve an imposter?" The error between the closure member position and actuator feedback position (readback) often approached 8%, leading even smart positioners to think everything was fine.

Control valve specifications have an entry for capacity and leakage, but nothing so far about precision and speed of response. Often the imposters are less expensive. The thought that bigger is better, the bid process, tightening of project budgets, and lying positioners have put us in dire straits for the past 50 years. This led me to join the committee for the ANSI/ISA-S75.25.01 standard and ANSI/ISA-TR75.25.02 technical report on how to do control-valve response testing. However, I didn't try to address the many control issues, so that we don't keep making the same mistakes.

James Beall is the chair of the committee and is going to reopen the reports for possible improvements. James has a history of identifying valve response and its effect on process performance. While at Eastman Chemical, he discovered the tremendous impact of small step sizes on valve response due sensitivity limitations in positioners. He went to work for Emerson in the then newly acquired EnTech Control organization that had a mission of helping all realize that more than 30% of the variability in control loops could be traced back to deficiencies in valve response. EnTech worked with Fisher Controls' research and development unit.

An EnTech valve response report was the starting point for ISA 75.25. We're also fortunate to have Cullen Langford, original chairman and current vice-chairman of ISA 75.25, joining us with some concluding remarks on how we can more specifically help users get the best responding valve for an application.

I realize that in a technical report we can't tell people what to do, but I was hoping we can alert them to the many problems and possible solutions, leaving it up to them to make the final decisions on final control elements as shown in my *Control* article, "How to specify valves and positioners that don't compromise control."

James, can we do this as an annex to the existing technical report? I've prepared a "Valve

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

Response and Control Loop Performance, TR75.25.02 annex proposal," which considers valve nonlinearities such as backlash, shaft windup, slew rate, dead time and valve flow gain from the installed flow characteristic. This is in addition to the existing nonlinearities noted and associated with dead band resolution and changes in 86% response time and travel gain. (Visit the online version of this column to download a PDF copy of Greg's proposal.)

JAMES: As you mention, the ISA 75.25 standard and technical report don't make any recommendations on specific performance metrics per ISA guidelines. However, I think it would be quite appropriate to elaborate about the impact of valve nonlinearities on process/loop performance, and help customers translate process performance requirements into valve-performance requirements.

GREG: We should explain the distinguishing characteristics of dead band originating from resolution, backlash, shaft windup and positioner settings. We should also note that the proper definition of hysteresis (hysteretic error) doesn't include dead band. The existing reports only briefly discuss hunting. What can the committee do to provide an understanding of limit cycles from backlash, shaft windup and resolution, as well as the burst of oscillations for small and large signal changes due to positioner limitations?

JAMES: My plans are to add a section to the technical report (TR) on the impact of nonlinearities. For example, as you pointed out, a non-zero “lost motion” nonlinearity such as backlash in the valve system will produce a limit cycle (aka hunting) when at least two integrating elements are in the loop. A non-zero resolution nonlinearity will produce a limit cycle when there is at least one integrating element in the loop. The integrating elements could be in the PID controller(s), the positioner or the process.

GREG: How can we increase understanding of how integral action in a positioner may increase limit cycles and response time, and that the benefit in gain ratio is not as important?

JAMES: I've seen the integral mode used two different ways in positioners. The first way is where the integral action isn't used as a primary positioning function. It's a slow integral with an error dead band (e.g., 1% travel span) that's used to keep the valve position close to the nominal input signal value. For this case, I've rarely seen it cause limit cycles. In the second case, the integral function is used as a major part of the positioning algorithm in the positioner. For this case, I've seen many cases where it resulted in limit cycles and extended response time, since the positioner gain must be lowered to maintain stability of the positioning algorithm.

GREG: Can we introduce the idea of external-reset feedback, secondary flow loops, and tuning to reduce oscillations and stop some limit cycles?

JAMES: If the smart positioner and control system provide fast and reliable valve position feedback, then external reset feedback and the fast, precise readback of actual valve position can be used to reduce the occurrence of oscillations and limit cycles. If the primary nonlinearity is resolution, this technique will result in an offset between process variable (PV) and setpoint. So, if the offset is less detrimental to the process than the oscillation, this technique will provide benefit. If the primary nonlinearity causing the limit cycle is a slow response time for small signal changes due to positioner limitations or due to lost motion, this technique will actually stop the limit cycle without a PV-SP offset.

GREG: Can we provide an alert about the types of actuators and valves that tend to have the worse resolution, backlash and shaft windup?

JAMES: By design, rotary-type valves and actuators have a greater propensity for these nonlinearities. We discovered many years ago that a valve shaft could actually twist due to the torque required to move the closure member. This twist, or shaft windup, could be as much as 8% of travel span. The loose fit of the closure member to the shaft can add significant backlash to the response.

Valves with high packing or internal-component friction typically have more of these nonlinearities. The larger the difference between the static and sliding friction coefficients, the larger the resolution will be. Valves designed for on-off service and “converted” to throttling service often have features designed for good on-off service but create significant nonlinearities for throttling applications.

With pneumatic actuation, actuators with a smaller force capacity tend to have higher nonlinearities. On the other hand, a larger volume in the actuator might produce a slower step-response time, another valve-system nonlinearity. Motor-driven or hydraulically-operated throttling valves could have an intentional dead band setting that's too high (to reduce motor operation). Oversized valves or using incorrect trim characteristics can result in a high loop gain that amplifies the impact of the valve nonlinearity on the process.

GREG: Can we note sources and consequences of excessive error between the actuator feedback (readback) and closure member?

JAMES: Depending on the valve, actuator, connection, linkage and positioner design, there can be a simple offset or quite a variable difference due to backlash, friction forces and shaft windup, particularly for rotary valves designed for tight shutoff with pinned or keylock connections. This can cause poor performance since the positioner response is based on the postion feedback!

GREG: Rotary valves with an integral cast ball or disc stem—together with splined actuator shaft-to-stem connections with minimal friction from seals and packing—greatly reduce shaft windup, leaving the problem to being mostly one of actuator design and method of reading actuator-shaft position.

The most precise pneumatic actuators are diaphragm. The piston actuators with the worst backlash or resolution are link-arm, rack-and-pinion, and scotch yoke. Higher pressure diaphragm actuators are now available, enabling their use on large valves and higher pressure drops. Can we include in the technical report calculations of allowable resolution and lost motion (backlash and shaft windup) as a function of allowable control error, process gain and PID-tuning settings?

JAMES: I recommend that you start with your process performance criteria and use the valve gain and process gain and dynamics to calculate the control valve performance specifications of lost motion, resolution and step-response time in the step-response regions.

GREG: Can we provide calculations to estimate installed flow characteristic from inherent valve characteristic and valve-to-system pressure drop ratio? We should alert users to the need for testing near the closed and open position to identify nonlinearities that are accentuated at these operating points.

JAMES: I have seen some excellent presentations on calculating installed flow characteristics using fairly rigorous techniques including the one by Robert Armstrong documented in your Control Talk column, "Why and how to establish installed valve flow characteristics." However, you can often get an estimate of the installed characteristics, or at least some guidance on selecting the best trim characteristic, by using the information that you mention.

An example I use to teach control engineers about this topic is the discharge-pressure control on a positive-displacement compressor. In this case, the discharge and inlet pressure are nearly constant, and the pressure drop across the recycle valve is much greater than in the recycle piping.

In this case, the installed flow characteristic is very close to the inherent valve characteristic and a linear trim is the correct choice.

GREG: Can we provide calculations to estimate installed rangeability as a function of installed flow characteristic, oversizing, resolution and backlash?

JAMES: The process impact of valve travel nonlinearities such as resolution and lost motion are amplified by the valve-flow gain. Thus, a high installed flow gain due to the installed flow characteristic and/or an oversized valve increase process variability and reduce rangeability.

GREG: Presently, valve specifications don't have anything to help minimize valve nonlinearities. Existing fields inadvertently lead the user to select a valve with maximum capacity, minimum leakage and minimum pressure drop, often resulting in a rotary valve with tight shutoff, a piston actuator and low valve-to-system pressure drop ratio.

These all lead to valves with the greatest nonlinearities. Chapter 7 on the effect of valve and variable-frequency-drive dynamics in *Tuning and Control Loop Performance, Fourth Edition* (Momentum Press 2014), offers equations on the consequences of poor choices and some best practices. What can we do, realizing that past inquiries about changing the existing forms for valve specification didn't progress?

CULLEN: James and I have helped Greg improve his proposed Annex A. I'm working on an Annex B to demonstrate how valve response affects control loop performance. ∞

For the top 10 things you don't want to hear about control valves and much more on needed next steps, see the online version of this column on ControlGlobal.com. You can also download a PDF copy of Greg's proposed Annex to ANSI/ISA-TR75.25.02.

Maybe don't save the CSB

Videos and reports are fine, but they need to be backed up by some louder advocacy

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"If all the CSB does is put out pretty post mortem pictures and recommendations after accidents and tragedies happen, and doesn't actively advocate for changes to stop them, then maybe it's actually a distraction and part of the problem."

JUST about three and a half years ago, I wrote about a presentation by Manuel "Manny" Ehrlich, then-board member of the U.S. Chemical Hazard Investigation Board (www.csb.gov). He explained how then-U.S. Rep. Henry Waxman was convinced to add $2 million to CSB's budget over six years to help it investigate other root causes of the fire, explosion and sinking of the Deepwater Horizon platform in April 2010, and how its funding was later removed from Congress' 2018 budget.

In "Save the CSB!," *Control*, Nov. '17 (www.controlglobal.com/articles/2017/save-the-chemical-hazard-investigation-board), I stated how much I appreciated CSB's computer-animated videos illustrating the causes of hundreds of process safety accidents, as well as its reports and safety recommendations about how to avoid similar events, and that I couldn't think of a more useful and valuable service to the people working in the process industries.

Sadly, I've had to rethink my longtime support for the CSB despite all the positive work it's done in the past and continues to do. I've made repeated requests over the years to interview CSB's experts and leaders, but lately their responses range from a voicemail box that's full and not accepting messages to repeated promises from its managers to make its experts available for interviews that never happen. They did relay an existing report about MGPI Processing's (www.mgpingredients.com) above-and-beyond corrective actions following an October 2016 chemical release at its plant in Atchison, Kan. (www.csb.gov/mgpi-processing-inc-toxic-chemical-release-). This is all good to know, but what I seek after and what's lacking from CSB is some advice on how other end users can do the same.

Of course, it can be argued accurately and successfully that I'm just a whiny journalist, who's upset that he can't get an interview that he wanted. It can also be argued that CSB and its staff have way more important work to do than explaining process safety to a media person who's not a practicing process industry professional.

Because I'm obviously not a process engineer, my only response is what if I was? My emails and cold calls could just as easily come from someone operating or managing a process application or facility, and maybe facing serious process safety issues. A person like that would no doubt have many questions about what to do to mitigate or reduce the severity and frequency of hazards at their site, and how to protect against them. There aren't many places to answer those questions, so what response would they get from the CSB? In light of my experience, I'd have to say who knows? Maybe they'd run into the same voicemail box that wasn't accepting messages.

My point is that, while all of CSB's investigations, reports, videos and recommendations are valuable, simply producing and putting them out there may not be enough. What could CSB do beyond its usual activities to prevent safety incidents from happening in the first place, so it wouldn't have to perform as many investigations, produce as many videos, and make as many recommendations in the future? I'm aware it's likely already achieved this for some end users and organizations, and that many potential incidents may have been prevented by its efforts and content. So how about proving it?

I know it's difficult to account for or add up the value and benefits that result from accidents avoided or cybersecurity breaches prevented, but I'm sure that intelligent professionals could make it happen. I know that insurers who are increasingly interested in process safety and security do it all the time. This could be a very useful investigation for CSB to conduct, and its results might support future budget requests.

I know it's counterintuitive and almost certainly won't be a popular argument, but if all CSB does is put out pretty post mortem pictures and recommendations after accidents and tragedies happen, and doesn't actively advocate for changes to stop them, then maybe it's actually a distraction and part of the problem. Again, I'd love to be proven wrong, so please do it. Thanks. ∞