AUGUST/SEPTEMBER 2025

Automation.com MONTHLY

A PUBLICATION OF THE INTERNATIONAL SOCIETY OF AUTOMATION

Process Automation and Control

ISA100 Wireless: Mature Technology, New Applications

Energy Optimization for Variable Speed Pump Systems

Process Automation in Bioprocessing

Importance of P&ID Accuracy

ISA Automation.com MONTHLY

AUGUST/SEPTEMBER 2025

A MESSAGE FROM ISA

The International Society of Automation (ISA)'s CEO and executive director, Claire Fallon, and other experts recently discussed the present and future of manufacturing and automation on WRAL News, a TV station near ISA headquarters in Durham, North Carolina. Fallon discussed the evolution of manufacturing and the critical role of technician training with reporter Dan Haggerty.

"We absolutely can bring manufacturing back and make it stronger," said Fallon. "It's evolved, though — it's not going to be the manufacturing that we saw in the '50s and '60s. Last year alone, [ISA] trained over 14,000 people, and many of them were technicians, not just engineers and managers. There is a great demand for those technicians and people to have those credentials."

"Automation depends on people," Fallon added. "That's the sentiment that inspired International Automation Professionals Day when we started celebrating it four years ago. Automation professionals are the driving force behind the systems, technologies and processes that make the world a better place. To realize automation's greatest potential, a skilled, knowledgeable and trained workforce has never been more important."

Find information on the ISA training and certification programs discussed in the segment at www.isa.org/training. Fallon also mentioned ISA position papers, which can be found at www.isa.org/position-papers.

EDITORIAL & PRODUCTION
CHIEF EDITOR
Renee Bassett rbassett@isa.org

SENIOR CONTENT EDITOR
Melissa Landon mlandon@isa.org

SENIOR CONTRIBUTING EDITOR
Jack Smith jsmith@isa.org

ADVERTISING PRODUCT MANAGER
Cathi Merritt cmerritt@isa.org

ART DIRECTOR Bonnie Walker

DIGITAL DESIGNER Colleen Casper

ISA Connect https://connect.isa.org/home

company/internationalsocietyofautomation

InternationalSocietyOfAutomation

Editorial and advertising offices are located at 3252 S. Miami Boulevard, Suite 102, Durham, NC 27703 USA. Phone: 919-549-8411 Email: info@isa.org

ISA | Automation.com MONTHLY

InTech IS NOW Automation.com Monthly!

AUGUST/SEPTEMBER 2025 | VOL 1, ISSUE 6

ISA Automation.com MONTHLY

AUGUST/SEPTEMBER 2025

A MESSAGE ABOUT OUR SPONSORS

ISA's mission and *Automation.com Monthly* digital magazine are supported by advertisers and sponsors. They contribute technical articles, case histories and other technical resources designed to educate, inform and inspire automation professionals and advance their careers. Articles from advertisers are identified with a "Sponsored" tag.

To obtain further information from any of the advertisers in this issue, contact them directly using the information found in their ad or author bio.

For news and product information from suppliers, visit Automation.com. The online directory of Featured Suppliers lists automation product vendors, machine manufacturers and systems integrators. You can also subscribe to topical newsletters and alerts that will deliver news, new product and technical resources via email.

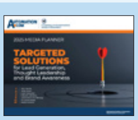
A Note to Potential Advertisers

With decades of experience crafting high-quality periodicals, the International Society of Automation (ISA) and its media brand Automation.com have helped thousands of automation and control professionals do their jobs and enhance their careers. We can help you inform these professionals about your solutions through our publications, events and sponsorship opportunities.

ADVERTISING & SPONSORSHIP

Rick Zabel, PUBLISHER - rzabel@isa.org
Ed Manns, SALES MANAGER - emanns@isa.org
Chris Nelson, MANAGER, ADVERTISING SALES & SPONSORSHIP - chris@isa.org

Send press releases to **Press@automation.com**
Send ad materials to **Materials@automation.com**



2025 Media Planner

To order reprints of digital articles, contact reprints@mossbergco.com or 800-428-3340.

Advertisers Index

ISA100 Wireless: Mature Technology Expands Its Application Portfolio

Although the ISA100 Wireless standard has remained largely unchanged since its final version, recent advances have focused on safety-critical applications.

By Jack Smith

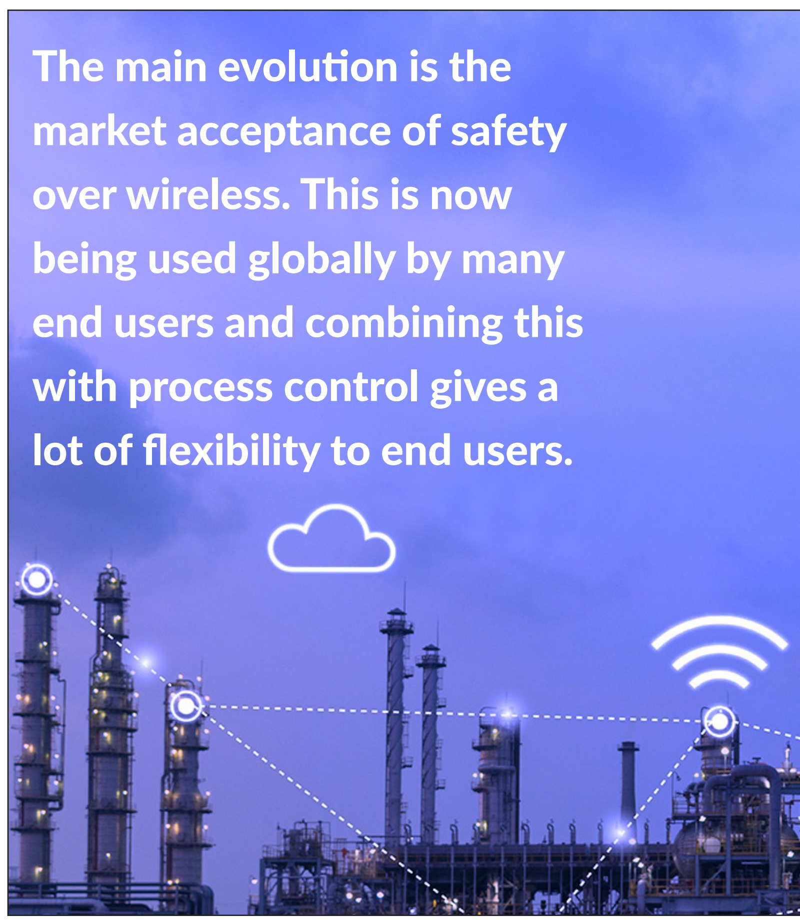
The International Society of Automation formed the ISA100 Committee in 2005 to establish standards, recommended practices and produce technical reports and related information for implesmenting wireless systems in the industrial automation and control environment with a focus on the field level. ISA-100.11a, the first project in the ISA100 family, addresses the performance needs of low-energy field devices used for periodic monitoring and process control where latencies on the order of 100 ms can be tolerated in constrained configurations. Mesh, star and hybrid network configurations are supported in scaled systems that in turn support various industrial internet of things (IIoT) applications.

Built from the ground up and driven by user requirements, the ISA100 Wireless standard received formal ANSI approval in January 2012 and approval as IEC 62734 and EN 62734 in September 2014. ISA100 Wireless is the only IPv6 over Low-Power Wireless Personal Area Networks (6LowPAN) industrial protocol designed for industrial automation. It has remained largely unchanged since its final version, and has proven to be a mature, stable technology well-suited for industrial applications.

"ISA100 is both incredibly mature and stable (being an IEC standard since 2014), and is also maturing in ways that complement and grow the technology but don't compromise the core protocol," said Paul Hodge, global lead, Experion System Infrastructure Product Managed Team at Honeywell HPS and ISA100 Wireless Compliance Institute (WCI) vice chair. "New features that WCI has added, such as Bluetooth Low Energy (BLE) along with OPC-UA, provide value-added configuration mechanisms and ways to access ISA100 data, but that doesn't fundamentally change the underlying mature, reliable protocol."

The greatest value of ISA100 Wireless lies in its ability to free customers from the limitations of a single-vendor approach, enabling them to combine the best-in-class ISA100 WCI-compliant devices from multiple global suppliers to meet their specific project requirements. From gas detectors for safety management, to steam trap monitoring for energy efficiency, vibration sensors for predictive maintenance and reliable temperature and pressure transmitters for process monitoring, all can be seamlessly integrated into a single ISA100 Wireless network, said Toshi Hasegawa, senior expert, Marketing Headquarters of Yokogawa Electric Corporation.

Recent advances have focused on expanding the application portfolio, with ISA100 now being used for safety-critical applications such as gas detection, corrosion monitoring and valve control in addition to general monitoring and control. "The main evolution is the market acceptance of safety over wireless," said Ådne Baer-Olsen, global business development lead for wireless safety at Dräger, one of the world's largest suppliers of fixed fire and gas detection solutions. "This is now being used globally by many end users and combining this with process control gives a lot of flexibility to end users."



Philippe Moock, former global director of the Thermal Insight Group at Armstrong International, added, "Over the past year, ISA100 Wireless technology has seen several significant advances aimed at improving interoperability, ease of deployment and integration with modern industrial systems. In addition to supporting BLE and OPC-UA, a key development is the integration of PA-DIM support, said Moock.

Further ISA100 technological advances include improved incorporation of IPv6 directly as part of its network layer and transport layer. IPv6, which stands for Internet Protocol Version 6, helps to identify and locate devices on the network. Interoperability and cybersecurity have been enhanced as well. ISA100 is now used for real-time device monitoring—such as steam traps, PRVs/SRVs and for safety or detection applications such as wireless gas and corrosion detection.

"For the last four or five years, ISA100 Wireless has increasingly been adopted in safety," said Robert Assimiti, CEO at Centero. ISA100 Wireless was architected with safety applications in mind. "Various types of ISA100 Wireless field devices are engaged in mission-critical applications such as gas detectors, sounders and beacons that are deployed on-shore as well as off-shore. Safety integrated systems [SIS] are connected to safety controllers; the field devices are SIL2 [Safety Integrity Level 2]-certified and vendors are offering ISA100 SIL2-certified instruments."

Assimiti added that other use cases such as corrosion monitoring and vibration monitoring used in predictive maintenance have also been picking up quite a bit in the last few years.

ISA100 wireless technology and WirelessHART

The explosive growth of wireless technology choices has made it hard to keep up with where ISA100 Wireless fits with WirelessHART and other technologies including LoRa, Wi-Fi, BLE and 5G industrial wireless (Figure 1).

Technology	Latency	Full Protocol	Data Costs	Security	Architected for PA
ISA100 Wireless	10 -100 ms	Yes – includes AL	No	Two-layered, link layer and end-to-end	Yes
Zigbee	10 -100 ms	Yes – includes AL	No	Two-layered, next-hop and end-to-end	No
Bluetooth Low Energy	1 - 5 ms	No	No	Link layer	No
Wi-Fi	1 - 3 ms	No	No	Link layer	No
LoRa	High	No	No	Two-layered, link layer and end-to-end	No
NB-IoT (LTE CAT NB2)	1 - 10 s	High	Yes	Link layer	No
LTE-M (LTE CAT M2)	10 – 15 ms	No	Yes	Link layer	No
5G (native)	10 ms	No	Yes	Link layer	No

Figure 1. Comparison of IIoT wireless technologies. *Courtesy: ISA100 Wireless Compliance Institute*

"There's no question that the abundance of protocols can be confusing," Hodge said. "ISA100 serves a particular market segment. There might be those who might not need that segment. For example, they might not need frequent updates and thus LoRa may be more suitable. End users also may be confused by the range of choice for which there is no real direct comparison such as BLE, LoRa, 5G, etc."

Moock said there is indeed ongoing confusion in the marketplace regarding ISA100 wireless, WirelessHART and other industrial wireless technologies. "This confusion stems from overlapping capabilities and varying levels of adoption across industries."

Considering ISA100 wireless versus WirelessHART: "Confusion arises because both are marketed as 'industrial wireless mesh networks' for similar use cases, but they differ in architecture, flexibility and integration paths," Moock explained. He also commented about ISA100 Wireless versus the other industrial wireless technologies: "These technologies are not direct competitors to ISA100 or WirelessHART but are often misunderstood as alternatives due to marketing or lack of technical clarity. Vendors often promote their preferred standard without clearly explaining how it fits into the broader wireless ecosystem. End users may struggle to understand which technology is best suited for their specific use case (e.g., safety, monitoring, control, analytics).

"There is limited outreach to educate the market on interoperability, coexistence and integration strategies," Moock said.

Baer-Olsen said that the main challenge is that "we talk about wireless in the overarching sense that 'all things wireless are the same.' But these are tools to achieve success in widely different applications. ISA100 [Figure 2] and

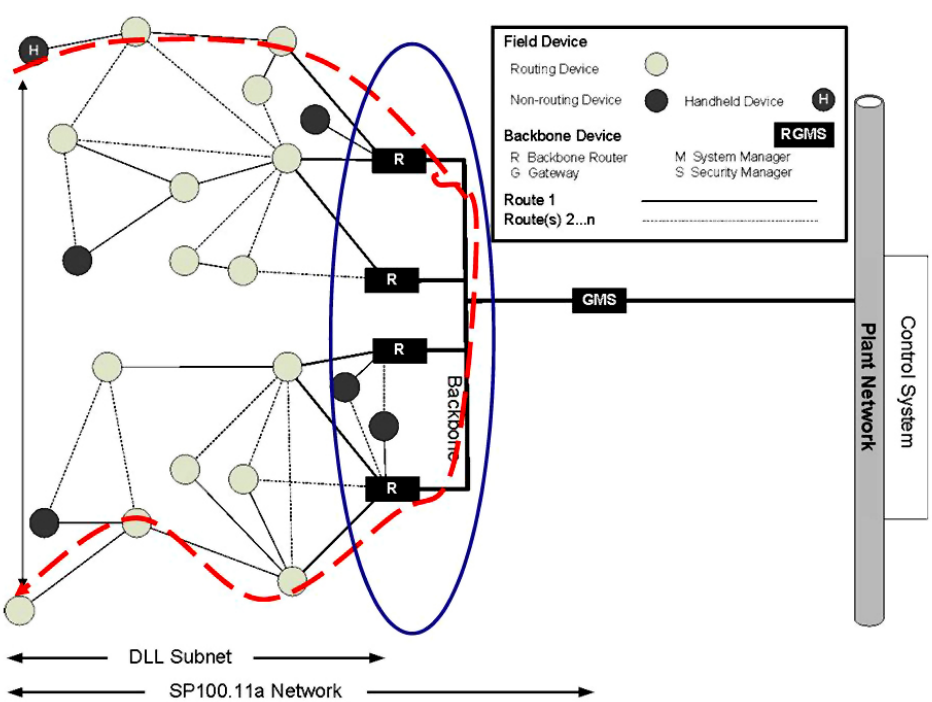


Figure 2. ISA100 Topology. *Courtesy: ISA100 Wireless Compliance Institute*

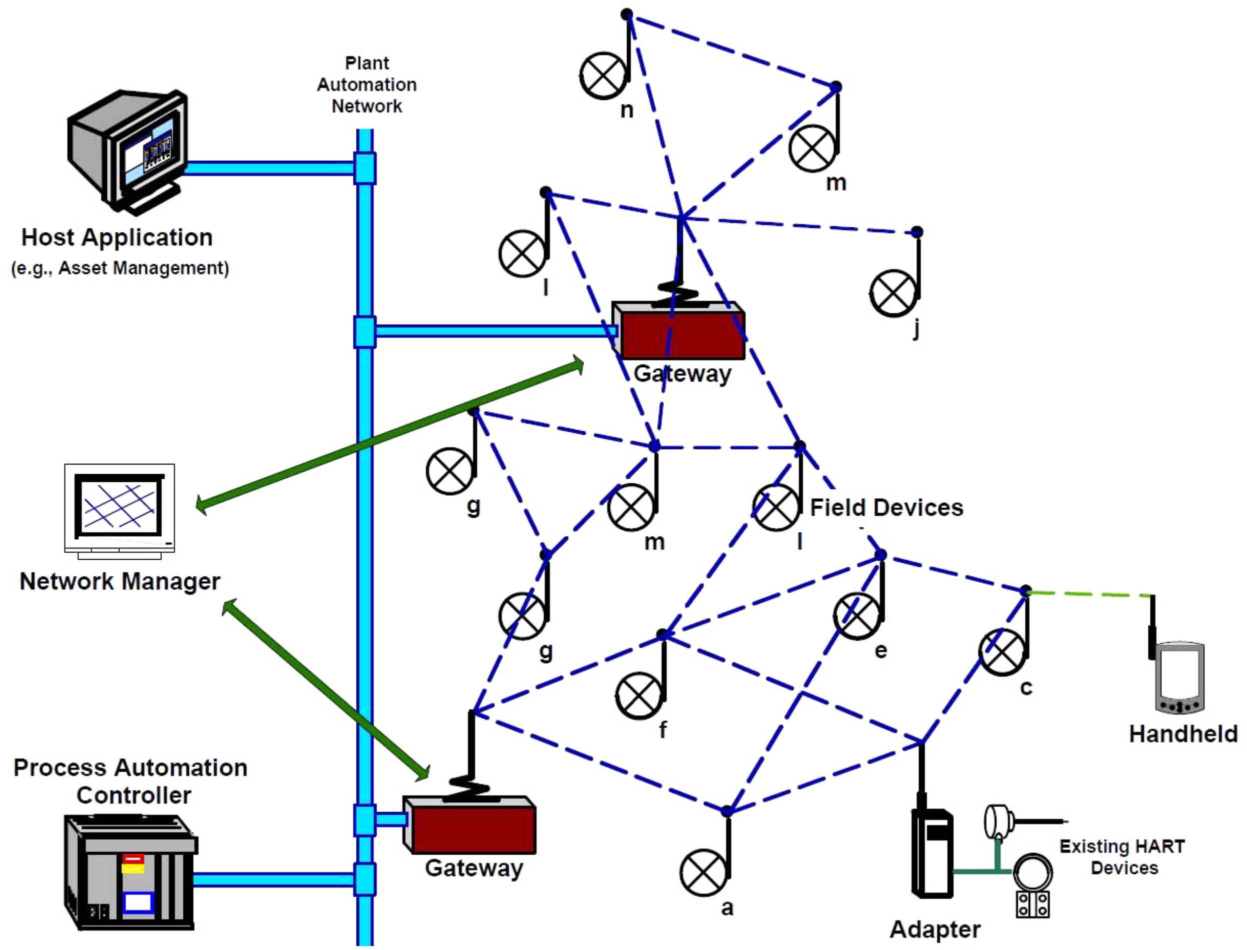


Figure 3. WirelessHART topology. *Courtesy: ISA100 Wireless Compliance Institute*

WirelessHART [Figure 3] seem to be linked the closest, but they have different specialties. WirelessHart was built to monitor and pass along messages that are not time-critical. They form sub-clusters and talk in mesh to ensure all messages get through. The messages get through in due time. First come, first served. [WirelessHart has] implemented burst messages to give some priority to time-critical messages, but not with a latency guarantee.

"Then comes ISA100, which also operates on 2.4 GHz and is also an industrial wireless standard. It can operate in a similar way as WirelessHART, using mesh and getting the messages through. But the main difference is the ability to tunnel foreign protocols such as Modbus, OPC and Profinet/ProfiSafe, which allows for more flexibility and the ability to achieve SIL2 level safety communication," Baer-Olsen said.

Combined with excellent redundancy and full latency control, ISA100 can be used with ProfiSafe-enabled controllers in executive action functions, Baer-Olsen continued. "So far, this is the only international standard wireless industrial communication that can achieve this. The requirement for the network is then to be a star configuration with strict communication plans for the devices to ensure there is redundancy while ensuring a maximum two-hop communication," he said.

LoRa is a wireless radio frequency technology that enables long-range, low-power communication between devices. "Like WirelessHART, it is very good for monitoring, but with perhaps 20 times the communication range at the cost of a lower amount of data," explained Baer-Olsen. It is used for collecting data that does not need to be acted on instantly—for example, low-level gas monitoring to calculate emissions over time—and where there is no other infrastructure available.

"Bluetooth is a short-range communication that we would use to program field devices and download logs. It also could be used to collect data from edge devices like portable gas detectors when they pass Bluetooth gateways to read past and present states," Baer-Olsen explained.

Comparing wireless technologies

Assimiti said that WirelessHART is in essence wired HART over wireless. "WirelessHART adapts the widely deployed wired HART protocol to wireless. You have the same commands and application layer structures augmented by wireless diagnostics and management parameters.

"It primarily depends on the Distributed Control System (DCS) or client applications end users have installed and are running on the plant network," Assimiti continued.

According to Moock:

- ISA100 Wireless is more flexible and future-ready, especially for multi-protocol environments and digital transformation initiatives.
- WirelessHART is mature and widely adopted, especially in facilities already using HART-based instrumentation.
- Both are reliable and secure, but ISA100 offers greater architectural openness (mesh, duo cast, star) and integration potential with modern Industrial Internet of Things (IIoT) systems.

Moock also compared ISA100 wireless technologies to LoRa, BLE, etc.:

- ISA100 Wireless is ideal for mission-critical industrial applications requiring reliability, flexibility and security.
- LoRa is great for long-range, low-power applications like environmental monitoring, but not suitable for real-time control.

ISA100 is now being used for safety-critical applications such as gas detection, corrosion monitoring and valve control in addition to general monitoring and control.

- BLE is increasingly used for device provisioning and short-range sensing, especially in conjunction with other protocols.
- Wi-Fi offers high bandwidth but lacks the determinism and robustness needed for industrial control.
- 5G is promising for future industrial automation, especially with private networks, but adoption is still in the early stages.

Wrapping up

ISA100 is not the only wireless technology being adopted by industry. No single wireless technology performs best across all dimensions because there are some design tradeoff limitations among transmission data rate, transmission range, battery life (power consumption) and other factors.

The developers of the ISA100 standard were counting on the type of radio used to be available for a long time. The radio has not only been available for a long time, it has gotten a lot better over the last 15 years. The performance users are getting today from ISA100 is a lot better than it would have been 15 years ago.

ABOUT THE AUTHOR

Jack Smith is senior contributing editor for Automation.com and *Automation.com Monthly* digital magazine, publications of ISA, the International Society of Automation. Jack is a senior member of ISA, as well as a member of IEEE. He has an AAS in Electrical/Electronic Engineering and experience in instrumentation, closed-loop control, PLCs, complex automated test systems and test system design. Jack also has more than 20 years of experience as a journalist covering process, discrete and hybrid technologies.


MOORE INDUSTRIES
WORLDWIDE
Demand Moore Reliability
Don't take chances with temperature

Energy Optimization for Parallel Variable Speed Pump Systems

Using variable speed drives on pumps reduces parasitic energy loss, enables proper maintenance and lowers capital costs.

By R. Russell Rhinehart and Luis J. Yebra

This article examines a method for determining the optimal number and speed of parallel pumps to operate in response to flow rate and head demands. Although motivated by a parabolic trough solar-to-thermal power generation facility—an environmentally friendly energy source—the procedure seems applicable to many processes that use parallel pumps or blowers: water distribution, exhaust fans, etc.

The use of several parallel, smaller fluid-moving units instead of one large unit increases the reliability of on-stream time, and optimizing the number of operating units reduces power consumption, wear, keeps spares available for maintenance or failures, and increases the chance to use off-the-shelf (lower-cost) items. Although flow rate can be controlled by throttling valves with fixed speed pump drives, using variable speed drives to adjust the flow rate has considerable energy savings. Many readers will have applications with similar characteristics and may benefit from seeing this as a solution.

The Plataforma Solar de Almeria (PSA-CIEMAT) is a full-scale research center in southern Spain exploring approaches to generate electricity from thermal collection of solar energy. One of the facilities in research projects MODIAG-PTC (TED2021-129189B-C21/TED2021-129189B-C22) and DISOPED (PCI2022-134974-2) is the TCP-100 parabolic trough collectors (PTC) (Figure 1). In PTC plants, the mirrors focus solar energy on a collection line through which thermal fluid (oil) runs and is heated to about 400 degrees C (752 degrees F), which makes steam to run turbo generators. The largest industrial PTC facilities in the world operate in the U.S (Mojave Solar Project and Solana Generating Station) generate 280 MW of electrical power and have more than 100 parallel collection lines. As the sun rises then sets and disturbances come and go, the required oil flow rate changes by about a 3:1 ratio and the system head requirement changes by about a 9:1 ratio. One challenge is to minimize pumping energy as solar irradiance and other conditions vary throughout the day.

Although the TCP-100 facility has three collection lines and one variable speed oil pump, this simulation study has 15 lines and five parallel pumps to preview complexity of the facility scale-up, a study that reveals the procedure. For other applications, the number of pumps and lines would depend on the technical and economic aspects of the project.

Figure 1. The Plataforma Solar de Almeria TCP-100 facility showing the parabolic trough collectors (PTC). Mirrors focus solar energy on a collection line through which thermal fluid (oil) runs and is heated to about 400 degrees C (752 degrees F), which makes steam to run turbo generators.

Figure 2 shows a representation of a PTC facility based on the TCP-100 plant design scale-up. There are ambient losses in each line, and for many reasons, the optical efficiency of each line is unique and changes over time. Oil from all lines is collected and fed to a boiler to produce steam. The variable speed pumps send cooled oil to the supply header for the solar collection lines. Throttling valves in the lines adjust the flow rate to make the exit temperature match a target. A reservoir provides oil thermal expansion, degassing and pump net positive suction head (NPSH) requirements.

The collection lines have individual efficiency factors. In addition, if covering a broad land area, irradiance on each line may be affected by local cloud shadows, mirror differences or such. This means that even if the flow rates through the lines are identical, the outlet temperatures may vary, but the mixed fluid must have the target temperature to operate the boiler. However, there is an upper temperature limit for the thermal fluid (typically about 400 degrees C [752 degrees F]).

To minimize pump energy consumption, the valve in the most efficient line is kept fully open and valves in the other N - 1 lines are adjusted to meet the temperature target in their outlets. The variable speed drives of the pumps are adjusted to keep the temperature of the most efficient line at target while providing the flow required by the other lines. There are M number of pumps, but only m are scheduled to be operating at any time instant with the objective of meeting flow-rate-head requirements near their most efficient operating point. In unconstrained operation, there are N + 1 decision variables: the number of pumps operating, pump speed and N - 1 valve positions.

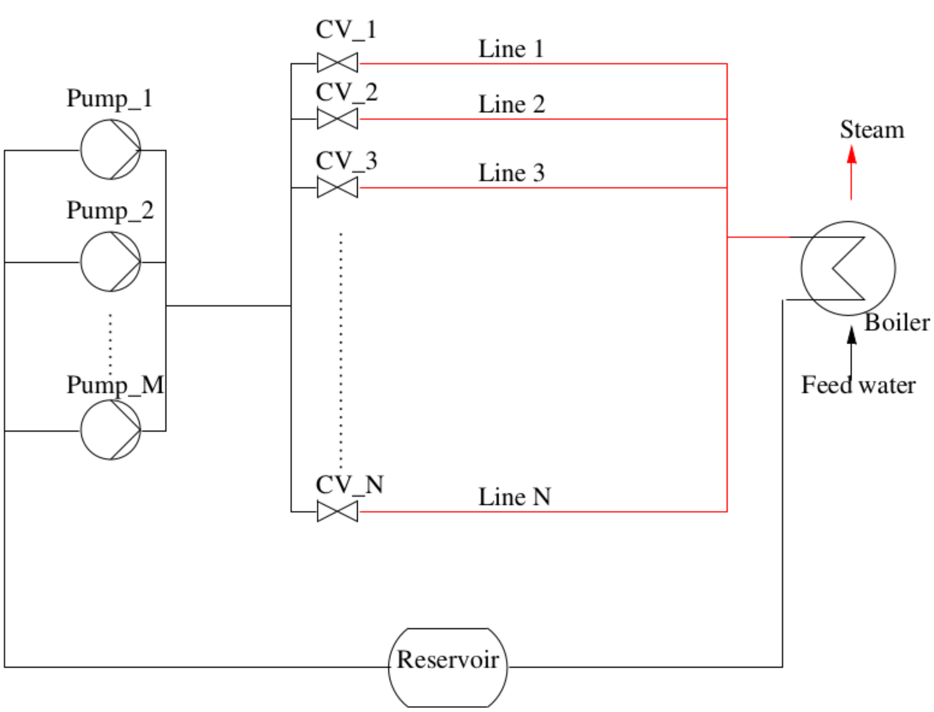


Figure 2. The Illustration is a representation of a PTC facility based on the TCP-100 plant design scale-up.

In this study it is assumed that each of the five pumps are like the Dickow 65/320 pump of the TCP-100 facility, which has a 3:1 speed turndown ratio. The control valves in the lines have an equal-percent characteristic with a rangeability factor of 50 and electromechanical actuators. The lines have a seven cm diameter and a two-pass arrangement of 96 m each pass.

Models

For this application, pump operating curves are very well matched with Formula 1a:

$$h = h_{max}[1 - (\frac{F}{F_{max}})^p] \quad (1a)$$

The classic similarity laws determine how the maximum flow rate and head scale with speed (Formulas 1b and 1c):

$$F_{max} = F_{max,reference}(\frac{speed}{speed_{reference}})^1 \quad (1b)$$

$$h_{max} = h_{max,reference}(\frac{speed}{speed_{reference}})^2 \quad (1c)$$

The coefficient values are shown in Table 1.

Reference speed	2970	rpm
$h_{max,reference}$	128	m
$F_{max,reference}$	224.6293	m^3/hr.
p, exponent	4.346734	dimensionless

Table 1. Coefficient values.

Figure 3 shows the characteristic curves.

Pump efficiency curves are very well matched with Formula 2:

$$\eta = (\frac{F}{s})[a + b(\frac{F}{s})^c] \quad (2)$$

Where F is in m^3/hr. and s is in rpm.

The coefficient values are shown in Table 2.

a	48.91052
b	-123.19
c	0.392747

Table 2. Coefficient values.

Figure 4 reveals how pump and drive overall power efficiency depends on flow rate and speed.

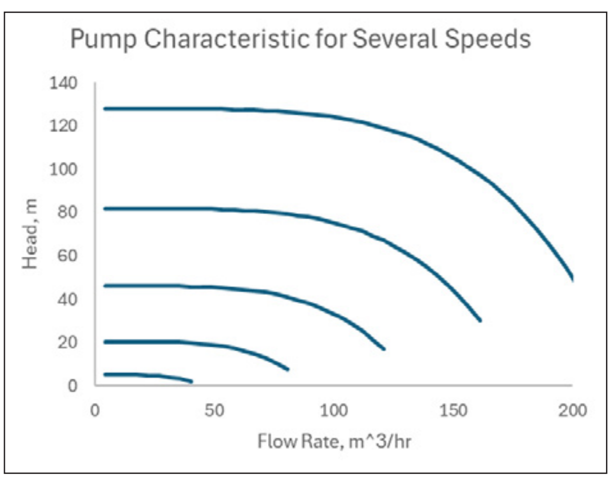


Figure 3. Pump characteristic curves.

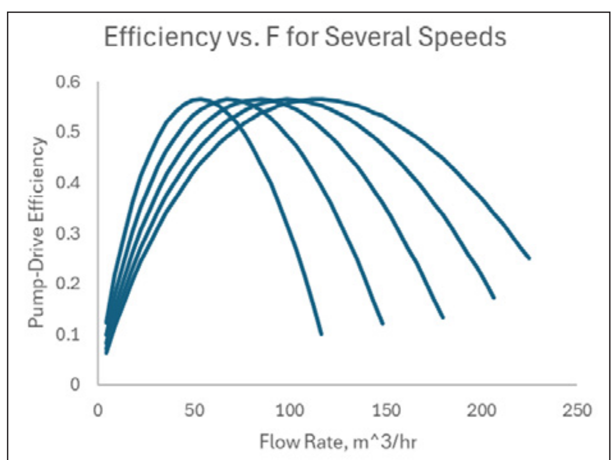


Figure 4. Pump and drive overall power efficiency depends on flow rate and speed.

Although many use quadratic models ($p = 2$ and $c = 1$) as generic and mathematically convenient, the power law models provide improved fits to the manufacturer's data. Users should find the model coefficients that best fit their pump/blower application.

Given operational requirements (F & H), Equation Set (1) can solve for pump speed using root-finding algorithms, and then Equation (2) will provide the efficiency. Power consumed by the pump is then calculated as shown in Formula 3.

$$P = \frac{F \cdot \Delta P}{\eta} = \frac{F \cdot \rho \cdot g \cdot H}{\eta \cdot g_c} \qquad (3)$$

Control

Model-based control of the collection line temperatures (Rhinehart, R. R., Nonlinear Model-Based Control: Using First-Principles Models in Process Control, International Society of Automation, Durham, North Carolina, 2024, ISBN 13:978-1-64331-242-2) uses online data to calibrate optical efficiency and fluid pressure loss factors. The models then determine the required flow rate through each collection line. This gives the total flow requirement for the parallel pumps and also head losses within the boiler and recycle sections. With the valve on the most efficient line fully open, the collection line pressure drop is calculated, which provides the pressure drop for each of the lines, which is used to set valve positions to obtain target flow rates on the remainder N - 1 lines. The combined pressure drops provide the total head requirement. Then the number of pumps, m, simultaneously operating and their pump speed are optimized to minimize parasitic power losses.

Variable speed drive versus throttling

It is relatively simple to show the benefit of variable speed drives over throttling to adjust flow rate. With an initial condition of $F = 150 \text{ m}^3/\text{hr}$ and $H = 50 \text{ m}$, the scaled speed obtained is 0.82, the pump efficiency is 0.43, and the power is 37.6 kW. The new objective is to obtain the new flow rate of $F = 50 \text{ m}^3/\text{hr}$. By keeping the pump speed unchanged (having a fixed speed drive) and throttling the valve to increase H to 85 m, the flow rate is on target, and power drops to 19.7 kW. The main reason for the power reduction is the 1/3 reduction in F, but this is helped by a small improvement in efficiency, and it is countered by the increase in Head. See the middle rows in Table 3. But if flow is not throttled, and the head requirement is dominated by system friction losses (dynamic head) then the head requirement drops to 10 m. As the last row of Table 1 indicates, the

Trial	F, m^3/hr.	H, m	Scaled speed	efficiency	Pump Power, kW
Initial Conditions	150	50	0.82	0.43	37.6
Change F by throttling	50	85	0.82	0.47	19.7
Change F using a lower speed	50	10	0.33	0.51	2.1

Table 3. A comparison of throttling and speed reduction.

pump speed can be reduced further, with a substantial improvement in power to 2.1 kW, representing about a 90 percent reduction compared to throttling.

Process pump optimization

With pumps in parallel, the number of active pumps at any moment can be chosen to minimize pumping energy. Nominally, if there are m number of operating pumps, each will have 1/mth of the total required flow capacity and the same head required to drive the total fluid through the entire piping system.

For each possible choice of the number of active pumps ($1 \le m \le M$) calculate the pump speed to make the pump model match h_{target} and $F_{perpumptarget}$. If the number of pumps is too few, then the speed, s, will be in excess of the maximum. If m is too large, then the speed will fall below the minimum. For valid m choices, calculate efficiency, then determine the total power required. Then, choose the feasible number of operating pumps that results in the minimum power.

Results

Figure 5 reveals how solar irradiance, normal to the aimed mirrors, changes during an 8-hr. operating period. At about 1:30 PM the irradiance drops by about 50 percent simulating an hour of cloud cover. The horizontal line represents the mixed oil temperature (all individual lines are within a tenth of a degree Centigrade of the setpoint). The control scheme keeps the temperature of each line at the setpoint of 395 degrees C (743 degrees F), except for a brief mid-day period that strains pump capacity, elevating the temperature by less than 1 degree C (33.8 degrees F), and a switching disruption that lowers the temperature by a few tenths of a degree Centigrade.

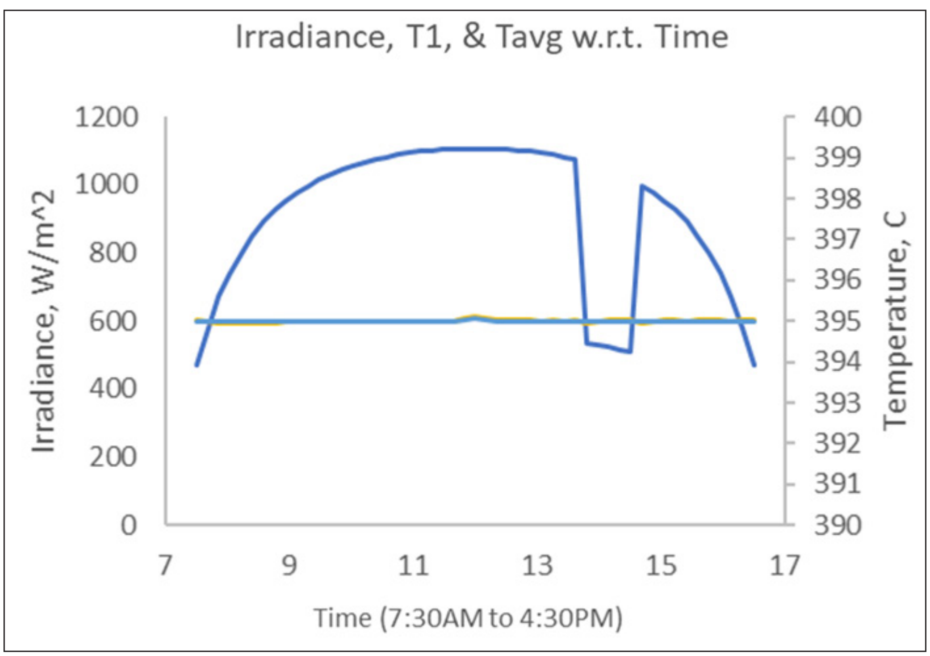


Figure 5. Irradiance and temperatures during the day.

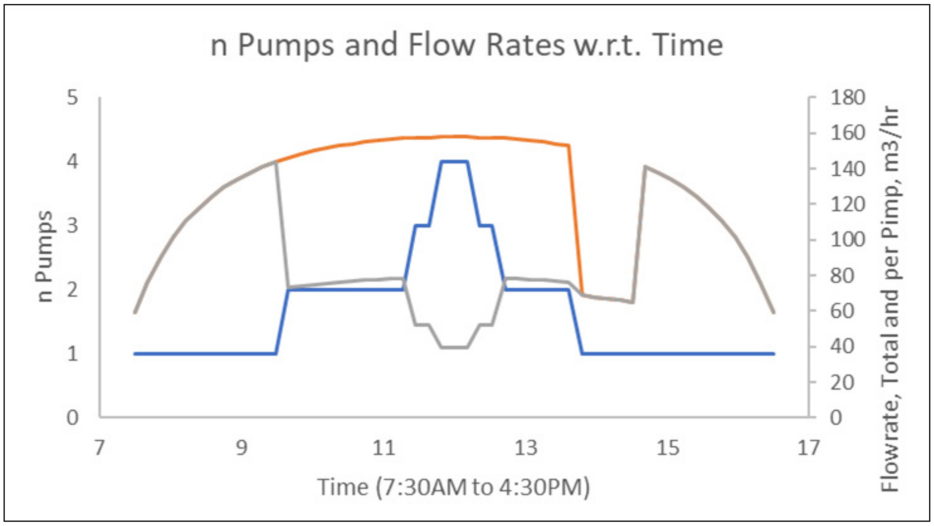


Figure 6. Optimum number of pumps and per pump flow rate during the day.

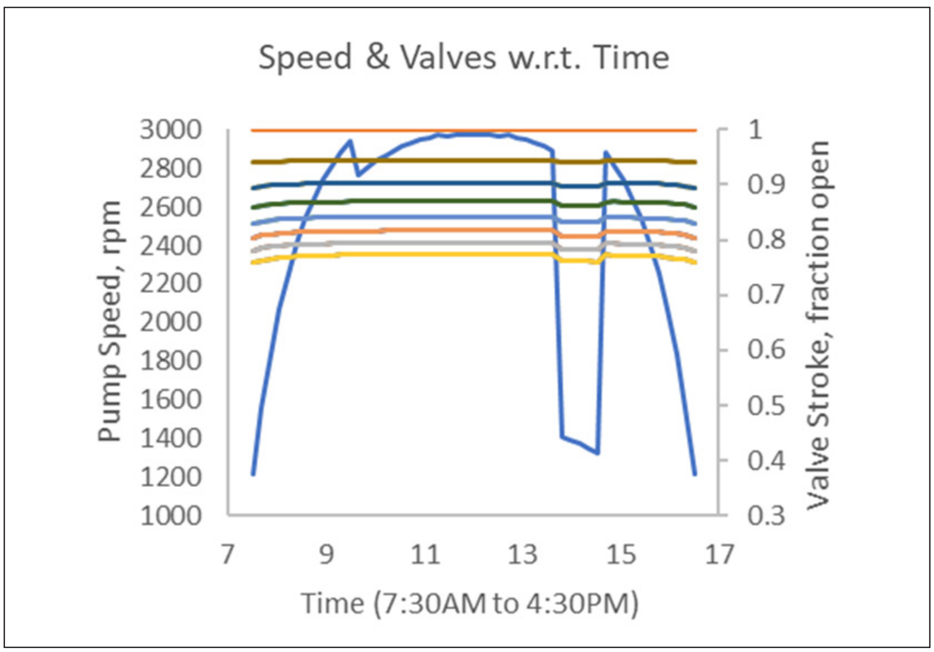


Figure 7. Pump speed and valve positions change with irradiance. {NOTE: keep these colors}

Figure 6 reveals how the total flow rate (red), optimum number of pumps (blue) and per pump flow rate (gray) change with time.

For most of the day (irradiance less than 1,000 W/m^2), optimization determines that only one of the five pumps should operate. Oil flow rate is nearly proportional to the irradiance, and pressure drop is roughly proportional to the square of flow rate (the square of irradiance), as a result the power required to drive the fluid is roughly proportional to the cube of irradiance, $P_{drive} \propto I^3$, which rapidly drops after reaching the peak irradiance of 1,100 W/m^2.

Figure 7 reveals how pump speed and valve positions change with time due to irradiance. The relatively horizontal lines at the top of the graph are valve positions. They trace a symmetrical path as the sun is rising or falling. The top line is Valve 1—the most optically efficient line—which stays fully open.

The blue curve represents the pump speeds, which are limited to 1,000 and 2,970 rpm. The discontinuities in speed are due to changing the number of pumps. The small speed discontinuities at about 11:30 a.m. and 12:30 p.m. are barely noticeable.

The power savings of the optimum number of pumps relative to running all five is shown in Figure 8.

This indicates a 3.4 percent savings in pump power for about half the day, because the m pumps are operating close to their optimum efficiency.

Reducing the number of pumps when they are not all needed means that operational wear on pumps can be lessened by running fewer when not all are required. In addition, this strategy has pumps running near the best efficiency point (BEP) and keeps the pumps operating in their preferred operating range.

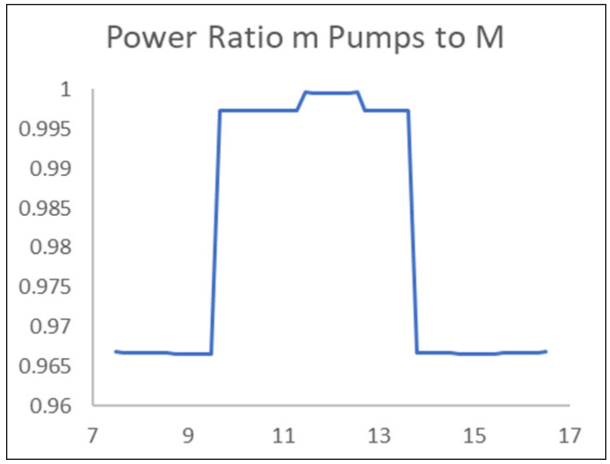


Figure 8. Power advantage of operating fewer pumps at their best efficiency point.

These are important ancillary benefits to the parasitic power reduction.

Wrapping up

Using variable speed drives and optimizing the number of operating pumps has a significant impact on parasitic energy losses. It also benefits maintenance. And, system design using several smaller standard sized pumps, instead of one special pump, provides capital cost savings and reliability advantages.

ABOUT THE AUTHORS

R. Russell Rhinehart is a professor emeritus at Oklahoma State University, Stillwater, Okla.

Luis J. Yebra is a researcher at CIEMAT research center, Plataforma Solar de Almeria (PSA-CIEMAT), in Almeria, Spain. This full-scale research center investigates approaches for generating electricity from the thermal collection of solar energy. The TCP-100 parabolic trough collectors (PTC) referenced here are some of the facilities in research projects MODIAG-PTC (TED2021-129189B-C21/TED2021-129189B-C22) and DISOPED (PCI2022-134974-2).

Industry 4.0 sets high standards for the future of sustainable production. Our level and pressure instrumentation is designed to meet these demands, combining the essential features that enhance quality, efficiency, and flexibility in your processes – every single day.

Everything is possible. With VEGA.

vega.com

VEGA HOME OF VALUES

Digital Optical Dissolved Oxygen Probes Enhance Operational Capabilities

By Kevin Stultz

Sensor advances help optimize process efficiency, safety and quality with reliable measurement, while reducing maintenance requirements and operational costs.

Analytical sensors play an indispensable role in ensuring process safety, product quality and efficient production in many industries. Depending on the application, dissolved oxygen (DO) sensors are often used to optimize aeration efficiency, monitor microbial conditions, ensure regulatory compliance and/or keep equipment corrosion to a minimum.

As DO instrument technology evolves, particularly with the combination of optical sensing and digital communication protocols, there are increasing opportunities for plants to operate optimally, with improved process control and reduced costs. This article describes these advances in DO instrumentation, and it compares modern capabilities to conventional measurement and maintenance methods.

Conventional sensing limitations

Historically, amperometric sensors were used for the bulk of industrial DO measurements. Although tried-and-true, these conventional methods introduced inherent challenges related to maintenance, calibration, accuracy and data integration.

Amperometric sensing is driven by an electrochemical reaction, where oxygen diffuses

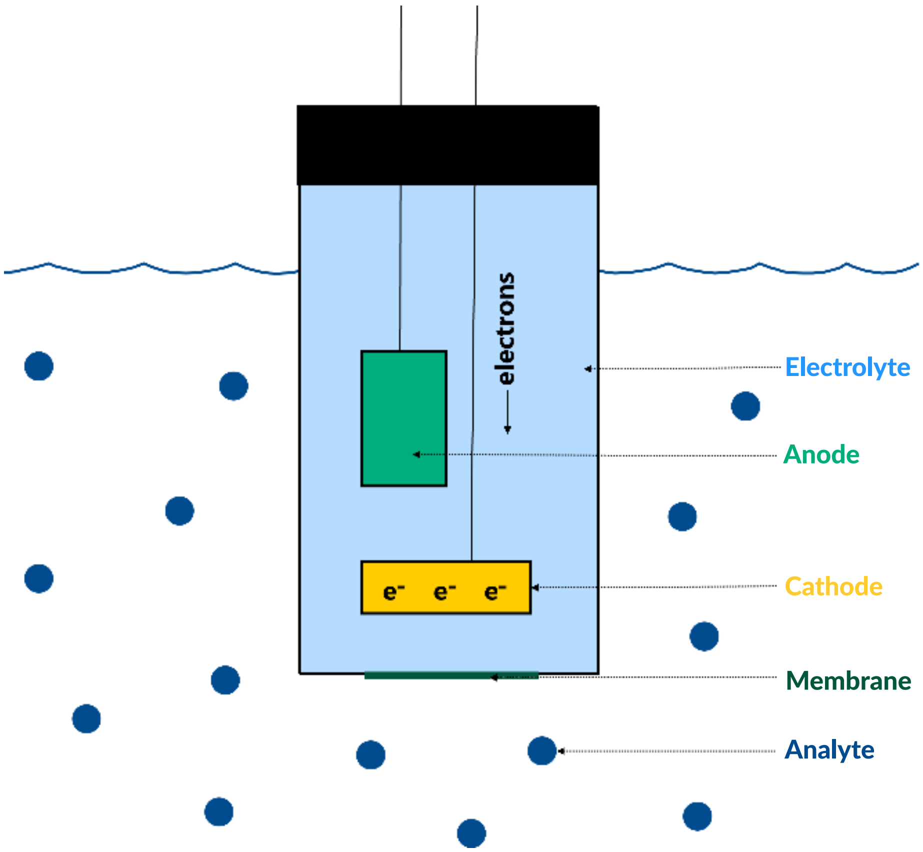


Figure 1: Amperometric sensors measure specific chemical species, such as dissolved oxygen, by monitoring current flow from electron transfer between the process fluid and sensor components across a selectively permeable membrane.

across a permeable membrane for reduction at a cathode. This reduction generates an electrical current proportional to the partial pressure of oxygen in the sample (Figure 1).

While effective under ideal conditions, amperometric sensors present several operational challenges:

- **High maintenance requirements:** Amperometric sensors rely on an internal electrolyte solution and a permeable membrane. The electrolyte depletes over time, requiring periodic replenishment, while the membrane is susceptible to both fouling and physical damage, demanding frequent cleaning and eventual replacement. These tasks consume valuable personnel time, introduce the risk of improper disassembly and reassembly and increase a sensor's lifetime cost.
- **Frequent and complex calibration:** Sensor drift is common with amperometric technology, requiring frequent calibration to maintain accuracy. Calibration typically calls for sensor immersion in a zero-oxygen solution, followed immediately by exposure to a solution of known oxygen concentration. The time requirements to conduct multipoint wet calibration add up over the course of many cycles, and each procedure includes potential for manual error.
- **Flow dependency:** Most amperometric sensors consume oxygen while measuring, requiring a minimum process flow to maintain a constant supply of oxygen

across the membrane surface and prevent localized depletion. This makes accurate measurement challenging in low-flow or static conditions, such as in tanks with minimal agitation, or during intermittent flow cycles.

- **Signal instability and warm-up time:** Amperometric sensors often require a significant polarization period after power-up or maintenance before providing stable readings. Signal drift can also occur due to changes in membrane permeability or electrolyte concentration.
- **Analog signal limitations:** Traditional amperometric instruments typically output an analog signal. While widely compatible with numerous host controllers, analog signals are susceptible to electromagnetic interference (EMI) and signal degradation over long cable runs. Furthermore, this analog signal can only transmit one data point.

These challenges place substantial demands on maintenance resources, requiring costly upkeep and limiting viability in challenging process environments.

Modern enhancements improve process control

Addressing these and other challenges, luminescence quenching optical sensors provide more accurate, timely and versatile DO measurement, with decreased maintenance and operational cost requirements. This technology uses a light-emitting diode (LED) and luminescent dye to determine DO content in process media (Figure 2).

To measure DO, the sensor's LED emits light of a known wavelength that excites the dye molecules. Oxygen molecules in the process media interact with the excited dye molecules, "quenching" some of the luminescence, which directly influences the resulting emitted wavelength and time for the dye molecules to return to their ground state. The degree of quenching is directly proportional to the partial pressure of oxygen in the process media. A photodiode then measures the characteristics of the emitted light, and internal sensor electronics calculate the dissolved oxygen concentration.

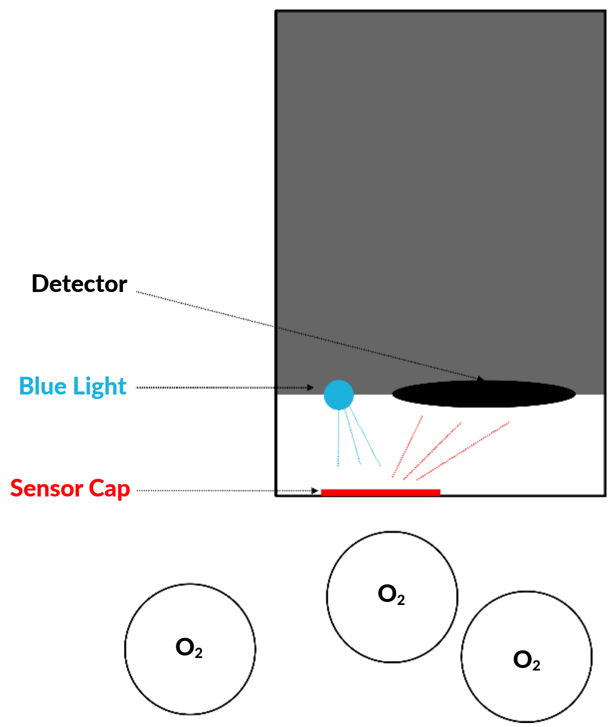


Figure 2: Optical sensors employ fluorescence quenching to measure DO. Blue light is emitted by an LED, causing the sensor cap to produce red light. This red light is inhibited by oxygen in the process media, and the resulting spectra is measured, with its intensity inversely proportional to the concentration of oxygen in a highly linear relationship.

Figure 3: The Rosemount 490A Dissolved Oxygen Sensor combines digital communication with advanced optical sensing technology, supporting application versatility in numerous applications.

Optical technology (Figure 3) addresses the most prominent drawbacks of amperometric sensors, eliminating oxygen consumption during measurement. This makes these sensors ideal for use in low-flow, no-flow and other flow conditions, and they are accurate even at low DO concentrations.

Additionally, optical sensors do not require electrolyte refills or traditional membrane replacements, significantly reducing routine maintenance needs. The sensor cap with luminescent dye is the primary consumable, providing a lifespan of up to two years, compared to amperometric membrane and electrolyte changes every few months.

These sensors also exhibit significantly lower drift than their conventional counterparts, potentially extending calibration intervals from weeks to many months, depending on regulatory requirements. Leading optical sensors can be conveniently air calibrated without the need for media immersion, simplifying the procedure considerably compared to wet chemical calibration.

Furthermore, today's leading optical DO instruments transmit measurement information as a digital instead of an analog signal. This advancement enhances information integrity because digital communication is not subject to electromagnetic noise or signal degradation over long distances. This improves the accuracy of the measurement value received by a host, typically a control or an asset management system. Supported digital protocols—such as Modbus RTU—allow multi-drop configurations to connect multiple sensors on a single loop with a shared transmitter, such as the Rosemount 1058 digital process transmitter.

Optical sensors provide pointed benefits in certain applications, as detailed below.

Use case: Aerobic aeration in wastewater treatment

In most municipal wastewater treatment plants, process control is divided among several programmable logic controllers (PLCs) distributed around the plant footprint near key treatment equipment. Following primary treatment, which removes larger solids from wastewater, the product is pumped into aeration basins to begin separating organic and suspended solids from the wastewater to prepare it for environmental discharge.

At this stage, air is introduced into the aeration basins to maintain DO levels, enabling aerobic microorganisms to convert organic waste into inorganic byproducts. These byproducts are separated from the product water streams during secondary clarification following aeration.

If the DO content in the basin is too low, the microorganisms die, causing sludge to build up. If this occurs, expensive procedures are required to remove biomass and reintroduce bacterial organisms to react with the wastewater. To avoid this risk, facilities often overdose DO in their processes, but this can create undesired excess microorganisms. Accurate and responsive DO measurement is therefore required to hold concentration at optimal levels.

In the past, traditional analog amperometric DO sensors required separately wired loops from a PLC or remote-input/outpud (I/O) cabinet to each aeration basin's DO transmitter. Long wire runs sometimes compromised measurement signal integrity before receipt by the host system due to the significant distances involved, and degradation due to EMI was often an issue.

Additionally, amperometric sensors required frequent maintenance to maintain accuracy. With some large facilities containing dozens of basins, the calibration procedure could take hours or even days. Each sensor disassembly, calibration and reassembly increased the likelihood of compromised measurement.

Digital optical DO sensors, such as the Rosemount 490A, dramatically decrease calibration and maintenance requirements, translating into lower ongoing operational costs. The compact sensor design includes standard NPT threads on both ends, providing versatile mounting options that simplify retrofitting and installation in tight spaces, whether inline, in tanks or in open basins. Robust construction materials and an IP-68 rating ensure durability in these demanding chemical or wet environments.

Furthermore, because optical sensors do not consume oxygen, localized oxygen depletion in the low-flow environments of aeration basins is not a concern. Additionally, process control derived from these more reliable measurements provides cost savings due to optimal oxygen dosing, alleviating DO overshoot.

Optical sensors can extend the calibration interval in aeration basin applications from biweekly to just once annually, or even more infrequently, such as only when the sensor cap with luminescent dye is replaced. Digital instrumentation also enables daisy-chaining multiple sensors together with a shared transmitter, eliminating the need for individual home-run wire loops to the host system from every sensor.

Use case: Steam generation optimization

Nearly all utility management applications require measuring and controlling water quality parameters, including DO, to assure process quality, prevent corrosion and ensure the integrity of equipment components.

The high temperature and pressure requirements for utility steam generation significantly accelerate the rate of corrosion and pitting of metal components, and DO can even cause oxygen tubercles over pitted areas. This condition allows corrosion to continue in the damaged areas, even when systems are properly maintained.

When used in boilers, the Rosemount 490A Dissolved Oxygen Sensor provides reliable DO measurement in these difficult environments, enabling quick transitions from wet to dry measurement. Flow changes are also common in these applications, and optical DO sensing can compensate quickly for variable flow with rapid response time, while conventional sensors cannot adjust as quickly to changing process conditions.

Innovation propels industry

Optical sensing technology, coupled with digital communication adoption, improves industrial DO measurement. Modern sensors provide a compelling value proposition in many industries, empowering plant personnel to overcome chronic maintenance burdens, calibration complexities and inherent limitations of older amperometric and analog systems. These new instruments provide more reliable, accurate and stable measurements, with significantly reduced maintenance requirements.

The ability to operate reliably in challenging conditions improves process efficiency, enhances product quality and provides regulatory compliance assurance, while reducing the propensity for human error, operational expenditures and total cost of ownership. As industry continues its pursuit of greater automation and efficiency, the addition of digital optical DO sensor technology provides another step forward for the operation and maintenance of process instrumentation.

All figures courtesy of Emerson

ABOUT THE AUTHOR

Kevin Stultz is a product management leader with more than 14 years of experience at Emerson. Currently serving as senior global product manager, Stultz leads a team overseeing both the liquid and combustion analysis portfolios. Holding an MBA from the University of Minnesota's Carlson School of Management and a bachelor's in chemical engineering from Iowa State University, Stultz combines technical expertise with strong business acumen.


General Monitors by MSA
FL5000

Safety: Understanding SIL, Cpt and PFDavg

Some facts about proof test coverage and how it affects safety integrity level calculations.

By Mathew Merten

When designing or verifying a safety instrumented function (SIF), it's common to hear terms such as PFDavg (average probability of failure on demand), safety integrity level (SIL) and test interval. However, a factor that's often misunderstood—or just overlooked—is proof test coverage (Cpt). Cpt is a critical element that directly impacts how effectively testing finds dangerous failures.

If a facility is working toward compliance with IEC 61511-1, understanding how Cpt works—and how to apply it—can make the difference between an overly optimistic SIL claim and a realistic, defensible safety case.

Cpt explanation

Proof test coverage (Cpt) is the fraction of dangerous undetected failures that a proof test is capable of finding. A Cpt of 1.0 (or 100 percent) means the test detects all dangerous undetected failures. A Cpt of 0.7 (or 70 percent) means the test finds only 70 percent of those failures. This is important because any dangerous failures that testing doesn't catch will accumulate over time, increasing the average probability of failure on demand (PFDavg).

Cpt is often used alongside another key term: proof test interval (TI), which is how often the testing is done. However, the test interval doesn't matter much if the testing isn't catching what matters.

Also worth noting: Cpt is not the same thing as diagnostic coverage (DC). Although they both relate to detecting failures, they're measured differently and come from different sources.

How Cpt affects PFDavg. The most common form of the PFDavg equation used in training is:

$$PFD_{avg} = \frac{1}{2}\lambda_{DU}TI$$

However, Equation 1 assumes all dangerous undetected failures are detected, which is rarely true. A more accurate form includes Cpt:

$$\mathrm{PFD}_{\mathrm{avg}} = \frac{\lambda_{DU}\, Cpt\, TI}{2} + \frac{\lambda_{DU}\,(1 - Cpt)\, LT}{2}$$

Where:

λ_{DU} is the dangerous undetected failure rate

TI is the proof test interval

LT is the SIS lifetime (e.g., 15 or 20 years).

The two terms in the equation represent different contributions to PFDavg. The first term is the contribution between tests. The second term is the contribution after the final test, over the system lifetime.

Increasing test frequency is not enough if the test itself isn't catching the right failure modes.

In many training or spreadsheet tools, the second term is omitted if the lifetime is similar to the test interval. However, when the lifetime is significantly longer (e.g., TI = 1 year, LT = 15 years), ignoring it underestimates risk as shown in the following comparison.

λDU = 2E-6 per hour

TI = 1 year (8,760 hours)

LT = 15 years (131,400 hours)

Case A: Cpt = 0.55

Case B: Cpt = 0.95

Case A: *PFDavg ≈ (2E-6 × 0.55 × 8760)/2 + (2E-6 × 0.45 × 131400)/2 = 1.04E-2 → RRF ≈ 96 (SIL 1)*

Case B: *PFDavg ≈ (2E-6 × 0.95 × 8760)/2 + (2E-6 × 0.05 × 131400)/2 = 2.06E-3 → RRF ≈ 485 (SIL 2)*

It is important to note that this is the difference between a SIL 1 system and a SIL 2 system—driven entirely by proof test coverage.

Even though both cases used the same failure rate, test interval and SIS lifetime, the lower test coverage in Case A pulled the risk performance down an entire SIL level. That's a powerful reminder that increasing test frequency is not enough if the test itself isn't catching the right failure modes.

Determining a realistic Cpt

Vendors or safety books often quote generic Cpt ranges. Table 1 is a guideline to help determine a realistic Cpt.

Component	Typical Cpt	Notes
Pressure transmitter	85 to 95 percent	Depending on how it's tested
Logic solver	95 to 99 percent	High diagnostic coverage helps
Final element (valve)	50 to 95 percent	It depends greatly on stroke testing

Table 1. Guideline to help determine a realistic Cpt.

Cpt is influenced by three broad factors: the test method (partial stroke, full stroke, leak test, etc.); the equipment design (some valves are inherently testable); and human factors (procedures, training, consistency)

Determining Cpt depends on whether IEC 61508-certified equipment is used.

If using IEC 61508-certified equipment. If using components that are certified according to IEC 61508, determining Cpt is easier. Check the SIL certificate or safety manual. Most will include Cpt values based on failure modes, effects and diagnostic analysis (FMEDA). For example, a final element might claim 65 percent for partial-stroke testing, and 90 percent for full-stroke testing. The test procedure must match what was assumed in the FMEDA. This is particularly important with valves. Partial stroke tests might not catch failure modes that a full test would and the difference in Cpt can be dramatic.

Using non-61508 equipment (route 2H or 2S). If the hardware isn't certified, obtain data and use the proven in-use method (this takes the Route 2H or 2S approach; routes are confusing and will be discussed elsewhere):

- Use industry databases such as the OREDA failure database.
- Refer to books such as "Safety Instrumented System Verification," by Goble.
- Review ISA technical reports and peer-reviewed FMEDAs.
- Document using engineering judgment and conservatism.

For example, a Cpt of 70 percent might be assigned to a test routine that checks for mechanical failure in a solenoid but can't detect seat leakage. Be transparent about assumptions; auditors and assessors will ask.

Common Cpt misunderstandings

Cpt does not equal diagnostic coverage. Diagnostic coverage comes from built-in self-checks. Cpt is about manual or automatic testing procedures. Don't assume 100 percent. Even a full-stroke test may not catch all dangerous failures, especially in actuators and valve internals. Test frequency doesn't override poor Cpt. Doing a weak test more often doesn't give the same benefit as a strong test less frequently.

Practical tips for beginners

- If possible, use certified equipment; it saves work and improves defensibility.
- For valves and final elements, be clear with the operations team. A test that's easy to perform—such as partial stroke valve testing—often has lower coverage.
- Document exactly what the test does and doesn't detect.
- For new designs, select devices that are easier to proof test.

Frequently asked questions

1. **How do I figure out what Cpt to use in my SIFs?**
   Start with the equipment documentation. If certified, use the FMEDA. If not, use judgment, external databases and document everything.
2. **Can I assume 100 percent Cpt if I fully test a valve via a FVST?**
   Not quite. While FVST gets close, it might miss failure modes like sticking during partial actuation or internal bypass.
3. **How is Cpt different from diagnostic coverage?**
   It measures what the test can catch. Diagnostic coverage measures what the device's self-checks can catch.
4. **Does increasing test frequency help more than increasing Cpt?**
   They both help, but increasing Cpt often gives more impact with fewer operational interruptions.
5. **What's the best way to improve Cpt without changing the system?**
   Upgrade the test method. Add leak testing, position feedback or combine manual and automated routines.

ABOUT THE AUTHORS

Mathew Merten is the owner and functional safety engineer at SIL Safe. This article was originally published in August 2025 and is part of a longer article on proof testing.

Process Control Charts Ensure Manufacturing Excellence

Control charts enable users to monitor process stability to help them achieve quality, reduce costs and increase production efficiency.

By Nikhil Makhija

Process control charts are an important application of statistical process control (SPC) that are used in the management of processes in various industries with the aim of maintaining consistency, reducing variation and improving quality of products and services. These charts are particularly important in Six Sigma and manufacturing organizations to achieve process stability and excellence.

Six Sigma is a data-driven approach to defect reduction and process improvement. Control charts are an important part of Six Sigma projects as they give real-time feedback on process capability, help with decision making based on data and thus help in identifying where there is room for improvement. In manufacturing, these charts are useful in achieving product quality, minimizing waste and increasing production yield.

What control charts are

Control charts are statistical tools used to study the behavior of a process over time (Figure 1). They are useful in distinguishing between the random or normal process fluctuations, also referred to as common cause variations and special cause variation, which are the atypical events that require correction.

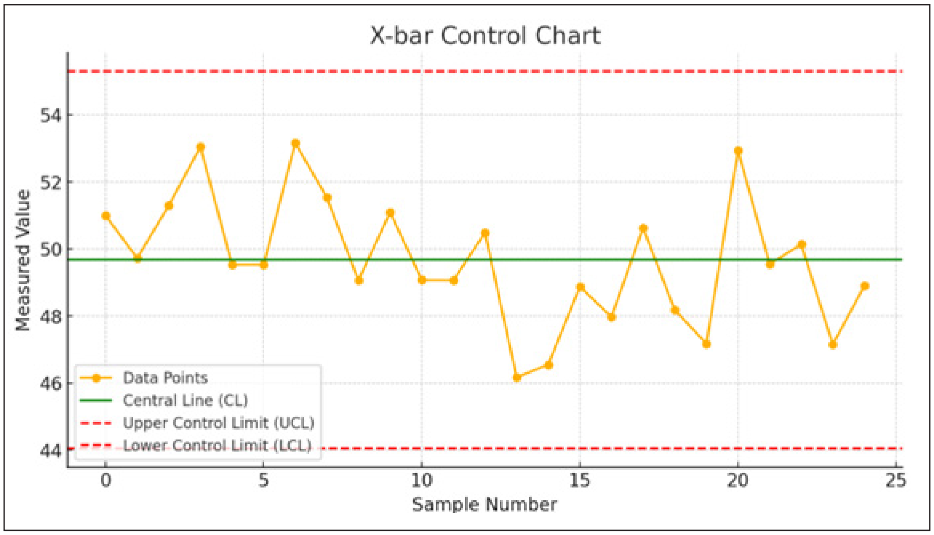


Figure 1. X-bar control chart.

Control charts are used throughout many industries. They are used for health care, service industries, supply chain management and quality control in manufacturing,

Control chart components. Control chart components include data points, a central line (CL), upper control limit (UCL), lower control limit (LCL), time axis and control limits calculation. Data points are the symbols that represent the process data at different points in time. The CL is the statistical measure of center of the dataset—the mean—which gives an idea of the location of the process. A point is said to be out of control if it is above the UCL; a point is said to be out of control if it is below the LCL.

The time axis shows the different times at which the data was collected in sequence. Finally, control limits calculations are usually set at +/-3 standard deviations from the mean to include the natural variation.

Control chart types. Types of control charts are variable control and attribute control. Variable control charts are used for measurable data and include X-bar and R charts for mean and range, X-bar and S charts for mean and standard deviation and individual and moving range (I-MR) charts.

Attribute control charts are used for countable data and include P charts for proportion of defectives, NP charts for number of defectives, C charts for number of defects per unit and U charts for defects per unit with varying sample sizes.

How control charts work

Control charts monitor processes continually and alert staff to conditions that are not typical of the process. They assist in the recognition of trends, shifts or patterns that are indicative of a point of change—be it a good one or a bad one. This approach is preventive in nature and is directed toward avoiding defects before they occur so that the process becomes stable and predictable.

Constructing a control chart involves selecting and understanding the process to be monitored along with its characteristics. Then, data must be collected—include enough data to establish a baseline. Next, calculate statistical parameters by finding the mean, standard deviation and the control limits.

Now, it's time to plot the data. Present the values in a time series and draw the control limits. Next, analyze trends. Look for patterns, signals and variations that could indicate a change in the process. If there are anomalies, take corrective action. If needed, find the route cause (or causes) and implement the solution(s).

Interpret the control charts by observing the representation of the data and understanding how it relates to the process. If the process is stable, data points remain within control limits without patterns or trends. An out-of-control process has data points outside the control limits, which indicate potential issues. Be aware of non-random patterns: trends, cycles or repeated patterns that could indicate an underlying cause that needs investigation. In addition, look for sudden shifts. A drastic shift in the process mean suggests there may be an external influence or a fundamental change in the system.

Control chart pros and cons

Benefits of using control charts include

- Early detection of issues
- Process Stability Improvement
- Enhanced decision-making
- Cost reduction
- Continuous improvement support.

Although control charts are beneficial in many cases, there are some disadvantages associated with using control charts:

- Initial setup complexity
- Misinterpretation risks
- Limited to historical data
- They are not a standalone solution; they should be combined with other quality management tools for optimal results.

Wrapping up

Control charts are useful tools in the control and improvement of process performance in most industries. They are useful in monitoring the stability of the process, which is crucial in any organization desiring to achieve quality, reduce costs and increase production efficiency. As there are some difficulties in the implementation and interpretation of the controls, the advantages clearly outweigh the disadvantages, and the charts are therefore a significant part of the quality management system based on data.

ABOUT THE AUTHORS

Nikhil Makhija is a senior manufacturing systems analyst at Fujifilm Dimatix and an advocate for Industry 4.0 innovation and digital transformation. A Senior Member of ISA and Program Chair of the ISA North Texas Section, Makhija brings more than 17 years of expertise in implementing smart manufacturing solutions using a combination of IoT, data driven analytics and enterprise solutions such as SAP Manufacturing Suite to drive operational excellence and scalability. He is dedicated to empowering organizations to achieve their digital transformation goals through cutting-edge strategies and technology integration. Makhija actively supports ISA initiatives and can be reached at LinkedIn.

PROCESS AUTOMATION

The Future of Process Automation in Bioprocessing

By Moira Lynch

Open standards, intelligent analytics and industry collaboration enable integrated, data-driven and sustainable operations to meet evolving life science demands.

The bioprocessing industry stands at a pivotal moment. Automation, which was once a futuristic vision for the sector, is rapidly becoming a practical necessity for manufacturers responsible for producing critical therapeutics and biologics. At the same time, as technology advances, true progress depends on more than simply adopting the latest tools or software.

The digital transformation underway is rooted in open standards, intelligent connectivity and cross-industry collaboration, which are reshaping how automation is impacting the biomanufacturing landscape. By using technology

and automation to drive quality and efficiency in R&D, process controls can be automated and managed, which allows improved productivity while maintaining high quality standards during process optimization and scale up.

The need for open standards

A central challenge in bioprocessing automation has always been connectivity. While automation shows a lot of promise, many laboratory and production ecosystems are comprised of equipment from multiple vendors, each with proprietary communication protocols. For automation to truly deliver its full value, systems must "speak" to each other seamlessly. Achieving this requires open standards and vendor-agnostic platforms to achieve the smart, responsive workflows that modern bioprocessing demands.

The inability for equipment to communicate freely often results in manufacturers implementing rigid workflows or costly workarounds, which limit innovation and slow the pace of production. Open architectures in which controllers and platforms are designed for interoperability are helping enable different components of the production process to integrate cohesively and scale as needed.

Beyond simple automation

The real value of automation comes from building intelligent systems. This involves integrating advanced sensing, process analytical technology (PAT) and data analytics into workflows with the goal to execute tasks more efficiently and gather actionable insights that improve overall process quality, reduce variability and accelerate development.

In addition, validation and regulatory compliance are still significant considerations. In bioprocessing, the stakes are considerably high, as workflows depend on reliably and must adhere to strict regulatory frameworks. The complexity requires that each stage in a process is measured and validated, which means that quality assurance must be a shared responsibility across the entire workflow.

The case for speed, efficiency and sustainability

Manufacturers today face growing pressures to get the most out of their processes. The drive for speed, efficiency and productivity is not only about cost savings, but also throughput, despite limited resources. Manufacturers are now focused on getting more out of their facilities, and automation is helping enable higher yields, faster changeovers and shorter timelines for bringing therapies to market.

Efficiency is as much about flexibility as it is about cost. For example, the ability to process 10 molecules instead of three with the same assets represents a transformational shift. Automation, when implemented correctly, enhances productivity by optimizing resource use and reducing downtime.

Sustainability is also an integral part of the equation. Bioproduction processes are traditionally associated with high energy consumption and substantial packaging waste, among other environmental impacts. As automation increases efficiency, it often leads to reductions in energy and water usage, less waste and more sustainable operations.

Ensuring accessibility for all

A notable trend in recent years is the democratization of digital tools. Software and analytics platforms—once only accessible to those with advanced technical backgrounds—are now widely available and increasingly user-friendly. Machine learning, predictive analytics and real-time monitoring are being woven into the fabric of bioprocessing, which allows organizations to make more informed, data-driven decisions.

However, as automation becomes more data-centric, the focus shifts from collecting information to generating actionable insight. Automation without intelligence is meaningless, as systems must be designed to execute workflows and learn from them. The integration of historical context, real-time data and predictive models enables bioprocessing teams to optimize quality, anticipate issues and continuously improve—all of which lead to safer, more effective therapeutics.

The digital transformation underway is rooted in open standards, intelligent connectivity and cross-industry collaboration, which are reshaping how automation is impacting the biomanufacturing landscape.

Collaboration is the final ingredient for progress

One of the most critical trends shaping the future of automation in bioprocessing is the spirit of collaboration. Industry progress requires a collective approach across technology providers, manufacturers, regulatory bodies and even competitors, all working together to solve shared challenges. Whether it is developing open standards, validating new technologies or sharing research and best practices, collaboration accelerates innovation and fosters adoption.

This collaborative mindset extends to the way organizations approach automation projects. Rather than seeking immediate transformation, the most successful teams embed automation incrementally by choosing technologies that are scalable and adaptable. Over time, these investments compound and result in exponential gains in efficiency, quality and sustainability.

Automation as a foundation for the future

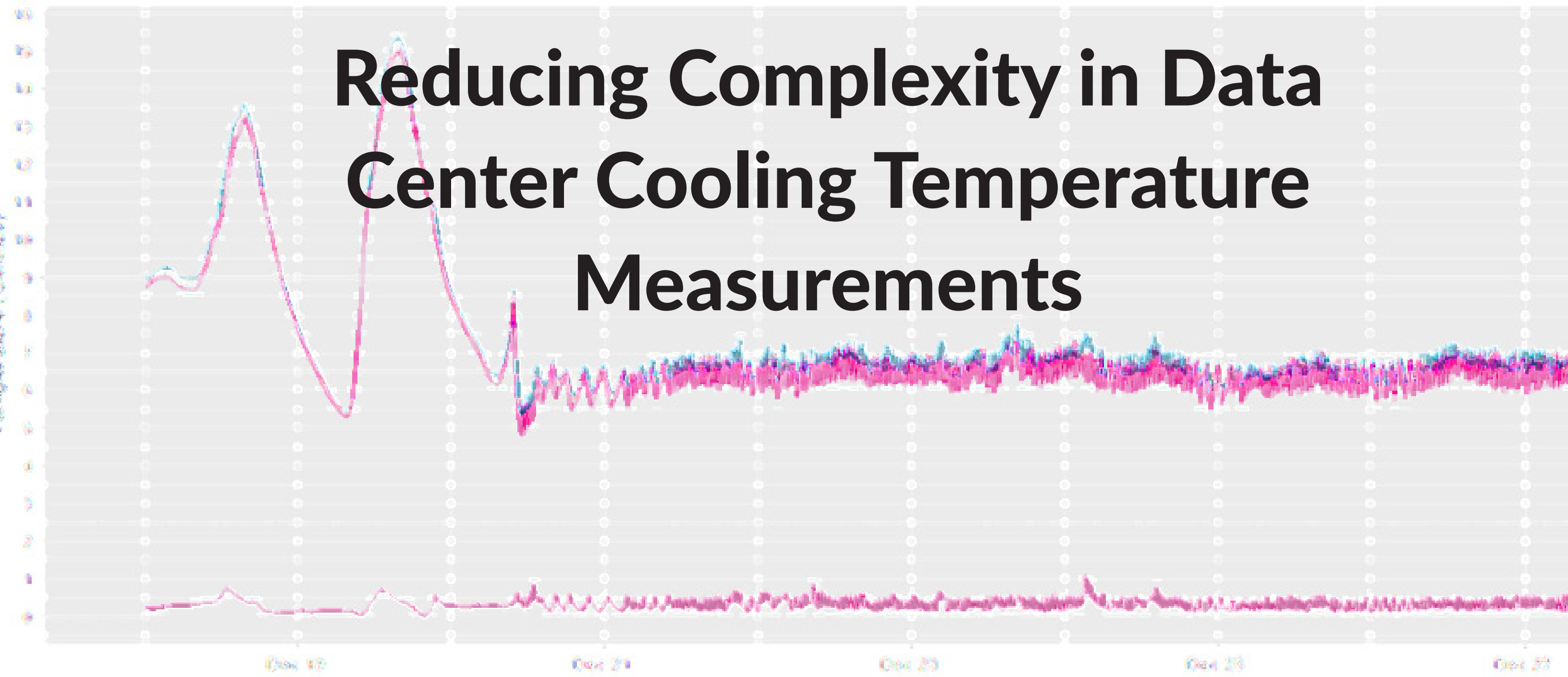
The journey toward process automation and control in bioprocessing is an ongoing, demanding investment in technology, as well as the willingness to rethink legacy systems, embrace open standards and collaborate across traditional boundaries. As manufacturers face mounting pressure to deliver therapies faster, more efficiently and more sustainably, the role of intelligent automation in bioprocessing will only become more critical.

Ultimately, the promise of automation is not just about replacing labor or cutting costs. It's about building flexible, resilient and data-driven operations that can respond to the evolving demands of the life sciences industry. By prioritizing integration, intelligence and collaboration, the industry can move beyond incremental improvements and embrace the transformative potential that true process automation holds for the future of bioproduction.

ABOUT THE AUTHORS

Moira Lynch is a director of Innovation and Strategic Projects for Bioproduction at Thermo Fisher Scientific. In this role, Lynch is responsible for accelerating the adoption of technologies aimed at supporting biomanufacturing customers, focusing on process analytical technologies (PAT) and digital integration initiatives through internal and external collaborations.

Reducing Complexity in Data Center Cooling Temperature Measurements



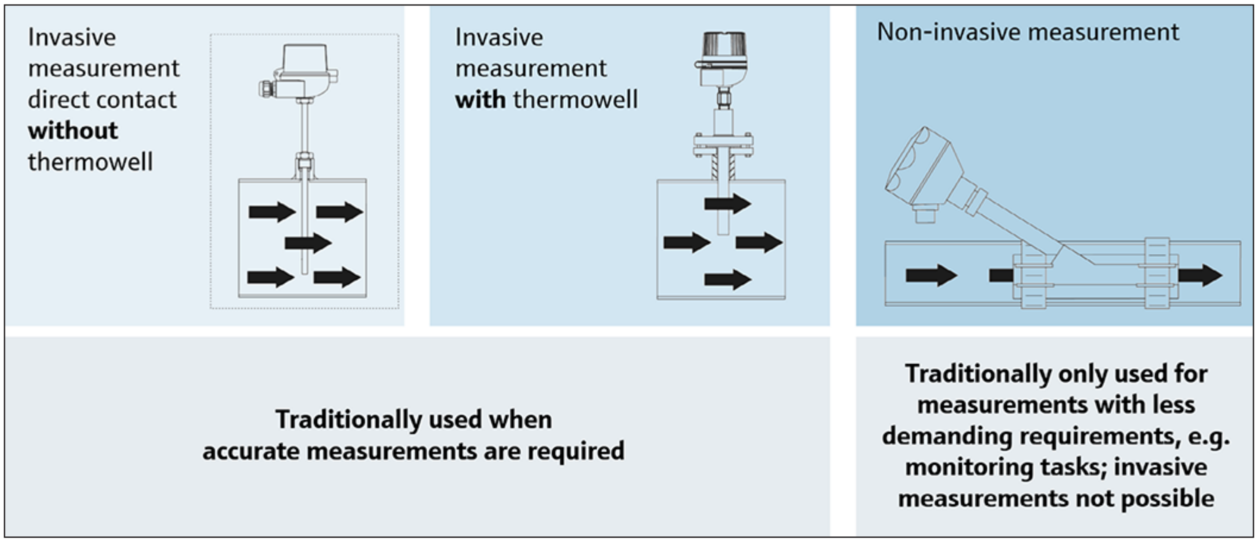
Liquid cooling for data centers moves ahead; air cooling falls behind.

By Endress+Hauser Communications

As computing workloads grow increasingly dense, hyperscale data centers are transitioning from air-based to liquid cooling solutions. Driven by advances in high performance computing (HPC) and artificial intelligence (AI) workloads, liquid cooling offers excellent thermal efficiency for modern hardware, such as GPUs and high-density CPUs. Air cooling struggles with thermal management in densely packed environments, which leads to hotspots and reduced efficiency.

The shift to liquid cooling is being driven by these limitations of air cooling, which may no longer be able to keep up with the thermal demands of cutting-edge technology. Liquid cooling offers superior heat transfer capabilities, addressing these limitations by efficiently dissipating heat from high-performance components. This trend has resulted in a growing demand for solutions, ensuring uptime and reliability in these high-performance environments.

This article explores the challenges of reducing complexity in data center cooling temperature measurements and how modern instrumentation like Endress+Hauser's iTHERM SurfaceLine TM611 can enhance related processes.



Invasive measurements are traditionally used for measurements with less demanding requirements.

Temperature measurements for process control (typical)

Temperature measurement in cooling loops, and many other industrial processes, has traditionally relied on invasive sensors like thermocouples and RTDs inside thermowells, which penetrate the process pipe or vessel. While effective, these setups may be prone to risks such as leakage, contamination, increased maintenance requirements and flow disturbances that impact system performance.

Thermowells also require specific engineering, such as wake frequency calculations, to avoid vibration-induced failures (Figure A), adding complexity and cost to the engineering and installation process. Wake frequency calculations ensure that thermowells are designed to avoid resonant frequencies that can cause vibration-induced failures, enhancing the reliability of temperature measurements.

Moreover, any disturbance in the flow, caused by the thermowells can increase energy consumption as pumps must work harder to overcome additional pressure drops created by these invasive sensors.

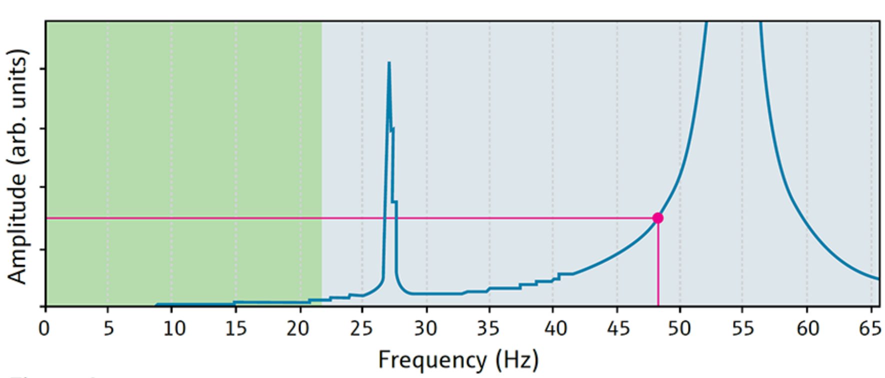


Figure A

Thermowells also require specific engineering, such as wake frequency calculations, to avoid vibration-induced failures.

Criticality of pump performance and pipe cleanliness

In liquid-cooled data centers, the reliability of pump performance is critical. Any disruption in the coolant flow can lead to rapid temperature spikes, risking hardware damage. Therefore, ensuring smooth, uninterrupted coolant flow is essential.

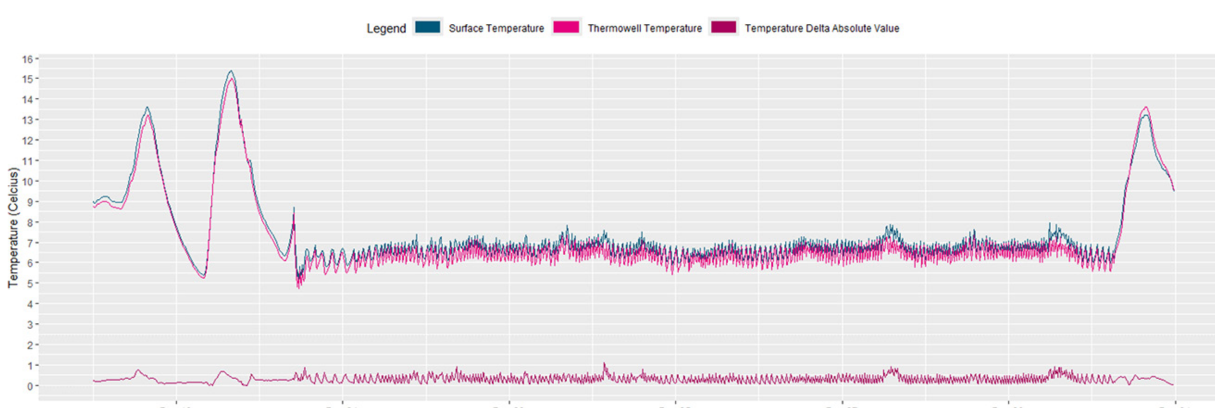
Additionally in these systems, the cleanliness of the cooling loop is paramount. Poor water quality, including contaminants or debris, can damage components and reduce cooling efficiency. Harmful contaminants include particulate matter, biological growth and chemical impurities. These can cause blockages, corrosion and reduced cooling efficiency.

Regular filtration, chemical treatment and UV sterilization are standard to maintain water purity and prevent fouling and corrosion that could lead to system failures. The frequency of these treatments depends on the specific system and water quality, but regular intervals (e.g., monthly or quarterly) are recommended to prevent contamination and maintain efficiency. Such measures ensure pumps operate efficiently, without unnecessary strain, and prevent performance degradation or downtime.

Innovation in non-invasive measurement

Endress+Hauser's iTHERM SurfaceLine TM611 non-invasive temperature sensor offers a unique solution that bypasses the need for thermowells or any penetration into the process pipe. The iTHERM SurfaceLine TM611 is ideal for environments where cleanliness is paramount, such as cooling loops in data centers, as well as applications with high flow velocities, high process pressures and corrosive media.

The iTHERM SurfaceLine TM611 uses a mechanical clamp-on interface that minimizes the impact of ambient temperature fluctuations, delivering superior accuracy without relying on electronic compensation algorithms. The mechanical clamp-on interface minimizes ambient temperature fluctuations by providing optimal thermal conductivity to the sensor, resulting in faster response times and improved accuracy compared to other non-invasive approaches, while providing similar performance to an insertion-style, industrial thermometer (Figure B).



By avoiding process penetration, the iTHERM SurfaceLine TM611 reduces the risk of contamination, making it particularly suitable for environments where cleanliness is crucial, such as cooling loops in data centers.

Furthermore, the iTHERM SurfaceLine TM611 enhances system efficiency by minimizing flow disturbances. Since it doesn't disrupt the flow with thermowells, pumps can operate more efficiently, reducing energy consumption. This also reduces the pressure drop across the system, leading to lower operational costs and greater reliability.

In liquid cooling systems, especially those using recycled or treated water, the risk of contamination is always a concern. The non-invasive nature of the iTHERM SurfaceLine TM611 minimizes this risk, helping preserve the cooling loop's integrity. Additionally, the absence of direct contact with the fluid lowers the need for frequent maintenance, making it a low-maintenance solution that contributes to long-term system stability.

Holistically, the iTHERM SurfaceLine TM611 aligns perfectly with the evolving demands of hyperscale data centers, where uptime and system efficiency are critical. The device's non-invasive design ensures consistent temperature monitoring while contributing to better cooling system performance, more significant energy savings and reduced risk of contamination. It's an ideal solution for environments where safety, cleanliness and operational efficiency are of the utmost importance.

All images courtesy of Endress + Hauser.

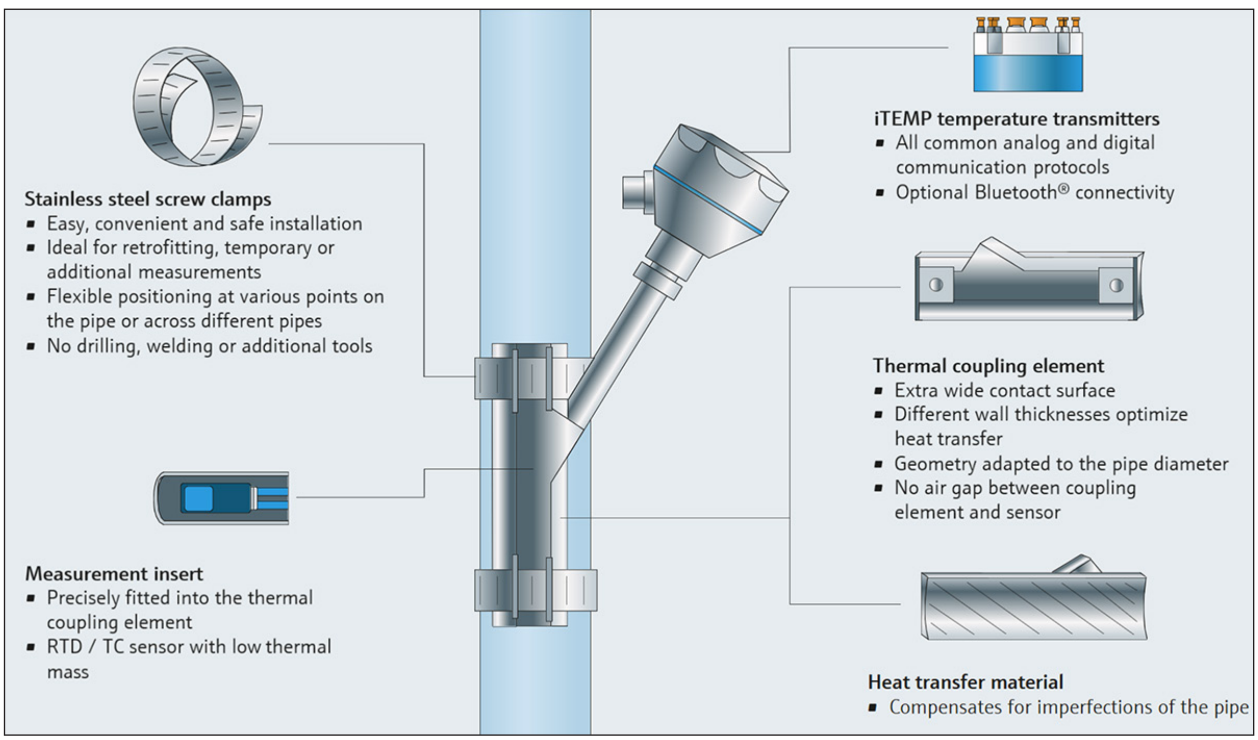
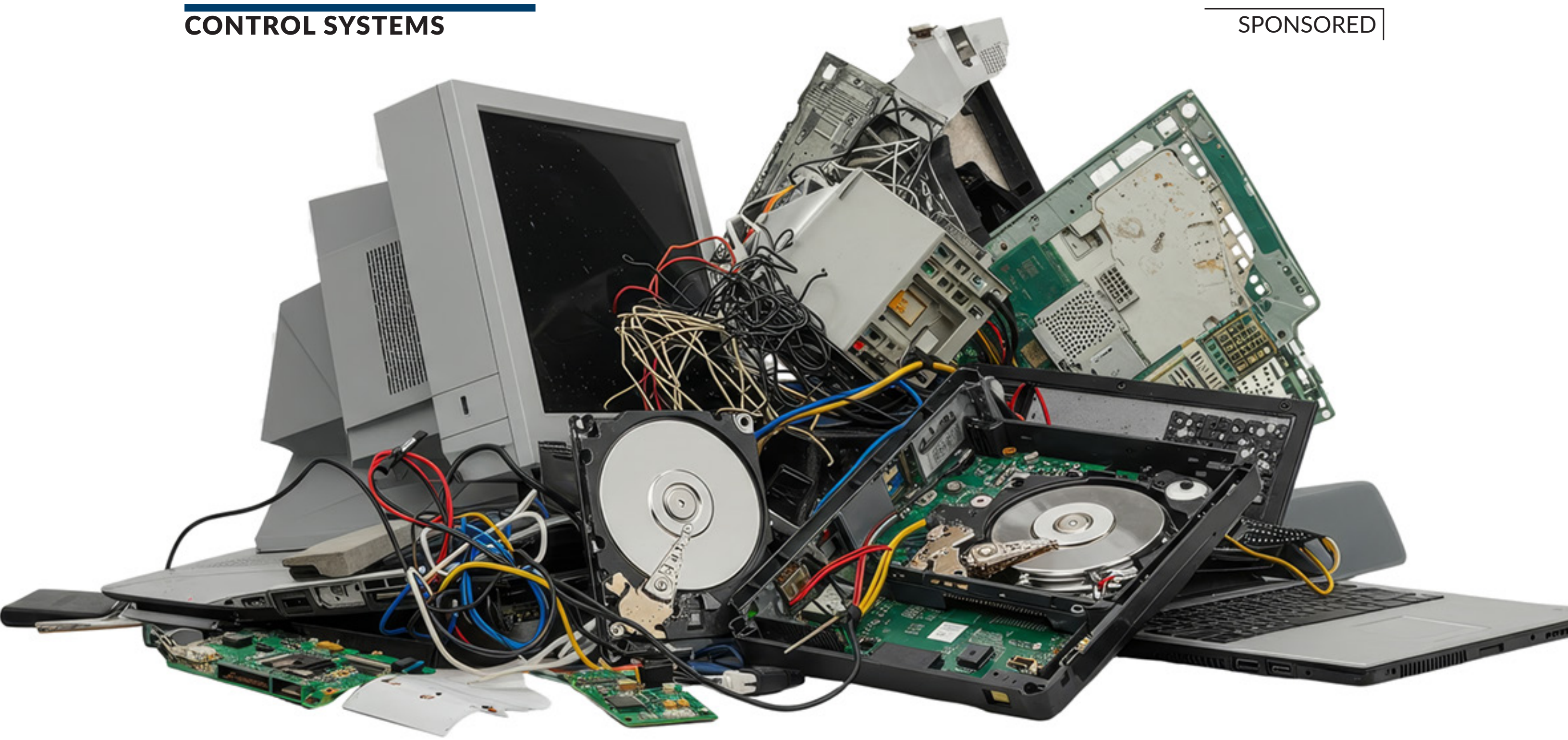


Figure B. The mechanical clamp-on interface minimizes ambient temperature fluctuations, ensuring accurate measurements without relying on electronic compensation.



Lifecycle and Obsolescence Management: Extending Control System Lifespans

Separating compute and I/O architectures pays off in the long run.

By Lee Boggs

Eventually, every automation system faces obsolescence, and failing controller hardware can derail uptime. However, a modular architecture lets you turn disruptive replacements into routine, predictable maintenance.

In automation systems, the controller is central to reliability, performance and integration across process control, operator interfaces and safety. When controller hardware ages out of production or reaches end-of-life, entire systems risk shutdown because critical components are no longer supported.

Traditional controller replacements often trigger rewiring, system revalidation and certification cycles, all of which carry cost, time and risk. A steadier approach is employing a modular architecture.

A modular architecture lets you upgrade compute modules while keeping I/O wiring and control logic intact, reducing disruption and extending system life. In environments where even brief downtime can create safety risks or production losses, this approach helps teams protect operations, budgets and uptime without sacrificing flexibility or long-term value.

Lifecycle forecasting

Smart asset management starts with spotting trouble before it hits. Lifecycle forecasting maps the expected life of controllers and key components so replacements are planned, not rushed. It ties part availability to the maintenance calendar, which lowers disruption and cost. The goal is to gain lead time and avoid last-minute buys.

Modern controller platforms often use a two-board modular design: a computer-on-module (also called compute module or COM module) with the CPU, memory, storage and high-speed interfaces, and a carrier board for field connections and application-specific I/O. That split matters for forecasting because risk in the compute layer points to a module swap while risk in the I/O layer points to a carrier revision.

Lifecycle forecasting enables you to track compute-first indicators and market signals such as CPU and chipset lifecycle notices, BIOS and firmware windows and OS and driver roadmaps. Then you add supplier updates, I/O component availability and broader supply-chain shifts.

For example, when a compute part such as the CPU moves into the red, plan to swap the computer-on-module and keep the existing carrier board and field wiring. When an I/O part moves into the red, plan a carrier revision and continue using the same module. In both cases, the unaffected layer stays put, which shortens the outage and narrows revalidation to only what changed.

Prioritize COM modules and CPUs early in their lifecycle, then select I/O parts to match. That sequencing stretches upgrade intervals and steadies inventory planning. Fold long-term availability commitments and parts traceability into your forecast so decisions are based on evidence, not guesswork.

Keep the process cross-functional. Engineering, procurement and supply-chain teams should review forecasts together, approve substitutes and set inventory buffers. Document assumptions, dates and owners in one place, then review regularly so the plan stays current. Handled this way, obsolescence management becomes routine work.

Obsolescence and end-of-life mitigation

Parts go out of production, suppliers shift plans and suddenly a controller refresh becomes a rushed retrofit that interrupts operations or forces a costly redesign. A steadier path combines planning with modular design.

One practical move is to separate compute from I/O. Build so that field wiring lands on a stable carrier interface rather than on the compute board itself. If the COM module reaches end-of-life, replace that module and leave the I/O layer and wiring alone. This keeps the change small and contained.

Modular systems that follow standard carrier board and computer-on-module formats have shown they can swap compute across generations without starting over on panel layout or I/O connectivity. The impact of obsolescence shrinks to a planned board change rather than a full rebuild.

You can also extend the life of installed assets with compatibility tactics. Add adapters or interfaces that let legacy I/O stay in service while you modernize the compute side. This kind of retrofit preserves investments, reduces waste and supports digital continuity goals.

The design principle is to separate compute from I/O with plug-compatible, backward-compatible system interfaces. Land field wiring on stable carrier connectors, not on the compute board. Decoupling compute from control wiring lets you upgrade processors, operating systems or algorithms with far less disruption. That separation is the foundation for future-proofing performance.

Future-Proofing Modular Architecture

The payoff for separating compute from I/O is long-term flexibility. COM modules plug into a carrier board to form the controller's processing layer. Built to open standards such as COM Express and COM-HPC, they package the CPU, memory and high-speed interfaces in a compact, replaceable unit.

The carrier is designed once for plant signals and stays put. Over time, you can drop in newer COM modules for performance or power gain. The processing layer evolves while the I/O layer and wiring remain unchanged. That stability preserves prior validation and shortens outages during upgrades.

In short, a modular architecture keeps the physical layer steady and lets the processing layer evolve. With that architectural baseline in place, the next step is a practical roadmap for planning and executing upgrades.

Decoupling compute from control wiring lets you upgrade processors, operating systems or algorithms with far less disruption. That separation is the foundation for future-proofing performance.

Roadmap to long-lasting automation

Catalog your compute, I/O and wiring. Start with compute: module family and type, CPU generation, memory, storage, BIOS and firmware levels, OS and driver versions. Then map I/O: analog, digital, serial, Ethernet, device interactions and where each signal lands. With a complete catalog, future compute swaps are replacements instead of rewires.

Adopt a two-board computing approach. Keep processing on a COM module and land field wiring on a stable carrier board. That way, you can upgrade the compute side without disturbing downstream wiring or control logic.

Verify lifecycle compatibility. Select modules with multi-year availability and published lifecycle guidance. Confirm I/O component availability. Plan refresh intervals so you schedule upgrades instead of reacting to obsolescence in a crisis.

Pilot before you roll out. Choose a non-critical segment to pilot modular swaps. Validate form, fit and function compatibility, I/O preservation and software continuity before adoption across the plant.

Align upgrades with capital and maintenance windows. Schedule computer-on-module replacements during budgeted capital projects or planned maintenance outages. When timing and availability line up, changes become routine rather than disruptive.

Record every configuration. Track compute module versions; image and OS details; BIOS and firmware levels; and carrier revisions, I/O pin maps and connector details. Good records make the next swap faster and repeatable.

Handled this way, obsolescence turns from a potential emergency into planned work, protecting uptime and capital while keeping the control platform modern.

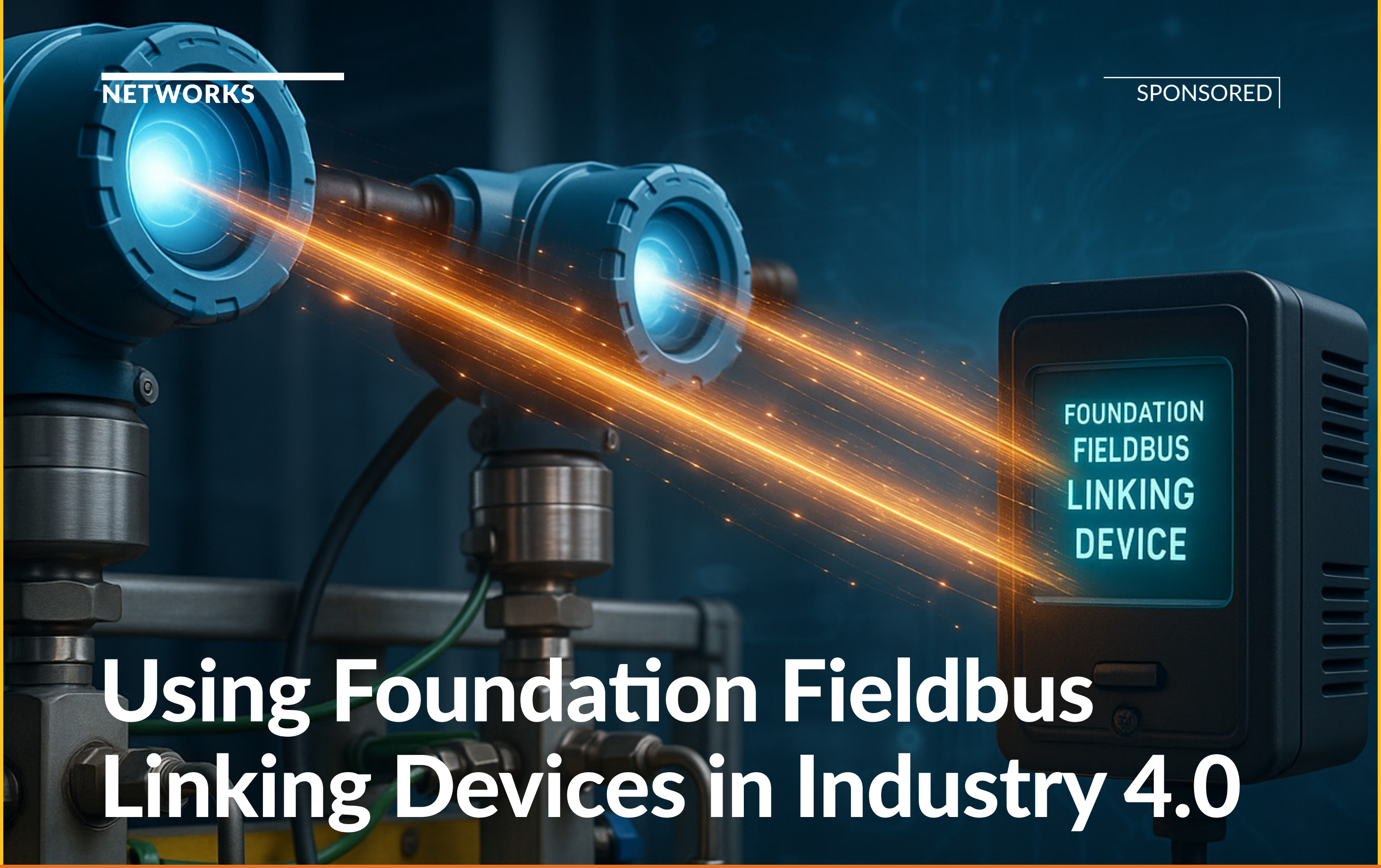
Sustaining lifespan through modular design

A planned migration to modular design turns control system obsolescence from an emergency into scheduled work. By separating the processing layer from the I/O layer, forecasting component lifecycles and aligning changes with planned capital projects and maintenance outages, organizations ensure operational continuity and reduce both cost and risk.

This approach preserves wiring and prior validation, so teams can improve performance without reopening panels or repeating certifications. Treated as an ongoing program, this strategy keeps compute performance and I/O integrity in lockstep as technology advances, redefining lifecycle management from reactive fix to proactive stewardship.

ABOUT THE AUTHOR

Lee Boggs is a content specialist for Sealevel Systems Inc., a designer and manufacturer of embedded computers, industrial I/O and software for critical communications. An experienced customer communicator and technical writer in government, health care and IT, Boggs creates content for Sealevel's technical community and business partners.



Using Foundation Fieldbus Linking Devices in Industry 4.0

Foundation Fieldbus linking devices enhance industrial automation systems.

By Graham Proctor

The evolution of industrial automation has spurred significant advances in communication protocols, efficiency and connectivity. At the heart of this transformation is Industry 4.0, which emphasizes smart manufacturing, data-driven decision making and real-time process optimization. While modern industrial instrumentation is transitioning to industrial Ethernet, previous capital outlay for older technologies such as Foundation Fieldbus and Profibus PA should not be wasted. To maximize their substantial investment in instrumentation, organizations must find effective ways to integrate legacy systems into newer digital infrastructures, such as modern distributed control systems (DCS) and programmable logic controller (PLC)-based control systems.

In addition to measuring primary process values, these digital devices can perform additional functions. They provide a wealth of status information that can inform the operator that the measured value might be compromised. Lord Kelvin's assertion that "to measure is to know" is meaningless if the measured information is not shared with the rest of the control system.

The role of Foundation Fieldbus in Industry 4.0

Foundation Fieldbus—a well-established digital communication protocol for process automation—has been widely adopted across industries including oil and gas, chemical and power generation. Unlike traditional 4-20 mA analog systems, Foundation Fieldbus enables multivariable communication, device status and diagnostics and distributed control functionality. However, as Industry 4.0 initiatives gain momentum, there is a growing need to integrate these existing networks with industrial Ethernet and cloud-based platforms for seamless automation, asset monitoring and historical data storage systems.

This is where Foundation Fieldbus linking devices come into play. These devices act as intelligent gateways that facilitate communication between Foundation Fieldbus field devices and higher-level control architectures such as PLCs, DCS and supervisory control and data acquisition (SCADA) systems. By providing a robust connection between legacy process control systems and Industry 4.0-enabled infrastructures, linking devices help industries maximize the value of their existing investments while embracing the digital future.

The importance of ease of integration, redundancy and diagnostics

Foundation Fieldbus linking devices offer a range of features designed to support data-driven decision-making:

1. **Seamless data exchange:** Linking devices facilitate the smooth and efficient data exchange between Foundation Fieldbus H1 networks and industrial Ethernet protocols such as EtherNet/IP and Modbus TCP, which ensures compatibility with current automation systems. This data is often repackaged or reformatted to suit the host control system. Once the data is in the DCS or PLC in its native format, it can be easily propagated through the rest of the system including human-machine interfaces (HMIs), SCADAs and historians.
2. **Advanced process diagnostics:** A key advantage of Foundation Fieldbus linking devices is their ability to provide in-depth diagnostics of the field instrumentation. This functionality provides a window into the usually hidden behavior of the process instrument's functionality by warning of a potential inaccurate reading or perhaps impending maintenance requirement. For example, a Magflow instrument could warn of a buildup of scale or sludge in the pipe, and although the instrument is still providing accurate readings, this information could be used to schedule specific maintenance in the near future. This approach of using all the information provided by the field device can have marked financial benefits, not only by decreasing production downtime, but also by guaranteeing quality of the final product.
3. **Continuous system health monitoring:** The ability to continuously monitor the status and health of the system, including the linking device, bus power conditioner,

the fieldbus network and all connected instruments, is necessary for rapid fault identification and remediation. By providing real-time communication data for each field device, as well as bus parameters such as current draw and bus voltage, diagnosing communications problems happens faster and improving system reliability by initiating corrective active actions before operations are affected. This data, previously limited to specialized asset management systems, is now accessible to all downstream systems—from the operator in the control room to advanced maintenance planning systems. When a field device replacement is required, the linking device can facilitate rapid and efficient deployment by downloading the previous configuration to the replacement device, with remote options if necessary. It also includes onboard tools, such as packet capture analysis, to help identify and resolve any commissioning hiccups.

4. **Redundancy for increased reliability:** Modern linking devices include redundancy capabilities to ensure uninterrupted operation in both simplex and redundant control systems. Redundant configurations help prevent single points of failure, which provides higher system availability and reduces the risk of unexpected downtime. Both linking device and networking cabling redundancy strategies can be accommodated.
5. **Secure and scalable connectivity:** As cybersecurity becomes a growing concern in industrial automation, linking devices incorporate advanced security features. Secure authentication, encrypted communication and firewall capabilities help protect industrial networks from cyber threats while ensuring reliable data transmission.
6. **Cloud and edge computing integration:** With the increasing adoption of cloud-based analytics and edge computing, linking devices provide connectivity to cloud platforms and edge gateways. This can be particularly relevant for remote applications by allowing real-time data processing, AI-driven insights and remote monitoring, which further drives the Industry 4.0 vision.

Foundation Fieldbus enables multivariable communication, device status and diagnostics and distributed control functionality.

7. **Asset management and FDT/DTM data provider:** The linking device needs to provide a communication tunnel to pass asset management communications as specified by the field device tool (FDT)/device type manager (DTM) framework to the instruments in the network, in addition to providing a DTM for its own management and monitoring. DTMs provide a visual interface to devices and are specific to each instrument manufacturer and type.

Industry 4.0 benefits of Foundation Fieldbus linking devices

The integration of Foundation Fieldbus linking devices into Industry 4.0 architectures offers numerous advantages to industrial operations.

1. **Improved operational efficiency.** By providing real-time access to process data, linking devices enable faster and more informed decision-making. Operators can optimize process variables, reduce energy consumption and enhance overall system performance. Detailed diagnostics of the network and the connected instruments enable timely troubleshooting and fault resolution.
2. **Extended equipment lifespan.** Measured system status data and advanced diagnostics help identify potential equipment failures before they occur. This not only minimizes unplanned downtime but also extends the lifespan of critical assets, thereby reducing capital expenditure.
3. **Interoperability with modern control systems.** Foundation Fieldbus linking devices ensure compatibility with Industry 4.0-ready control systems through Ethernet connectivity. A migration from older DCS can be accomplished without the disruption and additional investment in instrumentation.
4. **Enhanced data utilization.** With seamless integration into cloud and edge computing platforms, linking devices facilitate advanced data analytics, machine learning applications and remote monitoring. This enhances process optimization and drives continuous improvement initiatives.
5. **Increased system reliability through redundancy.** Redundancy in linking devices and their Ethernet media ensures uninterrupted communication between field instruments and control systems, which reduces downtime risks and improves overall process stability.

Wrapping up

As Industry 4.0 continues to reshape industrial automation, the role of Foundation Fieldbus linking devices becomes increasingly vital. By investing in Foundation Fieldbus linking devices with redundancy and advanced diagnostic capabilities, industries can unlock the full potential of their automation systems, enhance operational efficiency and future-proof their operations for the digital era.

With a commitment to innovation and reliability, Foundation Fieldbus linking devices empower industries to navigate the complexities of Industry 4.0 with confidence, which ensures a smarter, more connected future for industrial automation.

ABOUT THE AUTHOR

Graham Proctor is president of Aparian Inc., which he co-founded in 2014. Aparian is focused on providing innovative solutions to the industrial automation industry and specializes in communication gateways and process fieldbus linking devices.


aparian
Ok A B
Act IN ALx
FLOW
101

The Replace, Repair or Retrain Decision

Knowing when to repair an aging machine, purchase a new one or ensure team members are using them efficiently is important.

By Brandon Glenn

There comes a time in any product's lifecycle when a difficult decision may have to be made. Whether it's a faithful old pickup truck, that trusty 9-iron that always bailed you out or a tired 3-axis mill that seems to get a little farther from tolerance with each turn, it's easy to get attached.

Shop owners are familiar with these decisions. How do you know when it's time to fish or cut bait? Do I keep investing in replacement parts and take the hit on more downtime, or bite the bullet and invest in a new machine? Are my employees positioned for success on our current machine lineup or do we need to reassess our capabilities and retrain operators to do more work that the machines can handle better?

These can be tough decisions but consider the following four steps for making the best choices for your needs.

STEP 1: Assess machinery and operator skill levels

Good machines that are well maintained enable you to produce better and more accurate parts. However, there are a few variables to consider when determining what it takes to optimize shop performance and get to that level.

How frequently do you repair a certain machine? Does this machine still meet current production demands, or is it slowing operations (and profitability) down? How do ongoing annual maintenance costs—combined with your scrap rate—compare to the amortized costs of a new machine? Is it compatible with other machines in the shop (and industry), or does it stand out in its obsolescence and perform like a dinosaur

Figure 1. Okuma Machine Tool Academy is operated in partnership with Rowan-Cabarrus Community College.

among newer, more efficient and technologically advanced machines? Evaluate how a quality machine tool can pay for itself in time. Consider how your return on investment can provide a good comparison of where you are now, where you want to go and what it will take to get there.

When you evaluate your machines, you should also evaluate the people who operate them. Continuing education and training opportunities also can help breathe new life into old habits. Is it the older model lathe that needs an update, or is the real issue, "the loose nut behind the wheel?" Regardless of skill level or machine familiarity, technology changes with time, and there is always an opportunity for employees from shops of any size to refresh their skillset and learn about new techniques with education and training.

That's why Okuma established the Okuma Machine Tool Academy (Figure 1) in partnership with Rowan-Cabarrus Community College. Learn new skills or enhance time-honed talent with hands on and classroom instruction. Improve job performance and satisfaction. Boost employees' confidence with personal and professional development. Check out the upcoming class schedule and sign up for updates so you never miss an opportunity to give your team the added skills they need to raise your shop's game.

STEP 2: Evaluate repair versus replacement costs

We put our machines and our tools through a lot, and we expect a lot out of them in return. You can switch out ball screws and even change a spindle, but the years and revolutions take a toll. Sometimes, machines simply reach critical mass. Do the accumulating costs of repairing the same machine outweigh what you could put into a new, more productive machine?

If you've been in business long enough, you probably feel like you never have enough machines, so the thought of getting rid of one or spending just to have the same number of machines can be troubling. Honest consideration of the total cost of ownership (TCO) and the return on investment (ROI)—not including better performance with fewer interruptions you can expect with a new machine—can (and should) bear considerable weight on a purchasing decision.

When you buy a vehicle, you consider the ongoing, expected lifetime costs of maintenance, fuel, depreciation, etc. The same should be considered with your CNC machine tool; about 15 percent of a machine's total cost is in its initial purchase price, with the balance of 85 percent being realized over the lifetime of its operational costs. Warranty is another consideration. Our Affordable Excellence machines come with an industry-leading three-year warranty on parts and a five-year OSP control warranty. When you buy an Okuma machine, we consider you a customer for life.

STEP 3: Understand new machine advantages

What do you do with an aging machine lineup? Throw more money on the fire to try and fix machines or take on a little debt with new machines? Before long, you've spent tens of thousands to fix an old machine. Costs accumulate when you're dumping money into something that could have been replaced for the same cost years ago.

We referenced compatibility with other machines, and technological capability is an equally important consideration to make: how much more can I do today with a new machine than I could with an older machine that likely doesn't have the added benefits of technological innovation we've experienced in the last 10 to 20 years?

Not only does your tired but aging machine also lack the advances you need to be more productive and efficient, but you—and your customers'—confidence waivers. You also just don't trust the old ones to press a button and walk away. When you employ new technology, you unlock an expanded scope of capabilities, including introducing automation to your shop. Investing in built-to-last machines is a great sales tool that shows your customers you're committed to innovation and delivering precise and dependable parts.

Or consider a new machine with a next-generation CNC control. What happens when you upgrade an older mobile device with a new one? You're initially shocked at the enhanced performance and security upgrades and wonder how you got by for so long with an older, slower, outdated model. The same is true with your CNC control. Purchasing a new machine can be an eye-opening experience when you realize the greater processing power and performance that comes with a next-generation control like the Okuma OSP-P500 (Figure 2). You'll be able to run multiple programs simultaneously on a simple and secure interface that is also more energy efficient.

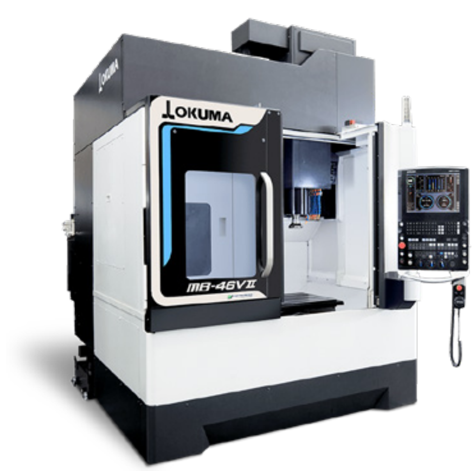


Figure 2. Okuma OSP-P500.

About 15 percent of a [CNC] machine's total cost is in its initial purchase price, with the balance of 85 percent being realized over the lifetime of its operational costs.

STEP 4: Realize new machine benefits

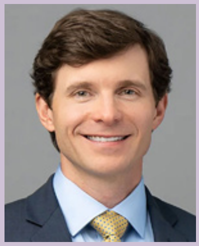
What happens when you and your team lose trust and faith in the machines to make good parts? You'll waste a lot of downtime, money and materials reworking excessive test pieces that only end up in the scrap bin—in addition to frustrating machine operators. If you spec out pricing on one part and need to make five to get there, your returns will be very skewed; with very expensive materials, it can add up quickly. You'll also spend more time rearranging production schedules than producing parts.

Investing in a new machine is an important decision that requires due diligence and careful consideration, but don't be intimidated. There are options available, regardless of the size or scope of your operations, that empower you to take on more profitable jobs and do more than you ever thought possible. One option is the Okuma Affordable Excellence line, an offering that makes quality machine tools available to everyone thanks to Okuma's accessible pricing program.

While replacing aged equipment with newer, more energy-efficient products certainly can impact capital expenditure budgets, these can be offset by lower operating expenses over its lifecycle. That's because, as no surprise to anyone, newer products like windows, refrigerators or vehicles are engineered to be more efficient so you can do more with less.

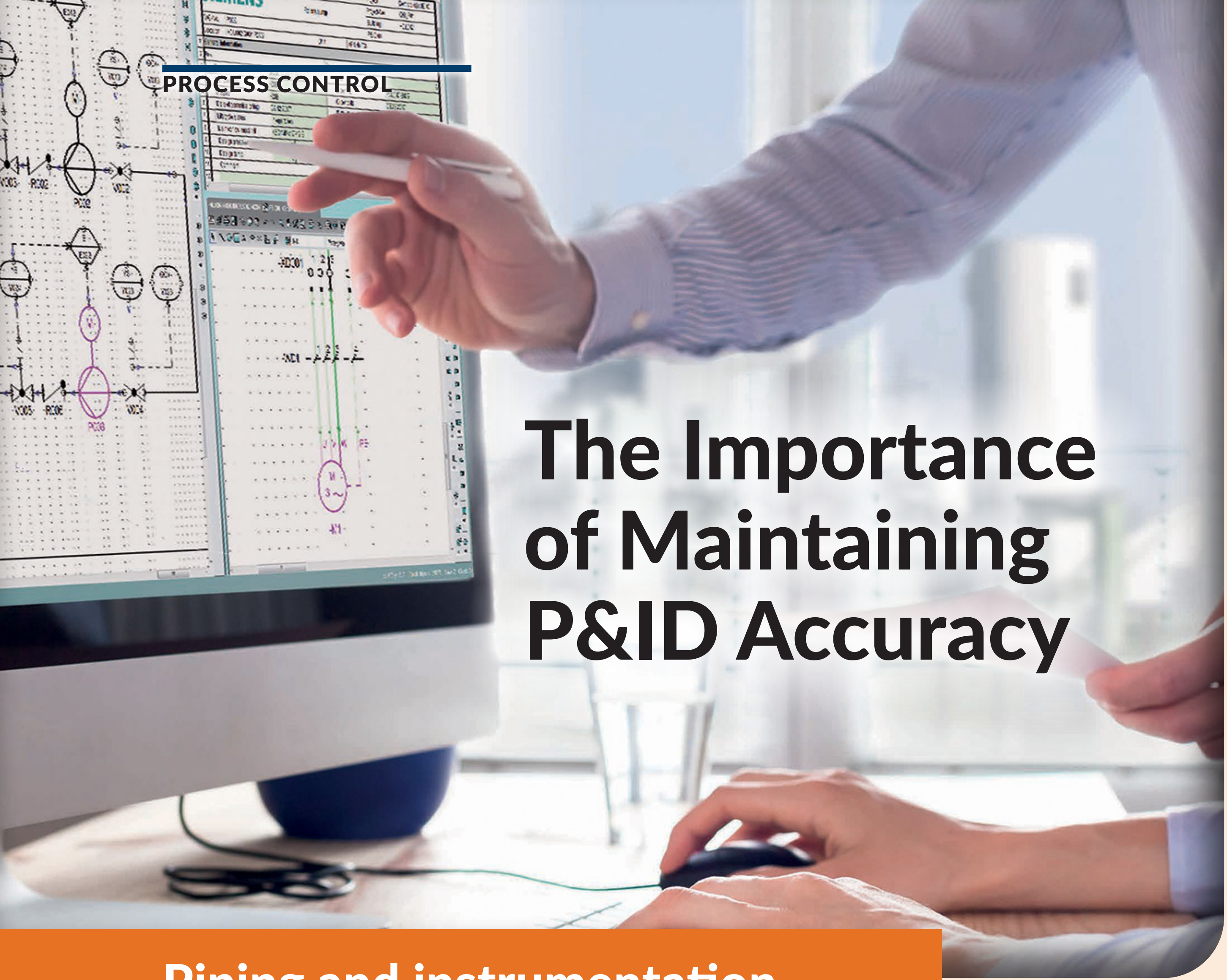
Final thoughts

If your operating structure follows a low- to no-debt model that relies on low overhead and uses cash to pay for capital expenses, the prospect of taking on new machine debt and lower margins may seem daunting. But there are always options—financing, budgeting replacement costs throughout the lifecycle of the equipment or overcoming your own misconceptions about new machine costs and the many ways that can be mitigated, including increased capabilities that yield greater returns.



ABOUT THE AUTHOR

Brandon Glenn is director of sales at Okuma America Corporation.



The Importance of Maintaining P&ID Accuracy

Piping and instrumentation diagrams need regular reviews, thorough documentation and standardization of symbols through ANSI/ISA-5.1. Here's why.

By André Éthier, P.Eng. and Michel Roy

Piping and instrumentation diagrams (P&IDs) serve as a visual representation of a process, representing functional relationships between mechanical equipment, its related piping, instrumentation and system components.

P&IDs are essential tools in the design, construction, commissioning, operation and maintenance of industrial processes. They are commonly based on process flow diagrams used in the basic engineering phase of a project.

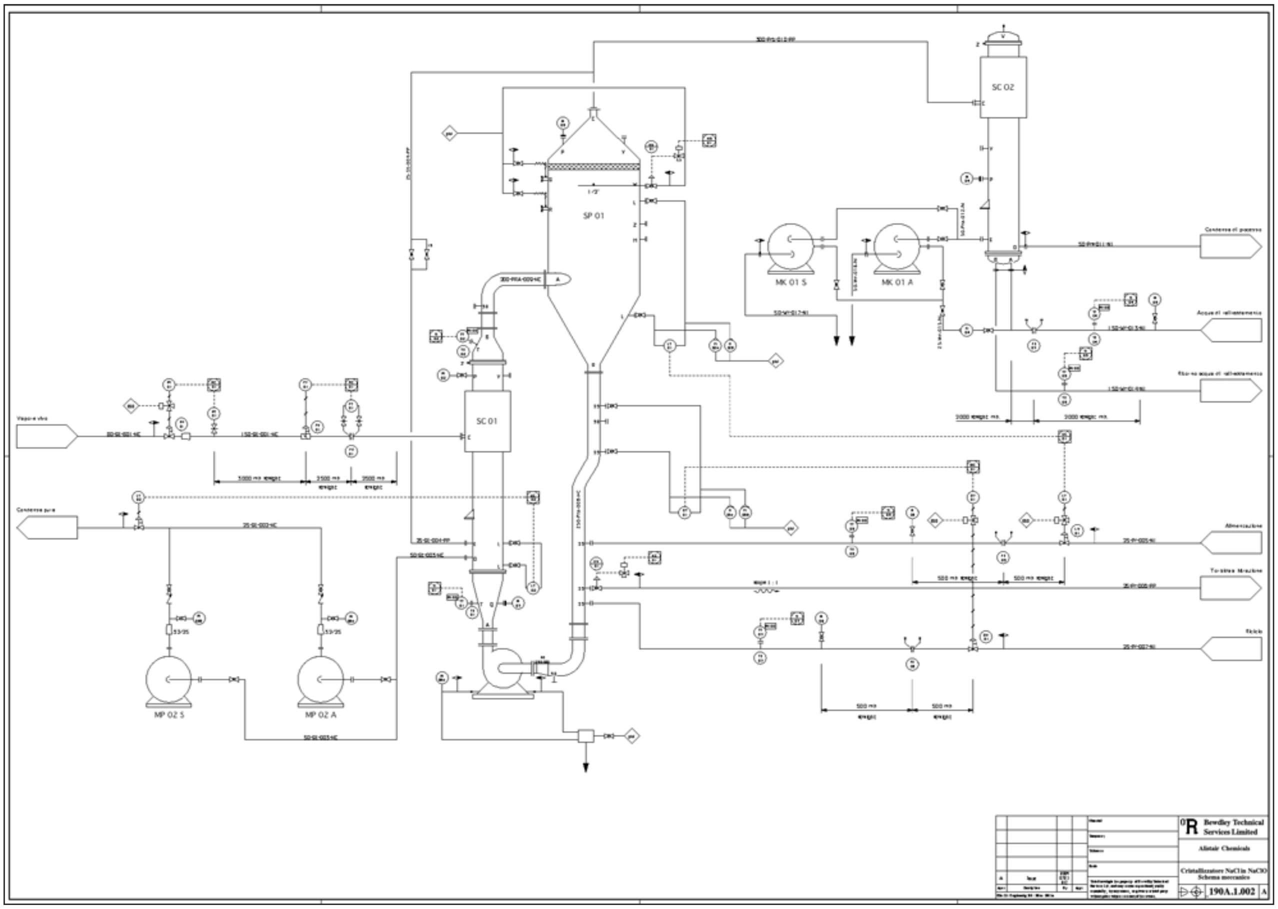


Figure 1. A P&ID is a detailed diagram in the process industry that shows process equipment together with the instrumentation and control devices. *Source: Ub, Own work, CC BY-SA 3.0.*

The significance of P&IDs and their role in industrial operations is explored here with an emphasis on the importance of maintaining accuracy and the related best practices for keeping the P&ID management effective. Real-world examples, challenges and recommendations highlighting the importance of improving P&ID practices are also examined.

Why P&IDs matter

P&IDs serve as critical blueprints in industrial operations. They provide a high-level overview of the process flows, control systems and equipment interconnections. They show a system's mechanical equipment, intricate network of pipes, valves, instruments and controls. As such, they provide engineers and operators with a detailed roadmap, detailing the flow of materials, energy and information throughout the system.

Accurate and up-to-date P&IDs are vital for safe and efficient plant operations. Outdated diagrams can lead to miscommunication, operational errors and safety incidents. Conversely, maintaining accurate P&IDs ensures compliance with regulations, improves troubleshooting and supports effective decision-making.

These diagrams support safety by identifying potential hazards, aid in design by offering a clear representation of system architecture and facilitate maintenance by helping technicians understand system layouts and dependencies.

In the rapidly evolving landscape of industrial automation, P&IDs remain a cornerstone of system design that ensures both operational excellence and engineering precision. Far more than a simple schematic, P&IDs guide the development, implementation and long-term maintenance of complex automation infrastructure.

P&IDs are instrumental in minimizing operational risks, thereby reducing costly design errors and preventing process-related failures. By clearly defining process interconnections, instrumentation and control logic, P&IDs help ensure safe operation, reduce downtime and protect both personnel and equipment.

Additionally, P&IDs enhance interdisciplinary collaboration by providing a common technical language for engineers, operators and maintenance teams. Their clarity and precision support transparent communication among stakeholders, which fosters alignment across all phases of a project.

The importance of accuracy

Accurate and up-to-date P&IDs are vital for safe and efficient plant operations. Outdated diagrams can lead to miscommunication, operational errors and safety incidents. On the other hand, maintaining accurate P&IDs ensures compliance with regulations, improves troubleshooting and supports effective decision-making.

Outdated or inaccurate P&IDs can lead to serious operational failures, safety incidents and costly downtime. For example, incorrect valve locations or missing instrumentation can result in hazardous conditions or inefficient processes.

Well-maintained P&IDs are more than just documentation; they are foundational tools that support every phase of the system lifecycle:

- **Clarity and communication:** They serve as a universal language among engineers, operators, maintenance crew and stakeholders.
- **Safety and reliability:** They enable hazard identification, risk mitigation and safe operation.
- **Design and optimization:** They support process design and system or equipment upgrades.
- **Maintenance and troubleshooting:** They facilitate efficient diagnostics and can reduce downtime.
- **Training tools:** They can be used for new employee training.
- **PLC programming:** They can be used for a quick reference guide for programmers by establishing the level of control that will be required, simple closed-loop control, predictive, adaptative or cascade, etc.

Best practices in P&ID management

Maintaining high-quality P&IDs, not only during the conception phase, but also during the lifecycle of a site, requires more than technical accuracy. It demands a disciplined approach rooted in standardization, collaboration and continuous improvement.

Best practices in P&ID management include the standardization of symbols, thorough documentation and regular reviews. Implementing a structured P&ID review process can reduce maintenance errors and streamline lockout/tagout (LOTO) procedures to avoid injuries during maintenance interventions. Leveraging continuous feedback from operators and engineers also enhances the quality and reliability of P&IDs and, in the same way, improves operation response time and improves safety of operation in case of a breakdown.

Going deeper, best practices include:

- **Thoroughness and detail:** Include comprehensive information; ensure all relevant data is captured—equipment tags, pipe sizes, valve types, instrumentation details.
- **Standardization and consistency:** Adopt industry standards such as ANSI/ISA-5.1 or IEC 62424 to ensure consistency across your plant documentation.
- **Support maintenance:** Detailed diagrams improve response times and reduce downtime by allowing operators and technicians to quickly locate and identify related components to prepare and validate their work.
- **Centralize information:** Having information in one document will avoid duplication and conflicting details from different sources.

Benefits of effective P&ID management include:

- **Improved efficiency:** Engineers at a chemical plant used accurate P&IDs to automate their plant while optimizing equipment and piping layout. By minimizing unnecessary bends and reducing pressure drops, they improved throughput and energy efficiency, which resulted in measurable cost savings and enhanced process performance (helpful for selection of instruments and valves sizing).
- **Enhanced safety:** In refineries, the lack of a remote isolation valve has caused several explosions. The valve addition and its integration inside a more detailed and up-to-date P&ID enabled operators to quickly locate isolation valves during an emergency. This will facilitate a rapid system shutdown, hopefully preventing a potential accident. The P&IDs also support comprehensive safety reviews and hazard assessments, ensuring regulatory compliance and risk mitigation.
- **Streamlined maintenance:** At a power plant, well-maintained P&IDs served as essential references in the preparation of a predictive maintenance (PdM) program. Clear documentation of equipment locations, isolation points and operating parameters allowed technicians to perform tasks efficiently, thereby reducing downtime and maximizing asset availability.

Common pitfalls and real-world consequences

Common pitfalls include neglecting updates after system changes, inconsistent symbol usage and poor version control.

Outdated or inaccurate P&IDs can lead to serious operational failures, safety incidents and costly downtime. The following real-world examples highlight the critical importance of maintaining accurate, up-to-date documentation and implementing rigorous verification processes. Real-world examples and consequences include:

- **Pipeline rupture due to incorrect valve labeling:** In a gas processing facility, the P&IDs failed to accurately depict the location of a critical isolation valve. During routine maintenance, operators mistakenly closed the wrong valve, causing a sudden pressure surge and pipeline rupture. The incident resulted in significant production losses and environmental damage—underscoring the need for precise documentation and clear labeling.
- **Product contamination from a bypassed safety interlock:** At a pharmaceutical manufacturing site, outdated P&IDs did not reflect recent control system upgrades. During a process changeover, operators unknowingly bypassed a newly installed safety interlock, leading to an uncontrolled reaction and product contamination. The resulting batch failure triggered costly recalls and regulatory penalties.
- **Equipment damage from incorrect flow direction:** At a petrochemical facility, misinterpretation of process flow—partly due to unclear or outdated P&IDs—led to a critical error during maintenance operations. A backflow of hydrocarbons entered equipment not designed to handle such conditions, resulting in an explosion that caused extensive damage.

Ways these issues could have been avoided include:

- **Process, operation and control (POC) review** during design and any subsequent change.
- **Functional description reviews** during design and any subsequent change.
- **HAZOP review** (hazardous operability study) may be required during design and any subsequent change.
- **Use of design change notice** to document and approve the change, evaluation if a POC/functional description/HAZOP review is required to ensure all relevant documentation is updated (including P&ID).
- **Use of one master markup copy** with a person responsible for it.
- **Involve SMEs** in reviews: Incorporating feedback from subject matter experts (SMEs) is essential for maintaining P&IDs to ensure they are technically accurate and operationally effective. Apart from huge organizations or consultants, there are not many SMEs in factories.
- **Operational insights:** End users offer firsthand knowledge of system behavior, constraints and safety priorities that can significantly improve design accuracy. End users' feedback helps identify usability issues, potential design flaws and opportunities for optimization (practical design improvements).
- **Maintain version control and documentation standards:** Significantly enhances P&IDs accuracy, usability and reliability throughout a facility's lifecycle. Version control ensures traceability of changes, supports regulatory compliance and enables rollback in case of errors. Standardized documentation practices—such as consistent symbols, clear labeling and revision tracking—promote clarity and reduce misinterpretation among multidisciplinary teams.

- **Conduct regular audits:** SMEs ensure alignment with industry standards, codes and regulatory frameworks, which minimizes the risk of noncompliance. Regular review sessions with operators and SMEs can uncover overlooked issues and lead to more robust, user-friendly diagrams that reflect the true needs of the facility.

Note: These audits are not current in many industries, but they should be considered.

Challenges in maintaining P&IDs

Maintaining accurate and up-to-date P&IDs is essential for ensuring safe, efficient and compliant operations. However, organizations often face significant challenges in keeping these diagrams current, especially in dynamic industrial environments where systems evolve over time. By recognizing these challenges and implementing practical solutions, teams can ensure that P&IDs remain reliable tools throughout the system lifecycle.

System upgrades, expansions and process modifications can quickly render P&IDs obsolete if not properly managed.

Maintaining related process flow diagrams. At the early stage of a project and even before initiating the development of detailed P&IDs, a process flow diagram (PFD) is usually created by process and mechanical engineers.

The PFD serves as a simplified graphical representation of the overall process by outlining the sequence of operations and interconnections between major system components. It provides a foundational understanding of the process by defining key system metrics such as flow rates and volumes at each stage, as well as the required inputs and outputs including water, chemical additives, airflow and thermal energy (heating or cooling).

Resources for further exploration

The following organizations and websites provide extensive resources, technical publications and valuable insights on P&IDs, automation equipment design and related fields. They offer excellent opportunities to deepen your expertise.

- American Society of Mechanical Engineers (ASME): asme.org
- American Society of Safety Professionals (ASSP): assp.org
- Automation Federation: automationfederation.org
- Control System Integrators Association (CSIA): controlsys.org
- Engineering Institute of Technology (EIT): eit.edu.au
- Institute of Electrical and Electronics Engineers (IEEE): ieee.org
- International Electrotechnical Commission (IEC): iec.ch
- International Society of Automation (ISA): isa.org
- *ISA Transactions (Journal of Automation)*: journals.elsevier.com/isa-transactions
- ISA-TR5.9-2023, Proportional-Integral-Derivative (PID) Algorithms and Performance
- National Institute for Occupational Safety and Health (NIOSH): cdc.gov/niosh
- Occupational Safety and Health Administration (OSHA): osha.gov
- Process Industry Practices (PIP): pip.org

Additionally, the PFD specifies the types of tanks needed (e.g., sealed or open, with or without agitation or recirculation) and outlines the loading and unloading systems.

Note: The P&ID and the associated PFD must be kept aligned through the evolution of a plant since changes can be initiated either from the PFD or the P&ID, but they need to be kept aligned at all times to insure conformity.

Technical challenges. Version control across different project phases or system updates can lead to confusion, outdated documentation and costly errors. The solution is to implement a robust version control system that tracks revisions, logs changes and ensures all stakeholders have access to the most current version. Use specialized software tools that support version comparison, change tracking and audit trails to maintain document integrity.

As industrial systems grow in scale and sophistication, P&IDs can become cluttered and difficult to interpret, especially when overloaded with components and annotations. This system complexity challenge can be addressed by breaking down complex systems into logical sections or layers that focus on individual process units or subsystems. Use color coding, grouping and hierarchical layouts to improve readability. Include consistent legends and symbol definitions to aid interpretation.

Organizational challenges. Communication gaps and a lack of stakeholder engagement can also pose problems. Geographic dispersion, time constraints and siloed workflows can hinder effective collaboration during P&ID development and review. The solution is to adopt collaborative platforms that support real-time communication, document sharing and commenting. Use cloud-based systems for centralized access and version control. Define clear workflows for feedback, approvals and signoffs to streamline collaboration.

Involve SMEs and operators early to improve stakeholder engagement. Establish a structured process for periodic review and revision of P&IDs. Engage cross-functional teams, including engineering, operations, maintenance and safety to identify and implement necessary updates. Leverage intelligent P&ID tools with built-in revision management and centralized document repositories.

Compliance challenges. Ensuring that P&IDs meet industry standards, regulatory requirements and internal guidelines can be particularly challenging in highly regulated sectors. The solution is to develop standardized templates and workflows that incorporate relevant codes and best practices. Train personnel on compliance requirements and use software platforms with built-in validation and compliance-checking features.

Documentation challenges can be met with a sound document design rationale. Record the assumptions, design decisions and justifications to provide context for future modifications or audits. Facilitate access and make P&IDs available in both digital and physical formats to support operations, maintenance and the emergency response team.

Recommendations for improvement

To improve P&ID management, organizations should invest in training and awareness programs, adopt intelligent P&ID tools and conduct regular audits. Establishing clear ownership and integrating P&ID updates into change management processes ensure accountability and consistency. These steps collectively enhance the reliability and utility of P&IDs.

Involving end users and subject matter experts throughout the P&ID development process ensures alignment with both operational requirements and regulatory standards. Regular review sessions and feedback loops allow timely adjustments based on real-world insights, which results in diagrams that are not only technically accurate but also practical and user-centric.

Well-developed P&IDs that reflect the input of those who operate and maintain the system are more likely to support safe, efficient and compliant operations.

Establishing ownership and accountability is one of the most important points. Assign responsibility for creating and maintaining P&IDs to specific roles or departments. Have one specific individual responsible for maintaining the master markup (typically the plant process engineer).

Integrating P&ID updates into change management processes is the second most important point. Each change must go through a change management process with approval—usually initiated by the industry process engineer and approved by all.

Also provide training. Educate personnel on how to read and interpret P&IDs to ensure safe and effective use. Schedule periodic reviews with cross-functional teams to ensure diagrams reflect current system conditions.

Use of intelligent P&ID tools.

Intelligent P&ID tools are not commonly present in plant maintenance but are mainly used during the engineering phase while developing new P&IDs. Intelligent P&IDs represent a significant evolution from traditional, static CAD-based diagrams. These dynamic, data-driven diagrams are linked to centralized databases that enable enhanced functionality, automation and cross-disciplinary integration throughout the engineering lifecycle. But such P&IDs are in most cases not supported by end users (plant engineering) since these tools are too costly and their integrity is hard to maintain.

Unlike conventional P&IDs, which are primarily visual representations, intelligent P&IDs treat each component, such as valves, pumps and instruments, as data objects enriched with metadata. This approach supports automated documentation and seamless integration with other engineering and enterprise systems. Intelligent P&IDs provide:

- Real-time updates and metadata integration.
- Support for digital twin and Industry 4.0 initiatives.
- Enhanced visualization and data export.
- Improved data integrity and consistency.

These systems can interface with enterprise tools such as ERP systems, asset management platforms and digital twin environments that enable a unified data ecosystem and improved collaboration.

Intelligent diagrams are often interactive, which allows users to click on components to access metadata, maintenance history, operational status and documentation.

Looking ahead

Technologies like artificial intelligence (AI) and digital twins are transforming P&ID management. AI can digitize legacy diagrams, automate updates and enhance accuracy. These innovations promise a future where P&IDs are seamlessly integrated into intelligent, data-driven industrial ecosystems. Many prerequisites may be required to achieve theses goals and remain to be defined.

P&IDs are indispensable tools in industrial operations. Their accuracy directly impacts safety, efficiency and compliance. By adopting best practices, addressing common challenges and leveraging digital technologies, organizations can significantly improve their P&ID management.

Accurate P&IDs reduce risk, improve communication and support long-term operational success. They are not just technical drawings, they are a strategic asset.

ABOUT THE AUTHORS

André Éthier, P.Eng. Is a senior engineer in IT systems and process control with more than 38 years of experience integrating IT systems and industrial automation. He has led projects across the full lifecycle—from feasibility studies to commissioning—on an international scale. With more than 22 years at Hatch, André has contributed to major project initiatives in mining, metals, oil and gas, EV battery manufacturing and small modular reactors. His expertise includes design optimization, construction planning, startup commissioning, ramping up and operational readiness. As a former technical support specialist and speaker in industrial automation, André brings a unique blend of technical depth and practical insight to today's complex engineering challenges.

Michel Roy is an electrical, systems and process control technician with more than 25 years of experience in consulting engineering. He brings deep expertise in project management, contract administration and the design and supervision of electrical and control systems. Throughout his career, he has led projects of various scales, contributed to the design of electrical panels and technical drawings and developed PLC programming interfaces. He is known for his strong commitment to operational excellence and regulatory compliance.

More from Automation.com

This month's topical roundup will teach you the best way to keep your manufacturing equipment in great shape, explain how operational maturity bolsters cybersecurity and show how modern alarm design and management strategies are reshaping operational safety and efficiency. Get the news delivered straight to your inbox by subscribing to Automation.com.

Process Automation & Control

Open Process Automation Systems Advance

Automation.com publisher Rick Zabel discusses how the Open Process Automation (OPA) initiative will impact the future of industrial automation systems. As an example, he mentions ExxonMobil's Lighthouse Project, demonstrating OPA's visibility when used as the design basis for automating a resin plant near Baton Rouge, LA.

Can Europe's Domestic Lithium-Ion Battery Manufacturers Gain Firm Foothold in the 800 GWh Race?

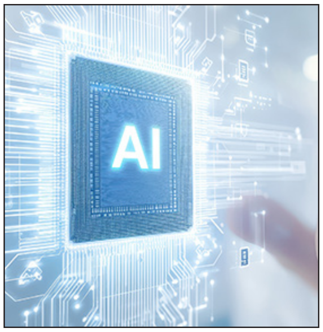
In early August, the European Union announced an investment of €852 million ($1 billion) in six lithium-ion battery factories. This is part of the EU's Battery Value Chain Enhancement Plan, with a total budget of €30 billion ($35 billion).

IIoT & Digital Transformation

Industrial Foundation Models Are Transforming Engineering and Manufacturing

AI helps bridge the gap between human expertise and machine efficiency, but traditional AI models don't always meet the complexity, precision and safety benchmarks of manufacturing environments. Industrial Foundation Models can help.

How AI Improves Signal Processing in Industrial IoT



Signal processing automation experts have long fought interference and disruptions. AI promises to bolster the sector and make transmissions faster and clearer. AI will help through noise reduction, signal enhancement, anomaly detection and more.

Industrial Cybersecurity & Safety

Operational Maturity: The Missing Link in Cybersecurity Success

The biggest risk to organizations isn't the sophistication of cybercriminals—it's the absence of mature, repeatable processes. Aligning security processes with business objectives can transform reactive security postures into resilient, strategic programs.

Rethinking Industrial Alarms for a Safer, Smarter Plant

This article examines the evolving role of alarms—from basic notifications to intelligent safeguards—and discusses how modern alarm design, integration and management strategies are reshaping operational safety and efficiency.

Operations and Management

Digital Twin or Digital Flop? Why Companies Need Document Control Before 3D Models

Despite the investment and buzz around photorealistic 3D twins and visually rich models, the real challenges are more fundamental. Some barriers to digital twin success include digitizing documents, data disorganization, lack of governance and a lack of alignment of purpose with operational needs.

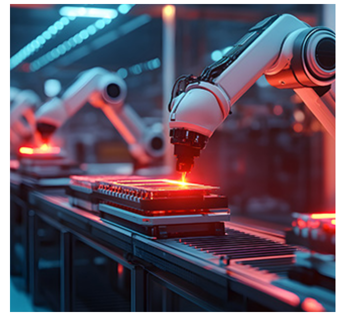
What Tariffs Reveal: A Wake-Up Call to Strengthen Manufacturing Skills

As manufacturers grapple with the uncertainty of tariffs and their potential impact, many are speculating whether digital manufacturing technologies–such as additive manufacturing–might be key to overcoming these challenges. Tariffs and their continued impact also highlight the need to invest in workforce skills.

Factory Automation & Control

Modernization or Migration—Which One Is Right for You?

Managing aging technology and infrastructure is a big challenge for many manufacturers. According to industry findings from TWI Institute, 80% of all unplanned downtime in the manufacturing environment can be linked to equipment failure. How do you determine whether you should update equipment or fully replace it?



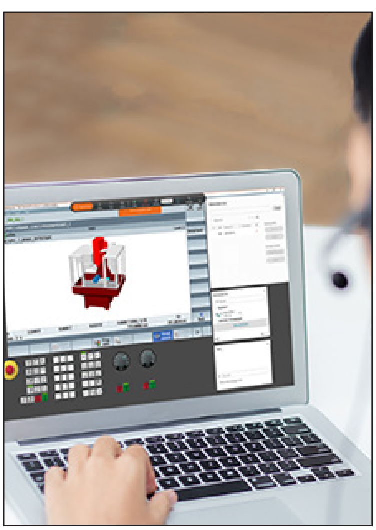
New A3 Report Signals Steady Automation Investment in First Half of 2025

The Association for Advancing Automation (A3) released a report indicating robot orders increased by 4.3%, and revenue rose 7.5% in the first half of 2025 compared with the first half of 2024. North American companies ordered 17,635 robots valued at $1.094 billion in the first six months of 2025.

Product Updates

Siemens Offers Virtual Product Expert for CNC

Siemens CNC community members will be able to interact with a product expert and get answers to programming and operations questions on demand.



ABB's Global NEMA Motor Meets Needs of Industrial Applications Worldwide

The U.S. Department of Energy reports that HVACR systems account for as much as 40% of energy use in commercial buildings, with space heating, cooling and ventilation driving most of the consumption. This makes energy efficiency a top priority. ABB, a NEMA motor manufacturer, engineered the Baldor-Reliance GNEM motor solution to answer this need.

Association News

The International Society of Automation loves to inspire, educate and celebrate the engineers, technicians and managers engaged in industrial automation through its events, publications and foundational standards-based technical resources. Find out what's available and get involved.

ISA Recognizes 2025 Celebrating Excellence Awardees

ISA has announced the 2025 ISA Celebrating Excellence award recipients. This program formally showcases and celebrates the remarkable achievements and contributions of ISA members, partners and other automation industry professionals. This year's awardees will be honored at the ISA Honors and Awards Gala as part of the Automation Summit and Expo to be held 5-7 October 2025 in Lake Buena Vista, Fla.

The 2025 award for Enduring Society Service goes to Carlos Mandolesi. Carlos was ISA president in 2022, but his service to the society started long before and continues today. He is an enthusiastic champion of the automation industry and has helped create programs that educate, inspire and support automation professionals worldwide. Here are a few highlights.

Mandolesi helped ISA create International Automation Professionals Day, held annually in April and celebrated online via #IAPD or #AutomationProDay. The digital event engages automation professionals from all around the globe to recognize their efforts in the vastly growing automation industry.

Mandolesi helped ISA create International Automation Professionals Day, held annually in April.

Mandolesi said, "It is very common that our friends, relatives and population in general do not understand what we do when we say that we work with automation. It is important to have our own date to celebrate and promote the automation profession. ISA, as the home of automation, is the perfect organization to create it."

Mandolesi also focuses on the future to help ISA members stay on top of emerging topics. In September 2020, he was instrumental in establishing ISA's Smart Manufacturing and IIoT (SMIIoT) division along with Sujata

Tilak, currently an ISA executive board member. Soon the largest and fastest-growing division in ISA, SMIIoT encompassed eight aspects of smart manufacturing: Industrial Internet of Things (IIoT), cloud technologies, artificial intelligence and machine learning, communication and networking (industrial Internet), cybersecurity, cyber-physical systems, digital twin and simulation and virtualization technologies, including virtual reality and augmented reality.

When ISA reorganized its governing structure late last year to remove division designations, the importance of those and other topics did not diminish. Mandolesi became ISA's Technical Assembly Chair and ISA announced a new way for members to exchange ideas and build expertise: technical communities called Connect Forums.

Connect Forums are hosted on ISA Connect, ISA's members-only online community and discussion board. They cover key ISA technical content topics, allowing ISA members to engage with automation professionals across sectors, discuss cutting-edge automation topics and get real-time answers to their toughest questions.

Said Mandolesi, "As ISA members directly connect across sectors, we will learn, share our expertise and grow as professionals for the duration of our careers. Connect Forums are an invaluable benefit to ISA membership that you can't get anywhere else."

Additional 2025 Honorees

A number of other individuals will be recognized in October for their contributions and achievements. They include Edson da Costa Bortoni for excellence in education; Hector Puyosa for excellence in mentoring; Sarah Fluchs for excellent work on standards; and Xiaowei Yue for excellence in technical achievement.

ISA geographic sections being recognized for excellence include the Bangalore section, the Nigeria section and the Spain section.

Sagacity Allstream Fabrication Engineering is being honored for excellence in corporate technical innovation.

ISA volunteers of the year include Greg Potter, Jane Buchanan, Jose Bielza, Olawale Akande and Vaibhav Subhash Narkar. ISA student volunteers of the year are Atharva Joshi, Julia Feijoo and Lucia Freire.

—Renee Bassett

Upcoming Conferences

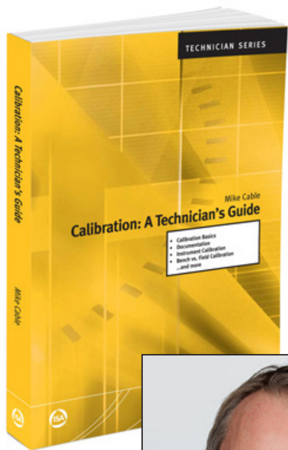
2025 ISA Automation Summit & Expo–USA, 5-7 October, Disney's Coronado Springs Resort, 1001 W. Lake Buena Vista Dr., Lake Buena Vista, Fla. 32830

2026 ISA OT Cybersecurity Summit, 16-18 June, Vienna House by Wyndham Diplomat, Prague, Evropská 15, 160 41 Praha 6, Czech Republic

2026 ISA Automation Summit & Expo–USA, 27-29 September, Walt Disney World Swan and Dolphin, 1200 Epcot Resorts Blvd, Lake Buena Vista, Fla. 32830

Process Instrumentation Calibration Guide

Named ISA's Best-Selling Book



As part of the 2025 Celebrating Excellence Awards Calibration: A Technician's Guide is being recognized as a best-seller for 2025.

This comprehensive review of process instrument calibration provides a foundation for understanding the principles and applications of the most frequent tasks that a technician performs. It also serves as an excellent study guide for the Calibration portion of the Certified Control System Technician (CCST) certification.

The book is designed as a structured learning tool with questions and answers in each chapter.

The book is designed as a structured learning tool with questions and answers in each chapter. The extensive appendix is an excellent reference containing sample P&IDs, loop diagrams, spec sheets, sample calibration procedures and conversion and reference tables. Topics include terminology, bench calibration versus field calibration, loop calibration versus individual instrument calibration, instrument classification systems, documentation and calibration techniques for temperature, pressure, level, flow, final control and analytical instrumentation.

Author Mike Cable is the head of engineering at the Durham, N.C. location of CARsgen, a global biopharmaceutical company. Cable is a Level 3 Certified Control System Technician who started his career as an electronics technician in the Navy Nuclear Power Program as a reactor operator and engineering watch supervisor aboard the USS Los Angeles submarine.

After the military, Cable spent 11 years as a validation contractor. His career was highlighted by an assignment managing instrument qualification projects for Eli Lilly Corporate Process Automation.

This book is part of the Technician Series Library from ISA, which includes the following books:

- Calibration: A Technician's Guide by Mike Cable
- Loop Checking: A Technician's Guide by Harley M. Jeffery
- Project Management: A Technician's Guide by Leo Staples
- Start-Up: A Technician's Guide, Third Edition by Diane R. Barkin
- Troubleshooting: A Technician's Guide, Second Edition by William L. Mostia, Jr., PE.

—Renee Bassett

Attendees Enjoy OT Cybersecurity Summit in Brussels

The International Society of Automation (ISA) hosted its third-annual OT Cybersecurity Summit in Brussels, Belgium, on 18-21 June 2025, and what a great event it was!

Attendees had many good things to say about what has quickly become the industry's leading event for industrial cybersecurity and technical content surrounding the ISA/IEC 62443 series of standards.

"ISA events offer a unique blend between global cybersecurity professionals and newcomers," said Nasser Al Alawi from Oman, "and they are all talking the same language about automation and cybersecurity. You can take away immediate actionable insights from expertise and peers facing the same challenges as you are."

Available exclusively at the ISA OT Cybersecurity Summit for the second time, a virtual escape room experience targeted the training needs of OT cybersecurity and automation engineers. This experience, programmed by the advanced visualizations team at Visco, was a walkthrough of a ransomware attack on an offshore oil and gas production unit. Many attendees cited the escape room experience as one of the highlights of the event. (Users who go to the ISA Automation Summit & Expo this October in Orlando can visit the Igloo Vision booth in the exhibit hall to enjoy the same full-immersion experience.)

The OT Cybersecurity Summit featured two content tracks—on threat intelligence

The OT Cybersecurity Summit featured trainings, workshops and content tracks on threat intelligence and securing the supply chain.

and securing the supply chain—with 40 speakers across 35 sessions. Two hundred and fifty attendees and 21 sponsors enjoyed lively discussions, technical demonstrations, and so much more.

"At ISA, everyone is open-minded," said SZ Lin from Taiwan. "We can stick together and discuss the standards, and how to make the world better. And more than that, we have similar perspectives and a fantastic culture. We know about cybersecurity and we know about automation, but the key factor is the people and relationships."

Keynote sessions kicked off each day. Bola Adesina, director of AI governance and ethics, diversity and inclusion specialist at her own consulting company, discussed how to embrace artificial intelligence technologies while keeping cybersecurity in mind. "We aren't protecting systems from systems," Adesina said. "We're protecting people from people."

Keynote speaker John Fitzpatrick, founder of Lab539, discussed resilience in OT cybersecurity. ISA President Scott Reynolds also gave a presentation on improving cybersecurity for a more resilient supply chain. His advice: "Just start somewhere. Do something. The easiest way is to start with a passive asset inventory. If you start with 90% of what you have now and you start securing it, that's better than waiting two years to get the funding to do your 100%."

Highlights

The ISA Global Cybersecurity Alliance (ISAGCA) and ISASecure programs cosponsored this year's OT Cybersecurity Summit to raise further awareness about their offerings for the operational technology cybersecurity community.

ISAGCA hosted a panel discussion on international regulatory issues and sought feedback from the end-user community in a special session. ISAGCA also shared two whitepapers focused on the intersection of IT and OT:

- Applying ISO/IEC 27001/2 and the ISA/IEC 62443 Series for Operational Tech Environments
- Understanding the ISA/IEC 62443 Series of Standards from an ISO/IEC 27001 and ISO/IEC 27002 Perspective

ISASecure shared information about its forthcoming IACS Security Assurance (ACSSA) program to demonstrate operating site compliance with the international standard ISA/IEC 62443. The proposed ISASecure site assessment fills a gap in the OT cybersecurity landscape. It addresses the operating site itself, and is the only standards-based program that does so. "We anticipate it will become the global standard used by operating sites, certification bodies, internal auditors and public policymakers," said Liz Neiman, managing director of strategic engagement for ISA.

Incident Command System for Industrial Control Systems (ICS4ICS) is an ISA program that is designed to improve cybersecurity incident response efforts. ICS4ICS has hosted workshops all over the world to share its training exercises and provided a workshop on emergency cyber response at the summit. ISA also offered its two most popular training courses as add-ons for those interested in deepening their knowledge of the ISA/IEC 62443 series of standards:

- Using the ISA/IEC 62443 Standards to Secure Your Control Systems (IC32)
- Assessing the Cybersecurity of New and Existing IACS Systems (IC33)

2026 OT Cybersecurity Summit Planned for Prague

The OT Cybersecurity Summit goes to Prague, Czech Republic, in 2026. Save the date for 16-18 June and check back at otcs.isa.org for details coming soon. As attendee René Matthiassen from Denmark said, "This is definitely the event you want to attend on a yearly basis. It is an opportunity to network and hear what's going on in the industry, speak to a lot of interesting people and see new technologies."

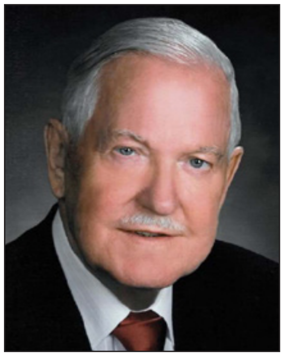
—Renee Bassett

A virtual escape room experience programmed by Visco was available at the ISA OT Cybersecurity Summit.

In Memoriam

These obituaries honor three members of the automation community who died this year. If you know of someone else from the ISA family we should be remembering, send information to press@automation.com.

Hans D. Baumann, Ph.D., PE



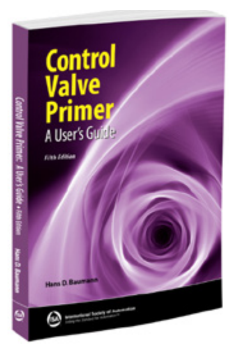
Dr. Hans D. Baumann, PE, a world-renowned process control and control valve expert, passed away at his home in West Palm Beach, Fla. in the early hours of March 25, 2025. He was 94.

Baumann's contributions to his chosen field are vast and varied, and his dedication to advancing the state-of-the-art is unsurpassed. Baumann designed or directed the development of more than 30 valve lines during his professional career, including the well-known CAMFLEX valve, which has been produced in eight countries and sold more than three million units.

Baumann served in various leadership roles within professional societies, including Director of the ISA Standards and Practices Board, U.S. Technical Expert for IEC TC 65/SC 65B/WG 9 and Chair of the ISA-75.11 Work Group. The International Society of Automation's (ISA's) *InTech* magazine named him one of the 50 Most Influential Industrial Innovators, and he was inducted into the Process Automation Hall of Fame.

Patents, publications and fundamentals

Baumann is credited with more than 150 U.S. and worldwide patents and has published more than 200 papers and articles in addition to authoring/co-authoring seven handbooks on valves and instrumentation. He recently wrote Fluid Mechanics of Control Valves: How Valves Control Your Process, a practical reference guide to control valve design, selection and operations, as well as the fifth edition of Control Valve Primer, both published by ISA.



Preferring the practical over the political, Baumann was never shy about steering away from the crowd to get to the underlying fundamentals or to resolve a conflict with a practical approach. Getting to the physical truths of process control was of key importance to him. In that spirit, Baumann pioneered many of what are now fundamental concepts relating to valve sizing and valve noise prediction, such as the critical flow factor (FL), the pipe reducer correction factor (Fp) and a modified valve style modifier (Fd).

His proposal in 1970 to use modified jet noise theories for aerodynamic valve noise prediction became the basis for

ISA-75.17-1989 and IEC Standard 60534-8-3. His most recent efforts resulted in the development of a novel, simplified, physics-based noise prediction method known as the ABC Method. His scientific and engineering appetites were insatiable right to the end.

Baumann's career

Baumann's professional career, spanning nearly 70 years, began in his native Germany in the early 1950s. Early in his career, he worked at a foundry and with a tool and die maker. These experiences proved invaluable in his ability to design practical and cost-effective control valves.

He began his professional career at Welland & Tuxhorn, where he worked as an engineering manager. In 1958, Baumann moved to the United States to work for Masoneilan Company as a development engineer. From there, he progressed to director of engineering at A.W. Cashco in Illinois, manager of R&D at Worthington S/A in France and corporate vice president of Masoneilan International. In 1977, while working as an international consultant, he determined it was time to form his own control valve manufacturing company (H. D. Baumann Assoc., Inc.). After selling his company to Emerson Electric, he worked for Fisher Controls as a senior vice president.

A well-received guest speaker around the globe, he also served as a guest professor at Kobe University in Japan and the Korean Advanced Institute of Technology in South Korea.

Baumann's professional affiliations include the following: Honorary Member of the ISA, Life Fellow of the American Society of Mechanical Engineers (ASME), Honorary Life Member of the Fluid Controls Institute (FCI) and member of Sigma Xi, the Scientific Research Honor Society.

He was a member of the ASME Bioprocessing Equipment Executive Committee and Chairman of the Equipment Subcommittee on Seals. He was also the former Standards Chairman for Control Valves for the Fluid Controls Institute (FCI).

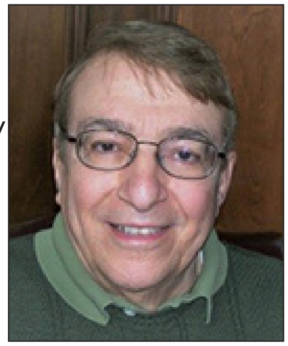
"I would advise students and graduates alike to make more use of their brain and imagination." *—Hans D. Baumann*

Baumann's control valve designs earned many notable awards including seven U.S. Vaaler awards, the ISA UOP Technology Award, the ISA Chet Beard Award, a Gold Medal from Germany and prizes from France and Japan. He was also named Entrepreneur of the Year by the New Hampshire High Technology Council.

Baumann lived purposefully, authentically and fully. He was very generous, sharing his knowledge, his experience and his success. He was ever the gentleman in manner and appearance. He is survived by his two children, five grandchildren and a great-grandson. If someone would like to donate in memoriam, The Palm Beach Opera and The Palm Beach Symphony "were both close to my father's heart," according to his son Peter.

—Renee Bassett

Ronald L. Krutz, Ph.D., PE



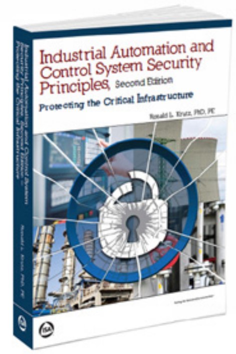
Ronald L. Krutz, Ph.D., PE, CISSP, ISSEP, age 86, of Gibsonia, Pa., formerly of North Huntington, Pa., died on January 16, 2025. He was a distinguished author, teacher and cybersecurity specialist with more than 30 years of experience in industrial automation and control systems, distributed computing systems, computer architectures, information assurance methodologies and information security.

Born in Duquesne, Pa., on August 27, 1938, he is the son of the late Louis and Rose (Cardamone) Krutz. He served in the U.S. Army Ordinance Corps as a 1st lieutenant at Redstone Arsenal in Huntsville, Ala. He held a Ph.D. in electrical and computer engineering from the University of Pittsburgh and was a licensed electrical engineer.

His distinguished career started at Gulf Oil Corp. and continued at Carnegie-Mellon University, where he was a faculty member in the electrical and computer engineering (ECE) department. While there, Krutz founded and led the Carnegie Mellon Research Institute (CMRI) Cybersecurity Center.

Later in his career, he was a professor at Webster University, a distinguished visiting lecturer at the University of New Haven and a senior fellow of the International Cybersecurity Center of George Mason University. Later, he was chief scientist at Security Risk Solutions Inc., in Mount Pleasant, S.C.

Krutz is the author of 16 books in the areas of cybersecurity, microprocessors, system design and computer architecture. He authored the book *Securing SCADA Systems*, as well as the first and second editions of ISA's Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure. He holds seven U.S. patents in the area of digital systems and has also published a variety of technical papers.



The second edition of his book contains a significant amount of new and enhanced content, including emerging approaches to industrial automation and control system (IACS) security. Topics include Industrial Internet of Things (IIoT), the open platform communications unified architecture (OPC UA) (IEC 62541), Industry 4.0, the "OWASP IoT Top Ten" security categories, big data analytics, the NIST Big Data Interoperability Framework, the NIST Framework for Cyber-Physical Systems, the NIST Framework for Improving Critical Infrastructure Cybersecurity and software-defined elements.

Krutz was the beloved husband of Hilda (Napolitano) Krutz, the loving father of two daughters and the admired grandfather of four. He met his wife at a young age, married in 1961 and was a devoted husband for 63 years. According to his obituary, "he most enjoyed being a grandfather and his proudest and most beautiful accomplishment was his family."

—Renee Bassett

H. Reed Wiegle

H. Reed Wiegle, 81, of Glenmoore, Pa., passed away on Sunday, June 8, 2025, at his residence. He was a long-time contributor to a variety of ISA standards and practices.

Reed was born on July 10, 1943, the son of Howard Harrison Wiegle and Frieda Lois Linnert. Growing up, Reed thought that his Uncle Charlie was a really interesting person and he wanted to be just like him. Charlie Linnert was a nuclear engineer who worked on the Manhattan Project during World War II and developed control rod drives for the first nuclear submarine, the USS Nautilus.

Wiegle graduated in 1965 with a degree in electrical engineering from the University of Pennsylvania. In 1971, he earned his master's degree in electrical engineering with a thesis on Muddy Run Pumped Storage Station. He was then hired by Philadelphia Electric Company, where he worked in substations; fossil, hydro and nuclear generating stations; and quality management systems until he retired.

Wiegle's next act was as a consultant for Canus and later Shaw Group. He travelled to South Africa to observe modular reactors and was involved in oversight teams for restarting Comanche Peak in Glen Rose, Texas and Davis-Besse in Oak Harbor, Ohio. While at Davis-Besse, he was fortunate enough to meet Herbert Estrada, who had known his uncle Charlie and shared several stories.

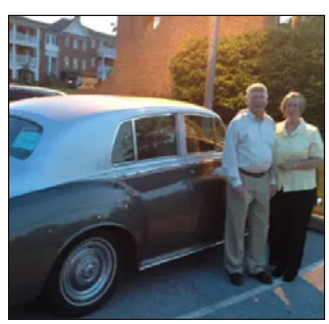
Wiegle retired from The Shaw Group when the Fukushima Daiichi Nuclear Power Plant became one of the worst nuclear disasters in history.

Wiegle was an ISA Standards and Practices (S&P) Board Member through December 2004. He was a long-time ISA committee member for ISA67, Nuclear Power Plant Standards, and ISA67 managing director through July 2005. He received an ISA Service Award in 1992 for his work with ISA67.

Wiegle also received an ISA Achievement Award in 1997, "in recognition for outstanding contributions in the development of ISA-TR88.0.03, *Possible Recipe Procedure Presentation Formats*, and for pioneering work in developing ISA standards and technical reports using the Internet." ISA-TR88.0.03-1996 explores possible presentation formats for recipe procedures in batch process automation, based on the ISA-88.00.01-2010, Batch Control Part 1: Models and Terminology (formerly ANSI/ISA-S88.01-1995) and IEC standards.

According to his obituary, Wiegle "had an incredible capacity to fix anything. His mind could figure out how things worked and if they broke, he could fix them. He loved operating equipment and would happily spend an entire weekend on his tractor mowing fields."

—Renee Bassett



Reed Wiegle had many interests besides automation standards, including vintage cars, auto racing and foxhunting.

FROM THE EDITOR

Process Control Books Help You Identify Real Experts

"In the current age of YouTube, TikTok and the like, there's no shortage of 'experts' providing their brand of loop tuning, performance criteria/monitoring, instrument selection, etc.," said Michael Taube, a process industries consultant and regular contributor to ISA's long-running Ask the Automation Pros column.

Columnist Greg McMillan had asked 10 automation professionals to provide their recommendations for the most useful books covering measurements, final control elements, control strategies, controller algorithms and controller tuning. McMillan himself is a prolific author and well-known expert with a new book (more on that in a moment), so it seems the perfect time to discuss such books—especially since this issue of Automation.com Monthly is focused on process control.

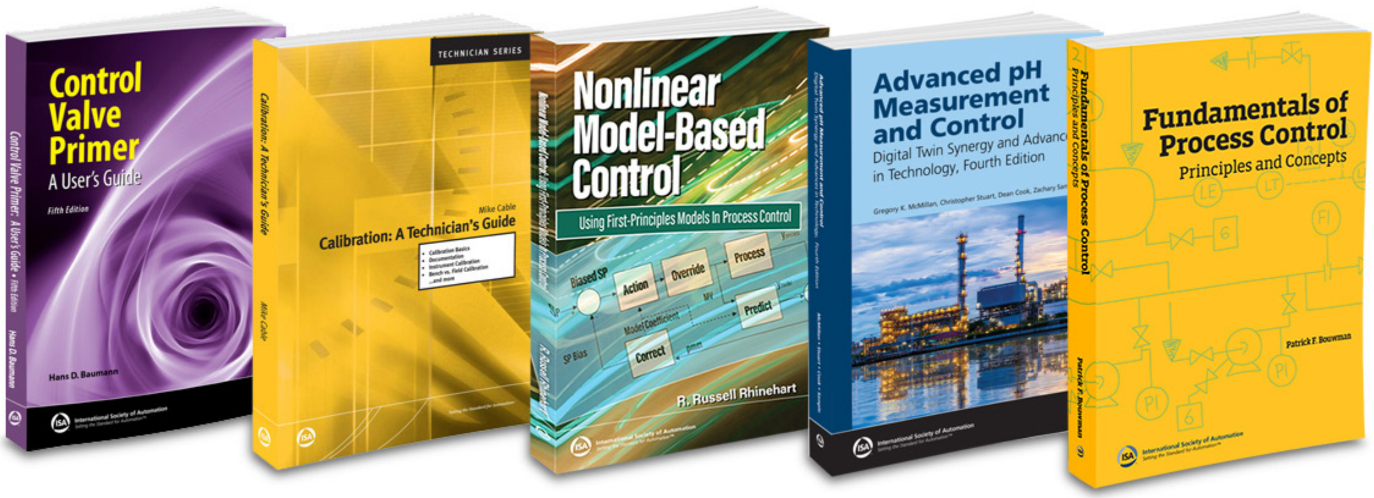
Taube reminds us that "Too often it seems that people try to make the process fit their preconceived notions of instrumentation, control structure and loop tuning rather than making the instrument selection, control structure and loop tuning fit the process and its operational objectives. Thus, the books that I've found most helpful are those that describe the process, the operational intent/objectives and limitations/constraints (both 'safety' as well as nominal design), mechanical design considerations (e.g., centrifugal pump/compressor versus positive-displacement, etc.) and types of quality measurements (i.e., lab versus online, inferential, etc.)."

The automation professionals who take the time to distill and share their knowledge are some of the greatest assets of our industry.

Finding the experts

Other contributors to the Ask the Automation Pros column listed a wide range of specific books from ISA and elsewhere, especially Harold L. Wade's *Basic and Advanced Regulatory Control: System Design and Application*, an ISA book in its 3rd Edition. Peter Morgan cited McMillan's *Tuning and Control Loop Performance* 4th Edition as a book that every student of process control and automation should have at hand. "This book puts a reference into the hands of automation specialists that is based on a lifetime of experience," he said.

Books tend to gather and present lifetime experiences in a way that no TikTok video



can. Our In Memoriam section this month discusses the life experience of Hans D. Baumann and how it informed his two books, the fifth edition of *Control Valve Primer* and *Fluid Mechanics of Control Valves: How Valves Control Your Process*.

McMillan's life experiences and achievements inform his latest book, *Advanced pH Measurement and Control - Digital Twin Synergy and Advances in Technology*, Fourth Edition. ISA's St. Louis section is having him give a presentation based on the book as part of their 2025-2026 Technical Program in October. All advanced registrations include a free copy of the book.

ISA books transition

This year, ISA is transitioning its book sales and distribution to its publishing partner, Wiley. That means print titles will be temporarily unavailable via isa.org as of 12 August 2025, but Kindle and ePub formats are still available via the links on each book's product page. Note: not all books are available in all formats.

Beginning 1 January 2026, print and ebook formats of all ISA books will be available for purchase through Wiley. In the meantime, you can purchase ebook formats from the VitalSource website via the links provided on individual book product pages. Purchase Kindle formats on Amazon.com via the links provided on the individual book product pages.

Whether it's real-world fundamentals or cutting-edge new techniques, books can provide the experience and insight you need to solve your toughest automation challenges. The automation professionals who take the time to distill and share their knowledge—whether through books or live presentations—are some of the greatest assets of our industry. The International Society of Automation helps you find them.

Renee Bassett Chief Editor,
Automation.com Monthly